HANDBOOK OF INDUSTRIAL TOXICOLOGY AND HAZARDOUS MATERIALS

Nicholas P. Cheremisinoff

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PREFACE

The *Handbook of Industrial Toxicology and Hazardous Materials* has been prepared as a practical reference for those individuals and organizations dealing with dangerous or potentially hazardous chemicals and materials. The intent of the volume is to provide easily understood information that can assist in the proper management and handling of chemicals, as well as providing basic information and guidance that can aid first responders to a hazardous materials incident. The handbook is not intended to be used as a textbook for instructional purposes; however it could serve as a reference for students and instructors of hazmat course studies.

There are numerous databases and publications on hazardous materials, many of which have been referenced in this volume and highlighted for the reader's attention. Depending on the nature and extent of the reader's chemical handling, management and/or level of responsibilities for chemicals and worker safety issues, these other references, including electronic databases, may have to be consulted. Additionally, authoritative organizations such as the ACGIH, OSHA, NIOSH, NFPA, IARC, UNDP, USDOT and others identified in this handbook, as well as local and company specific safety practices, should be heavily consulted when dealing with worker safety and health related issues.

It is important to note that many OSHA (U.S. Occupational Safety and Health Act) terms are used throughout the handbook; however the author has made efforts to use and apply internationally recognized terminology and definitions as opposed to those which stem from the U.S. regulatory system. It is essential that industry, because of its global nature and widespread international chemical shipments, continue to develop and apply universally accepted terminology concerning chemical hazards.

The primary information contained in this handbook includes health and safety information for over one thousand commercial chemicals, fire and chemical compatibility information, guidelines for responding to hazardous materials incidents involving spills and fires, physical and chemical properties information important to the safe handling of chemicals, personal protection information and data, and guidelines for personnel and work area safety monitoring and sampling. Chemical specific and safety information is provided in six chapters that follow an introductory chapter that provides an explanation of important terms used throughout the handbook along with detailed explanation on the organization of materials and how to apply them. The reader should carefully review Chapter 1 to understand these terms, the limitations of data, and the references used in compiling the information that has been organized. A substantial Glossary of Terms containing nearly seven hundred definitions is also provided at the end of the handbook for the reader's convenience. The reader must recognize that unless a specific reference source for certain information has been cited, data and information were derived from reviews of company specific material safety data sheets (MSDS). In these cases, which are numerous, the exact sources were not cited because several chemical suppliers' MSDS were reviewed for any one chemical and the worst case and more serious notation for safety issues were compiled. Hence, the reader should view such information as being typical rather than rigorous, and should always consult with chemical suppliers and manufacturers

of specific products. Additionally, although the author has made every reasonable attempt to verify the accuracy of information presented in the handbook by review of multiple open literature sources, neither he nor the publisher will guarantee complete accuracy of the information and data, and we do not recommend or endorse the application of this information for design purposes or emergency response procedures. The handbook provides guidance only, and much of the data will require interpretation and prudent judgement on the part of a knowledgeable reader with training in chemistry, engineering, and hazardous materials handling operations, as well as detailed knowledge of federal and local regulations and company specific safety practices. The reader will also come across company specific information and data, particularly with regard to discussions on chemical protective clothing and certain field monitoring instrumentation described. References to these companies and their products are not intended to be an endorsement, but rather this information is included as illustrative and general only. Further, the exclusion of references to other company specific safety products should not be interpreted as a negative review.

A final note is that the handbook does not address the subjects of labeling packages and containers of chemicals and hazardous materials, placarding of shipments, or performance oriented packaging requirements, or related safety transportation standards. This information can be found in great detail in the U.S. Code of Federal Regulations, Title 49. Transporters of hazardous materials may still find a great deal of useful information in this handbook. However; this volume is not aimed at assisting in the transportation issues for hazardous materials.

The author wishes to acknowledge and thank the following organizations for advice and suggestions in organizing the materials in this volume: the United States Environmental Protection Agency - Region IV, the United States Agency for International Development, the Environmental Policy & Technology Project providing assistance to the Newly Independent States of the former Soviet Union, members of the National Academy of Sciences of Ukraine, the World Health Organization, and Marcel Dekker, Inc.

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TERMINOLOGY AND HOW TO USE THE HANDBOOK

I. INTRODUCTION

This handbook has been compiled to assist industry managers and safety professionals working with or who have the responsibility for safety issues involving the handling of commercial chemicals. The handbook is not definitive, but is extensive in coverage, containing thousands of data entries pertinent of assisting the safety professional in formulating proper and safe handling practices that will protect workers and the public who may be potentially at risk from a hazard materials incident. The handbook is intended as a supplemental reference to other well known literature sources cited in the volume.

All chemicals are potentially hazardous. Even those materials which humans are exposed to on a daily basis, can pose a threat. A simple example is sodium chloride (table salt) which many people use daily to flavor their foods. Over the course of a life time, the body is exposed to large amounts of this chemical, but in small quantities at any one time. This degree of exposure usually does not lead to serious health problems. In contrast, if one were to consume an 8 ounce tumbler of sea water, which contains about 6 weight percent sodium chloride, the body would have a violent reaction, including vomiting, abdominal cramps, and possibly even death for some. This example helps to illustrate that the degree of health risk depends on several factors: the amount of chemical exposure and the time frame over which the exposure to the chemical occurs (known as the dosage), and the sensitivity of the receptor to the chemical exposure. Receptor sensitivity in turn depends on many variables, such as the person's age, his or her general health, genetic and or hereditary parameters, prior historical exposure to other chemicals which may have additive or synergistic effects, and others. We would be remiss not to note that the route of exposure is also important to the degree of risk and type of reaction that could occur, with the most common routes of exposure being inhalation, oral ingestion, absorption through the shin, and direct injection or puncturing through the epidermis.

Chemicals are part of our every day lives, and indeed if we look to the United States as one example, the chemical industry has experienced the most dramatic and progressive growth of any one industry throughout the history of modern times. It is an industry that in only six decades, has produced more products having direct and indirect impacts on society than any other. This enormous expansion in manufacturing and innovation has been driven by the needs and demands of technologically advanced societies, but also by a society which until recent years, has been consumer oriented without regard for the preservation of limited resources or the potential risk associated with mismanagement. Indeed, there are still many parts of the world, particularly those countries that are engaging in the transition to free economy systems and attempting to compete with well established chemical suppliers, that manage manufacturing operations without resource conservation and safety management practices. As a chemical engineer, with nearly twenty years of industry, applied research, and international business experience, the author has witnessed both dramatic differences in the way manufacturing operations are managed in many parts of the world, as well as enormous philosophical changes as this industry has matured in more technologically advanced countries and companies. Perhaps among the more dramatic philosophical changes are those derived from embracing the ISO (International Standards Organization) standards dealing with environmental management systems, which incorporates safety management principles.

Safety management and environmental management are best handled side by side because there are many overlapping concerns both from a regulatory viewpoint and the standpoints of worker productivity, and worker and general public safety. For these reasons, many companies today combine the talents of the so-called environmental manager and safety engineer under an Environmental, Health and Safety (EHS) program. A major implementor in such a program is the health and safety officer, which more often than not these days is an industrial hygienist, or a combination of specialists which includes consultations and interactions with the industrial hygienist.

In the United States, environmental regulations have dramatically altered the chemical industry and in fact, one can argue that it is environmental regulations that have been the principle driving force for safety management, training requirements, and the promulgation of ISO standards among the workforce. RCRA (Resource Conservation and Recovery Act), CERCLA (Comprehensive Environmental Reclamation, Cleanup and Liability Act), SARA (Superfund Amendments and Reauthorization Act), TSCA (Toxic Substances Control Act) have created the need for the so-called hazmat specialist; hazmat meaning hazard materials specialist or worker. The term perhaps first appeared in the early 1980's/late 1970's, among asbestos remediation workers, but became more popular throughout the 1980's through the early to mid 1990's, most often associated with those individuals having specialized training to work on hazardous waste remediation sites. But the term, hazmat, is really very broad and should not be associated exclusively with the handling of hazardous wastes. In this handbook, the hazmat specialist covers first responders, transporters of hazardous materials (in fact, anyone involved in the transportation process, not just the carrier), warehousing and storing operations, chemical suppliers and manufactures, laboratory personnel, and in fact any person, who by the nature of handling or dealing with chemicals, requires special knowledge of their properties from the standpoints of health risks, chemical reactivity/stability, and fire and explosion. The level of training and experience of the hazmat specialist is a function of the specific responsibilities and chemical handling requirements of the individual. Still, the term hazmat specialist carries special meaning under U.S. OSHA standards, and this designation is pointed out in the volume.

In this handbook, three primary risk factors are concentrated on, namely: the health risks of chemicals, risks associated with chemical stability and handling, and risks associated with the fire and explosion characteristics of chemicals. Technical information is provided to assist safety managers and industrial hygienists in addressing the following areas:

- determining proper monitoring requirements for work areas - the objective being to quantify chemical contaminants in the work site in order to define health risks through personal exposure. Once health risks are assessed, safety managers can recommend proper engineering controls, or material substitutions that are less hazardous, or management practices to minimize worker risks, or personal protection;
- through the use of specific information, data and guidelines, assist the safety manager in the selection, use and maintenance of personal protective equipment such as chemical protective clothing and respirators;
- through the use of well recognized safety practices and authoritative sources, assist first responders in formulating initial emergency response action plans that will isolate and contain spills or fires;
- using a compilation of fire and explosion, and chemical stability data derived from company specific material safety data sheets, NIOSH, OSHA, the CHRIS data base, the USDOT, IARC and others, provide an extensive data base that can be used as basis for safe handling and storing of chemicals in laboratories, warehousing operations, during transport, and during intermediate handling and usage applications.

This is not a management oriented reference, but rather a technical data and information handbook designed to be used by those individuals who already have management skills in safety and have extensive backgrounds in or rely on other members of their organization or group who are engineers, chemists, safety professionals, industrial hygienists, that are qualified and experienced in applying the information compiled in this reference volume. The handbook should be used in conjunction with other well recognized references and data base systems and there is no intent to compete or displace such works with this reference.

As noted the Handbook of Industrial Toxicology and Hazardous Materials is intended as a guide to the safe handling of chemical compounds used throughout industry and by consumers. It is intended for use by those individuals who have either direct contact with or indirect contact through the management of chemicals or dangerous

materials. This includes laboratory personnel, plant and refinery engineers and technicians, safety managers, emergency response personnel, hazardous materials workers, firefighters, transporters of dangerous products and materials, the On-Scene Coordinator (OSC) of a hazardous materials incident, hazardous materials workers and others. The handbook provides an extensive compendium of information on the properties of chemical compounds, along with safe handling and emergency response information. Specifically, the user will find information dealing with personal exposure risks, protective clothing and respirator information for safe handling, chemical compatability and conditions of instability, isolation distances in the event of spills or fires, and first aid guidelines. Procedures for safe handling, personal protection, and personal sampling for industrial hygiene monitoring are also included in this handbook. The sources of information used in this handbook are largely based on a review of thousands of material safety data sheets provided by chemical manufacturers and suppliers, plus information gathered from well known and authoritative organizations (such as NIOSH, OSHA, USDOT, IARC, ACGIH). Although this handbook is extensive in its coverage, not all commercially available chemicals have been covered. Additionally, only certain aspects as related to the most significant safety issues associated with those chemicals that are covered are included in this volume. The reader may therefore need to consult other references from time to time. A list of key references is provided at the end of this chapter, but additionally one should always consult with the supplier and or manufacturer of a specific product, and closely review and follow his or her company safety policies and practices.

The purpose of this first chapter is to orient the reader to the information provided in the handbook. There are eight chapters to the handbook with specific terms, acronyms and terminology pertinent to each section and the data contained therein. This chapter provides first an overview of the informational data base and discussions provided in each chapter, and second, it provides specific description of the terms pertinent to the eight reference chapters. The reader will find that some primary definitions are repeated in the chapters, however, in most cases, the reader will be referred either to this first chapter or the Glossary at the end of the handbook.

II. GENERAL CONCEPTS, PHILOSOPHY, AND TERMINOLOGY OF INDUSTRIAL HYGIENE

Much of the following discussions are included to orient the reader to the safe handling practices and personal protection procedures described in Chapter 2. The traditional definition of industrial hygiene is the recognition, evaluation and control of chemical, physical and biological agents. In recent years, this definition has been expanded to include the anticipation of potential hazards. This anticipation phase is especially important to design and process engineers, as well as to occupational health professionals, since the control of hazardous agents is accomplished most efficiently and economically if incorporated into engineering plans from the inception of a project. In order to anticipate hazards and effectively design the necessary controls into a process, industrial hygienists and toxicologists must be consulted. These professionals inform the engineer of the potential hazards of chemicals used in the process, acceptable airborne concentrations which have been established for those chemicals, and environmental information and regulations which may affect the project. The health professionals should be included in the earliest phases of any project to avoid the costly process of redesigning and retrofitting engineering controls into a complete or partially complete process. Often, the engineer is called upon to design and implement changes in an existing process. Again, cooperation between the engineer and the appropriate health and safety professionals is critical to the success of the project.

The industrial hygienist and toxicologist have been trained to recognize environmental and workplace hazards and stresses. Hazards may arise from over-exposures to chemicals, physical agents, such as noise and radiation, biological agents or ergonomic stresses. To understand the level of hazard in an existing process, the industrial hygienist must use monitoring techniques to evaluate the exposures associated with the materials handled in the process. The results of such monitoring are then compared to established standards and, if necessary, used to recommend and develop corrective measures. These measures may include engineering controls such as process substitution, isolation, enclosure or ventilation, substitution of hazardous materials with less hazardous substances, or administrative controls to reduce exposure time.

Most industrial hygienists have received undergraduate training in biology, chemistry, engineering and other basic sciences. Usually, they have obtained graduate degrees in industrial hygiene or related fields and many have been certified in industrial hygiene practice by certification boards. Graduate training in industrial hygiene includes study in toxicology, industrial hygiene chemistry, environmental monitoring techniques, control methodology, epidemiology, statistical analysis, ventilation and radiation science.

Industrial hygiene departments of chemical and manufacturing companies often report through Health, Safety and Environment (HS&E) or other similar organizations. These HS&E groups often include Medical, Toxicology, Product Safety, Regulatory, Environmental and Safety departments. The industrial hygienist often works in conjunction with these professionals and the appropriate manufacturing and engineering personnel to recommend changes or controls for existing processes or for new ones being designed. In some companies, HS&E and Engineering may report through a single department or through manufacturing teams to create the opportunity to develop close working relationships during process design.

A. OSHA Regulations

In 1970, the U.S. Congress enacted the Williams-Steiger Occupational Health and Safety Act, which became effective in April, 1971. At that time, the Occupational Safety and Health Administration, commonly known as OSHA, was created. OSHA, which is organized under the Department of Labor, is responsible for carrying out the responsibilities assigned to the Secretary of Labor in the Act. Among other things, the Act gives the Secretary of Labor and OSHA the authority to promulgate health and safety standards, to enforce the standards and issue citations, to conduct training for inspectors, employers and employees and to approve state plans for programs under the Act.

Another important provision of the OSH Act was the establishment of the National Institute for Occupational Safety & Health (NIOSH) within the Department of Health, Education and Welfare, now the Department of Health and Human Services (DHHS). NIOSH is responsible for conducting research on Occupational Health and Safety and acts as the technical arm for OSHA. Among the responsibilities of NIOSH are the identification of health hazards and research on chemical hazards. As part of these research activities, NIOSH often conducts workplace studies involving exposure assessment and medical surveillance, which are made publicly available. The Agency also reviews and summarizes the toxicological and scientific literature for hazardous agents and recommends workplace exposure limits and standards. The results of these chemical reviews have been published in a series of NIOSH Criteria Documents. NIOSH is also responsible for training professionals in health and safety to ensure an adequate supply of personnel to implement the OSH Act. The main research facilities of the Institute are located in Cincinnati, Ohio.

Under the Occupational Safety and Health Act, employers are responsible for complying with all standards and regulations promulgated under the Act and for furnishing to all employees a workplace environment which is free from recognized hazards which cause or are likely to cause death or serious physical harm. This so-called "general duty clause", section 5(a)(1) of the Act, also requires employees to comply with OSHA standards and regulations which are applicable to them. The general duty obligations may often be the basis for implementing engineering or other controls which may not otherwise be specified or required under OSHA regulations. For example, ventilation controls may be required to control exposures to a solvent which is known to be potentially toxic but has no permissible airborne limit under OSHA regulations. In other cases, citations may be issued for ergonomics hazards even though OSHA has not promulgated specific regulations concerning the control of such hazards.

OSHA develops health standards with technical assistance from NIOSH. Standards are based on research and other appropriate information available to the Agency. In addition to considering the most recent scientific data, OSHA must consider the health and safety of employees, experience with other health and safety laws, and the feasibility of standards that it promulgates.

Section 6 of the Occupational Safety and Health Act describes the process of establishing health and safety standards. Procedures for rulemaking under the Act include the publication of advanced notice of proposed rules and final rules. Throughout the process, public comments are solicited and considered in the development of the rules. The Secretary of Labor has the authority under Section 6© of the Act to establish emergency temporary standards when there is evidence to support the need. Emergency temporary standards have been promulgated for carcinogens such as benzene and asbestos.

Many of the current chemical standards were promulgated shortly after the enactment of the original Act in 1970. The initial health standards (29 CFR 1910.1000) were the airborne concentration limits which had been recommended in 1968 by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH is a group representing past or currently practicing governmental industrial hygienists. ACGIH publishes Threshold Limit Values® (TLVs) for several hundred materials. TLVs are guidelines developed to assist in controlling health hazards. ACGIH points out that these limits represent conditions under which nearly all workers

can be exposed daily without experiencing adverse health effects; however, the group recognizes that individual susceptibilities vary and that some workers may experience adverse effects or discomfort below the threshold limits. ACGIH also stresses that these values should be used only by people trained in industrial hygiene.

OSHA adopted the 1968 Threshold Limit Values as its original Permissible Exposure Limits (PELs). These limits, listed in 29 CFR 1910.1000, remained largely unchanged until 1989, when OSHA promulgated rulemaking updating them. At that time, all of the PELs were re-evaluated and a large percentage of them were updated to reflect current knowledge. As a result, the PELs were more consistent with the existing ACGIH Threshold Limit Values until they were overturned in a subsequent 1993 court decision. As a result of that decision, the PELs reverted to the pre-1989 levels. It is anticipated that OSHA will publish new limits through future rulemaking.

In addition to the early PELs, OSHA published expanded standards for fourteen substances in 1974. Included were asbestos and several carcinogens, such as benzidine, beta-naphthylamine and ethylenimine. These standards define requirements for workplace monitoring, training, labeling, medical surveillance, respiratory protection, and recordkeeping. Expanded standards have since been published for several additional chemicals, including benzene, ethylene oxide and formaldehyde. The standard for asbestos has been updated to address the carcinogenicity of that compound.

OSHA Permissible Exposure Limits and ACGIH Threshold Limit Values may be expressed in several ways. The most commonly used limit type is the eight-hour time weighted average (TWA), which is an expression of the average workplace concentration over a typical eight-hour workday. Additional limit types include ceiling limits, concentrations which must never be exceeded on an instantaneous basis, and short-term exposure limits (STELs), which are often expressed as 15 minute averages. A concept which was developed by OSHA is the action level, defined as one-half of the PEL. Many of the chemical specific standards incorporate the action level. Exceeding this level may invoke many of the monitoring, medical surveillance, training and other requirements of these standards. Many chemicals which are toxic by the dermal route or are highly absorbed through contact with skin are given an additional "skin notation". Skin contact with these materials must be minimized or prevented.

In addition to OSHA and ACGIH limits, several other agencies and groups recommend acceptable workplace exposure levels. NIOSH publishes Recommended Exposure Limits (RELs) and the American Industrial Hygiene Association publishes Workplace Environmental Exposure Limits (WEELs). Many companies use their handling expertise and their own toxicological studies to establish internal exposure guidelines for chemicals they market. These internal guidelines are commonly referred to as Occupational Exposure Limits or OELs. Often, industry associations jointly establish recommended exposure limits for chemicals which they have tested. These internal guidelines must be included on the Material Safety Data Sheets supplied by the companies recommending the limits. While OSHA PELs carry the force of law, health professionals often observe other exposure limits when evaluating workplace hazards.

ACGIH reviews its published limits and updates a portion of them on a yearly basis. Before placing a new Threshold Limit Value on its final list, the limit is published on a separate list of intended changes for two years, allowing time for public comment. OSHA does not have a procedure for regularly updating its PELs. Because all changes must be made through the rulemaking process, the PELs are updated much less frequently. Expanded chemical specific standards are developed based on priorities established by the Agency and, often, several years are required to promulgate a single standard. OSHA regularly publishes the status of current and proposed rulemaking.

B. The Terminology of Hazards Recognition

The evaluation of potential exposures from an operation or process begins with the collection of information on the raw materials, intermediates and final products present in the process. In the case of a process in the design phase, materials inventories may be supplied by the design engineer and other knowledgeable persons. Information concerning existing plants or processes should be supplied by manufacturing personnel. Often, chemists must be consulted to provide information concerning the potential formation of captive intermediates and unwanted by-products that may be hazardous. After developing the chemical inventories, the industrial hygienist consults with toxicologists and other health professionals to develop toxicity profiles of the materials. Following is a brief summary of the toxicity categories that are defined by OSHA in its Hazard Communication Standard.

Carcinogens — Carcinogens are agents which are capable of causing or initiating cancer in humans or animals. Animal carcinogenicity data exist for several hundred chemicals, including some metals, some chlorinated hydrocarbons, formaldehyde, dimethyl sulfate, ethylene oxide and common household products, such as saccharin. Because human data, obtained from epidemiological studies, is difficult to generate, relatively few chemicals or agents are recognized as human carcinogens. Examples of human carcinogens include vinyl chloride, bis(chloromethyl) ether, benzidine, its congeners and benzene. Ionizing radiation has long been recognized as causing cancer in animals and humans. Other materials are regarded as suspected human carcinogens, depending on the amount and quality of available data. Several groups publish lists of known or suspected animal and human carcinogens. These include the International Agency for Research on Cancer (IARC), which is a working group of the World Health Organization, ACGIH, and the National Toxicology Program (NTP), a group represented by several U.S. governmental agencies. These groups often classify carcinogens according to the amount and adequacy of evidence available for them.

Irritants — Substances that are irritating or corrosive to the skin or eyes are considered to be hazardous. Most strong acids or bases are corrosive and cause tissue damage on contact. Hydrochloric acid, ammonium hydroxide, sodium hydroxide, several amines and many other industrial chemicals are corrosive. Other chemicals, such as organic solvents and weak acids or bases, are irritating, but, do not cause tissue damage.

Acute Toxins — Chemicals can also be categorized according to the degree of toxicity they exhibit in acute oral, dermal or inhalation studies. OSHA classifies materials as toxic or highly toxic based on doses or concentrations that cause lethality in animals, usually rats. The values used in expressing acute toxicity for this purpose are the LD_{50} or LC_{50} values, which are statistically derived from animal studies. For example, aniline is considered toxic by the oral route, with an LD_{50} in rats of 250 milligrams per kilogram (mg/kg) of body weight. Chlorine, with a one-hour inhalation LC_{50} of 293 ppm in rats, is considered highly toxic. Many chemicals are toxic or highly toxic by dermal absorption and have been assigned TLVs or PELs with skin designations. These include aniline and several glycol ethers.

Sensitizers — Sensitizers comprise another OSHA hazard class. These are chemicals which produce immunological sensitization reactions in animals that have been administered initial and subsequent "challenge" doses to the skin. Several protocols are available for this kind of study, with the guinea pig being the most commonly used test species. Positive results indicate that the chemical is a potential human sensitizer. Examples include epoxy resins, isocyanates and many acrylates and amines. Many chemicals, such as toluene diisocyanate, may be dermal and pulmonary sensitizers.

1. Target Organ Effects

Finally, any chemical which has been shown to cause target organ effects in a "statistically significant" study is classified as hazardous. These target organ effects may result from acute or chronic over-exposures. Nephrotoxins are materials that cause kidney toxicity. Oxalic acid, a biotransformation product of ethylene glycol, may be precipitated as crystals in the kidney. If they are not eliminated, these crystals may lead to the formation of larger ones which obstruct the tubules of the kidneys and renal injury may result. Lead is a classical nephrotoxin, having been associated with acute and chronic renal failure at relatively high doses. Hepatotoxins are agents that are associated with liver toxicity. Many chlorinated and non-chlorinated organic solvents exhibit well documented hepatotoxicity. Lung toxins, such as fibrogenic (fibrosis-causing) dusts and the herbicide paraquat, are considered to be OSHA hazards. Of particular concern in more recent times, are chemicals which injure the central nervous system. Overexposure to many organic solvents, phosphorus compounds, pesticides, and other chemicals can result in central nervous system (CNS) effects, including nausea, vomiting, diarrhea, headaches and drowsiness. Some solvents, such as n-hexane and methyl butyl ketone, also affect the extremities, causing peripheral neuropathies in the limbs. Often, these nervous system effects are irreversible. Other target organs include the hematopoietic (blood and blood-forming) system, the brain and the reproductive system. Obviously, many chemicals exert toxicity on many organ systems.

2. Evaluation

The industrial hygienist utilizes toxicological data and other health effects information to develop exposure assessment strategies. Qualitative toxicity and exposure ranking systems are used to prioritize the chemicals and agents found in a process or job task. An industrial hygiene sampling program can then be established to characterize potentially significant hazards associated with the process.

The actual hazard posed by a material depends upon several factors, including exposure, toxicity of the material, process controls and individual factors and susceptibilities. After the industrial hygienist or health and safety professional has identified potential chemical, biological, physical, or ergonomic stresses, monitoring must be conducted to determine the extent of exposure to those stresses. The following discussions will serve as an introduction to the chemical hazards, to which this handbook focuses on.

In the evaluation phase, the industrial hygienist will utilize information concerning sampling volume and the mass of contaminant collected to determine its airborne concentration in mass per unit volume. Concentrations of particulates are most often expressed in units of milligrams of contaminant per cubic meter of air (mg/m^3) and gases and vapors are generally reported in parts per million by volume (ppm). Because the concentrations of gases and vapors are often reported as mass of material collected per volume of air sampled, it may be necessary to convert between mg/m^3 and ppm. This can be done using the following equation;

$$C\,(ppm) = \frac{C(mg/m^3) \times 22.45}{Molecular\ Wt} \times \frac{T(^\circ K)}{298} \times \frac{760}{P(mm\ Hg)} \quad (1)$$

where C is the concentration, T is temperature, P is pressure and 22.45 represents the volume of air, in liters, occupied by one gram-mole of an ideal gas at 298°K and one atmosphere (760 mm Hg) of pressure.

The industrial hygienist can use information concerning the vapor pressure of a chemical to estimate the highest airborne concentration attainable for that material. This so-called saturated vapor concentration (SVC) is estimated using the following equation:

$$SVC = \frac{vapor\ pressure \times 10^6}{760} \quad (2)$$

where vapor pressure is measured in mm of Hg and SVC is the saturated vapor concentration, in ppm, at one atmosphere and the temperature at which the vapor pressure was measured. This estimate is often useful in predicting "worst case" scenarios. Inhalation of gases, vapors, aerosols and dusts is a primary route of exposure to industrial chemicals. Gases are materials with very low density and viscosity which expand and contract readily with changes in pressure and temperature. Gases typically expand with uniformity to completely occupy any container. The behavior of gases can be predicted and explained using the various gas laws. Examples of gases often encountered in industrial settings include hydrogen chloride, hydrogen cyanide, ethylene oxide, chlorine, ammonia, formaldehyde and phosgene. Some of these gases, such as hydrogen chloride, ammonia and formaldehyde, may be handled as liquid solutions, in which the gas has been dissolved in a solvent such as water. Often, the resulting solution is a strongly irritating acid or base.

In addition to the irritation and dermal concerns generally associated with these types of liquid materials, they are likely to present inhalation hazards due to off-gassing. However, it is likely that the inhalation hazards associated with the liquid solutions are much less than those associated with the gases. A vapor is the gaseous form of a material which is a liquid at normal temperature and pressure. Examples of such materials include organic solvents such a benzene, toluene and naphtha, alcohols, isocyanates, some amines and many ketones, ethers and aldehydes. The maximum potential concentration of a vapor above its liquid source is dependent upon the vapor pressure of the liquid at a given temperature.

Particulates are particles of liquid or solid matter. Dusts are solid organic or inorganic particulates which are formed by crushing, grinding, impaction or other physical activities. Aerosols are liquid or solid particles with diameters of less than 0.1 μm which will remain suspended in air. Fumes, which are often confused with vapors, are airborne particulates formed by the evaporation and subsequent condensation of solid materials such as metals during welding operations. Fumes typically have diameters of less than one micron.

The industrial hygienist must understand the characteristics of each of these types of contaminants in order to effectively evaluate exposures with accuracy and precision. The engineer must also understand these characteristics to be able to design effective controls. Of special concern are factors which influence the collection of particulates. In selecting a method for the collection and analysis of particulates, the composition of the material, the size of its particles and its potential reactivity or volatility must be considered. The diameter of the particulate being collected, the size of the orifice through which it is being drawn and the physical obstructions around the sampling instrument can all have a significant impact on the accuracy and precision of the method.

Before monitoring an operation, one must understand the process and characterize the physical state of the material throughout the operation. For example, methylene bisphenyl isocyanate (MBI), a chemical used in many polyurethane foaming operations, is often handled as a heated liquid and escaping vapors may condense to an aerosol. Prepolymers of MBI, which are liquids at room temperature, are often sprayed during processing, resulting in aerosol formation. These emissions must be collected using particulate sampling methods. However, MBI has a vapor pressure and is reactive; therefore, the sample must be chemically stabilized if it is collected on filter media. If it is not stabilized, collection efficiency will be low and unpredictable due to evaporation. To assure that proper collection techniques are used in monitoring airborne chemical contaminants, the industrial hygienist will attempt to use a well-validated published method whenever possible.

Before a field survey is initiated, the industrial hygienist typically will conduct a project review or a walk-through survey of an existing site to become familiar with plant processes and job operations and to identify potential sources of exposures. The hygienist will also observe control methods, such as ventilation, isolation and employee administrative controls that may be in use. During this evaluation phase of the survey, the industrial hygienist should work with process engineers to obtain detailed information on the process flow, process equipment, machinery and other potential emission sources. After this initial review, a sampling strategy is developed which includes lists of materials to be sampled, validated sampling and analytical methodologies and protocols for obtaining representative samples.

The samples which will be collected during the survey may be of several types. Depending on need, the health professional may decide to collect personal, area or grab samples. Personal and area samples may be collected over long or short periods of time using active or passive methods. Short-term or instantaneous samples, often called grab samples, can be collected by instrumental methods, by the use of absorption techniques or in collectors of known volume. These collectors include flexible plastic bags and heavy-walled glass vacuum bottles that can be taken back to the laboratory for analysis. An advantage of grab samples is that the collection efficiency of this method is considered to be 100 percent; however, the method must not be used when sampling atmospheres with reactive gases. Highly reactive compounds may react with particulates, the sample collector, other components of the sampled atmosphere or moisture in the air and will require special techniques.

Personal Sampling

Personal samples are those collected on individuals to estimate personal exposures. If the sampling strategy has been designed to collect representative samples for a job operation, these personal sampling results will yield the most reliable estimates of exposure. Personal samples may be obtained for chemical hazards and physical stresses, such as heat, noise and radiation. They are generally collected in what is called the breathing zone, which has recently been redefined as a hemisphere forward of the shoulders with a six to nine inch radius. In developing the monitoring program, the industrial hygienist must ensure that samples are random and representative in order to assess them statistically. Personal monitoring should also include samples to estimate ceiling and short-term exposures to ensure compliance with the respective exposure limits.

Area Sampling

Area samples are collected to estimate exposures at different locations and areas throughout the workplace. If the workplace exposures are well characterized by location, it is possible to estimate the average worker's exposure by determining the person's movements and activities throughout the workplace. An advantage of area monitoring is that the industrial hygienist is able to understand the daily fluctuations in levels of airborne contaminants at each location and is able to develop an understanding of the contribution of each part of the process to workplace exposures. Area monitoring is particularly useful to the engineer since it can also be used to locate fugitive emissions so that engineering controls can be effectively designed and implemented. Because it is often not feasible to adequately characterize the workplace and workers' movements to develop reliable estimates of personal exposure, area monitoring is most often employed to characterize the process and locate sources of exposure while personal monitoring is used to estimate employee exposure.

Active and Passive Monitoring

The industrial hygienist may employ active or passive monitoring techniques for collecting personal or area samples. Active monitoring involves the use of pumps to collect grab samples or to pull samples through collecting

media, such as adsorbent tubes and filters. In contrast, passive monitoring employs diffusional collection devices which work on the principles of Fick's first law of diffusion. In passive collection, transport of the contaminant to a collecting surface occurs by diffusion along a concentration gradient. The sampling rate for a specific sampler is fixed and depends on the length of the diffusion path, the area of the sampler orifice and the diffusion coefficient of the sampler. Temperature, pressure and air movement can have positive or negative effects on sampling rate and must be considered when using this method. Because of their simplicity and ease of use, passive monitors are often used when industrial hygiene resources are limited. Passive monitoring devices are available for a variety of contaminants, including organic vapors, ethylene oxide, formaldehyde and phosgene. These devices generally have limited use in identifying short-term exposures and sources of exposures. Whether using active or passive methods, the industrial hygienist must consider the accuracy, precision and level of validation of the method.

Active Monitoring Equipment

Active sampling methods for particulates, gases and vapors involve the use of a sampling train, which includes a collecting medium, a flow meter and a vacuum pump. In the case of particulates, a pre-selector is often used upstream of the collector in order to select for particles of various diameters. The order in which air is pulled through the sampling train is as follows: 1) pre-selector, when used, 2) collecting medium, 3) flow meter, and 4) pumps.

The pump is a critical part of the sampling train. Typically, industrial hygiene pumps are small, portable, battery operated units with flow rates ranging from 0.1 liter per minute (lpm) to more than 5 lpm. Several factors are considered in selecting the most appropriate pump for a situation. Higher sampling rates are generally used when sampling for particulates and for short-term monitoring of some gases and vapors. Lower flow rates are usually required when collecting samples of organic vapors and gases in order to maintain collection efficiency and avoid overloading the collection medium. Low-flow pumps are generally used to monitor for organic vapors, which are typically collected at a rate between 50 and 200 ml per minute. An important factor when selecting battery powered pumps is the environment in which it will be used. Only pumps which are intrinsically safe and have been approved for such use can be used in atmospheres that may contain explosive or flammable vapors or gases.

Flow Meters

The air flow rate is critical in determining the volume of sample which has been collected and in determining the contaminant's airborne concentration in mass per unit volume. In order to assure operation at constant flow rates, pumps employ the use of flow rate meters such as critical orifices, stroke counters and rotameters. The rotameter, which is typically incorporated into high-flow pumps collecting at rates of more than 1 liter per minute, consists of a float which moves up and down a vertical tapered tube. Air passing through the tube causes the ball to move upward until the ball's weight and the force exerted by the air movement have reached equilibrium. The rotameter must be calibrated to a primary source prior to its use in the field. Some pumps employ critical orifices to assure constant flow rates. The critical orifice consists of a sharp, narrow constriction, such as a precision drilled hole, through which the air stream is directed. Under certain conditions, the critical orifice assures a nearly constant flow rate. Some pumps utilize piston or diaphragm stroke counters to record the number of strokes which can be related to air volume when calibrated with a bubble meter or other flow meter.

Flow meters on field sampling instruments are calibrated using one of several methods. Primary standards are those which measure volume directly and are, therefore, preferred. Primary air flow standards include bubble meters, spirometers and Mariotti bottles. The time required to draw a measured volume of air through these systems is measured and the resulting flow rate is calculated. These methods are typically accurate to within one percent.

Where primary methods cannot be used, the industrial hygienist often uses secondary calibration methods, which include rotameters, critical orifices, dry-gas meters and wet-test meters. These standards must be periodically calibrated against primary standards. The rotameter is typically accurate to within 5 percent. The critical orifice, which maintains a constant flow-rate through a small opening when the downstream absolute pressure is less than 53 percent of the upstream absolute pressure, has a similar accuracy. The dry gas meter, which consists of a counter mechanism and two chambers being alternately filled and emptied, can be highly accurate. The wet test meter is a partitioned drum which is half submerged in a liquid, typically water. As air enters a partition, it causes it to raise and develop a rotation motion. A counter records the number of revolutions. While this standard has a high degree of accuracy, it may be influenced by corrosion, leaks and the absorption of gas into the liquid.

Other secondary standards, including the venturi meter, orifice meter and manometer have less accuracy than those previously discussed and therefore, are not often used by industrial hygienists for pump calibration.

Collection Media

A key consideration when monitoring for gases, vapors and particulates is the collecting medium. Among the more common air sampling media are glass or metal sorbent tubes containing adsorbents such as charcoal, silica gel and alumina gel, impingers with absorptive or chemical reaction reagents and tillers which mechanically or chemically collect contaminants.

Many of the early collection methods employed the use of impingers, which are glass containers through which the contaminated airstream is bubbled. The airstream enters the impingers in the form of small bubbles, making the contaminant of concern more available to react with the collecting reagent to form a non-volatile product. Examples of this process include neutralization of acid gases such as HCl using caustic scrubbing solutions. Other contaminants may be collected in specialized solutions. For example, isocyanates, including toluene diisocyanate (TDI), are collected by the modified Marcali method, which utilizes a solution of hydrochloric and acetic acids. In solution, the isocyanate is hydrolyzed to the corresponding amine, which is then diazotized and coupled with a substituted ethylenediamine to form a colored complex which can be analyzed spectrophotometrically. The more recent method of sampling for isocyanates involves the collection of vapors and particulates on glass fiber filters impregnated with 1-(2-pyridyl)piperazine and subsequent analysis using high performance liquid chromatography. Another chemical for which impinger methods have been traditionally used is formaldehyde. This method, used for aldehydes, involves the use of chromotropic acid in concentrated sulfuric acid to collect formaldehyde in an impinger. After heating to ensure complete reaction, spectrophotometry is used to determine the amount of formaldehyde collected. A more recent method employs the use of coated XAD-2 adsorbent lubes, toluene desorption and gas chromatography to determine formaldehyde concentrations in air.

Particulates and aerosols are most often collected on filter media which are inserted into a plastic support cartridge. Several types of filter materials are available, including Teflon, PVC and mixed cellulose ester, all of which are porous materials. Others include glass, plastic, cellulose, which are fibrous filters. Collection of particles on the filters occurs by several mechanisms; however, the primary mechanisms are impaction and direct interception. As with the collection of gases and vapors on adsorbents, the choice of filters is based on several factors. Glass fiber filters, for example, are not hygroscopic, are temperature resistant, and have high capacity. Metals are typically collected on mixed cellulose ester fiber filters, which can be dissolved in acid solution prior to atomic absorption analysis. Before selecting a filter type, the industrial hygienist will refer to a method validated for the contaminant of concern.

Preselectors may be used at the beginning of the sampling train to select for particulates of specific sizes or to separate particles by size. Often, cyclones are incorporated into the sampling train to collect the respirable particulate fractions. These instruments select for particles less than 10 microns in diameter which can penetrate into the lungs. Cyclones operate by the circular movement of air which has been drawn through an orifice; unwanted heavier particles are thrown from the center of the airstream and drop out while lighter particles of the desired size are retained in the airstream and are collected on the filter medium.

Adsorbent tube sampling methods have been developed for hundreds of organic vapors. The type of sorbent tube to be used depends upon the physical and chemical characteristics of the material being collected. Generally, activated charcoal and polymers, such as Tenax, are used to adsorb organic vapors while silica gel is used to collect polar and high boiling materials. The contaminant adsorbs onto the surface of the medium through surface forces until it is desorbed for analysis. Because silica gel is polar, it is much more sensitive to the effects of high relative humidity than charcoal and other non-polar media.

Many vapors, including those of n-hexane, 2-hexanone, isoamyl acetate, benzene, and toluene are collected on charcoal tubes and desorbed with carbon disulfide. The resulting solution is then analyzed using gas chromatography with a flame ionization detector. Several other chemicals, including 2-methoxyethanol and other glycol ethers, are collected on charcoal and desorbed with specialized solvents, such as carbon disulfide and methanol. Still other gases and vapors are collected using special adsorbants. For example, ethylene oxide, a highly reactive gas, is collected on a hydrobromic acid coated charcoal tube to produce 2-bromoethanol. The reaction product is then desorbed with N,N-dimethylformamide, derivatized to a heptafluorobutyrate ester and analyzed by gas chromatography using an electron capture detector.

After a material has been collected on a granular adsorbent, or a filter or in an impinger solution, the medium must be analyzed to determine the amount collected. This information, in conjunction with the known sampling volume, is then used to determine the airborne concentration in mass per unit volume. Preparation of the sample for analysis may involve desorption of organics from granular adsorbents in various solvents, reactions of contaminants absorbed in liquid solvents, digestion of filters for metal analysis or various other procedures. After the sample has been appropriately prepared, analysis is accomplished using various methods, including atomic absorption spectroscopy, spectrophotometry, gas chromatography, liquid chromatography, mass spectrometry, ion chromatography and microscopy. NIOSH and OSHA have published validated methods for hundreds of workplace contaminants (refer to the references on the end of this chapter for specific references).

Many instruments exist for directly monitoring for contaminants. These include colorimetric indicator tubes (often referred to as detector tubes) infrared and ultraviolet spectrophotometers, flame ionization detectors, electrochemical cells, portable gas chromatographs and chemiluminescence detectors. Direct reading methods for detecting aerosols are also available; they include light scattering photometers, piezoelectric balances and beta radiation attenuation detectors. The advantages of these direct-reading instruments are that they give instantaneous concentrations and are sufficiently accurate to be useful in locating fugitive emissions. Combustibility and Lower Explosive Limit (LEL) meters employing catalytic combustion detectors are available for monitoring for the presence of explosive atmospheres.

Many currently available instruments employ some of the methods described above to continuously monitor for workplace contaminants. Gas chromatographic and infrared systems are common. Continuous monitoring systems are capable of monitoring at several points and sounding alarms when unacceptable concentrations are detected. These monitors should be located close to anticipated emission sources and in areas where the highest potential airborne concentrations are expected. It must be remembered that the range, selectivity and sensitivity of each instrument must be considered and that maintenance is critical to their operation.

Biological Monitoring

The best measure of an individual's exposure to a chemical is derived from biological monitoring. This type of monitoring involves the analysis of body fluids, tissues or exhaled breath for contaminants or metabolic products of the contaminants. Biological monitoring is particularly useful for estimating exposure to chemicals that are easily absorbed through intact skin or have low vapor pressures and consequently, lower potential for inhalation. In such cases, simple airborne monitoring provides no information about whether an individual has been exposed by the dermal route or how the contaminant has been absorbed. Biological monitoring can assist the industrial hygienist and engineer in recommending personal protective equipment or other control measures which may be appropriate for an operation.

Unfortunately, there are few validated biological monitoring methods for industrial chemicals. Many of those that are available have been published by ACGIH as Biological Exposure Indices (BEIs). Among the chemicals for which biological monitoring methods are available are N,N-dimethylformamide (monomethylformamide in urine), alcohols (breath), lead (blood), dichlorobenzidine (DCB in urine), aniline (p- aminophenol in urine) and several metals (urine and body tissues). In order for biological monitoring methods to be valid and meaningful, a large database must exist on the pharmacokinetics, metabolism and chemistry of the material. Extensive data from human monitoring are also essential in interpreting the results of biomonitoring. These monitoring programs are generally administered by site or corporate medical departments with assistance from the industrial hygiene department.

3. Industrial Hygiene Data

Industrial hygiene data must be maintained for many years and stored in an accessible way. There are several reasons for this. First, in order to conduct epidemiological studies, good estimates of worker exposures are essential. Industrial hygienists often work with epidemiologists many years after data have been collected to develop exposure histories for epidemiological studies. To do so, it is important that data are stored in such a way that they can be searched by chemical, job classification, process, plant, employee identification and date. Another important reason for storing industrial hygiene data is to satisfy constantly expanding regulatory requirements.

Most large companies have purchased or developed sophisticated computer systems to store and access this data in order to be able to generate reports for use in epidemiological studies. In some of these systems, interfaces exist between medical, personnel and industrial hygiene data, assisting medical departments in performing

epidemiological studies and administering screening programs. Other systems incorporate other types of health and environmental information, including toxicological, safety, and regulatory data. Industrial process designers and production engineers must become familiar with the databases that are available and the information they provide.

C. Control Methods and Industrial Ventilation

1. Control Methods

After a source of contamination has been identified in a process, several methods of control are available to the industrial hygienist and engineer. Because of the costs associated with retrofitting, it is preferable to implement controls in the design phase of a project. The physical properties, acceptable exposure limits, toxicological properties and other health and safety issues related to the process materials must be considered early in planning. In some cases it will be necessary to implement controls in existing plants and retrofit processes. Since many of these methods involve engineering controls, the industrial engineer is crucial to this phase of industrial hygiene.

The task of controlling potential exposures must be shared by the industrial hygienist, plant management, line supervisors, engineers and employees. Control methods include material and process substitution, process isolation, wet controls, housekeeping and maintenance, personal hygiene, administrative controls, personal protective equipment and ventilation. Because most exposures occur as a result of the process design or failures in the process equipment, it is critical for the engineer to be involved in the design of the project and the programs for maintenance. It is unusual for engineers to receive adequate training in the evaluation and control of hazards during their formal education. Professional training courses and workshops dealing with subjects such as noise control, industrial ventilation and other related topics are valuable in providing engineers with the information necessary to design controls for potentially hazardous materials.

Material Substitution

The first control method which should be considered is material substitution. This method involves the substitution of one material in a process with one that is less hazardous. In some cases, this decision may be based on toxicological information available for the materials. In other cases, a material may be selected as a replacement because its physical properties make it less hazardous. Chemicals with high flash points are often used to replace flammable or combustible materials. Many of the chlorinated solvents have been chosen in the past because of their favorable flammability characteristics. Vapor pressure is another important physical property to be considered when selecting potential process chemical substitutions. As discussed previously, vapor pressure is a critical factor in determining potential airborne exposure to a chemical. Chemicals with lower vapor pressures exhibit lower saturated vapor concentrations (SVCs). These materials generally present lower exposure hazards and are typically easier to handle and control. For example, N-methylpyrrolidone, with a vapor pressure of 1 mm Hg at 20°C, has a theoretical SVC of about 1,315 ppm at that temperature. Methanol, on the other hand, with a vapor pressure of 92 mm Hg at 20°C, has a saturated vapor concentration of more than 12,000 ppm. The physical properties, such as vapor pressure, and the toxicity of each material must be considered before using substitution as a method of reducing potential hazard. Substitution has been used extensively to replace many organic and inorganic chemicals which present safety or toxicological hazards. For example, lead or chromium based paint pigments have been largely replaced over the last several years by less toxic metals and organic pigments. Some of the more toxic chlorinated solvents, such as carbon tetrachloride, have been replaced with less toxic chlorinated hydrocarbons and some non-chlorinated solvents. The traditional solvent-home paints are now being largely replaced with "water-borne" paints, which generally contain lower amounts of volatile organic compounds (VOCs). Another example of the use of less toxic materials is the substitution of glycol ethers, which are used extensively in industry as solvents in the manufacture of lacquers, resins, varnishes, dyestuffs, printing inks and stripping compounds. They are also present in some consumer products, including latex paints. Ethylene glycol ethers, such as 2-ethoxyethanol, are now being replaced with the corresponding propylene glycol ethers in processes and products. This shift to the propylene glycol ethers is due primarily to the fact that the ethylene glycol ethers have been reported to cause birth defects and male and female reproductive effects in several animal species. The propylene glycol ethers, on the other hand, appear to be less toxic and do not have the same potential for adverse reproductive effects.

A common mistake when substituting materials is to replace a chemical of known toxicity with one which has not been adequately or completely evaluated for toxicity, under the assumption that lack of information implies that a chemical is safe. The identification of less hazardous substitutes will depend on having adequate and current data and to-

xicological information. In some cases, a less hazardous, effective substitute may not be available or feasible to use and the hygienist and engineer must consider alternative controls.

Process Substitution

Another method for controlling the occupational environment is process substitution, in which a process is modified to make it less hazardous or is replaced by another, less hazardous process. For example, a spraying operation might be substituted with a less hazardous dipping process. The application of industrial coatings or paints in dip tanks can minimize or eliminate the creation of mists and aerosols. Local ventilation may then be used to control vapors emitted from the operation. Another advantage of substituting with less hazardous processes, such as dip tanks, is that personal protective equipment is often no longer necessary. As is the case with many other control methods, process substitution is most efficient if considered during the design phase of the process or plant.

Process Enclosure and Isolation

One of the most effective exposure control strategies is to isolate the process from the control areas where employees are located during normal operations. While more difficult and costly to implement in existing processes, this can be among the most effective of control strategies for new plants. Most modern chemical plant processes are controlled from enclosed or distant control areas. Remote processing often offers production and efficiency advantages and serves to isolate the potential process emissions from the workforce. Other examples of process isolation include the well-recognized isolation techniques used in the handling of radioactive materials and the use of acoustical sound barriers to enclose or isolate noisy operations.

Wet Controls

One of the oldest and most effective methods for controlling exposures to dusts is the practice of wetting or spraying the operation or dusty area to be cleaned. Such wet methods are common at dusty construction sites, in sand casting operations and at quarrying operations. Sweeping operations in plants can be performed more cleanly and with less dust generation by wetting the area before sweeping. This can also make it easier to collect and prepare the material for proper disposal.

Housekeeping and Maintenance

Good housekeeping practices are a critical element to any program for controlling potentially hazardous materials. All work areas must be kept clean of process chemicals, solvents and dusts. Sweeping is sometimes done when the dusty material being collected is of low toxicity: however, vacuum cleaners with high efficiency particulate filters are employed when cleaning areas contaminated with toxic materials such as asbestos, lead, and cadmium. Leaks or spills should be stopped and remediated immediately. Engineers should be involved in assuring that equipment is well maintained and that processes are periodically shut down to facilitate the maintenance activities. Comprehensive, written maintenance programs should be developed for all processes, with substantial input from engineering and maintenance groups. Careful attention must be paid to providing the appropriate personal protective equipment and training necessary for employees to remediate spills and emergencies safely. OSHA has published regulations governing the remediation of hazardous waste operations and emergencies in 29 CFR 1910.120, also known as the HAZWOPER standard.

Personal Hygiene

Personal hygiene is also essential in effectively controlling employee exposures to hazardous materials.. Eating, drinking and smoking should be discouraged in all work areas and workers should be instructed to wash or shower before eating or leaving the workplace at the end of the day. Appropriate eyewash and emergency shower facilities must be provided throughout the workplace, especially in areas where corrosive or irritating materials are handled. Many of the OSHA expanded standards, such as those for benzene and acrylonitrile, contain extensive hygiene requirements, including the establishment of regulated areas and clean/dirty shower facilities.

Persons working in areas where hazardous materials are handled should wear clean clothing daily, leaving the dirty clothing at the place of employment. This will prevent workers from carrying potentially hazardous materials home and exposing family members. In some cases, it may be necessary to discard contaminated leather articles to prevent dermal contact. Often, the employer supplies clean clothing and has it laundered by professional laundering services.

Administrative Controls

In some cases, administrative controls may be effective in reducing employee exposures to hazards. Reducing the length of work periods, for example, is an accepted way of decreasing the cumulative exposures of an individual to such agents as noise, heat and chemicals. It should be kept

in mind that reducing the length of time for each worker's rotation may increase the total number of persons potentially exposed to a process. In addition, limiting the amount of time that persons are exposed to workplace contaminants does nothing to reduce emissions and remove potential sources of exposure in the process. Administrative methods are often used to control exposures to noise. For example, under the OSHA noise standard, one can be exposed to 90 dBA for eight hours, 95 dBA for four hours, 100 dBA for two hours, etc. If monitoring has indicated that an area has noise levels for which eight-hour exposures are unacceptable, the employer may choose to limit employee access to the area to an acceptable exposure period.

Personal Protective Equipment

If other means of controls prove to be impossible or infeasible, the use of personal protective equipment by employees may become necessary. Such control methods, however, do not reduce or eliminate the source of the potential hazard and are the least preferred choice for controlling exposure. Personal protective equipment includes air-purifying and air-supplying respirators, hearing protection to reduce noise exposures, eye and face protection and gloves, boots and other impervious clothing.

2. Ventilation Methods

Industrial Ventilation

Industrial ventilation is the removal and replacement of air to maintain concentrations of potentially hazardous contaminants to levels which ensure a healthy workplace. Although the main purpose of ventilation is the control of hazardous gases, vapors and particulates, it is also used to replenish oxygen, control odors, control flammable and combustible materials and to heat, cool and control humidity. The industrial hygienist must work with the engineer to design the appropriate ventilation system for each operation within a process. Ventilation systems often are not given sufficient attention in the design phase because they are not part of the production process; however, failure to design effective systems may incur additional work and cost later. The following discussion will highlight the basic principles of controlling hazardous contaminants using natural and mechanical ventilation; however, the engineer and industrial hygienist should consult the many available references on this subject from such groups as ACGIH and the American Society for Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) (key references are cited at the end of this chapter).

Natural Ventilation

Ventilation systems may be of two types, natural or mechanical, both of which may be used within the same process. Natural ventilation systems are those that do not utilize mechanical equipment, such as fans, to move air. Such a system depends upon convective temperature currents within buildings and air movements across the exteriors of buildings, causing differential pressures to remove contaminants. Natural ventilation is generally more effective in older buildings, which are not as tightly constructed as newer buildings and have windows that can be opened. Older buildings can be opened to allow outside air movement and air convections from rising warm air inside to move air through the building. Natural ventilation is often not feasible due to the fact that outside air movement is variable and cannot always be predicted. Although hot processes are possible candidates for the use of this type of ventilation, they are less effective than mechanical systems in controlling air movement and directing the contaminated air away from employees running the operation. In addition, it is not possible to collect and prevent the release of contaminants to the environment when using natural ventilation.

Unlike natural ventilation, mechanical systems employ fans to control the movement of air from processes. Mechanical ventilation may utilize local exhaust to trap and remove contaminated air at its source, or it may utilize fans to dilute the general room atmosphere with fresh make-up air.

General Mechanical Ventilation

It is sometimes impractical to attempt to control large operations with local exhaust systems. In such cases, fans may be used to provide general dilution ventilation for the process. Although the system may be effective in controlling the movement of air throughout a room, perfect mixing of air seldom occurs and high concentrations of contaminants may exist in localized areas. Because of this, the systems must be well understood and the process must be closely monitored for high concentrations. Dilution ventilation is sometimes employed in processes where large amounts of solvents are evaporated, such as solvent cleaning operation and painting and dipping processes. In these cases, the average solvent evaporation rate can often be predicted using information concerning the solvent's physical properties and its use volume. The cubic feet per minute (cfm) of dilution ventilation required to control the airborne levels of solvents to acceptable levels can be estimated using the following:

$$Q = \frac{pints\ evaporated}{hour} \times \frac{6.7 \times SG \times 10^6 \times K}{MW \times TLV} \quad (3)$$

where Q is the dilution ventilation in cfm, SG is the specific gravity of the solvent, K is a safety factor, MW is the molecular weight of the solvent and TLV is the threshold limit value or other desired concentration in parts per million.

The ACGIH has published dilution air volumes for vapors of many commonly used solvents. It should be cautioned that a safety factor must be used when making these estimates in order to ensure that workplace concentrations are below acceptable exposure levels. Often, one half of the PEL or TLV, or a safety factor of 2, is used; however, this varies depending on the physical characteristics of the room, the location of people around the process and the toxicity of the chemicals being processed. When diluting more than one contaminant the required dilution volume requirements should be considered additive if the effects of all materials are similar or are. When the effects of the materials of all potential contaminants are different, the lowest PEL or TLV should be used to determine dilution requirements. Dilution ventilation may be used to control airborne levels of flammable materials by controlling to the Lower Explosive Limit (LEL) rather than the acceptable exposure level. In such cases, the LEL for the most flammable material in the process should be used to estimate the necessary ventilation volume. Again, care must be taken to ensure that high localized concentrations of contaminants do not exist.

Fan location is critical to achieving efficient general ventilation. Fans should always be located so that contaminated air is pulled away from the breathing zone of workers. Contaminants must never be drawn through the breathing zone. Likewise, fresh air inlets are best situated so that the clean air is drawn through the worker's breathing zone to the contaminated area and the air exhaust outlet.

A concept that is sometimes utilized is that of "air changes per hour." Some guidelines and building codes employ this method to provide guidance on the amount of ventilation necessary to control exposures from certain operations. While this concept has the advantage of being simple and reduces the amount of engineering required to design a system, it is inappropriate for use in controlling hazardous materials. Because complete mixing and air displacement seldom occur, the number of calculated air changes does not accurately reflect the true number of exchanges. The industrial hygienist and engineer must recognize that the design criteria for ventilation systems should be a function of the process and problems associated with it, not a function of the room size. However, air changes per hour may be used as a basis for ventilating some operations where toxic materials are not handled.

Replacement air must always be considered when designing a ventilation system. Air being exhausted from a building or process area must be replaced. This replacement may come from openings in the building or room, especially in old buildings, or it may be delivered to the building by design. The ACGIH publication *Industrial Ventilation - A Manual of Recommended Practice* (see reference section of this chapter) provides guidance in providing make-up air so as to assure the efficient operation of the ventilation system and to assure better control of air movement.

Although it is not effective in removing potentially toxic contaminants, general ventilation is often acceptable in providing comfort ventilation to control humidity, temperature, odors and carbon dioxide build-up and to remove dusts and biological agents from the air supply.

Local Exhaust Ventilation

A second way of providing mechanical ventilation to control potentially hazardous materials is to design a local exhaust system which remove contaminants from the workplace at the point where they are emitted. Such a system can then move the contaminated air to a single exhaust point, where it can be treated to remove contaminants prior to sending the air to the environment. Local exhaust systems are often preferred because they provide better control of toxic contaminants and because they often handle much smaller volumes of air. As a result of handling smaller air volumes, smaller fans and air cleaners are required and less heat/cold loss occurs. Local exhaust prevents the movement of contaminants from their sources to other work areas. Local exhaust should be considered for operations or processes involving toxic materials, variable emission rates, widely dispersed emission sources and flammable substances. In addition, such systems are necessary if general ventilation is ineffective in removing contaminants from the breathing zones of workers or if high localized concentrations exist.

Measurements for velocity, pressure and flow rate are employed in evaluating the effectiveness of ventilation systems. Static pressure, which results from the random

movement of molecules, is expressed as a measure compared to atmospheric pressure. Velocity pressure is the pressure exerted by airflow; it acts only in the direction of the flow of air. The total pressure of the system is the sum of the static and velocity pressures. Total pressure and static pressure in local exhaust systems are measured using U-tube manometers. The velocity pressure is measured with a pitot tube, which consists of two concentric tubes measuring total pressure and static pressure. The two tubes are connected in such a way that the static pressure is nullified, giving a reading for the velocity pressure. Specific procedures have been published for performing pitot traverses of ductwork in ventilation systems (refer to Cheremisinoff, N.P., Pumps, Pipes and Channels, Ann Arbor Science, Ann Arbor, MI, 1980).

At 70°F and 29.92 inches of mercury (one atmosphere), velocity pressure can be related to air velocity using the equation:

$$v = 4005\,(VP)^{1/2} \qquad (4)$$

where v is the air velocity in feet per minute and VP is velocity pressure in inches of mercury. The air velocity and cross sectional area of flow can then be used to calculate the flow rate in the system using:

$$Q = vA \qquad (5)$$

where Q is the flow rate in cubic feet per minute (cfm), v is the velocity in feet per minute and A is the area in square feet.

These measurements of pressures and flow rates are used by engineers and industrial hygienists in designing and balancing systems for specific operations. Each system must be designed to collect and carry specific contaminants. The collection and movement of large particles, for example, will require the use of greater flow rates and velocities than will be needed for gases and vapors. The industrial hygienist must work with the industrial engineer in designing efficient, effective local exhaust systems.

Components of Local Exhaust Ventilation Systems

There are five components in a local exhaust ventilation system. These are the hood, the point at which the contaminant is collected; ductwork, the pathway through which the air is moved to a single point; air-cleaning equipment, which is designed to remove certain contaminants, such as dusts and organic vapors; the fan, which creates airflow through the system; and the stack, through which the cleaned air is discharged to the environment.

a. Hoods

The hood is the point of entry for contaminants into the local exhaust system. Obviously, the contaminant must be collected efficiently at this point for the system to be effective.

Three types of hoods are used in these systems: capture hoods, enclosing hoods and receiving hoods.

Capture Hoods - Capture hoods are located near the source of emission to draw air and contaminants from the process into the ventilation system. This is accomplished through suction created by the low pressure area formed at the opening of the hood by air movement from the fan. Capture hoods may be designed to be simple duct openings, flanged openings, tapered inlets, bell month inlets or slot openings. In each case, the air velocity through the opening can be predicted from the opening area and the flow rate. The placement of a flange around a duct opening increases its collection efficiency by reducing turbulence at the opening. This will decrease entry loss and may increase airflow into the system by as much as 40%, depending on the size of the flange. Entry loss, expressed as a percentage of velocity pressure, and the coefficient of entry, a ratio of actual flow rate into the hood to the flow rate if no entry losses occurred, can be predicted for each type of hood. For example, ACGIH has reported an entry loss of 0.93 VP and a coefficient of entry of 0.72 for plain opening ducts, and an entry loss of only 0.49 VP and coefficient of entry of 0.98 for the more efficient bell mouth inlet. The previously described ACGIH publication should be consulted for additional information concerning other types of hoods.

Examples of processes for which capture hoods may be effective include drumming operations, welding operations, processes in which solvents are mixed or charged, and open plating tank processes. In designing a system, the toxicity of materials, worker's breathing zone, temperature of the process and other factors must be considered in determining the correct hood type and placement. In general, however, the hood should be located as close to the operation as possible and should draw air away from the breathing zone of employees.

Enclosure Hoods - Enclosure hoods are especially effective because they are designed to completely contain the process and, therefore, the contaminant. Examples of processes for which enclosure hoods are commonly used include operations involving drumming and bagging, powder charging and grinding wheels and tools. Sealed glove boxes are often used in handling radioactive substances, toxic chemicals and pharmaceuticals. Complete enclosures generally provide the greatest control of airborne contaminants and should be considered whenever feasible.

Hoods used for grinding wheels and polishing equipment must provide sufficient exhaust ventilation to remove dusts and particulates and must supply the structural strength necessary to contain the wheel and protect the worker from potential wheel breakage. The American National Standards Institute (ANSI) and ACGIH publications provide guidance concerning the design and flow requirements for grinding operations.

A special type of enclosing hood is the booth, an enclosure with an opening on one side for access. Operations are conducted inside a booth which has sufficient exhaust air drawn through the opening to prevent contaminants from escaping through the open side. These booths are designed so that contaminants are drawn away from the breathing zone of the worker. Paint spray operations, biological agent handling and laboratory chemical handling are commonly carried out in booth-type hoods. While booth hoods reduce the need for exhaust air, they require more than complete enclosures because one side is open.

Receiving Hoods - The receiving hood, often referred to as the canopy hood, is located in such a way that the natural movement of air from the process flows toward its opening. This is a commonly used ventilation method employed above hot processes, such as solvent cleaning tanks. Certain dust collection systems also utilize this design. For example, dusts from many grinding machines and radial saws are controlled using receiving hoods.

Many operations involve the use of solvent tanks for surface treatment, metal cleaning, degreasing, stripping and acid treatment. Canopy receiving hoods are sometimes utilized to collect contaminants from some of these operations: however, they are most effective when used for hot processes. The engineer must consider air movement and currents which may allow the release of the contaminant into the workplace when designing such a system. In addition, some processes may involve the movement of workers' heads over the tank or the lifting of parts from the tank. In these cases, receiving hoods are not appropriate. The engineer should consult with the industrial hygienist and ventilation publications before incorporating this type of hood into a process.

b. Ducts

After process air and contaminants have been collected by the hood, ducts are utilized to carry the contaminated air to the air cleaner or to the outside environment. As air moves through the ducts, energy is lost in overcoming friction between the air (and entrained particles) and duct walls. The velocity of the air in the duct must be sufficiently high to transport the contaminants of concern. For example, vapors, gases and smoke typically require minimum duct velocities of 1,000 to 2,000 feet per minute (fpm) while dusts and powders require velocities ranging from 2,500 to more than 4,500 fpm, depending on particle size. ACGIH has published information concerning transport velocities for specific operations.

While ducts may be made of several materials, including concrete, fiberglass and flexible materials, most are made of circular galvanized steel. The choice of materials will be based on several factors, including cost, corrosion characteristics, performance, strength and the characteristics of the airstream.

Just as pressure losses occur at the entrances to hoods, friction losses occur in the ductwork of local exhaust ventilation systems. This friction loss is described by the following equation:

$$Friction\ Loss = \frac{fLv^2}{D} \qquad (6)$$

where f is the friction coefficient, L is the length of the duct, v is the velocity in the duct and D is the diameter. As indicated by the above equation, friction in a duct is directly related to the length of the duct and the square of the air velocity. It is inversely related to the diameter. In addition, rough surfaces inside the ductwork tend to increase friction loss in the system. Charts are available which provide estimates of friction loss based on velocity, duct diameter and flow rates.

Friction losses also occur due to turbulence caused by branch entries, elbows and contractions and expansions in duct diameter. For example, when the diameter of a duct is contracted, the static pressure in the larger diameter duct

is converted to velocity pressure in the small duct. During the conversion from static pressure to velocity pressure, energy is lost, since the conversion is less than 100 percent. To minimize losses, tapered conversions are designed into the system to reduce losses due to turbulence. It is generally recommended that each elbow have a radius of 2.5 diameters; as the radius becomes larger or smaller, the amount of velocity pressure loss increases. Branches are designed to enter ducts gradually, at entry angles of 30 percent or less. The maximum entry angle is 45 percent. Additional information on duct losses and losses in other parts of the local exhaust ventilation system are available from ACGIH.

In designing a system, the engineer or industrial hygienist must first consider the amount of air flow required at each hood to collect the contaminated air. Duct sizes are then selected for each branch in the system so that will air movement will be distributed between hoods as necessary. During this design phase, the goal of the engineer is to maintain the proper air velocities in order to prevent the deposition of contaminants and to hold cost and power requirements to a minimum. Because of the potentially high costs associated with an incorrectly designed or balanced ventilation system, the industrial hygienist must work closely with an engineer in the design phase.

c. Air Cleaners

Air cleaners are often designed into ventilation systems to remove contaminants from the airstream. Those intended for use in heating and air conditioning systems are designed to handle large volumes of air. These systems clean incoming air from outside and recirculated air from within the building using filters that are often disposable.

Industrial ventilation systems carrying airstreams contaminated with potentially toxic materials must remove materials to prevent their release to the environment. Removal of contaminants may also be required because of regulations or to recover valuable materials. Such systems may have to efficiently remove dusts, such as silica, metals and pigments, gases, vapors, fumes and aerosols. The cleaners may have to operate under high or low loading conditions.

The cleaning method selected will depend upon the physical state of the contaminant, its physical properties, the airflow in the system, particle characteristics and other factors. Various cleaners exist for collecting dusts. These include cyclones and wet/dry centrifugals, electrostatic precipitators, fabric filters and settling chambers. Filters and baghouse filters operate under the principles of interception, impaction and diffusion of particles. The mechanism for cyclones and centrifugal collectors is the generation of circular motions which move particles to the outer walls of the cleaner where they impact and fall out of the airstream. Electrostatic precipitators operate by creating an electrical field which charges particles in the airstream. The charged particles subsequently migrate to an oppositely charged plate where they are collected and removed. Each of these methods has advantages and disadvantages which must be considered when designing the system.

Gases or vapors are collected or removed from airstreams using one of three methods; adsorption, absorption or combustion. Adsorption is the process in which a gas or vapor adheres to the surface of a solid material, such as activated carbon or silica gel. In such a system, no chemical reaction occurs and breakthrough may occur if all active sites on the adsorbant are occupied by the material being collected. The capacity of an adsorbant will depend upon several factors, including its surface area and the concentration of the contaminant in the airstream. After the adsorbant has been saturated, the solvents can often be reclaimed and the adsorbant reactivated.

Absorption is also utilized to collect vapors and gases. In this process, the contaminated airstream is fed to a scrubber or packed tower containing a liquid which will dissolve or chemically react with the contaminant. Because of its low toxicity and its ability to dissolve many materials, water is often used for this purpose. Often, water-soluble gases such as ammonia and hydrogen chloride are collected in this type of cleaning system. The resulting solutions from these operations must ultimately be disposed of responsibly.

Finally, airstreams may be cleaned of vapors or gases using combustion techniques. In some cases, waste streams may be directly burned as fuel. Catalytic combustion, in which catalysts are utilized to accelerate combustion, is sometimes employed for removing odors and vapors from many operations.

In designing the air cleaning device for an operation, the engineer will work with environmental specialists and industrial hygienists to select the appropriate method. These professionals will provide information on the health and environmental effects of the various contaminants and the resulting wastes and byproducts of the cleaning operations. In addition, they will advise the engineer on the impact of regulations on the collection and ultimate disposal of these materials.

d. Fans

Fans, exhausters and blowers are called air-moving devices. Fans are critical to the local exhaust ventilation system since they supply the energy to produce a continuous flow of air, resulting in the system's air movement. Whenever possible, the fan should be located downstream from the air cleaner so that it will not handle contaminated air and will pull, rather than push, air through the system.

Two kinds of fans are used in industrial ventilation: axial flow types and centrifugal types. Axial flow fans, using propellers or blades, have airflow parallel to the shaft. For centrifugal fans, the airflow is perpendicular to the shaft. Axial fans are typically more efficient, more compact and less costly than centrifugal types. However, centrifugal fans, which have radial, forward curved or backward inclined blades, are generally less noisy than axial types. Because different fans exhibit different noise characteristics, it is important to consider the "noise rating" of the fan and the requirements of the process before selecting the fan to be used in the system. The appropriate fan for a particular system is chosen based on several factors. Fans are characterized by the following factors; flow volume, the static pressure at which the flow is produced, motor horsepower, noise level, efficiency and material handling characteristics. The selection must be made based on the "fan curve" for the fan, which graphically shows the relationship between the fan's flow rate and its static pressure, and the system curve, which describes volumetric flow and static pressure for the exhaust system. The fan is then selected based on these characteristics and the system requirements.

For systems in operation, the four "fan laws" are particularly useful to the industrial hygienist and engineer in predicting the effects of changes in operating parameters. These laws define the relationships between the following parameters: volume flow rate (CFM), revolutions per minute (RPM), horsepower (HP) and static pressure (SP). The four "laws" are as follows:

$$\frac{CFM_2}{CFM_1} = \frac{(SP_2)^{1/2}}{(SP_1)^{1/2}} \qquad (7)$$

As the equations indicate, volume flowrate changes by the square root of the static pressure and is directly related to the revolutions per minute (RPM). Static pressure changes by the square of RPM and horsepower changes by the cube of the RPM.

$$\frac{CFM_2}{CFM_1} = \frac{(RPM_2)}{(RPM_1)} \qquad (8)$$

$$\frac{SP_2}{SP_1} = \frac{(RPM_2)^2}{(RPM_1)^2} \qquad (9)$$

$$\frac{HP_2}{HP_1} = \frac{(RPM_2)^3}{(RPM_1)^3} \qquad (10)$$

Finally, in order for the ventilation system to work well, sufficient make-up air must be supplied to the areas from which contaminated air has been exhausted. Although the amount of make-up air must be equal to the volume of exhausted air, systems typically are designed to replace a 10% excess. Actual make-up air requirements will depend upon the operation and area being ventilated.

e. Exhaust Stacks

Exhaust stacks must be carefully designed to prevent the recirculation of exhaust air into clean make-up air intakes. Prior to designing this part of the local exhaust system, ventilation manuals should be consulted in determining the impact of air currents and stack height on contaminant dispersion. In addition, it must be kept in mind that stack heights are often controlled by local zoning laws; therefore, the appropriate environmental personnel must be consulted while designing this part of the system.

In summary, the engineer responsible for designing a ventilation system for a process must understand the complex principles of industrial ventilation. The engineer must consult with the hygienist to obtain information on potential emission sources in the process and the toxicities of the materials being handled. The many references for ventilation principles and methods should be consulted throughout the design of the system.

D. The Industrial Hygiene Program

The elements of industrial hygiene discussed above must be brought together and incorporated into effective indust-

rial hygiene programs on both site and corporate levels. Site programs must include written policies, procedures and practices which promote the recognition, evaluation, control and prevention of health hazards and stresses.

These programs must address the issue of workplace exposure assessment of specific job operations and tasks. As discussed previously, it is important for workplace exposures to be characterized accurately in order to ensure that potential health hazards are minimized. If costly engineering controls, such as ventilation, are to be recommended, it is critical for the data to be reliable and truly representative. Evaluations of constantly changing, complex work environments require the development of logical exposure assessment strategies by site and corporate industrial hygienists. These strategies should include basic characterization of the workplace, workforce and chemical inventory. Using this information, individuals are categorized into groups of workers who are expected to have similar exposure profiles. These are called heterogeneous exposure groups. The assessment strategy should also rank exposures using professional judgement and qualitative risk assessment tools. Monitoring programs are then written and formalized. Judgement and statistical tools can then be utilized to interpret the data and to make decisions regarding the need for controls or process changes.

The industrial hygiene program should also include procedures to ensure that employees and contractors receive appropriate training. This must include training as part of an effective hazard communication program as required by OSHA in 29 CFR 1910.1200. Information concerning the potential hazards of chemicals and other stresses must be conveyed to the workforce. Employees must understand the health hazards they may encounter and how they can prevent these exposures. Training must also be conducted so that labeling systems used by the workers are understood. In addition to the need for worker training, it is essential that line management is trained to understand the requirements of the industrial hygiene program. Only with the strong commitment of management can the program be effectively developed and implemented.

After the workplace and workforce have been characterized with respect to exposures, each plant or site must ensure that all potential hazards are controlled or prevented. Whenever feasible, engineering controls, such as ventilation, process isolation, substitution or barriers, should be utilized. When necessary, administrative controls may be used and, as a last resort, the use of personal protective equipment may be necessary. Policies addressing these issues should be included, in writing, as part of the program. The program should also include documented procedures for ongoing inspections, preventative maintenance, housekeeping practices, respiratory protection training and use, annual program reviews and maintenance of accurate records. These records include exposure information, as required by 29 CFR 1910.20, and documentation of training records. As discussed earlier, the OSHA HAZWOPER standard requires the development of plans for emergency response activities and training and drills to prepare potential responders. Finally, responsibilities relating to all aspects of the program must be clearly defined in writing.

To assure that the industrial hygiene program is running efficiently, periodic audits should be conducted. These audits should address all aspects of the program, including training, hazard communication, worksite analysis, hazard control, recordkeeping and management commitment aspects. Most companies are organized so that health and safety audits are conducted by persons who are trained in the appropriate disciplines but are not directly responsible for the programs being audited. This allows the auditors to maintain an objective and fresh perspective of the program and its effectiveness. These audits should be conducted in a cooperative spirit to the largest extent possible. Identifying inadequacies in programs and finding constructive solutions must be a joint effort of auditors, the appropriate industrial hygiene professionals and engineers within an organization.

E. Incorporating Industrial Hygiene Concerns into Process Planning

Close cooperation between the engineer and health and safety personnel is essential in designing a safe workplace. Several things must be considered during the new plant review process. Formal procedures should be developed for conducting these reviews, with the appropriate input from toxicology, industrial hygiene, environmental and safety representatives. It is critical that this process be incorporated into the earliest planning and design stages of a project. Failure to do so may result in costly process modifications or retrofitting later in the project. The following issues should be considered as part of these new project reviews.

The toxicity of the raw materials and final products must be considered by the group or department that will be operating the process. A product which has extremely high toxicity, for example, may not have a viable long-term

market. Potential regulations which may impact the production or sales of the product must be carefully reviewed prior to designing and building a production facility.

The engineer must design a process which will adequately control exposures to whatever materials are used or manufactured in the plant. In doing this, toxicologists and industrial hygienists must be consulted to determine the necessary controls for the raw materials and intermediates handled in each part of the process. The health professionals will summarize the toxicological concerns and work with the engineer to design the process appropriately.

During the evaluation of the toxicological profiles for the raw materials and products of the planned process, the industrial hygienist and engineer should review the Permissible Exposure Limits, Threshold Limit Values or other acceptable concentrations for each chemical. These limits will assist the engineer in designing the process controls. In addition, many of the ventilation guidelines and manuals discussed previously incorporate safety factors and acceptable airborne limits into design criteria for ventilation systems.

Regulations must also be discussed with the appropriate departments early in the design phase. Environmental and other workplace regulations may impact the need for emissions controls and air cleaners. Many OSHA regulations, such as the expanded chemical standards discussed previously, include specific requirements for permissible exposures, clean-up stations and other issues which affect the design process. It is essential that these considerations be addressed during the design phase.

Other industrial hygiene concerns should also be addressed by the engineer. Work practices for maintenance, quality control sampling and operations must be considered. For example, the level of controls designed into sampling ports will depend on the toxicity of the material being collected. Some operations may be designed so that much of the process is controlled remotely from a centralized control room. Again, the industrial hygienist will assist the engineer by providing input into these issues as appropriate.

III. COMPONENTS OF THE HANDBOOK

A. Organization of General and Personal Safety Information

The handbook contains information intended for use by technical personnel that are largely familiar with the concepts of proper safety management practices and who already have backgrounds or experiences in hazardous materials handling. It is not intended as a textbook or instructional aid for students, although it could be a useful reference for those individuals. Additionally, it is not the intent to reinvent or introduce new terminology or hazards classifications and systems. Its purpose is to provide a concise reference that will aid those professionals that have responsibilities in managing and or directly handling hazardous chemical compounds. The author has indeed encountered many different terms and classification systems while working internationally, with most notable differences existing between Western European and U.S. terminology, and those used within republics of the former Soviet Union. Although such distinctions exist, only internationally accepted terminology and definitions should be used when dealing with hazardous materials. Therefore, only terms and definitions that are well established in the United States and European Union are used throughout the handbook, and no attempt to compare different classification systems or definitions are made. Many terms used under the U.S. OSH standards are employed in the handbook, however the author has been careful to rely most heavily on those definitions which are more universally accepted as opposed to legal definitions that are unique to the U.S. regulatory system.

The first main reference section that the reader will encounter deals with general information on safety protocol, and in particular provides descriptive information on work environment sampling techniques, instrumentation and sampling protocol, and personal protection issues as related to hazardous site investigations. In particular, information on action levels that would require certain types of sampling, sampling plans and personal protection are described in Chapter 2 ("Industrial Hygiene Sampling and Personal Protection"). Chapter 2 is designed to provide descriptive information on safety protocol and equipment and will serve as an overall reference guide for site safety managers and health and safety officers working on hazardous sites, particularly in remediation type programs. Generic types of protective clothing and respirators are described in this chapter. The reader may refer to this chapter for additional terminology that are referenced in the data sections of the handbook.

B. Organization of Chemical Classification Guide

Chapter 3 ("Chemical Classification Guide") contains information than can assist the reader in identifying information on chemical compounds. It has one section which is an index to chemical names, which is comprised of an alphabetical listing of chemicals by their most common names, along with the best known synonym for each chemical. The reader may also refer to the Hazard

Materials Table of Title 49 of the Code of Federal Regulations which includes the chemical shipping name, the shipping number designation, the hazard class and division, the warning label required on shipping containers, and the packing group designation. These terms are defined in section IV below. The reader may also refer to the author's book on *Pollution Prevention Software Systems* (Noyes Publications, Westwood, N.Y., 1997), which provides a summary of commercially available software systems that the reader may refer to for more extensive health and safety information, for conducting risk assessments, documentation control, and health risk site management. This summary should not be viewed as endorsements of the commercial software or data bases identified. The reader will need to make her or his own assessment as to the usefulness of each system; however the features of each are described to facilitate an assessment of the management tool.

C. Organization of Chemical Reactivity, Fire and Explosion Information

The handbook contains information needed to help personnel make the proper decisions for the safe handling of chemical compounds and dangerous materials. Fire and explosion hazards represent a class of situations which is labeled as being immediately dangerous to life and health (IDLH), a term favored by the United States Occupational Safety and Health Standards (OSH standards). Chemicals that fall into this category pose imminent danger to human health and property. Information on the fire characteristics of common chemicals can be found in Chapter 4 ("Guide to Chemical Reactivity, Fire and Explosion"). Basic fire property data on chemicals are included in this chapter, largely derived from the NIOSH and CHRIS data bases, along with published information on material safety data sheets provided by several hundred chemical suppliers. Fire terms and terminology that are used in the tabulated information provided in Chapter 4 can be found in section IV in this chapter. The reader should therefore review section IV of Chapter 1 and understand the terms before using the data in Chapter 4. Information on chemical reactivity can also be found in Chapter 4. This data is particularly useful for determining chemical compatibility. The reader should cross-reference the information on specific chemicals in Chapter 4 with the chemical classification guide in Chapter 3.

D. Organization of Hazardous Chemical Data

The handbook contains information needed to help personnel make the proper response to handling chemicals and in particular during an emergency situation; as such, this handbook could be carried to the actual scene of a hazardous materials incident. In the latter case, it is intended for use by personnel and others who may be the first to arrive at the site of an accidental discharge or fire and who need readily available and easily understood information about the hazardous properties of the chemical involved. The information provided can assist in determining the proper actions that should be taken immediately to safeguard life and property and to prevent contamination of the environment.

Health hazard and toxicological information on chemicals is provided in Chapter 5 ("Health Risk Information"). This chapter contains tabulated data and text which describes the chemical and biological hazards of various materials so that personnel at the scene of a hazards materials incident can assess the danger and consider the appropriate large-scale response. Chapters 4 and 5 are the cornerstone of the handbook. For each substance, Chapter 5 lists the specific chemical, physical, and biological data needed for the preparation and use of emergency response and safe handling decisions. In this respect, Chapter 5 is most beneficial to the On-Scene Coordinator (OSC) of a hazardous materials incident. Additionally, Chapter 5 provides the type of health and safety information needed to conduct a risk assessment for standard chemical handling and storing operations. The chapter's data can be used for selection of personal protective equipment, and along with the information in Chapter 4, be used to ascertain the chemical reactivity of the chemical compound. This information is important to safe handling operations both for laboratory environments as well as bulk chemical handling facilities. The use of specific tables and information are described before each table or text summary, however there are certain terms that are abbreviated, as well as terminology that some readers may not be totally familiar with. The basic terminology used in this chapter can be found in section IV of this chapter. Other terms and definitions not described in section IV below may be found in the *Glossary* at the end of the handbook.

E. Organization of Emergency and Spill Response Information

The U.S. Department of Transportation (DOT) has developed specific guidelines for transporters faced with a hazards materials incident while chemicals are in transit. This information forms the basis for chapters 6 and 7. Chapter 6 ("Emergency Response Fact Sheets") provides a compendium of chemicals, listing them

alphabetically and cross-referencing them to DOT Emergency Response Fact Sheets that are included in that chapter. Those chemicals which are known to be extremely dangerous in a fire or spill situation are highlighted in Chapter 6 and cross referenced to the information in Chapter 7.

Chapter 7 ("Isolation Distances for Fires and Spills") contains DOT recommended initial isolation distances for spills and leaks involving high hazard chemicals. The information in this chapter is based on the terms and definitions provided in section IV below. The reader should carefully review the following section in order to become acquainted with the proper use of the data provided throughout the handbook.

The spill or leak from a container, storage vessel or any type of transport vehicle of a potentially flammable or even combustible material can pose a serious fire hazard and health risk. In the United it is the U.S. Department of Transportation's (DOT) responsibility to enforce regulations that ensure that transporters not only follow all safety precautions and meet technical requirements for the safe transport of hazardous materials, but that in the event of an emergency such as a spill or leak, that proper emergency response action is implemented. Additionally, the DOT is in part responsible for enforcing environmental regulations in that it must work along with the environmental regulatory agencies to ensure that both the general public and the environment are not exposed to a hazardous chemical spill and that proper clean up action is implemented.

The U.S. DOT *Emergency Response Guidebook* forms the basis of the information in Chapters 6 and 7, for use by firefighters, police, and other emergency services personnel who may be the first to arrive at the scene of a hazardous materials incident. In applying the information provided in Chapters 6 and 7, the reader should be aware of an organization supported by industry in the United States, which is the Chemical Transportation Emergency Center or CHEMTREC. CHEMTREC is an emergency information center that can provide technical advise on how best to handle a specific hazard materials incident. In the U.S., the toll free number to contact CHEMTREC is 1-800-424-9300. CHEMTREC is a service of the chemical industry. Detailed information on how CHEMTREC can assist in a hazards materials incident is provided in Chapter 7.

IV. EXPLANATION OF TERMS

This section explains the special terms used in the handbook, gives the sources of specific items, and includes other information that will be useful to the reader in interpreting the data.

The expression "Not Pertinent" means that the data item either has no real meaning (such as the flash point of a inflammable chemical) or is not required for assessing a hazardous situation. The expression "Data Not Available" means that the information sought was not found in the general data sources consulted during the preparation of this handbook. In a few cases where important data were not available, values were estimated by usually reliable procedures; all such values are labeled "(est.)". If more accurate values for those items are found, they will be included in later revisions.

The *name* used for each of the chemicals included is either (1) that specified in the Code of Federal Regulations (CFR), Titles 46 and 49 or (2) a common name for those chemicals known to be hazardous during shipment. In this regard, for most chemical names, the shipping name recommended by the U.S. DOT is used as it appears in Title 49 of the CFRs. The data are arranged in alphabetical order by chemical name, not by the 3-letter code. Although the letter code system rarely used in the handbook, the reader familiar with the CFR should note that the *3-letter code* is designed to facilitate correct identification of chemicals in oral or written communication. The code should be used only in addition to the compound name; it should not be used alone. For transmitting the code, use the phonetic alphabet given in the "International Code of Signals".

A. Response to Discharge

In every case of a discharge or leak, it is obvious that an effort should be made to reduce, stop, or contain the flow of material at its source if this can be done safely. The purpose of the terms used in this section is to describe in a general way the cautionary and corrective responses that are well recognized by trained emergency response personnel.

- *"Issue warning"* is used when the chemical is a *poison*, has a *high flammability*, is a *water contaminant*, is an *air contaminant* (so as to be hazardous to life), is an *oxidizing material*, or is *corrosive*. This type of response warning is most often applied for cautionary purposes to restrict ignition, and to restrict contaminated water for human use, farm use, and industrial use.

- *"Restrict access"* is used only for those chemicals that are unusually and immediately hazardous to personnel

unless they are protected properly by respirators, eye goggles, protective clothing, etc. This type of cautionary response is sometimes used in a broader sense to ensure exclusion of spectators and others who might ignite flammable compounds.

- *"Evacuate area"* is used primarily for unusually poisonous chemicals or those that ignite easily. The same expression can be used for a cautionary response.

- *"Mechanical containment"* is used for water-insoluble chemicals that float and do not evaporate readily. The corresponding corrective response is *"Contain"*.

- *"Should be removed"* is used for chemicals that cannot be allowed to disperse because of their harmful effect on humans or on the ecological system in general. The term is not used unless there is a reasonable chance of preventing dispersal, after a discharge or leak, by chemical and physical treatment.

- *"Chemical and physical treatment"* is recommended for chemicals that can be removed by skimming, pumping, dredging, burning, neutralization, absorption, coagulation, or precipitation. The corrective response may also include the use of dispersing agents, sinking agents, and biological treatment.

- *"Disperse and flush"* is used for chemicals that can be made non-hazardous to humans by simple dilution with water. In a few cases the response is indicated even when the compound reacts with water because, when proper care is taken, dilution is still the most effective way of removing the primary hazard.

B. Chemical Designations

Synonyms —Alternative systematic chemical names and commonly used trivial names are given. Commercial or trade names are shown in a few cases where they are in common use. An index of synonyms is included in this handbook (Chapter 3); it includes mostly those names given in Chapters 4 and 5.

Chemical Compatibility Classification — The U.S. Coast Guard defines 43 cargo groups listed in Navigation and Vessel Inspection Circular No. 4-75, "Guide to Compatibility of Chemicals". Appropriate parts of the Guide are included in this handbook, primarily in Chapter 3.

Chemical Formula — This has been limited to a commonly used one-line formula. In the case of some organic compounds it has not been possible to represent chemical structure within such a limitation.

MOO/United Nations Numerical Designation — The designation is that of the "International Maritime Dangerous Goods Code" originally published by the Inter-Governmental Maritime Consultative Organization (IMCO), London, 1972. The designation is not used in this handbook, but the reader should be aware of it.

Packing Group — This designation has been given by the USDOT and is assigned to all hazardous materials being shipped. A packing group designation defines the relative hazard of a chemical shipment. This designation is used extensively in the tables in Chapter 5. The packing group appears as an upper case Roman Numeral **I**, **II** or **III**, depending on the degree of hazard. The meanings of these designations are as follows: **I** refers to Most Hazardous (or Most Regulated); **II** refers to Moderately Hazardous (or Moderately Regulated); **III** refers to Least Hazardous (or Least Regulated). The reader should refer to Section 172.101, part f of Title 49 of the U.S. Code of Federal Regulations (parts 100 to 177) when engaged in the shipment of hazardous materials.

C. Observable Characteristics

Physical State (as shipped) - All chemicals that are listed in Code of Federal Regulations, Title 46 are shipped as liquids. Other designations include liquefied gas, liquefied compressed gas, and solid. Where a compound may be shipped either as a liquid or solid, both designations are given. The reader should also refer to Title 49 of the CFRs for guidelines on the transportation of hazardous materials.

Color — All color descriptions found in the common reference sources are included. The color description is that for pure material. Occasionally the color of a chemical changes when it dissolves in water or becomes a gas.

Odor — All odor descriptions found in the common reference sources are included. The expression "characteristic" is used only when no other reasonable description was found. The odor description is that for pure material.

D. Health Hazards

Personal Protective Equipment — The items listed are those recommended by (a) manufacturers, either in

technical bulletins or in Material Safety Data Sheets, (b) the Manufacturing Chemists Association, or (c) the National Safety Council, for use by personnel while responding to fire or accidental discharge of the chemical. They are intended to protect the lungs, eyes, and skin. Safety showers and eyewash fountains are considered to be important protective equipment for the handling of almost all chemicals; they are not usually listed.

Symptoms Following Exposure — These are brief descriptions of the effects observed in humans when the vapor (gas) is inhaled, when the liquid or solid is ingested (swallowed), and when the liquid or solid comes in contact with the eyes or skin.

Treatment for Exposure — "First-aid" procedures are recommended. They deal with exposure to the vapor (gas), liquid, or solid and include inhalation, ingestion (swallowing) and contact with eyes or skin. The instruction "Do not induce vomiting" is given if an unusual hazard is associated with the chemical being sucked into the lungs (aspiration) while the patient is vomiting. "Seek medical attention" or "Call a doctor" is recommended in those cases where only competent medical personnel can treat the injury properly. In all cases of human exposure, seek medical assistance as soon as possible. The sources of these recommendations are entirely from product specific MSDSs.

Toxicity by Inhalation (Threshold Limit Value) — The threshold limit value (TLV) is usually expressed in units of parts per million (ppm) - i.e., the parts of vapor (gas) per million parts of contaminated air by volume at 25°C (77°F) and atmospheric pressure. For a chemical that forms a fine mist or dust, the concentration is given in milligrams per cubic meter (mg/m^3). The TLV is defined as the concentration of the substance in air that can be breathed for five consecutive eight-hour workdays (40-hour work week) by most people without adverse effect. (This definition is given by American Conference of Governmental Industrial Hygienists, "Threshold Limit Values for Substance in Workroom Air, Adopted by ACGIH for 1972"). As some people become ill after exposure to concentrations lower than the TLV, this value cannot be used to define exactly what is a "safe" or "dangerous" concentration.

No entry appears when the chemical is a mixture; it is possible to calculate the TLV for a mixture only when the TLV for each component of the mixture is known and the composition of the mixture by weight is also known.

Short-Term Inhalation Limits — The parts of vapor (gas per million parts of contaminated air by volume at 25°C (77°F) and atmospheric pressure is given. The limits are given in milligrams per cubic meter for chemicals that can form a fine mist or dust. The values given are the maximum permissible average exposures for the time periods specified. The term Short Term Exposure Limit (STEL) is also used and is considered interchangeable with Short - Term Inhalation Limit. The STEL designation is derrived from OSH standards.

In some instances the values disagree, or the short-term limits overlap the TLV. These are not errors; the values were supplied by several laboratories, each of which used its own experimental techniques and methods of calculation.

Toxicity by Ingestion — The designation and corresponding LD_{50} value are those defined in most cases by the National Academy of Sciences, Committee on Hazardous Materials, "Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals, A Tentative Guide," Washington, D.C., 1972. Actual data were collected from other sources such as material safety data sheets. The term LD_{50} (meaning "lethal dose at the 50th percentile population") signifies that about 50% of the animals given the specified dose by mouth will die. Thus, for a chemical whose LD_{50} is below 50 mg/kg, the toxic dose for 50% of animals weighing 70 kg (150 lb) is 70x 50 = 3500 mg = 3.5 g, or less than one teaspoonful; it might be as little as a few drops. For a chemical with an LD_{50} of between 5 to 15g/kg, the LD_{50} would be between a pint and a quart for a 150-lb man. All LD_{50} values have been obtained using small laboratory animals such as rodents, cats, and dogs. The substantial risks taken in using these values for estimating human toxicity are the same as those taken when new drugs are administered to humans for the first time.

Late Toxicity — Where there is evidence that the chemical can cause cancer, mutagenic effects, teratogenic effects, or a delayed injury to vital organs such as the liver or kidney, a qualitative description of the effect is given. The term can be interpreted as implying long term or chronic effects due to exposure to the chemical. In this respect, a distinction must be made between acute and chronic effects. An acute effect is one in which there is a short term or immediate response, usually due to exposure of the chemical at a high concentration. A chronic effect implies a long term exposure to small doses, with symptoms sometimes taking years to materialize.

Vapor (Gas) Irritant Characteristics — Since MSDSs often provide non-qualifying statements, the most appropriate of five statements listed below is given. (Source: National Academy of Sciences, Committee on Hazardous Materials, "Evaluation of the Hazard of Bulk Water Transportation of Industrial Chemicals, A Tentative Guide," Washington, D.C., 1970.)

1. Vapors are nonirritating to eyes and throat.
2. Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
3. Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.
4. Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations.
5. Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations.

Liquid or Solid Irritant Characteristics — The most appropriate of the following four statements is given (same source as above):

1. No appreciable hazard. Practically harmless to the skin.
2. Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin.
3. Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure.
4. Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact. Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes.

Odor Threshold — This is the lowest concentration in air that most humans can detect by smell. The value cannot be relied on to prevent overexposure, because human sensitivity to odors varies over wide limits, some chemicals cannot be smelled at toxic concentrations, odors can be masked by other odors, and some compounds rapidly deaden the sense of smell.

E. Fire Hazards

Flash Point — This is defined as the lowest temperature at which vapors above a volatile combustible substance will ignite in air when exposed to a flame. Depending on the test method used, the values given are either Tag Closed Cup (C.C.) (ASTM D56) or Cleveland Open Cup (O.C.) (ASTM 093). The values, along with those given below, provide an indication of the relative flammability of the chemical. In general, the open cup value is about 10° to 15°F higher than the closed cup value.

Flammable Limits in Air — The percent concentration in air- (by volume) is given for the lower (LFL) and upper (UFL) limit. The values, along with those for flash point and ignition temperature, give an indication of the relative flammability of the chemical. The limits are sometimes referred to as "lower explosive limit" (LEL) and "upper explosive limit" (UEL). Chapter 4 provides a detailed technical explanation.

Flammabilty Range — Defined as the difference between the UFL and LFL. This difference provides an indication of how wide the falmmability limits of a chemical are. Generally, the wider the range, the more hazardous the chemical may be considered from a fire standpoint.

Fire Extinguishing Agents — The agents are listed in Chapter 4 for specific chemicals in decreasing order of importance. The general capabilities of all agents are described in the fire safety references cited at the end of this chapter.

Fire Extinguishing Agents Not to be Used — The agents listed for specific chemicals in Chapter 4 must not be used because they react with the chemical and create an additional hazard. In some cases they are listed because they are ineffective in putting out the fire.

Special Hazards of Combustion Products — Some chemicals decompose or burn to give off toxic and irritating gases. Such gases may also be given off by chemicals that vaporize in the heat of a fire without either decomposing or burning. If no entry appears with a chemical citation in Chapter 4, the combustion products are thought to be similar to those formed by the burning of oil, gasoline, or alcohol; they include carbon monoxide (poisonous), carbon dioxide, and water vapor. The specific combustion products are usually not well known over the wide variety of conditions existing in fires; some may be hazardous.

Behavior in Fire — Any characteristic behavior that might increase significantly the hazard involved in a fire is described for specific chemicals in Chapter 4. The

formation of dense smoke or flammable vapor clouds, and the possibility of polymerization and explosions is stated. Unusual difficulty in extinguishing the fire is also noted.

Ignition Temperature — This is the minimum temperature at which the material will ignite without a spark or flame being present. Along with the values of flash point and flammable limits in air, it gives an indication of the relative flammability of the chemical. It is sometimes called the "autoignition temperature". The method of measurement is given in ASTM A2155.

Electrical Hazard — The ease with which the chemical is ignited by electrical equipment is indicated by the Group and Class assignment made in "Fire Codes", Vol. 5, National Fire Protection Association, Boston, Mass" 1972, pp. 70-289.

Burning Rate — The value is the rate (in millimeters per minute) at which the depth of a pool of liquid decreases as the liquid burns. Details of measurement are given by D.S. Burgess, A. Strasser, and J. Grumer, "Diffusive Burning of Liquid Fuels in Open Trays," Fire Research Abstracts and Reviews, 3,177 (1961).

F. Chemical Reactivity

Reactivity with Water — The term "No Reaction" means that no hazard results when the chemical reacts or mixes with water. Where a hazard does result, it is described for specific chemicals cited in Chapter 4.

Reactivity with Common Materials — This is limited to hazardous reactions with fuels and with common materials of construction such as metal, wood, plastics, cement, and glass. The nature of the hazard, such as severe corrosion or formation of a flammable gas, is described for specific chemicals in Chapter 4.

Stability During Transport — The term "Stable" means that the chemical will not decompose in a hazardous manner under the conditions of temperature, pressure, and mechanical shock that are normally encountered during shipment; the term does not apply to fire situations. Where there is a possibility of hazardous decomposition, an indication of the conditions and the nature of the hazard is given for specific chemicals cited in Chapter 4.

Neutralizing Agents for Acids and Caustics — In all cases involving accidental discharge, dilution with water may be followed by use of the agent specified, particularly if the material cannot be flushed away; the agent specified need not necessarily be used. This information can be found in Chapter 4.

Polymerization — A few chemicals can undergo rapid polymerization to form sticky, resinous materials, with the liberation of much heat. Under these conditions the chemical's containers may explode due to internal pressure buildup. For these chemicals the conditions under which the reaction can occur are given in Chapter 4.

Inhibitor of Polymerization — The chemical names and concentrations of inhibitors added by the manufacturer to prevent polymerization are given where apropriate.

G. Hazard Classifications

Code of Federal Regulations — The hazard class specified in the Code of Federal Regulations, Title 49,Part 172. Chemicals not specifically listed therein have been classified as "Flammable" if their flash point (closed cup) is below 100°F.

UN Hazard Classes and Divisions — The hazard class of a material is indicated either by its class (or division) number, or its class name. For a placard corresponding to the primary hazard class of a material, the hazard class or division number must be displayed in the lower corner of the placard. The UN (United Nations) hazard classes are as follows:

Class 1 *Explosives*
- Division 1.1 Explosives with a mass explosion hazard
- Division 1.2 Explosives with a projection hazard
- Division 1.3 Explosives with predominantly a fire hazard
- Division 1.4 Explosives with no significant blast hazard
- Division 1.5 Very insensitive explosives; blasting agents
- Division 1.6 Extremely insensitive detonating substances

Class 2 *Gases*
- Division 2.1 Flammable gas
- Division 2.2 Non-flammable, non-poisonous compressed gas
- Division 2.3 Gas poisonous by inhalation
- Division 2.4 Corrosive gas

Class 3 *Flammable liquid and Combustible liquid*

Class 4 *Flammable Solid; Spontaneously combustible material; and Dangerous when wet material*

Class 5 *Oxidizers and Organic Peroxides*
Division 5.1 Oxidizer
Division 5.2 Organic peroxide
Class 6 *Poisonous material and infectious substance*
Division 6.1 Poisonous materials
Division 6.2 Infectious substance
Class 7 *Radioactive material*
Class 8 *Corrosive material*
Class 9 *Miscellaneous hazardous material*

NFPA Hazard Classifications — The indicated ratings are given in "Fire Protection Guide on Hazardous Materials," National Fire Protection Association. The classifications are defined in Table 1.

Table 1. Explanation of NFPA Hazard Classifications

Classification	Definition
Health Hazard (blue)	
4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment were given.
3	Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment were given.
2	Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.
1	Materials which on exposure would cause irritation but only minor residual injury even if no treatment is given.
0	Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.
Flammablity (red)	
4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.
3	Liquids and solids that can be ignited under almost all ambient temperature conditions.
2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.
1	Materials that must be preheated before ignition can occur.
0	Materials that will not burn.
Reactivity (yellow)	
4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.
3	Materials which in themselves are capable of detonation or explosive reaction but require a strong initiating source or which must be heated under confinement before initiation or which react explosively with water.
2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently.
0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.
Other (white)	
W	Materials which react so violently with water that a possible hazard results when they come in contact with water, as in a fire situation. Similar to Reactivity Classification.
Oxy	Oxidizing material; any solid or liquid that readily yields oxygen or other oxidizing gas, or that readily reacts to oxidize combustible materials.

H. Physical and Chemical Properties

Physical State at 15°C and 1 atm — The statement indicates whether the chemical is a solid, liquid, or gas after it has reached equilibrium with its surroundings at "ordinary" conditions of temperature and pressure.

Molecular Weight — The value given is the weight of a molecule of the chemical relative to a value of 12 for one atom of carbon. The molecular weight is useful in converting from molecular units to weight units, and in calculating the pressure, volume and temperature relationships for gaseous materials. The ratio of the densities of any two gases is approximately equal to the ratio of their molecular weights. The molecular weights of mixtures can be calculated if both the identity and quantity of each component of the mixture are known. Because the composition of mixtures described in this handbook is not known exactly, or because it varies from one shipment to another, no molecular weights are given for such mixtures.

Boiling Point at 1 atm — The value is the temperature of a liquid when its vapor pressure is 1 atm. For example, when water is heated to 100°C (212°F) its vapor pressure rises to 1 atm and the liquid boils. The boiling point at 1 atm indicates whether a liquid will boil and become a gas at any particular temperature and sea-level atmospheric pressure.

Freezing Point — The freezing point is the temperature at which a liquid changes to a solid. For example, liquid water changes to solid ice at 0°C (32°F). Some liquids solidify very slowly even when cooled below their freezing point. When liquids are not pure (for example, salt water) their freezing points are lowered slightly.

Specific Gravity — The specific gravity of a chemical is the ratio of the weight of the solid or liquid to the weight of an equal volume of water at 4°C (or at some other specified temperature). If the specific gravity is less than 1.0 (or less than 1.03 in seawater) the chemical will float; if higher, it will sink.

Vapor (Gas) Specific Gravity — The value is the ratio of the weight of vapor to the weight of an equal volume of dry air at the same conditions of temperature and pressure. Buoyant vapors have a vapor specific gravity less than one. The value may be approximated by the ratio M/29, where M is the molecular weight of the chemical. In some cases the vapor may be at a temperature different from that of the surrounding air. For example, the vapor from a container of boiling methane at -172°F sinks in warm air, even though the vapor specific gravity of methane at 60°F is about 0.6.

Latent Heat of Vaporization — The value is the heat that must be added to the specified weight of a liquid before it can change to vapor (gas). It varies with temperature; the value given is that at the boiling point at 1 atm. The units used are Btu per pound, calories per gram, and joules per kilogram. No value is given for chemicals with very high boiling points at 1 atm, because such substances are considered essentially nonvolatile.

Heat of Combustion — The value is the amount of heat liberated when the specified weight is burned in oxygen at 25°C. The products of combustion, including water, are assumed to remain as gases; the value given is usually referred to as the "lower heat value." The negative sign before the value indicates that heat is given off when the chemical burns. The units used are Btu per pound, calories per gram, and joules per kilogram.

Heat of Decomposition — The value is the amount of heat liberated when the specified weight decomposes to more stable substances. The value is given for very few chemicals, because most are stable and do not decompose under the conditions of temperature and pressure encountered during shipment. The negative sign before the value simply indicates that heat is given off during the decomposition. The value does not include heat given off when the chemical burns. The units used are Btu per pound, calories per gram, and joules per kilogram.

Heat of Solution — The value represents the heat liberated when the specified weight of chemical is dissolved in a relatively large amount of water at 25°C ("infinite dilution"). A negative sign before the value indicates that heat is given off, causing a rise in temperature. (A few chemicals absorb heat when they dissolve, causing the temperature to fall.) The units used are Btu per pound, calories per gram, and joules per kilogram. In those few cases where the chemical reacts with water and the reaction products dissolve, the heat given off during the reaction is included in the heat of solution.

Heat of Polymerization — The value is the heat liberated when the specified weight of the compound (usually called the monomer) polymerizes to form the polymer. In some cases the heat liberated is so great that the temperature rises significantly, and the material may

burst its container or catch fire. The negative sign before the value indicates that heat is given off during the polymerization reaction. The units used are Btu per pound, calories per gram, and joules per kilogram.

Liquid Heat Capacity — The value is the heat (in Btu) required to raise the temperature of one pound of the liquid one degree Fahrenheit at constant pressure. For example, it requires almost 1 Btu to raise the temperature of 1 pound of water from 68°F to 69°F. The value is useful in calculating the increase in temperature of a liquid when it is heated, as in a fire. The value increases slightly with an increase in temperature.

Liquid Viscosity — The value (in centipoise) is a measure of the ability of a liquid to flow through a pipe or a hole; higher values indicate that the liquid flows less readily under a fixed pressure head. For example, heavy oils have higher viscosities (i.e., are more viscous) than gasoline. Liquid viscosities decrease rapidly with an increase in temperature. A basic law of fluid mechanics states that the force per unit area needed to shear a fluid is proportional to the velocity gradient. The constant of proportionality is the viscosity.

Solubility in Water — The value represents the pounds of a chemical that will dissolve in 100 pounds of pure water. Solubility usually increases when the temperature increases. The following terms are used when numerical data are either unavailable or not applicable: The term "Miscible" means that the chemical mixes with water in all proportions. The term "Reacts" means that the substance reacts chemically with water; thus, its solubility has no real meaning. "Insoluble" usually means that one pound of the chemical does not dissolve entirely in 100 pounds of water. (Weak solutions of "Insoluble" materials may still be hazardous to humans, fish, and waterfowl, however.)

I. Information Systems

Chemical Transportation Emergency Center (CHEMTREC) — In the United States, the Manufacturing Chemists Association operates CHEMTREC 24 hours a day. By calling the appropriate toll-free number listed below, one can consult experts on chemicals and spill response.

Continental United States (except Alaska & District of Columbia) 800-424-9300
Alaska, Hawaii, and District of Columbia 202-483-7616

National Fire Protection Association (NFPA) — The NFPAs "Recommended System for the Identification of the Fire Hazards of Materials" (NFPA No. 704M) provides basic warning information to fire fighters in industrial plants and storage facilities. This system uses a diamond-shaped warning symbol. The top, left, and right boxes refer to flammability, health, and reactivity hazards respectively and contain a number from 0 to 4. The exact meaning of each number is explained in Table 1 of this chapter, and the applicable numbers for each chemical are listed in Chapter 4. The bottom box is used for special hazards; the most common of these is a warning against the use of water, indicated by the symbol W.

Department of Transportation (DOT) — The DOT provides guidelines and mandatory requirements for the safe transportation of hazardous materials. This information can be found in Title 49 of the Code of Federal Regulations (CFR). Information on emergency response for a hazardous materials incident occurring during transportation is provided in a DOT publication (see references at the end of this chapter). Chapters 6 and 7 of the handbook contain information.

Poison Control Centers — Throughout the United States and many parts of Western Europe, local Poison Control Centers are maintained at hospitals. These Centers can provide information on the chemical composition, appearance, and toxicity of common poisonous materials as well as information on the symptoms of exposure and on the emergency procedures recommended in the event of exposure. The information available at these centers deals mainly with common household materials. In the United States, Poison Control Centers are coordinated through the Department of Health, Education and Welfare in Washington, D.C., but information can be requested through the local centers.

V. REFERENCES AND RECOMMENDED READINGS

This section cites the primary references that were used in compiling the data for the handbook, and provides an organized summary of key references that the reader should refer to for additional information.

A. References

In addition to a review of several thousand material safety data sheets, the author consulted and extracted information from the following sources:

1. Cheremisinoff, N.P., J.A. King, Dangerous Properties of Industrial and Consumer Chemicals, Marcel Dekker Publishers, Inc., New York, 1994.
2. NIOSH and OSHA Guidebook to Chemical Hazards, SciTech Publishers, Inc., Morganville, New Jersey, 1987.
3. Title 49 of the Code of Federal regulations, Parts 100 to 177, Washington, DC, Oct. 1993.
4. Emergency Response Guidebook, U.S. Department of Transportation, Washington, DC, 1995.
5. OSHA Analytical Methods Manual, Second Edition, Occupational Safety and Health Administration, Salt Lake City, Utah, 1990.
6. NIOSH Manual of Analytical Methods. Volumes 1 - 7, National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1981.
7. Industrial Ventilation, 21st Edition, A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1992.
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14. ACGIH, Industrial Noise Manual, American Industrial Hygiene Association, Akron, Ohio, 1994.
15. AIHA. Industrial Hygiene. A Guide to Technical Information Sources. American Industrial Hygiene Association, Akron, Ohio, 1984.
16. Aitio, A.V., Riihimaki and H. Vainio. Biological Monitoring and Surveillance of Workers Exposed to Chemicals, Hemisphere Publishing Corporation, Washington, D.C., 1984.
17. Alien, M.D., Ells and A. W. Hart, Industrial Hygiene. Prentice-Hall, Inc., Englewood Cliffs, N. J., 1976.
18. ASHRAE, Pocket Handbook for Air Conditioning Heating Ventilation Refrigeration, American Society of Heating, Refrigeration and Air-Conditioning Engineers, Atlanta, Georgia, 1987.

B. Recommended Readings

The following references should be consulted for either general information about a specific subject or more detailed data and information. These references are organized for the reader by subject category.

1. Chemical Specific Data and Information References:

1. Hazards Associated with Organic Chemical Manufacturing: Vinyl Acetate by Hydroacetylation, Mitre Corp., McLean, VA, Report No. MTR-7900378-04, April 1980.
2. Hazards Associated with Organic Chemical Manufacturing: Oxychlorination and Pyrolysis Processes for Vinyl Chloride Production, Mitre Corp., McLean, VA, Report No. MTR-79W00378-03, April 1980.
3. Hazards Associated with Organic Chemical Manufacturing: Esterification Process for Acrylic Acid Esters Production, Mitre Corp., McLean, VA, Report No. MTR-79W00378-01, April 1980.
4. Hazards Associated with Organic Chemical Manufacturing: Condensation Process for DL-Methionine Production, Mitre Corp., McLean, VA, Report No. MTR-79W00378-02, April 1980.
5. Hazards Associated with Organic Chemical Manufacturing: Tetraalkyl Lead by Lead Alkylation, Mitre Corp., McLean, VA, Report No. MTR-78W00364-03, May 1979.
6. Hazards Associated with Organic Chemical Manufacturing: Polymerization Processes for Polyvinyl Chloride and Polyether Glycols, Mitre Corp., McLean, VA, Report No. MTR-79W00364-04, May 1979.
7. Hazards Associated with Organic Chemical Manufacturing: Acetic Acid by Methanol Carbonylation, Mitre Corp., McLean, VA, Report No. MTR-79W00364-01, February 1979.
8. Hazards Associated with Organic Chemical Manufacturing: Acetaldehyde by Liquid Phase Ethylene Oxidation, Mitre Corp., McLean, VA, Report No. MTR-79W00364-02, April 1979.
9. Cheremisinoff, N.P., J.A. King , Dangerous Properties of Industrial and Consumer Chemicals, Marcel

Dekker Publishers, Inc., New York, 1994.
10. Federal Motor Carrier Safety Regulations, U. S. Department of Transportation: Federal Highway Administration, Washington, DC, 1992.
11. Driver's Pocket Guide to Hazardous Materials, Tri-State Motor transit Co, Joplin, Missouri, J. J. Keller & Assoc., Wisconsin, 1995.
12. Existing Chemicals of Environmental Relevance: Criteria and List of Chemicals, VCH Verlagsgesellschaft, Federal Republic of Germany, 1989.
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21. Cralley L.V. and L.J. Cralley, Editors. Industrial Hygiene Aspects of Plant Operations, Volume 1, Process Flows. Macmillan Publishing Co., Inc., New York, 1982.
22. Cralley L.V. and L.J. Cralley, Editors. Patty's Industrial Hygiene and Toxicology. Third Edition, Volumes 1 - 3. John Wiley & Sons, New York, 1979.
23. Garrett J.T., L.J. Cralley and L.V. Cralley, Editors. Industrial Hygiene Management, John Wiley & Sons, New York, 1988.
24. Halliday D.A., Editor. Air Monitoring Methods for Industrial Contaminants, Biomedical Publications, Davis, CA, 1983.
25. Hawkins N.C., S.K. Norwood and J.C. Rock, Editors. A Strategy for Occupational Exposure Assessment. American Industrial Hygiene Association, Akron, OH, 1991.
26. Klaassen C.D., M.O. Amdur and J. Doull, Editors. Casarett and Doull's Toxicology, Third Edition. Macmillan Publishing Company, New York, 1986.
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2. General Information References:

1. Pipitone, D.A., Safe Storage of Laboratory Chemicals, Wiley-Interscience Publication, New York, 1984.
2. Occupational Carcinigenesis, Edited by U. Saffiotti and J. K. Wagoner, National Academy of Science, ANYAA 9, Vol. 271, New York, 1976.
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2

INDUSTRIAL HYGIENE SAMPLING AND PERSONAL PROTECTION

I. INTRODUCTION

This chapter is organized into an introductory discussion on the chemistry of hazardous materials, followed by two main sections. The first deals with personal sampling practices that would be implemented by an industrial hygienist to determine worker exposure to chemicals. The information in this section covers OSHA recommended sampling techniques. The second major section provides an overview of worker safety with regard to handling chemicals and other hazardous materials. Discussions largely cover personal protective equipment such as chemical protective clothing and respirators. The discussions are general and are designed to provide the reader with an overall working knowledge of personal protection options and the levels of protection that are available to choose from. Discussions pertinent to Hazmat (hazardous materials workers) are included in this section. Specific information that can assist the reader in selecting respirators for respiratory protection are given in this section.

It is important to note that the industrial hygienist is not just restricted to assessing and correcting problems dealing with exposure to chemicals. His or her role extends to evaluating and recommending corrective actions for all types of workplace hazards, including biological, fire, electrical, ergonomics, physical injuries and back disorders, eye protection, noise exposure, heat stress, and others. This handbook does not address these other important areas, but the reader will find comments and references to these other worker safety issues throughout this chapter.

II. CHEMISTRY OF HAZARDOUS MATERIALS

The reader should note that there are a number of important terms that should be committed to memory. These terms include important properties of general classes of chemicals and of a few commonly used industrial chemicals. This section will attempt to familiarize the reader with the main points. This section is not intended for practicing industrial chemists, nor is it intended as anything other than a refresher for those with strong backgrounds in chemistry. It is intended to provide a brief introduction to chemistry for the safety manager who must, as a part of his responsibilities, deal with hazardous materials issues.

A. Chemical Properties

All chemicals, including hazardous ones, are commonly described in terms of their physical, chemical, and biological properties. To use this information fully, it is necessary to understand the meaning and importance of the various individual properties, and also to have some grasp of the significance of the various numerical values within the context of chemicals at large. These properties can then be used along with other information to predict the likely behavior of hazardous chemicals, and to recognize and avoid potentially dangerous situations. The first step is to define and comment on several of the more critical properties that are useful in the handling of hazardous materials. Some basic terminology are listed in Table 1.

Physical State at 20°C — the physical nature of the chemical (solid, liquid, or gas) at 20°C (i.e., room temperature). Changing the temperature may alter the physical state, depending on the magnitude and direction of the change relative to the melting and boiling points of the chemical.

Table 1. List of Commonly Measured Physical/Chemical Properties

Color	BOD_5
Odor	ThOD
Physical state at 20°C	Fire point
Molecular weight (MW)	Auto-ignition temperature
Chemical formula	Flashpoint
Melting point (MP)	Explosive limits
Boiling point (BP)	Heat content
Vapor pressure (VP)	Threshold limit value (TLV)
Density	Specific gravity (SG)
Vapor density (VD)	Solubility (water;
Octanol/water partition coefficient (K_{ow})	other solvents)

Boiling Point (BP) — the temperature at which a liquid changes to gas under standard atmospheric pressure (760 mm mercury). The BP of water is 100°C, while the BPs of ethyl alcohol and n-hexane are 78.4°C and 68.7°C, respectively. Lowering the atmospheric pressure (e.g., by applying a vacuum) will lower the BP; conversely, higher pressures result in elevated boiling points.

Melting Point (MP) — the temperature at which a solid changes to a liquid. The melting point is not particularly sensitive to atmospheric pressure, but it is responsive to dissolved salts which depress the melting point. Thus, in winter, it is usual to salt sidewalks to keep water from freezing.

Vapor Pressure (VP) — the pressure exerted by the vapor in equilibrium with its liquid at a given temperature. Vapor pressure is a measure of the relative volatility of chemicals. Liquids with high vapor pressures generally represent a greater fire hazard than those with lower vapor pressures. For a given liquid the vapor pressure increases with increasing temperature. Consequently, drummed materials with high vapor pressures in particular should not be stored in direct sunlight, as overheating of the materials and resultant increases in vapor pressures could result in "pregnant" drums with failed or weakened seams. When used with solubility data, vapor pressure values can be used to predict the rate of evaporation of dissolved solvents from water. At 20°C, water, ethanol, and benzene exert vapor pressures of 17.5, 43.9, and 74 mm of mercury, respectively.

Vapor Density (VD) — the mass per unit volume of a given vapor/gas relative to that of air. Thus, acetaldehyde with a vapor density of 1.5 is heavier than air and will accumulate in low spots, while acetylene with a vapor density of 0.9 is lighter than air and will rise and disperse. Heavy vapors present a particular hazard because of the way they accumulate: if toxic they may poison workers; if nontoxic they may displace air and cause suffocation by oxygen deficiency; if flammable, once presented with an ignition source, they represent a fire or explosion hazard. Gases heavier than air include carbon dioxide, chlorine, hydrogen sulfide, and sulfur dioxide.

Density — the mass per unit volume of any substance, including liquids. The density of a liquid determines whether a spilled material that is insoluble in or immiscible with water will sink or float on water. Knowledge of this behavior is essential in checking whether to use water to suppress a fire involving the material.

Specific Gravity (SG) — the ratio of the density of a liquid as compared with that of water. Insoluble materials will sink or float in water depending on the SG. Materials heavier than water have SGs >1, and materials lighter than water have SGs <1. Thus, lead, mercury, and carbon tetrachloride with SGs of 11.3, 13.6, and 1.6, respectively, will sink, whereas gasoline with a SG of 0.66 to 0.69, will float on water. This is an important property to know when a material has spilled, particularly in a water body.

Solubility — the amount of a given substance (the solute) that dissolves in a unit volume of a liquid (the solvent). This property is of importance in the handling and recovery of spilled hazardous materials. Water-insoluble chemicals are much easier to recover from water than spills of water-soluble chemicals. Acetone, which is miscible/soluble in water in all proportions, is not readily recoverable from water. In contrast, benzene, which is lighter than water and insoluble as well, can be readily trapped with a skimmer. For organic compounds, solubility tends to decrease with increasing molecular weight and chlorine content.

Flashpoint — the lowest temperature of a liquid at which it gives off enough vapor to form an ignitable mixture with air near the surface of the liquid within the vessel used. Two tests are used—Open Cup and Closed Cup. Generally, the Open Cup method results in flashpoints 5° to 10° higher than the Closed Cup method. Flashpoint < 140°F (Closed Cup) is the criterion used by EPA to decide whether a chemical is hazardous by ignitability. DOT defines materials with flashpoints of < 100°F as flammable materials, and between 100° and 200°F as combustible.

Fire Point — the temperature at which a liquid gives off enough vapor to continue to burn when ignited.

Auto-Ignition Temperature — the temperature at which ignition occurs without an ignition source and the material continues to burn without further heat input.

Flammable or Explosive Limits — the upper and lower vapor concentrations at which a mixture will burn or explode. The lower explosive limit of p-xylene is 1.1 percent by volume in air, whereas the upper explosive limit is 7.0 percent in air. A mixture of p-xylene vapor and air having a concentration of <1.1 percent in air is too lean in p-xylene vapor to burn. Conversely, a mixture containing more than 7.0 percent is too rich in p-xylene to burn. By subtraction (7.0 - 1.1), p-xylene is said to have a flammable range of 5.9. Materials having low explosive limits and wide flammable ranges are extremely dangerous.

Heat Content — the heat released by complete combustion of a unit weight of material. Methane has a heat content of about 21,500 Btu/lb while benzene contains about 17,250 Btu/lb.

Octanol/Water Partition Coefficient (K_{ow}) — the equilibrium ratio of the concentrations of material partitioned between octanol and water. This coefficient is considered to be an index of the potential of a chemical to be bioaccumulated. Higher values of K_{ow}, are associated with greater bioaccumulative potential.

Biochemical Oxygen Demand at Five Days (BOD_5) — the quantity of oxygen required by microbes for the oxidative breakdown of a given waste material during a 5-day test period. BOD_5 is usually taken as an index of the ultimate oxygen demand (i.e., oxygen required when sufficient time is allowed to achieve maximum microbial decomposition). BOD_5 is used to predict the impact of a spill or release of material on the oxygen content of a body of water.

Theoretical Oxygen Demand (ThOD) — the cumulative amount of oxygen needed to completely oxidize a given material. The ThOD is the upper limit for BOD_5 values, although it is seldom achieved. A comparison of the BOD_5 and ThOD values for a given chemical provides an indication of the biodegradability of that chemical.

Threshold Limit Value (TLV) — the exposure level under which most people can work for eight hours a day, day after day, with no harmful effects. A table of these values and accompanying precautions for most common industrial materials is published annually by the American Conference of Governmental Industrial Hygienists (ACGIH). TLV values for specific chemicals can be found in this handbook.

pK_a — the negative logarithm of the equilibrium constant for acids or bases. This parameter is an indicator of the strength of an acid or base. Strong acids, such as H_2SO_4, and HCl, have low pK_as (i.e., ~1.0) while strong bases such as KOH and NaOH, have pK_as close to 14.0. Weak acids and weak bases fall in the intermediate range.

B. Key Concepts

Concentrations — Chemists and engineers seldom work with pure solutions of materials. In fact, more often than not we work with very minute amounts of materials dispersed in environmental media. A knowledge of units of concentration is required. Units of concentration in common usage for aqueous solutions include parts per million (ppm) and with increasing analytical capability and environmental awareness, parts per billion (ppb), and even parts per trillion (ppt), milligrams per liter (equivalent to ppm for dilute aqueous solutions), moles per liter or molar solutions (a weight of substance equivalent to the gram-molecular or gram atomic weight in a liter of solution), equivalents per liter (commonly used for acids and bases; a one equivalent per liter solution is stated to be a one normal solution), and finally percent by weight or volume. For vapors and gases, mists, and particulates in air, common units of concentration are ppm, micrograms per m^3, and percent by volume.

Solubility Product — The solubility product constant commonly referred to as the solubility product provides a convenient method of predicting the solubility of a material in water at equilibrium. Copper hydroxide, for example, dissolves according to the following equilibrium:

$$Cu(OH)_2\,(s) \leftrightharpoons Cu^{2+} + 2OH^- \qquad (1)$$

The resultant solubility product is represented in the following manner:

$$[Cu^{2+}][OH^-]^2 = K_{sp} \qquad (2)$$

Note that the brackets, [ ], refer to the concentration of the species. K_{sp} is the solubility product constant; hence $[Cu^{2+}]$ and $[OH^-]^2$ are equal to the molar concentrations of copper and hydroxyl ions, respectively. The K_{sp} is commonly used in determining suitable precipitation reactions for removal of ionic species from solution. In the same example, the pH for removal of copper to any specified concentration can be

determined by substituting the molar concentration into the following equation:

$$[OH^-][H^+] = \sqrt{\frac{K_{sp}}{[Cu^{2+}]}} \quad (3)$$

and then applying the derived values in turn to these other equations:

$$[OH^-][H^+] = 10^{-14} \text{ and } pH = -\log [H^+] \quad (4)$$

Use of the K_{sp} for precipitation information is often complicated by a number of interfering factors including complexation of metallic ions, high ionic strength solutions, and high solids contents. This principle is applicable solely to ionic compounds, i.e., primarily inorganic compounds.

Adsorption — An important physico-chemical phenomenon used in treatment of hazardous wastes or in predicting the behavior of hazardous materials in natural systems is adsorption. Adsorption is the concentration or accumulation of substances at a surface or interface between media. Hazardous materials are often removed from water or air by adsorption onto activated carbon. Adsorption of organic hazardous materials onto soils or sediments is an important factor affecting their mobility in the environment. Adsorption may be predicted by use of a number of equations most commonly relating the concentration of a chemical at the surface or interface to the concentration in air or in solution, at equilibrium. These equations may be solved graphically using laboratory data to plot "isotherms." The most common application of adsorption is for the removal of organic compounds from water by activated carbon.

Volatilization — Volatilization is a physico-chemical phenomenon of particular interest to environmental managers as well as safety managers. It is the tendency of a material to transfer from a liquid phase (either pure or dissolved as in aqueous systems) to a gaseous phase (commonly air). The volatilization, or evaporation as it is more commonly called, is controlled by a number of factors, the most important of which are the vapor pressure of the material, temperature (vapor pressure increases with temperature), and air/material interfacial surface area, and the action of active mass transfer agents such as wind.

The processes of dissolution/precipitation (for inorganics), dissolution/phase separation (for organics), adsorption, and volatilization control the distribution of a spilled material in the environment. Conversely, knowledgeable manipulation of these same processes can be used to advantage in either cleaning up or mitigating the effects of spilled material. Thus, for example, groundwater contaminated with volatile organics of limited aqueous solubility can be decontaminated by air stripping of these compounds which can then be concentrated by adsorption on activated carbon for subsequent disposal. From a safety standpoint, if a volatile hazardous chemical is spilled, the concern over inhalation exposure may warrant the need for respirators.

C. Hazard Categories and Chemistry Principles

The testing of chemicals/wastes to establish the nature of their hazard capacity/threat in accordance with regulatory requirements, falls into four categories: (1) reactivity, (2) ignitability/flammability, (3) corrosivity, and (4) EP toxicity. Commercial chemical products, specific wastes, and wastes from specific processes may be listed as hazardous wastes because they are known to present toxic hazards in the manner of the tests above and/or are known to present serious toxic hazards to mammals/humans. In the discussion to follow, various chemical groups will be examined primarily in the context of reactivity, ignitability, and corrosivity.

1. Chemistry of Corrosives

The EPA defines corrosivity in terms of pH (i.e., wastes with pH <2 or ≥ 2.5) or in terms of ability to corrode steel (SAE 20) at a rate of >6.35 mm (0.250 in.) per year at a temperature of 55°C (13°F). This discussion will address corrosivity as it applies to acids and caustics. Acids are compounds that yield H^+ ions (actually H_3O^+ ions) when dissolved in water. Common industrial acids include acetic, nitric, hydrochloric, and sulfuric. acids. The terms *concentrated* and *dilute* refer to the concentrations in solution. Mixing a concentrated acid with enough water will produce a dilute acid. For example, a bottle of concentrated HCl direct from the manufacturer is approximately 12N in HCl, while a solution of HCl used in a titration may be only 0.5N. The latter is a dilute acid solution.

Strong and *weak* acids are classified by how completely they ionize in solution. For example, HCl is classified as a strong acid because it is completely ionized to H^+ and Cl^- ions. Acetic acid is classified as a weak acid because it does not totally ionize in solution. As mentioned earlier, weak acids

such as acetic acid have higher pK_as. The pK_a for acetic acid is 4.75. The negative antilog of this value (1.76×10^{-5}) can be used to calculate the concentrations at equilibrium of the acetate and hydrogen ions. Strong acids include perchloric, hydrochloric, sulfuric, nitric, and hydriodic acids. Examples of weak acids include boric, hydrocyanic, carbonic, and acetic acids. Thus, the terminology "strong versus weak acid" may bear little relationship to the nature or extent of potential hazard, while the terms "concentrated versus dilute" most often do.

The acidic nature of a given solution is characterized by its pH, where pH is the negative logarithm of the molar H^+ concentration ($-\log (H^+)$). A solution with pH < 7 is acid, a solution with pH 7 is neutral, and a solution with pH > 7 is basic. For example, the pH of lemon juice is 2, while the pH of lye is about 14.

Acids

Acids may be inorganic, such as H_2SO_4, and are then known as mineral acids, or they may be organic, like acetic acid. Mineral acids may be weak or strong, but organic acids tend to be uniformly weak. Table 2 gives a list of commonly occurring acids along with their relative strengths. It should be noted that salts of several metals (e.g., Al^{3+}, Fe^{3+}, and Zn^{4+}) dissolve in water to produce acid solutions. Acids include a variety of compounds, many of which have other significant properties that contribute to their "reactivity." Typical reactions of acids are: neutralization of bases (strong and weak) and oxidation of substances. Characteristics of common acids are presented in Table 3. Examples of neutralization of bases are the following reactions:

$$H^+ + OH^- \rightarrow H_2O$$
$$HCl + NaOH \rightarrow H_2O + NaCl$$
$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H2O + CO_2$$

Examples of oxidation reactions are as follows:

$$Zn^\circ + 2HCl \rightarrow Zn^{2+} + 2Cl^- + H^2\uparrow$$
$$2NaI + 2H_2SO_4 \rightarrow I_2 + SO_2 + 2H_2O + Na_2SO_4$$

Bases

A base is any material that produces hydroxide ions when it is dissolved in water. The words alkaline, basic, and caustic are often used synonymously. Common bases include sodium hydroxide (lye), potassium hydroxide (potash lye), and calcium hydroxide (slaked lime). The concepts of strong versus weak bases, and concentrated versus dilute bases are exactly analogous to those for acids. Strong bases such as sodium hydroxide dissociate completely while weak bases such as the amines dissociate only partially. As with acids, bases can be either inorganic or organic. Typical reactions of bases include neutralization of acids, reaction with metals, and reaction with salts:

Table 2. Relative Strengths of Acids in Water

Perchloric acid	$HClO_4$	↑
Sulfuric acid	H_2SO_4	↑
Hydrochloric acid	HCl	↑
Nitric acid	HNO_3	↑
Phosphoric acid	H_3PO_4	Increasing
Hydrofluoric acid	HF	Acid
Acetic acid	CH_3COOH	Strength
Carbonic acid	H_2CO_3	↑
Hydrocyanic acid	HCN	↑
Boric acid	H_3BO_3	↑

Table 3. Properties of Some Common Acids and Bases

Acids—Sulfuric, Nitric, Hydrochloric, Acetic

a. These acids are highly soluble in water.
b. Concentrated solutions are highly corrosive and will attack materials and tissue.
c. If spilled on skin, flush with lots of water.
d. Sulfuric and nitric acids are strong oxidizers and should not be stored or mixed with any organic material.
e. Sulfuric, nitric, and hydrochloric acids will attack metals upon contact and generate hydrogen gas which is explosive.
f. Acetic acid (glacial) is extremely flammable. Its vapors form explosive mixtures in the air. It is dangerous when stored with any oxidizing material, such as nitric and sulfuric acids, peroxides, sodium hypochlorite, etc.
g. Breathing the concentrated vapors of any of these acids can be extremely harmful. Wear appropriate equipment.
h. When mixing with water, always add acids to water, never water to acids.

Bases (Caustics)—Sodium Hydroxide, Ammonium Hydroxide, Calcium Hydroxide (Slaked Lime), Calcium Oxide (Quick Lime)

a. These bases are highly soluble in water.
b. Concentrated solutions are highly corrosive. They are worse than most acids because they penetrate the skin (Saponification reactions).
c. If spilled on skin, flush immediately with lots of water.
d. When mixed with water, they generate a significant amount of heat - especially sodium hydroxide and calcium oxide.
e. Unless unavoidable, do not store or mix concentrated acids and bases, as this gives off much heat--diiute, then mix.
f. Do not store or mix ammonium hydroxide with other strong bases. It can release ammonia gas which is extremely toxic.
g. Do not store or mix ammonium hydroxide with chlorine compounds (i.e., sodium hypochlorite). It can release chlorine gas which is extremely toxic.

An example of a reaction with a metal is

$2Al + 6NaOH \rightarrow 2Na_3AlO_3 + 3H_2 \uparrow$
(reaction goes slowly)

An example of a reaction involving salt is:

$Pb(NO_3)_2 + 2NaOH \rightarrow Pb(OH)_2 + 2NaNO_3$

Characteristics to remember about some common bases are presented in Table 3.

2. General Properties and Nomenclature of Organics

Most compounds in which carbon is the key element are classified as organic. Common examples of organic compounds include degreasing solvents, lubricants, and heating and motor fuels. This subsection highlights some of the more common characteristics of organics as they relate to hazards. Various relevant classes of organics are presented in terms of chemical behavior and physical properties. In order to facilitate the discussion to follow, a few basic definitions will be presented first.

Definitions

Covalent — refers to a chemical bond in which there is an equal/even sharing of bonding electron pairs between atoms. This is typical of the bonding between carbon atoms and between carbon and hydrogen atoms in organic compounds.

Hydrocarbons — chemical compounds consisting primarily of carbon and hydrogen.

Aliphatic — organic compound with the carbon backbone arranged in branched or straight chains (e.g., propane).

Aromatic — organic molecular structure having the benzene ring (C_6H_6) as the basic unit (e.g., toluene, xylene).

Saturated — the condition of an organic compound in which each constituent carbon is covalently linked to four different atoms. This is generally a stable configuration (e.g., $CH_3CH_2CH_3$--propane).

Isomers — different structural arrangements with the same chemical formula, (e.g., n-butane and t-butane).

Unsaturated — an organic compound containing double or triple bonds between carbons (e.g., ethylene [$CH_2=CH_2$]). Multiple bonds tend to be sites of reactivity.

Functional Group — an atom or group of atoms, other than hydrogen, bonded to the chain or ring of carbon atoms (e.g., the -OH group of alcohols, the -COOH group of carboxylic acids, the -O- group of ethers). Functional groups determine the behavior of molecules. Consequently, the unique hazards of an organic compound are often determined by its functional group(s).

General Properties

Most organic compounds are flammable. They tend to melt and boil at lower temperatures than most inorganic substances. Because many organic compounds volatilize easily at room temperature and possess relatively low specific heats and ignition temperatures, they tend to burn easily. Moreover, organic vapors often have high heats of combustion which, upon ignition, facilitate the ignition of surrounding chemicals, thus compounding the severity of the hazard.

Most organic compounds are less stable than inorganics. However, the presence of one or more halogen atoms (F,Cl,Br,I) in the molecular structure of an organic compound increases its stability and inertness to combustion. Thus, partially halogenated hydrocarbons burn with less ease than their nonhalogenated analogs. Fully halogenated derivatives, such as carbon tetrachloride (CCl_4) and certain polychlorinated biphenyls (PCBs) are almost noncombustible.

Most organic compounds are water-insoluble. Notable exceptions are the lower molecular weight alcohols, aldehydes, and ketones, all known to be "polar" molecules. This characteristic is of importance to firefighting because the specific gravity of the compound will then be a major determinant of the suitability of water for the suppression of fires involving the chemical.

Except for alkanes and organic acids, organic compounds tend to react easily with oxidizing agents such as hydrogen peroxide or potassium dichromate. Moreover, a mixture of an oxidizing agent and organic matter is usually susceptible to spontaneous ignition. Notably, except for flammability and oxidation, organic compounds tend to react slowly with other chemicals.

Nomenclature

This subsection will familiarize the reader with the naming system for some of the more common and simple organic groups, and present the salient characteristics of these groups. The basic system of aliphatic organic nomenclature is shown in Table 4. The prefix for the name is based on the number of carbons involved and remains the same for each type of compound described. The suffix is determined by the type of compound and is independent of the number of carbons in the molecule. Thus, methane, methanol, methanol (formaldehyde), and methanoic (formic) acid represent an alkane, an alcohol, an aldehyde, and a carboxylic acid, respectively, each with one carbon per molecule. In contrast, methanol, ethanol, and propanol are all alcohols, but with one, two, and three carbons per molecule, respectively. The boiling points provided in Table 4 show the systematic trends in chemical properties as the number of carbons per molecule increases within a given chemical group, and as the various chemical groups are compared for a specific number of carbons per molecule. Thus, in general, within any group, the larger molecules are less volatile than the smaller ones. Also, alkanes tend to be more volatile than aldehydes. Systematic trends can also be observed for other properties, such as water solubility. It should be noted than the boiling points provided in Table 4 are for the straight-chain isomers of the molecules. If the values for branched chain molecules are included, the comparisons become complicated.

Table 4. Nomenclature for Aliphatics

Number of Carbons	Prefix	Alkanes		Alcohols		Aldehydes		Acids	
		Ending	b.p.	Ending	b.p.	Ending	b.p.	Ending	b.p.
1	Meth	ane	-150°C	anol	65°C	anal		anoic (formic)	100°C
2	Eth		-90°C		78°C		20°C	(acetic)	120°C
3	Prop		-40°C		95°C		50°C	(propionic)	140°C
4	But		0°C		120°C		75°C	(butyric)	160°C
5	Pent		35°C		140°C		105°C	(valeric)	185°C
6	Hex		70°C		160°C		130°C		205°C
7	Hept		100°C		175°C		155°C		225°C
8	Oct		125°C		195°C		170°C		240°C
9	Non		150°C		215°C		185°C		255°C
10	Dec		175°C		230°C		210°C		270°C
11	Undec		195°C						

Number of Carbons	Prefix	Alkenes Ending	Alkynes Ending
1	as- above	-	-
2		ene	yne
4			

Alkenes and alkynes are similar in structure to the alkanes except the alkenes contain a carbon-to-carbon double bond (C=C) and the alkynes contain a carbon-to-carbon triple bond (C≡C). The name prefixes are exactly the same as for the alkanes with the same number of carbons, but the endings are -one for compounds with double bonds and their derivatives and -yne for compounds with triple bonds and their derivatives. Ethene (ethylene) and propene (propylene) are alkenes. Ethyne (acetylene) is an alkyne.

Aromatics are molecules based on single or triple benzene rings. Some of the more common aromatics include benzene, toluene, xylene, and phenol. As previously mentioned, benzene is a 6-carbon ring with the formula C_6H_6. The ring has alternating double and single bonds, and is quite stable. The substitution of a methyl group ($-CH_3$) for one of the hydrogens gives methyl benzene or toluene. The substitution of another methyl group gives dimethyl benzene or xylene. Substitution of a hydroxyl ($-OH$) for a hydrogen on the benzene ring gives hydroxy benzene or phenol. Aromatics can also be named more specifically based on a system of assigning names or numbers to various positions on the benzene ring. By using the numbering system for the carbons on single or multiple benzene rings in combination with the names of the relevant substituents, any aromatic compound can be assigned a unique name.

3. Properties of Individual Functional Groups

Alkanes — Presented as (C_nH_{2n+2}), these are saturated hydrocarbons. The lower molecular weight alkanes (ethane through butane) are gases at standard temperature and pressure. The remainder are water-insoluble liquids, that are lighter than water and thus form films or oil slicks on the surface of water. Hence, water is not used to suppress fires involving materials, such as gasoline, that include substantial proportions of liquid alkanes. Alkanes are relatively unreactive with most acids, bases, and mild oxidizing agents. However, with addition of sufficient heat, alkanes will react and burn in air or oxygen when ignited. In fact, low molecular weight alkanes (LPG, butane, gasoline) are commonly used as fuels. Consequently, the biggest hazard from alkanes is flammability.

Organic Carboxylic Acids — (RCOOH) are usually weak acids but can be very corrosive to skin. However, The substitution of Cl atoms on the carbon next to the carboxylic carbon, produces a stronger acid. Thus, trichloracetic acid is almost a strong acid whereas acetic acid is a weak one.

Organic Sulfonic Acids — (RSO_2H) are generally stronger acids than organic carboxylic acids.

Organic Bases — (such as amines, RNH_2) are weak bases but can be corrosive to skin or other tissue.

Alcohols — (ROH) are not very reactive. The lower molecular weight alcohols (methanol, ethanol, propanol) are completely miscible with water, but the heavier alcohols tend to be less soluble. Most common alcohols are flammable. Aromatic alcohols like phenol are not as flammable (flashpoint = 79°C) and are fairly water soluble (~9 g/L).

Alkenes — Also known as olefins, and denoted as C_nH_{2n} the compounds are unsaturated hydrocarbons with a single carbon-to-carbon double bond per molecule. The alkenes are very similar to the alkanes in boiling point, specific gravity, and other physical characteristics. Like alkanes, alkenes are at most only weakly polar.

Alkenes are insoluble in water but quite soluble in nonpolar solvents like benzene. Because alkenes are mostly insoluble liquids that are lighter than water and flammable as well, water is not used to suppress fires involving these materials. Because of the double bond, alkenes are more reactive than alkanes.

Esters — These are not very reactive. Only the lowest molecular weight esters have appreciable solubility in water (e.g., ethyl acetate, 8 percent). Methyl and ethyl esters are more volatile than the corresponding unesterified acids. Most common esters are flammable. Esters are often easily recognizable due to their sweet to pungent odors.

Ethers — (R-O-R) are low on the scale of chemical reactivity. Aliphatic ethers are generally volatile, flammable liquids with low boiling points and low flashpoints. Well known hazardous ethers include diethyl ether, dimethyl ether, tetrahydrofuran. Beyond their flammability, ethers present an additional hazard, they react with atmospheric oxygen in the presence of light to form organic peroxides.

Organic Peroxides — (R-O-O-R) are very hazardous. Most of the compounds are so sensitive to friction, heat, and shock that they cannot be handled without dilution. As a result, organic peroxides present a serious fire and explosion hazard. Commonly encountered organic

peroxides include benzoyl peroxide, peracetic acid, and methyl ethyl ketone peroxide.

Aldehydes and Ketones — These share many chemical properties because they possess the carbonyl (C=O) group as a common feature of their structure. Aldehydes and ketones have lower boiling points and higher vapor pressures than their alcohol counterparts. Aldehydes and ketones through C_4 are soluble in water and have pronounced odors. Ketones are relatively inert while aldehydes are easily oxidized to their counterpart organic acids.

4. Chemistry of Flammables

Flammability, the tendency of a material to burn, can only be subjectively defined. Many materials that we normally do not consider flammable will burn, given high enough temperatures. Neither can flammability be gauged by the heat content of materials. Fuel oil has a higher heat content than many materials considered more flammable because of their lower flashpoint. In fact, flashpoint has become the standard for gauging flammability.

The most common systems for designating flammability are the Department of Transportation (DOT) definitions, the National Fire Protection Association's (NFPA) system, and the Environmental Protection Agency's (EPA) Resource Conservation and Recovery Act's (RCRA) definition of ignitable wastes, all of which use flashpoint in their schemes. The NFPA diamond, which comprises the backbone of the NFPA Hazard Signal System, uses a four-quadrant diamond to display the hazards of a material. The top quadrant (red quadrant) contains flammability information in the form of numbers ranging from zero to four. Materials designated as zero will not burn. Materials designated as four rapidly or completely vaporize at atmospheric pressure and ambient temperature, and will burn readily (flashpoint <73°F and boiling point <100°F). The NFPA defines a flammable liquid as one having a flashpoint of 200°F or lower, and divides these liquids into five categories:

1. Class IA: liquids with flashpoints below 73°F and boiling points below 100°F. An example of a Class IA flammable liquid is n-pentane (NFPA Diamond: 4).

2. Class IB: liquids with flashpoints below 73°F and boiling points at or above 100°F. Examples of Class IB flammable liquids are benzene, gasoline, and acetone (NFPA Diamond: 3).

3. Class IC: liquids with flashpoints at or above 73°F and below 100°F. Examples of Class IC flammable liquids are turpentine and n-butyl acetate (NFPA Diamond: 3).

4. Class II: liquids with flashpoints at or above 100°F but below 140°F. Examples of Class II flammable liquids are kerosene and camphor oil (NFPA Diamond: 2).

5. Class III: liquids with flashpoints at or above 140°F but below 200°F. Examples of Class III liquids are creosote oils, phenol, and naphthalene. Liquids in this category are generally termed combustible rather than flammable (NFPA Diamond: 2).The DOT system designates those materials with a flashpoint of 100°F or less as flammable, those between 100°F and 200°F as combustible, and those with a flashpoint of greater than 200°F as nonflammable. EPA designates those wastes with a flashpoint of less than 140°F as ignitable hazardous wastes. To facilitate the comparison of these systems they are presented graphically in Figure 1.

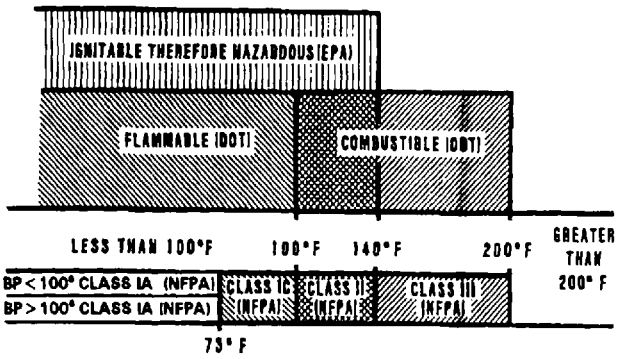


Figure 1. Illustrative classification of flashpoint designators.

These designations serve as useful guides in storage, transport, and spill response. However, they do have limitations. Since these designations are somewhat arbitrary, it is useful to understand the basic concepts of flammability.

The elements required for combustion are few--a substrate, oxygen, and a source of ignition. The substrate, or flammable material, occurs in many classes of compounds but most often is organic. Generally, compounds within a given class exhibit increasing heat contents with increasing molecular weights (MW) (see Table 5).

Other properties specific to the substrate that are important in determining flammable hazards are the auto-ignition

temperature, boiling point, vapor pressure, and vapor density. Auto-ignition temperature (the temperature at which a material will spontaneously ignite) is more important in preventing fire from spreading (e.g., knowing what fire protection is needed to keep temperatures below the ignition point) but can also be important in spill or material handling situations. For example, gasoline has been known to spontaneously ignite when spilled onto an overheated engine or manifold. The boiling point and vapor pressure of a material are important not only because vapors are more easily ignited than liquids, but also because vapors are more readily transportable than liquids (they may disperse, or when heavier than air, flow to a source of ignition and flash back). Vapors with densities greater than one do not tend to disperse but rather to settle into sumps, basements, depressions in the ground, or other low areas, thus representing active explosion hazards.

Oxygen, the second requirement for combustion, is generally not limiting. Oxygen in the air is sufficient to support combustion of most materials within certain limits. These limitations are compound specific and are called the explosive limits in air. The upper and lower explosive limits (UEL and LEL) of several common materials are given in Table 6.

The source of ignition may be physical (such as a spark, electrical arc, small flame, cigarette, welding operation, or a hot piece of equipment), or it may be chemical in nature, such an an exothermic reaction. In any case, when working with or storing flammables, controlling the source of ignition is often the easiest and safest way to avoid fires or explosions.

Once a fire has started, control of the fire can be accomplished in several ways: through water systems (by reducing the temperature), carbon dioxide or foam systems (by limiting oxygen), or through removal of the substrate (by shutting off valves or other controls). Chapter 4 provides detailed discussion on the theories of fire and specific information on hydrocarbons, as well as chemical specific fire characteristics.

5. Chemistry of Water Reactive Materials

The characteristics of a chemical or substance that would categorize it as a reactive material include (1) it reacts violently with water, (2) it forms potentially explosive mixtures with water, or (3) when mixed with water or other chemicals, it generates toxic gases, vapors or fumes in a quantity sufficient to present a danger to human health or the environment. Because water is the most common fire suppressant, the characteristic of reactivity is

Table 5. Heat Content/Increasing Weight Relationships

Compound	MW	Heat Content Kg Calories/gm.MW
methane	16	210.8
ethane	30	368.4
propane	44	526.3
methanol	32	170.9
ethanol	46	327.6
propanol	60	480.7

Table 6. Explosive Limits of Hazardous Materials

Compound	LEL %	UEL %	Flashpoint °F	Vapor Density
Acetone	2.15	13	-4	2.0
Acetylene	2.50	100	Gas	0.9
Ammonia, anhydrous	16	25	Gas	0.6
Benzene	1.30	7.1	12	7.8
Carbon monoxide	12.4	74	Gas	1.0
Gasoline	1.4	7.6	-45	3-4
Hexane	1.1	7.5	-7	3.0
Toluene	1.2	7.1	40	3.1
Vinyl chloride	3.6	33	Gas	2.2
p-xylene	1.0	6.0	90	3.7

especially relevant since the application of water to eliminate or prevent the spread fires may be counter-productive rather than helpful. Several categories of chemicals will be discussed from this standpoint; however, several of these same chemicals also present additional hazards.

Substances That Produce H_2

Metals — Several metals react with water and air with the extent of reactivity being dependent upon the physical state of the metal. The highly reactive metals such as lithium, sodium, and potassium are pyrophoric (i.e., they ignite spontaneously in air without an ignition source). In contrast, the less reactive metals such as magnesium, zirconium, titanium, aluminum, and zinc, are highly pyrophoric only as dusts.

Lithium, sodium, and potassium (alkali metals) react rapidly with water to release hydrogen (H_2) gas:

$$2Na + 2H_2O \rightarrow 2Na^+ + 2OH^- + H_2 \uparrow$$

Sufficient heat is generated to ignite the hydrogen gas so that it can react explosively with the oxygen in air. Metals like magnesium, aluminum, titanium, and zirconium in pure form also react with water to release H_2, but heat must be supplied to initiate the reaction. The generalized representation is:

$$metal + water + heat \rightarrow metal\ oxide\ or\ hydroxide + H_2 \uparrow \quad (5)$$

Hydrides — True hydrides (i.e., those in which the hydrogen is in its anionic or most reduced form) are salt-like compounds in which the hydrogen is combined with alkali metals, either alone as simple hydrides or in association with other elements as complex hydrides. Hydrides react with water to release hydrogen.

Simple hydrides:

$$LiH + H_2O \rightarrow H_2 \uparrow + LiOH$$

Complex hydrides:

$$LiAlH_4 + 4H_2O \rightarrow Al(OH)_3 + LiOH + 4H_2 \uparrow$$

Peroxides — Compounds containing the O^{2-} ion are hazardous primarily as oxidizing agents but also as water reactives. An example is the liberation of oxygen from the mixture of sodium peroxide and water:

$$2Na_2O_2 + 2H_2O \rightarrow 4NaOH + O_2 \uparrow$$

Substances That Produce Alkaline Aqueous Solutions

This group is exemplified by nitrides, carbides, and phosphides. Nitrides will react with water to generate ammonia (NH_3), which can be released depending on how alkaline the solution becomes. It is unlikely that sufficient NH_3 will be produced under normal circumstances to create a hazard.

$$N_3 + 3H_2O \rightarrow NH_3 \uparrow + 3OH^-$$
$$Mg_3N_2 + 6H_2O \rightarrow 3Mg(OH)_2 + 2NH_3 \uparrow$$

Carbides, which are binary compounds containing anionic carbon, occur as covalent and as salt-like compounds. The salt-like carbides are water-reactive and, upon hydrolysis, yield flammable hydrocarbons. Typical hydrolysis reactions include:

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2 \uparrow \text{ (acetylene)}$$
$$Al_4C_3 + 12H_2O \rightarrow 4Al(OH)_3 + 3CH_4 \uparrow \text{ (methane)}$$

Other similar carbides are Be_2C and Mg_2C_3. Notably, each reaction is sufficiently exothermic to ignite the specific RBS formed upon hydrolysis.

Phosphides are binary compounds containing anionic phosphorus (P^{3-}). Heavy metal, alkali, and alkaline earth metal phosphides exist but few of them are commercially important. Phosphides hydrolyze to the flammable and toxic gas phosphine (PH_3). The hydrolysis reaction of aluminum phosphide is given below:

$$AlP + 3H_2O \rightarrow PH_3 \uparrow + Al(OH)_3$$

Substances That Produce Acidic Aqueous Solutions

Inorganic Chlorides/Halides — These metallic salts are formed from the reaction of a weak base with the strong acid HCl. Salts such as these dissolve in water to produce a markedly acidic solution. This is exemplified by aluminum chloride, which is corrosive due to the acidity resulting from the hydrolysis that produces aluminum and chlorine ions. Anhydrous $AlCl_3$ hydrolyzes violently when contacted by water.

Several nonmetallic chlorides also react with water with varying degrees of violence to produce hydrochloric acid. Although these compounds are themselves nonflammable, the heat generated by hydrolysis is sufficient to ignite adjacent flammable materials. These nonmetallic chlorides include antimony pentachloride ($SbCl_5$), boron trichloride (BCl_3), phosphorus oxychloride ($POCl_3$), phosphorus

pentachloride (PCl_5), phosphorus trichloride (PCl_3), silicon tetrachloride ($SiCl_4$), thionyl chloride ($SOCl_2$), sulfuryl chloride (SO_2Cl_4) and titanium tetrachloride ($TiCl_4$). Because of their acid-producing tendencies, many of these chlorides are considered to be corrosive.

Organic Chlorides/Halides — Several organic compounds also are hydrolyzed (or react with water) to produce corrosive materials. Notable inclusions among these compounds are acetic anhydride ($[CH_3CO_2]_2O$), and acetyl chloride (CH_3COCl), both of which produce acetic acid upon reaction with water. Both acetic anhydride and acetyl chloride are corrosive; in addition, mixtures of the vapors of acetic anhydride and acetic acid are flammable in air, and acetyl chloride itself is flammable.

Oxidation/Reduction Phenomena

The explosive potential of oxidation/reduction reactions has resulted time and time again in chemical disasters. Perhaps the largest of these was the explosion of the S.S. Grandcamp at Texas City, Texas, in 1947, where thermal decomposition (redox reactions of ammonium nitrate and subsequent oxidation reactions of the decomposition products) lead to the deaths of over 600 people and over $33 million (1947 dollars) damage. The addition or loss of electrons involves an accompanying transfer of energy, often a violently exothermic transfer. The substance that gives up electrons (and is therefore oxidized) is the reducing agent. The substance that gains electrons (and is therefore reduced) is the oxidizing agent.

Oxidizing agents are generally recognizable by their structures or names. They tend to have oxygen in their structures and often release oxygen as a result of thermal decomposition. Oxidizing agents often have "per-" prefixes (perchlorate, peroxides, permanganate) and often end in "-ate" (chromate, nitrate, chlorate).

Strong oxidizers have more potential incompatibilities than perhaps any other chemical group (with the exception of water reactive substances). It is safe to assume that they should not be stored or mixed with any other material except under carefully controlled conditions. Common oxidizing agents listed in decreasing order of oxidizing strength include:

Fluorine	Chlorine
Ozone	Suifuric acid (concentrated)
Hydrogen peroxide	Oxygen
Hypochlorous acid	Metallic iodates
Metal chlorates	Bromine
Lead dioxide	Ferric salts
Metallic permanganates	Iodine
Metallic dichromates	Sulfur
Nitric acid (concentrated)	Stannic salts

Reducing agents present similar problems. They react with a broad spectrum of chemical classes, and the reactions can be exothermic and violent. Reducing agents are, by definition, highly oxidizable and may react with air or moisture in the air. Common reducing agents include:

Hydrogen	Sulfides
Metals (Li, Na, K, Ca, Sr, Ba)	Sulfites
Hydrazine	Iodides
Metal acetylides	Nitrides
Complex hydrides	Nitrites
Metal hydrides	Phosphites
Metal hypoborates	Metallic azides
Metal hypophosphites	

6. Toxics

This subsection provides only a general overview of toxic substances. Detailed information on specific chemicals are provided in Chapter 5.

Toxic Metals

The most common toxic metals in industrial use are cadmium, chromium, lead, silver, and mercury; less commonly used are arsenic, selenium, (both metalloids), and barium. Cadmium, a metal commonly used in alloys and myriads of other industrial uses is fairly mobile in the environment and is responsible for many maladies including renal failure and a degenerative bone disease called "itai itai" disease. Chromium, most often found in plating wastes, is also environmentally mobile and is most toxic in the Cr^{+6} valence state. Lead has been historically used as a component of an antiknock compound in gasoline and, along with chromium (as lead chromate), in paint and pigments. Lead, because of its history as an air emission, has been fairly mobile and is particularly soluble in acid environments. Silver is used widely in the electronics industry. Intake of silver compounds can result in permanent discoloration of the skin and may result in damage to kidneys, lungs, mucous membranes, and other organs.

Mercury enjoys its seeming environmental ubiquity due to its use as a fungicide and as an electrode in the chlorine

production process. Elemental mercury is relatively immobile, but is readily transformed to more mobile organometallic compounds through bacterial action. Mercury is the responsible agent for the infamous Minimata syndrome which is characterized by degeneration of the central nervous system. Arsenic and selenium are both commonly used to decolorize glass or to impart a desirable color. Arsenic occurs in a number of important forms, many of which have been used as contact herbicides. Important forms of arsenic include arsenic trioxide and pentoxide, and arsenic acids, arsenites and arsenates, and various organic arsenic compounds. Selenium often occurs as selenous acid. Both arsenic and selenium are fairly mobile and toxic. In general, toxic metals can be readily removed from aqueous solution through precipitation reactions, either as the sulfide or (more commonly) as the hydroxide.

Cyanides

Cyanides are dangerously toxic materials that can cause instantaneous death. They occur in a number of industrial situations but are commonly associated with plating operations, and sludges and baths from such sources. Cyanide is extremely soluble and many cyanide compounds, when mixed with acid, release deadly hydrogen cyanide gas. Cyanide is sometimes formed during the combustion of various nitrile, cyanohydrin, and methacrylate compounds. Cyanides (CN^-) are commonly treated by chlorine oxidation to the less toxic cyanate (CNO^-) form, then acid hydrolyzed to CO_2 and N_2. Obviously, care should be taken that the cyanide oxidation is complete prior to acid hydrolysis of the cyanate.

Hydrogen Sulfide

Hydrogen sulfide is a commonly occurring decomposition product of organic matter. It is relatively water soluble at higher pHs where it is predominantly dissociated as H^+ and $S^=$ ions. As the pH is decreased below 7, undissociated gas H_2S begin to predominate and is released. Since its vapor density is > 1.0, H_2S gas tends to settle in low places and creates a toxicity hazard. H_2S is readily oxidizable by a number of means to less toxic $SO_3^=$ or $SO_4^=$ forms.

Pesticides and Bioaccumulators

Pesticides include the broad categories of insecticides, fungicides rodenticides, and herbicides. Insecticides in common use fall into three categories. The chloroinsecticides have chlorine in their structure. They are less soluble than the other insecticide forms and much less biodegradable (i.e., more persistent). While they are less acutely toxic, several have been identified as potential carcinogens. Carbamatea are a relatively new form of pesticide. They are less persistent and less toxic than chioroinsecticides, but some are also suspected carcinogens. Organophosphate insecticides are generally more acutely toxic than the other categories but they are not persistent.

Many formerly common herbicides now have been banned or restricted in their use, e.g., 2,4-D and 2,4,5-T. However, the number and diversity of herbicides far exceeds that of insecticides. There are both organic and inorganic herbicides. Examples of inorganic herbicides are $CuSO_4$ and $NaClO_4$.

There are at least 22 chemical families of organic herbicides. Even a cursory treatment of the chemistry of these materials would be extensive. Herbicides of limited toxicity (Treflan, Atrazine) as well as extremely toxic ones (Paraquat, Dinoseb) are in use in many parts of the world. They range from water soluble to insoluble. The detailed chemistry of each should be determined prior to handling.

7. Chemical Compatibility

Chemical incompatibility can manifest itself in many ways; however, discussions will be limited to those combinations resulting in fires, explosions, extreme heat, evolution of gas (both toxic and nontoxic), and polymerization throughout the handbook.

Because of the number of chemicals and subsequent multiple number of potential reactions, it is impractical and (perhaps impossible) to list all potential reactions. Several systems exist for determining the reactions between classes of chemicals however none of them are definitive. Because all of the potential reactions for individual chemicals are not cataloged and because there are no (or very few), pure solutions of waste materials, laboratory compatibility testing is recommended for most materials. An appropriate protocol for compatibility testing would involve the following steps:

1. Obtain all available information about the material. If it is a surplus or off-specification product, obtain an analysis or a Material Safety Data Sheet. If it is a waste, check for previous analyses, and if none exists, obtain one. (Even if a previous analysis exists, consi-

der running a few screening-type field analyses for confirmation of important properties such as pH, redox potential or other oxidizer test, cyanide, sulfide, and flashpoint.)

2. Once the identity of the material is known, the literature can be consulted to determine potential reactions. At this point, incompatibility may be obvious. If not, then laboratory testing for compatibility is required.

Compatibility testing is almost by nature an experiment with the unknown. As such, safety must be the watchword. Procedures for compatibility testing should take into account the most severe adverse reaction possible, not just that expected. Such testing should always be performed under a vent hood while wearing, as a minimum, face shield, rubber apron, and gloves. Generally, compatibility testing entails mixing a small volume of one substance with another and observing for heat, gas generation, or polymerization. Polymerization need not be violent to cause problems. Anyone who has ever had to chisel out or replace a tank of solidified material can attest to this. Often it is advisable to heat the mixture to expected storage or process temperature and then observe for further heat, gas, or polymerization.

Observation of a reaction does not necessarily preclude mixing. Moderate heat or gas generation may not present a problem. However, a number of safety precautions should be taken before mixing the material if any heat or gas generation occurs. If heat is generated, the amount should be determined and a heat balance calculated so that effects of heating on the storage tank and tank base can be calculated. Expansion of the material with heating should also be considered so as to avoid overfilling the receiving tank.

Generation of gas requires a gas analysis before mixing. If the gas is toxic or if discharge of the resultant gas violates an air quality constraint, the materials should not be mixed. If the gas is nontoxic, care should still be taken to assure that the gas generation rate does not exceed the design venting capacity of the tank. Remember that most tanks are designed to withstand a water gage internal pressure of only about eight inches. (A typical person can provide about 24 inches water gage by blowing). Secondly, even if the gas is nontoxic, it may still displace air and (for inside tanks especially) create an asphyxiation hazard.

D. Toxicology Principles

Toxicology is the science that studies the harmful effects chemicals can have on the body. All chemicals affect man to some degree, depending on the time of exposure, concentration, and human susceptibility. One chemical may only cause a slight rash or dizziness while another may result in cancer or death. It is the degree of exposure and toxicity that are of practical concern.

The means by which chemicals enter the body are inhalation (breathing), ingestion (swallowing), and absorption (skin or living tissue contact). Once in the system these chemicals may produce such symptoms as tissue irritation, rash, dizziness, anxiety, narcosis, headaches, pain, fever, tremors, shortness of breath, birth defects, paralysis, cancer, and death, to mention a few. The amount of chemical that enters the body is called the "dose." The relationship that defines the body response to the dose given is called the "dose-response curve". The lowest dose causing a detectable response is the "threshold limit." The "limit" is dependent on factors such as particle size of contaminant, solubility, breathing rate, residence time in the system, and human susceptibility.

To accomplish meaningful studies, measurements of various parameters are essential. Dose is one of them, and in inhalation studies dose is proportional to the air concentration of the contaminant multiplied by the length of time it is breathed. The units of concentration are ppm (a volume/volume description of concentration--parts of air contaminant per one million parts of the air mixture) for gases and vapors, and mg/m^3 (a weight/volume description—milligrams of air contaminant per cubic meter of air mixture). Other concentration units exist, such as fibers per cubic centimeter (f/cc) for asbestos, and "rems" for radiation. Dose for oral or skin applications is measured by weight or volume in assigned units such as grams or cubic centimeters.

Toxicity data are presented in the literature by such terms as "LD_{50}" and "LC_{50}", that lethal dose per kilogram of body weight or lethal concentration that can kill 50 percent of an animal population. Such data are found, for example, in the Registry of Toxic Effects of Chemical Substances (RTECS). With data such as these obtained from animals closely resembling the human in biochemistry, relative toxicities can be established to characterize chemicals. These data in conjunction with air contaminant threshold limit values (TLV) or permissible exposure limits (PEL), set by law for short periods of exposure or eight-hour,

time-weighted average exposure, have produced safe working exposure limits for the worker. Many of these values are contained in the OSHA Standards and the American Conference of Governmental Industrial Hygienist's (ACGIH) in their publications on *Threshold Limit Values and Biological Exposure Indices.*

Human response to chemicals may be described by two types of biological effects--acute and chronic. An acute effect generally results after a single significant exposure, with severe symptoms developing rapidly and coming quickly to a crisis. An example of an acute effect is a few minutes exposure to carbon monoxide of various concentrations that cause headache, dizziness, or death. The chronic effect results from a repeated dose or exposure to a substance over a relatively prolonged period of time. Examples of chronic effects are possible reduction in life span, increased susceptibility to other diseases, and cancer as a result of smoking. Some materials, such as lead, can bioaccumulate (be stored in the body) and cause continuing effects, or reach a threshold value where an effect on the body occurs after a prolonged period of time, or "latency" period. An example of such a chemical is asbestos, which may produce asbestosis twenty years after the initial exposure.

An effect which exists but has not been widely studied because of its immensity and related problems is "synergism." Synergism occurs when the effect of two chemicals is greater than or less than either chemical alone. Inhalation of isopropyl alcohol and carbon tetrachloride can be well below safe concentration limits separately, but together, produce severe effects including renal failure. Toxicology and epidemiology, the sciences that study diseases in a general population, are closely related. Most of the present occupational concentration limits for hazardous material have resulted from illnesses and deaths of workers, and from use of both disciplines.

Some materials cause genetic changes that can cause cancer (carcinogen), mutation (mutagens), and birth defects (teratogens). These effects are often hard to document due to latency periods and synergisms.

The USOSH Hazard Communication Standard, 29 CFR 1910.1200, has categorized certain target organ effects, including examples of signs and symptoms and chemicals which have been found to cause such effects. These examples are presented to illustrate the range and diversity of effects and hazards found in the workplace, and the broad scope employers must consider in this area, but they are not intended to be all-inclusive. These are summarized for the reader in Table 7.

Table 7. Target Organ Effects Categorized Under the Hazard Communication Act

A. **Hepatotoxins:** Chemicals which produce liver damage;
Signs and Symptoms: Jaundice; liver enlargement;
Chemicals: Carbon tetrachloride; nitrosamines.

B. **Nephrotoxins:** Chemicals which produce kidney damage;
Signs and Symptoms: Edema; proteinuria;
Chemicals: Halogenated hydrocarbons; uranium.

C. **Neurotoxins:** Chemicals which produce their primary toxic effects on the nervous system;
Signs and Symptoms Narcosis: Behavioral changes; decrease in motor functions;
Chemicals: Mercury; carbon disulfide.

D. **Agents which act on the blood or hematopoietic system:** Decreases hemoglobin function; deprive body tissues of oxygen; Signs and Symptoms: Cyanosis; loss of consciousness;
Chemicals: Carbon monoxide; cyanides.

E. **Agents which damage the lung:** Chemicals which irritate or damage the pulmonary tissue;
Signs and Symptoms: Cough; tightness in chest; shortness of breath;
Chemicals: Silica; asbestos.

F. **Reproductive toxins:** Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis);
Signs and Symptoms: Birth defects; sterility;
Chemicals: Lead: KEPONE.

G. **Cutaneous hazards:** Chemical which affect the dermal layer of the body;
Signs and Symptoms: Defatting of the skin; rashes; irritation;
Chemicals: Ketones; chlorinated compounds.

H. **Eye hazards:** Chemicals which effect the eye or visual capacity;
Signs and Symptoms: Conjunctivitis; corneal damage;
Chemicals: Organic solvents; acids.

III. PERSONAL SAMPLING FOR AIR CONTAMINANTS

A. General Considerations

Provided first is a summary of OSHA recommended guidelines for air sampling programs normally implemented under the guidance of an industrial hygienist. Unnecessary air sampling can tie up laboratory resources and produce delays in reporting results of necessary sampling. One must evaluate the potential for employee overexposure

through observation and screening samples before any partial or full-shift air sampling is conducted. Do not overexpose the employee to gather a sample. Screening with portable monitors, gravimetric sampling, or detector tubes can be used to evaluate the following:

a. Processes, such as electronic soldering,
b. Exposures to substances with exceptionaily high PELs (Permissible Exposure Limits) in relatively dust-free atmospheres, e.g., ferric oxide and aluminum oxide,
c. Intermittent processes with substances without STELs (Short Term Exposure Limits),
d. Engineering controls, work practices, or
e. To assess the need for personal protection.

The objective of a proper sampling program is to take a sufficient number of samples to obtain a representative estimate of exposure. Contaminant concentrations vary seasonally, with weather, with production levels, and in a single location or job class. The number of samples taken depends on the error of measurement and differences in results. It is important also that if the employer has conducted air sampling and monitoring in the past, a thorough review of the records should be made.

Bulk Samples are often required to assist the laboratory in the proper analysis of field samples.

The following are some general sampling procedures:

1. Screen the sampling area using detector tubes, if appropriate. Determine the appropriate sampling technique. Prepare and calibrate the equipment and prepare the filter media.
2. Select the employee to be sampled and discuss the purpose of the sampling. Inform the employee when and where the equipment will be removed. Stress the importance of not removing or tampering with the sampling equipment. Turn off or remove sampling pumps before an employee leaves a potentially contaminated area (such as when he/she goes to lunch or on a break).
3. Instruct the employee to notify the supervisor if the sampler requires temporary removal.
4. Place the sampling equipment on the employee so that it does not interfere with work performance.
5. Attach the collection device (filter cassette, charcoal tube, etc.) to the shirt collar or as close as practical to the nose and mouth of the employee). Employee exposure is that exposure which would occur if the employee were not using a respirator. The inlet should always be in a downward vertical position to avoid gross contamination. Position the excess tubing so as not to interfere with the work of the employee.
6. Turn on the pump and record the starting time.
7. Observe the pump operation for a short time after starting to make sure it is operating correctly.
8. Record the information required.
9. Check pump status every two hours. More frequent checks may be necessary with heavy filter loading. Ensure that the sampler is still assembled properly and that the hose has not become pinched or detached from the cassette or the pump. For filters, observe for symmetrical deposition, finger prints, or large particles, etc. Record the flow rate, if possible.
10. Periodically monitor the employee throughout the work day to ensure that sample integrity is maintained and cyclical activities and work practices are identified.
11. Take photographs, as appropriate, and detailed notes concerning visible airborne contaminants, work practices, potential interferences, movements, and other conditions to assist in determining appropriate engineering controls.
12. Prepare a blank(s) during the sample period for each type of sample collected. For any given analysis, one blank will suffice for up to 20 samples collected. These blanks may include opened but unused charcoal tubes, and so forth.
13. Before removing the pump at the end of the sample period, check the flow rate to ensure that the rotameter bail is still at the calibrated mark (if there is a pump rotameter). If the ball is no longer at the mark, record the pump rotameter reading.
14. Turn off the pump and record the ending time.
15. Remove the collection device from the pump and seal it as soon as possible. The seal should be attached across sample inlet and outlet so that tampering is not possible.
16. Prepare the samples for transport to laboratory for analysis.
17. Recalibrate pumps after each day of sampling (before charging).

B. Sampling Techniques

The following are recommended procedures from the OSHA Technical Manual, issued February 5, 1990.

1. Detector Tubes

a. Each pump should be leak-tested before use. Calibrate the detector tube pump for proper volume at least quarterly or after 100 tubes.

2. Total Dust and Metal Fume

a. Collect total dust on a pre-weighed, low-ash polyvinyl chloride fitter at a flow rate of about 2 liters per minute (lpm), depending on the rate required to prevent overloading.
b. Collect metal fumes on a 0.8 micron mixed cellulose ester filter at a flow rate of approximately 1.5 lpm, not to exceed 2.0 lpm. Do not collect metal fumes on a low-ash polyvinyl chloride filter.
c. Take care to avoid any overloading of the filter, as evidenced by any loose particulate.
d. Calibrate personal sampling pumps before and after each day of sampling, using a bubble meter method (electronic or mechanical) or the precision rotameter method (that has been calibrated against a bubble meter).
e. Weigh filters before and after taking the sample.

3. Respirable Dust

a. Collect respirable silica dust using a clean cyclone equipped with a pre-weighed low-ash polyvinyl chloride filter.
b. Collect silica only as a respirable dust. A bulk sample should be submitted to the laboratory.
c. All filters used should be pre-weighed and post-weighed.
d. Calibration Procedures:
   1) Do the calibration at the pressure and temperature where the sampling is to be conducted.
   2) Replace the filter with a 1-liter jar containing the cassette holder assembly and cyclone or the open face filter cassette.
   3) Connect the tubing from the electronic bubble meter to the inlet of the jar.
   4) Connect the tubing from the outlet of the cyclone holder assembly or from the filter cassette to the outlet of the jar and then to the sampling pump.
   5) Calibrate the pump. The calibration readings must be within 5% of each other.
e. Cyclone cleaning
   1) Clean the cyclone thoroughly after each use to prevent excess wear or damage and to prevent contamination of a sample. Inspect the cyclone after cleaning for signs of wear or damage, such as scoring. Replace the unit if it appears damaged.
   2) Gently clean the interior, avoid scoring the interior surfaces. Never insert anything into the cyclone during cleaning. Refer to Figure 2.
   3) Leak test the cyclone at least once a month with regular usage.

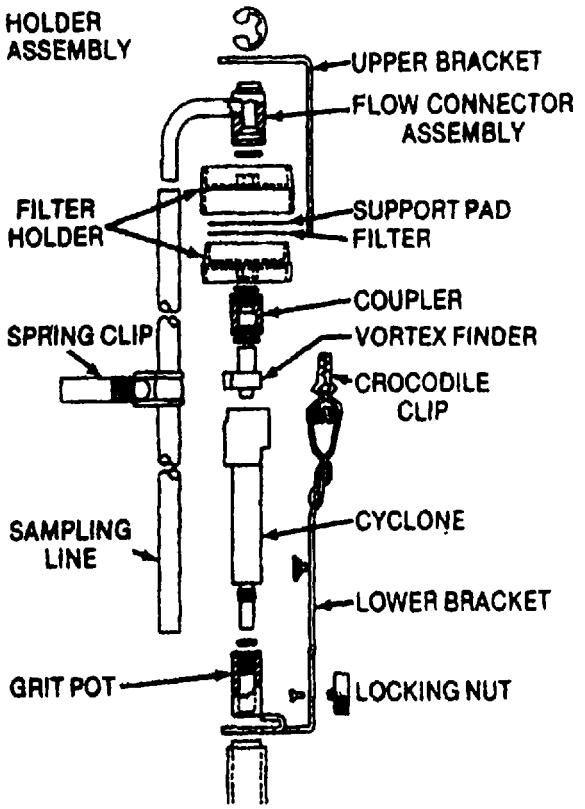


Figure 2. Illustrates the cyclone (chamber) of the cyclone assembly which is sensitive to scratches.

4. Organic Vapors and Gases

a. Organic vapors and gases may be collected on activated charcoal, silica gel, or other adsorption tubes using low flow pumps.
b. Immediately before sampling, break off the ends of the charcoal tube so as to provide an opening approximately one-half the internal diameter of the tube. Wear eye protection when breaking ends. Use tube holders, if available, to minimize the hazards of broken glass. Do not use the charging inlet or the exhaust outlet of the pump to break the ends of the charcoal tubes.
c. Use the smaller section of the charcoal tube as a back-up and position it near the sampling pump. The charcoal tube shall be held or attached in an approximately vertical position with the inlet either up or down during sampling.
d. Draw the air to be sampled directly into the inlet of the charcoal tube and do not allow it to pass through any hose or tubing before entering the pump tubing.

Figure 3a. Correctly, sealed "C"-Tube. Sample is completely enclosed in the seal and no tampering is possible.

e. Cap the charcoal tube with the supplied plastic caps immediately after sampling and seal as soon as possible. (See Figures 3a and 3b, C-tube seal.)

f. For other adsorption tubes, follow the same procedures as those for the charcoal tube, with the following exceptions:

1) Set up the calibration apparatus as shown in Figure 4 replacing the cassette with the solid sorbent tube to be used in the sampling (e.g., charcoal, silica gel, etc.). If a sampling protocol requires the use of two charcoal tubes, then the calibration train must include two charcoal tubes. The air flow must be in the direction of the arrow on the tube.

2) Calibrate the pump.

5. Midget Impingers/Bubblers

a. Method:

1) Take care in preparing bubblers and impingers to see that frits or tips are not damaged and that joints

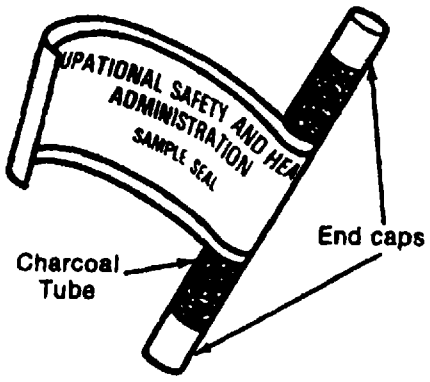


Figure 3b. Incorrectly, sealed "C"-Tube. End caps can be removed and sample integrity jeopardized without disturbing the seal.

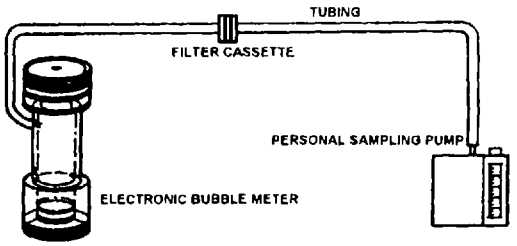


Figure 4. For calibration, the cassette is attached to an electronic bubble meter as shown in the illustration.

can be securely tightened.

2) Rinse the impinger/bubbler, Figure 5, with the appropriate reagent. Then, add the specified amount of this reagent to the impinger flask. If flasks containing the reagent are transported, caps must be placed on the impinger stem and side arm. To prevent overflowing, do not add over 10 milliliters of liquid to the midget impingers.

3) Collect contaminants in an impinger at a maximum flow rate of 1.0 lpm.

4) The impinger may either be hand-held by the industrial hygienist or attached to the employee's clothing using an impinger holster, in either case, it is very important that the impinger does not tilt, causing the reagent to flow down the side arm to the hose and into the pump.

5) In some instances, it will be necessary to add additional reagent during the sampling period to prevent the amount of reagent from dropping below one-half of the original amount.

6) After sampling, remove the glass stopper and stem from the impinger flask.

7) Rinse the absorbing solution adhering to the outside and inside of the stem directly into the impinger flask

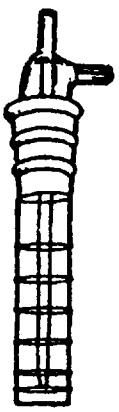


Figure 5. A typical glass bubbler is illustrated.

with a small amount (1 or 2 ml.) of the sampling reagent. Stopper the flask tightly with the plastic cap provided or pour the contents of the flask into a 20 cc. glass bottle. Rinse the flask with a small amount of the reagent and pour the rinse solution into the bottle. Tape the cap shut to prevent it from coming loose due to vibration. If electrial tape is used, do not "stretch" the tape since it will contract and loosen the cap.

b. Calibration Procedure:
   1) Set up the calibration apparatus as shown in Figure 4, replacing the cassette with the impinger/bubbler lied with the amount of liquid reagent specified in the sampling method.
   2) Connect the tubing from the electronic bubble meter to the inset of the impinger/bubbler.
   3) Connect the outlet of the impinger/bubbler to the tubing to the pump.
   4) Calibrate the pump at a maximum flow rate of 1.0 lpm.

6. Vapor Badges

a. Passive diffusion sorbent badges are useful for screening and monitoring certain chemical exposures, especially vapors and gases.
b. Badges are available to detect mercury, nitrogen oxides, ethylene oxide, formaldehyde, etc.
c. Interfering substances should be noted.

For asbestos sampling:

a. Collect asbestos on a special , 0.8 micrometer pore size, 25 mm diameter mixed cellulose ester filter, using a back-up pad.
b. Use fully conductive cassette with conductive extension cowl, as shown in Figure 6.
c. Sample open face in worker's breathing zone.
d. Assure that the bottom point (between the extension and the conical black piece) of the cassette is sealed tightly with a shrink band of electrical tape. Point the open end of the cassette down to minimize contamination.
e. Use a flow rate in the range of 0.5 to 2.5 liters per minute. One liter per minute is suggested for general sampling. Office environments allow flow rates of up to 2.5 lpm. Calibrate pump before and after sampling.
f. Sample for as long a time as possible without overloading (obscuring) the filter.
g. Submit at the most 10 blanks, with a minimum in all cases of 2 blanks. Where possible, collect and submit to the laboratory a bulk sample of the material suspected to be in the air.
h. Mail bulks and air samples separately to avoid cross-contamination. Pack the samples securely to avoid any rattle or shock damage (do not use expanded polystyrene "packing"). Use bubble sheeting as packing. Put identifying paperwork in every package. Do not send samples in plastic bags or in envelopes.
i. Instruct the employee to avoid knocking the cassette and to avoid using a compressed air source that might dislodge the sample.

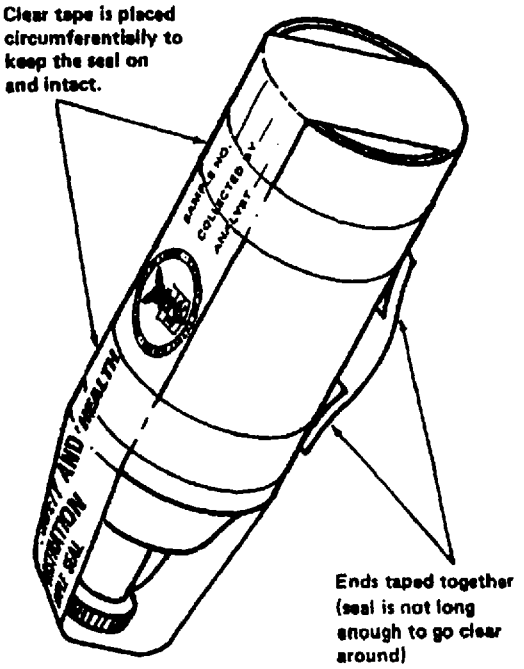


Figure 6. A standard asbestos cassette (25mm.) sealed properly with an OSHA 21 form.

C. Equipment Preparation and Calibration

1. Replace alkaline batteries frequently (once a month). Also carry fresh replacement batteries with the equipment.
2. Check the rechargeable Ni-Cad batteries under load (e.g., turn pump on and check voltage at charging jack) before use.
3. Calibrate personal sampling pumps before and after each day of sampling, using either the electronic bubble meter method or the precision rotameter method (that has been calibrated against a bubble meter).

4. Electronic Flow Calibrators:
   a. These units are high accuracy electronic bubble flowmeters that provide instantaneous air flow readings and a cumulative averaging of multiple samples. These calibrators measure the flow rate of gases and present the results as volume per unit of time.
   b. These calibrators should be used to calibrate all air sampling pumps.
5. When a sampling train requires an unusual combination of sampling media (e.g., glass fiber filter proceeding impinger), the same media/devices should be in line during calibration.

The electronic bubble meter method consists of the following:

1) Allow the pump to run 5 minutes prior to voltage check.

2) Assemble the polystyrene cassette filter holder, using the appropriate filter for the sampling method. Compress cassette by using a mechanical press or other means of applying pressure. Use shrink tape around cassette to cover joints and prevent leakage. If a cassette adapter is used, care should be taken to ensure that it does not come in contact with the back-up pad. When calibrating with a bubble meter, the use of cassette adapters can cause moderate to severe pressure drop at high flow rates in the sampling train, which will affect the calibration result, If adapters are used for sampling, then they should be used when calibrating. Nylon adapters can restrict air flow due to plugging over time. Stainless steel adapters are preferred.

3) Connect the collection device, tubing, pump and calibration apparatus as shown in Figures 4 and 7, cassette and cyclone samplers, respectively.

4) A visual inspection should be made of all Tygon tubing connections.

5) Wet the inside of the electronic flow cell with the supplied soap solution by pushing on the button several times.

6) Turn on the pump and adjust the pump rotameter, if available, to the appropriate flow rate setting.

7) Press the button on the electronic bubble meter. Visually capture a single bubble and electronically time the bubble. The accompanying printer will automatically record the calibration reading in liters per minute.

8) Repeat step 7 until two readings are within 5%.

9) While the pump is still running, adjust the pump, if necessary.

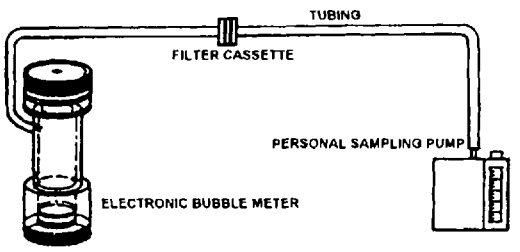


Figure 7. The cyclone is calibrated by placing the cyclone in a 1 liter vessel attached to an electronic bubble meter.

10) Repeat the procedures described above for all pumps to be used for sampling. The same cassette and filter may be used for all calibrations involving the same sampling method.

The precision rotameter, Figure 8 is a secondary calibration device. If it is to be used in place of a primary device such as a bubble meter, care must be taken to ensure that any introduced error will be minimal and noted. The precision rotameter may be used for calibrating the personal sampling pump in lieu of a bubble meter provided it is:

a) Calibrated with an electronic bubble meter or a bubble meter.

b) Disassembled, cleaned as necessary, and recalibrated. It should be used with care to avoid dirt and dust contamination which may affect the flow.

c) Not used at substantially different temperature and/or pressure from those conditions present when the rotameter was calibrated against the primary source.

d) Used such that pressure drop across it is minimal.

If altitude or temperature at the sampling site are substantially different from the calibration site, it is necessary to calibrate the precision rotameter at the sampling site where the same conditions are present.

D. Filter Weighing Procedure

The step-by-step procedure for weighing filters depends on the make and model of the balance. Consult the manufacturer's instruction book for directions. In addition, follow these guidelines:

1. There shall be no smoking or eating in the weighing area. All filters will be handled with tongs or tweezers. Do not handle the filters with bare hands.

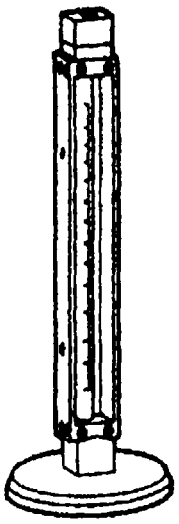


Figure 8. A single column precision rotameter can be used a secondary calibration device.

2. Dessicate all filters at least 24 hours before weighing and sampling. Change dessicant before it completely changes color (e.g., before blue dessicant turns all pink). Evacuate dessicator with a sampling or vacuum pump.
3. Zero the balance prior to use.
4. Calibrate the balance prior to use and after every 10 samples.
5. Immediately prior to placement on the balance, pass all filters over an ionization unit after 12 months of use to the distributor for disposal.
6. Weigh all fitters at least twice.
   a. If there is more than 0.005 milligram difference in the two weighings, repeat the zero and calibration and reweigh the filter.
   b. If there is less than 0.005 milligram difference in the two weighings, average the weights for the final weight.
7. Record all the appropriate weighing information in the weighing log .
8. In reassembling the cassette assembly, remember to add the unweighed backup pad (refer to Figure 9).
9. When weighing the filter after sampling, include any loose material from an overloaded filter and cassette. At all times take care not to exert downward pressure on the weighing pan(s). Such action may damage the weighing mechanism.

E. Detector Tubes/Pumps

1. Principle/Description

Detector tube pumps are portable equipment which, when used with a variety of commercially available detector tubes, are capable of measuring the concentrations of a wide variety of compounds in industrial atmospheres. Operation consists of using the pump to draw a known volume of air through a detector tube designed to measure the concentration of the substance of interest. The concentration is determined by a colorimetric change of an indicator which is present in the tube contents.

2. Applications/Limitations

1. Detector tubes/pumps are screening instruments which may be used to measure hundreds of organic and inorganic gases and vapors or for leak detection. Some aerosols can also be determined.
2. Detector tubes of a given brand are to be used only with a pump of the same brand. The tubes are calibrated specifically for the same brand of pump and may give erroneous results if used with a pump of another brand.
3. A limitation of many detector tubes is the lack of specificity. Many indicators are not highly selective and can cross-react with other compounds. Manufacturer's' manuals describe the effects of interfering contaminants.
4. Another important consideration is sampling time. Detector tubes give only an instantaneous interpretation of environmental hazards. This may be beneficial in potentially dangerous situations or when celling exposure determinations are sufficient. When long-term assessment of occupational environments is necessary, short-term detector tube measurements may not reflect time-weighted average levels of the hazardous substances present.
5. Detector tubes normally have a shelf-life at 25°C of 1 to 2 years. Refrigeration during storage lengthens the shelf-life. Outdated detector tubes (i.e., beyond the printed expiration date) should never be used.

3. Performance Data

1. Detectable concentration ranges are tube-dependent and can be anywhere from one-hundredth to to several thousand ppm. The limits of detection depend on the particular detector tube.

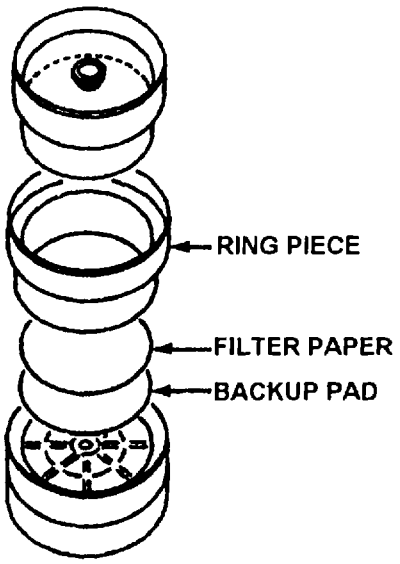


Figure 9. Exploded view of a three piece cassette shows placement of backup pad.

2. Accuracy ranges vary with each detector tube.
3. The pump may be handheld during operation (weighing from 8 to 11 ounces), or it may be an automatic type (weighing about 4 pounds) which collects a sample using a preset number of pump strokes. A full pump stroke for either type of short-term pump has a volume of about 100 cc.
4. In most cases where only one pump stroke is required, sampling time is about one minute. Determinations for which more pump strokes are required take proportionately longer.

4. Leakage Test

1. Each day prior to use, perform a pump leakage test by inserting an unopened detector tube into the pump and attempt to draw in 100 ml of air. After a few minutes, check for pump leakage by examining pump compression for bellows-type pumps or return to resting position for piston-type pumps. Automatic pumps should be tested according to the manufacturer's instructions.
2. In the event of leakage which cannot be repaired in the field, send the pump to the manufacturer.
3. Record that the leakage test data.

5. Calibration Test

1. Calibrate the detector tube pump for proper volume measurement at least quarterly.
2. Simply connect the pump directly to the bubble meter with a detector tube in-line. Use a detector tube and pump from the same manufacturer.
3. Wet the inside of the 100 cc bubble meter with soap solution.
4. For volume calibration, experiment to get the soap bubble even with the zero ml mark of the buret.

   a. For piston-type pumps, pull the pump handle all the way out (full pump stroke) and note where the soap bubble stops; for bellows-type pumps, compress the bellows fully; for automatic pumps, program the pump to take a full pump stroke. For either type pump, the bubble should stop between the 95 cc and 105 cc marks. Allow 4 minutes for the pump to draw the full amount of air.

   b. Also check the volume for 50 cc (1/2 pump stroke) and 25 cc (1/4 pump stroke) if pertinent. A +5 percent error is permissible. If error is greater than +8 percent, send the pump for repair and recalibration.
5. Record the calibration information required on a calibration log.
6. It may be necessary to clean or replace the rubber bung or tube holder if a large number of tubes have been taken with the pump.

6. Additional Information

1. Draeger, Model 31 (bellows): When checking the pump for leaks with an unopened tube. the bellows should not be completely expanded after 10 minutes.
2. Draeger, Quantimeter 1000. Model 1 (automatic): A battery pack is an integral part of this pump. The pack must be charged prior to initial use. One charge is good for 1000 pump strokes. During heavy use, it should be recharged daily. If a "U" (undervoltage) message is continuously displayed in the readout window of this pump, the battery pack should be immediately recharged.
3. Matheson-Kitagawa, Model 8014-400A (piston): When checking the pump for leaks with an unopened tube, the pump handle should be pulled back to the 100-ml mark and locked. After 2 minutes, the handle should be released carefully. After taking 100 to 200 samples, the pump should be cleaned and relubricated. This involves removing the piston from the cylinder, removing the inlet and pressure-relief valve from the front end of the pump, cleaning, and relubricating.
4. Mine Safety Appliances, Samplair Pump, Model A, Part No. 463998 (piston): The pump contains a flow-rate control orifice protected by a plastic filter which periodically needs to be cleaned or replaced. To check

the flow rate, the pump is connected to a buret and the piston is withdrawn to the 100-ml position with no tube in the tube holder. After 24-26 seconds, 80 ml of air should be admitted to the pump. Every 6 months the piston should be relubricated with the oil provided.

5. Sensidyne-Gastec, Model 800, Part No. 7010657-1 (piston): This pump can be checked for leaks as mentioned for the Kitagawa pump; however, the handle should be released after 1 minute. Periodic relubrication of the pump head, the piston gasket, and the piston check valve is needed and is use-dependent.

7. Special Considerations

1. Detector tubes should be refrigerated when not in use to prolong shelf life.
2. Detector tubes should not be used when cold. They should be kept at room temperature or in a shirt pocket for one hour prior to use.
3. Lubrication of the piston pump may be required if volume error is greater than 5 percent.

F. Electronic Flow Calibrators

1. Description

1. These units are high accuracy electronic bubble flowmeters that provide instantaneous air flow readings and a cumulative averaging of multiple samples. These calibrators measure the flow rate of gases and report volume per unit of time.
2. The timer is capable of detecting a soap film at 80 microsecond intervals. This speed allows under steady flow conditions an accuracy of +/- 0.5% of any display reading. Repeatability is +/- 0.5% of any display.
3. The range with different cells is from 1 cc/min to 30 lpm.
4. Battery power will last 8 hours with continuous use. Charge for 16 hours. Can be operated from an A/C charger.

2. Maintenance of Calibrator

1. Cleaning before use: Remove the flow cell and gently flush with tap water. The acrylic flow cell can be easily scratched. Wipe with cloth "only." Do not allow center tube, where sensors detect soap film to be scratched or get dirty. Never clean with acetone solvent. Use only soap and warm water. When cleaning prior to storage, allow flow cell to air dry. If stubborn residue persists, it is possible to remove the bottom plate. Squirt a few drops of soap into the slot between base and flow cell to ease removal.
2. Leak Testing: The system should be leak checked at 6 inches H_2O by connecting a manometer to the outlet boss and evacuate the inlet to 6 inches H_2O. No leakage should be observed.
3. Verification of Calibration: The calibrator is factory calibrated using a standard traceable to National Institute of Standards and Technology, formerly called the National Bureau of Standards, (NBS). Attempts to verify calibrator against a glass one liter burette should be conducted at 1000 cc/min. for maximum accuracy. The calibrator is linear throughout the entire range.

3. Shipping/Handling

1. When transporting, especially by air, it is important that one side of the seal tube which connects the inlet and outlet boss, be removed for equalizing internal pressure within the calibrator.
2. Do not transport unit with soap solution or storage tubing in place.

4. Precautions/Warnings

1. Avoid the use of chemical solvents on flow cell, calibrator case and faceplate. Generally, soap and water will remove any dirt.
2. Never pressurize the flow cell at any time with more than 25 inches of water pressure.
3. Do not charge batteries for longer than 16 hours.
4. Do not leave A/C adapter plugged into calibrator when not in use as this could damage the battery supply.
5. Slack close fitting covers help to reduce evaporation of soap in the flow cell when not is use.
6. Do not store flow cell for a period of one week or longer with soap. Clean and store dry.
7. The Calibrator Soap is a precisely concentrated and sterilized solution formulated to provide a clean, frictionless soap film bubble over the wide, dynamic range of the calibrator. The sterile nature of the soap is important in the prevention of residue build-up in the flow cell center tube, which could cause inaccurate readings. The use of any other soap is not recommended.

G. Manual Buret Bubble Meter Technique

When a sampling train requires an unusual combination of sampling media (e.g., glass fiber filter proceeding

impinger). The same media/devices should be in line during calibration. Calibrate personal sampling pumps before and after each day of sampling.

1. Bubble Meter Method

1. Allow the pump to run 5 minutes prior to voltage check and calibration.
2. Assemble the polystyrene cassette filter holder using the appropriate filter for the sampling method. If a cassette adapter is used, care should be taken to ensure that it does not come in contact with the back-up pad. When calibrating with a bubble meter, the use of cassette adapters can cause moderate to severe pressure drop in the sampling train, which will affect the calibration result. If adapters are used for sampling, then they should be used when calibrating.
3. Connect the collection device, tubing, pump and calibration apparatus as shown in Figures 10 and 11.
4. A visual inspection should be made of all Tygon tubing connections.
5. Wet the inside of a 1-liter buret with a soap solution.
6. Turn on the pump and adjust the pump rotameter to the appropriate flow rate setting.
7. Momentarily submerge the opening of the buret in order to capture a film of soap.
8. Draw two or thee bubbles up the buret in order to ensure that the bubbles will complete their run.
9. Visually capture a single bubble and time the bubble from 0 to 1000 ml for high flow pumps or 0 to 100 ml for low flow pumps.
10. The timing accuracy must be within +1 second of the time corresponding to the desired flow rate.
11. If the time is not within the range of accuracy, adjust the flow rate and repeat steps 9 and 10 until the correct flow rate is achieved. Perform steps 9 and 10 at least twice, in any event.
12. While the pump is still running, mark the center of the float in the pump rotameter as a reference.
13. Repeat the procedures described above for all pumps to be used for sampling. The same cassette and filter may be used for all calibrations involving the same sampling method.

H. Sampling for Special Analyses

1. Silica Samples Analyzed by X-Ray Diffraction (XRD).

1. Air Samples: Respirable dust samples are analyzed for quartz and cristobalite by X-ray diffraction (XRD). XRD is the preferred analytical method due to its sensitivity, minimum requirements for sample preparation and ability to identify polymorphs (different crystalline forms) of free silica.

a. The analysis of free silica by XRD requires that the particle size distribution of the samples be matched as dosely as possible to the standards. This is best accomplished by collecting a respirable sample.

1) Respirable dust samples are collected on a low ash PVC filter using a 10mm nylon cyclone at a flow rate of 1.7 lpm.

2) A sample not collected in this manner is considered a total dust (or nonrespirable) sample. Total dust samples do not allow for an accurate analysis by XRD.

b. Quartz (or cristobalite) is identified by its major (primary) X-ray diffraction peak. Because other substances also have peaks at the same position, it is necessary to confirm quartz (or cristobalite) principally by the presence of secondary and/or tertiary peaks.

c. If they are considered to be present in the work environment, the following major chemicals which can interfere with an analysis should be noted:

Aluminum phosphate
Feldspars (microcline, orthoclase, piagiodase)
Graphite
Iron carbide
Lead sulfate
Micas (biotite, muscovite)
MontmoriHonite
Potash
Silver chloride
Talc
Zircon (Zirconium silicate)

d. A sample weight and total air volume shall accompany all filter samples. Sample weights of 0.1 to 5.0 milligrams are acceptable. Sample weights of 0.5 to 3.0 milligrams are preferred.

1) Do not submit a sample(s) unless its weight or the combined weights of all filter's representing an individual exposure exceed 0.1 mg.

2) If heavy sample loading is noted during the sampling period, it is recommended that the filter cassette be changed to avoid collecting a sample with a weight greater than 5.0 milligrams.

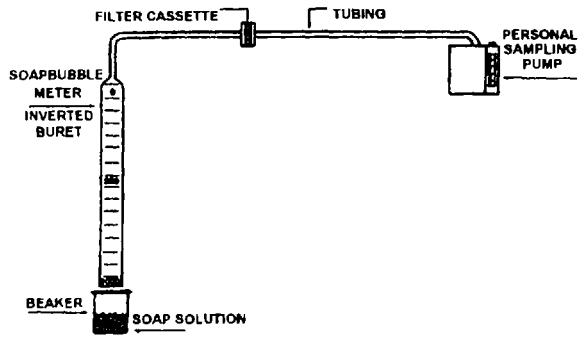


Figure 10. Calibration of cyclone respirable dust sampler using a bubble meter.

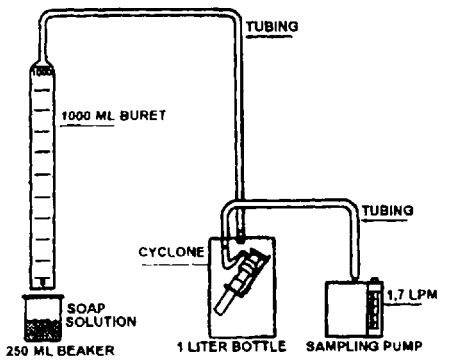


Figure 11. Alternative calibration method.

3) If a sample weight exceeds 5.0 mg, another sample of a smaller air volume, whenever possible, should be collected to obtain a sample weight of less than 5.0 mg.

e. Laboratory results for air samples are usually reported under one of four categories:

1) Percent Quartz (or Cristobalite). Applicable for a respirable sample in which the amount of quartz (or cristobalite) in the sample was confirmed.

2) "Less than or equal to" value in units of %. Less or equal to values are used when the adjusted 8-hour exposure is found to be less than the PEL, based on the sample's primary diffraction peak. The value reported represents the maximum amount of quartz (or cristobalite) which could be present. However, the presence of quartz (or cristobalite) was not confirmed using secondary and/or tertiary peaks in the sample since the sample could not be in violation of the PEL.

3) Approximate Values in Units of Percent: The particle size distribution in a total dust sample is unknown and error in the XRD analysis may be greater than for respirable samples. Therefore, for total dust samples, an approximate result is given.

4) Nondetected: A sample reported as nondetected indicates that the quantity of quartz (or cristobalite) present in the sample is not greater than the detection limit of the instrument. The detection limit is usually 10 micrograms for quartz and 50 micrograms for cristobalite.

- If less than a full-shift sample was collected, one should evaluate a nondetected result to determine whether adequate sampling was performed.
- If the presence of quartz (or cristobalite) is suspected in this case, the Industrial Hygienist may want to sample for a longer period of time to increase the sample weights.

2. Bulk Samples: Bulk samples must be submitted for all silica analyses.

a. They have two purposes:

1) For laboratory use only, to confirm the presence of quartz or cristobalite in respirable samples, or to assess the presence of other substances that may interfer in the analysis of respirable samples.

2) To determine the approximate percentage of quartz (or cristobalite) in the bulk sample.

b. A bulk sample submitted "for laboratory use only" must be representative of the airborne free silica content of the work environment sampled: otherwise it will be of no value.

c. The laboratory's order of preference for bulk samples for an evaluation of personal exposure is:

1) A high volume respirable area sample.
2) A high volume area sample.
3) A representative settled dust (rafter) sample.
4) A bulk sample of the raw material used in the manufacturing process.

A bulk sample is the last choice and the least desirable. It should be submitted "for laboratory use only" if there is a possibility of contamination by other matter.

d. The type of bulk sample submitted to the laboratory should be cross-reference to the appropriate air samples.

e. A reported bulk sample analysis for quartz (or cristobalite) will be semi-quantitative in nature because:

1) The XRD analysis procedure requires a thin layer deposition for an accurate analysis.

2) The error for bulk samples analyzed by XRD is unknown because the particle size of nonrespirable bulk samples varies from sample to sample.

2. Samples Analyzed by Inductively Coupled Plasma (ICP)

Metals — Where two or more of the following analytes are requested on the same filter, an ICP analysis may be conducted. However, the Industrial Hygienist should specify the metals of interest in the event samples cannot be analyzed by the ICP method. A computer print-out of the following 13 analytes may be typical reported:

Antimony
Beryllium
Cadmium
Chromium
Cobalt
Copper
Iron
Lead
Manganese
Molybdenum
Nickel
Vanadium
Zinc

Arsenic — Lead, cadmium, copper and iron can be analyzed on the same filter with arsenic.

I. Sampling for Surface Contamination

1. General Description

1. The terms "wipe sampling", "swipe sampling", and "smear sampling" are all used synonymously to describe the techniques used for assessing surface contamination. However, the term "wipe sampling" is one which will be used in this chapter.
2. "Wipe sampling" is most often used to screen for asbestos, lead, other metals, and PCBs.
3. The uses are:
   a. Skin Sampling
      1) Potential contact with skin irritants may be evaluated by wiping surfaces, which may be touched by workers.
      2) Skin wipes are not recommended for those substances which absorb rapidly through the skin. Biological monitoring for these substances or their metabolites, or biological markers, is often the only means of assessing their absorption. Wipe the inside surfaces of protective gear or other surfaces which may contact skin, instead.
   b. Surfaces
      1) Surfaces which may be contacted by food or other materials which are ingested or placed in the mouth (e.g., chewing tobacco, gum, cigarettes) may be wipe sampled (including hands and fingers) to show contamination.
      2) Contaminated smoking materials may allow the toxic materials, or their combustion products, to enter the body via the lungs (e.g., lead, mercury). Wiping of surfaces which smoking materials may touch (e.g., hands and fingers) may be useful in evaluating this possible route of exposure.
      3) Accumulated toxic materials may become suspended in air, and may contribute to airborne exposures (e.g., asbestos, lead or beryllium). Bulk and wipe samples may aid in determining this possibility.
   c. Personal Protective Equipment Sampling
      1) Effectiveness of personal protective gear (e.g., gloves, aprons, respirators, etc.) may sometimes be evaluated by wipe sampling the inner surfaces of the protective gear (and protected skin).
      2) Effectiveness of decontamination of surfaces and protective gear (e.g., respirators) may sometimes be evaluated by wipe sampling.
4. When accompanied by dose observation of the operation in question, wipe sampling can help identify sources of contamination and poor work practices.
5. Evaluation of Sampling Results
   a) False negative results, i.e., surface contamination is not detected by a wipe sample, are possible.
   b) The safety officer must use professional judgment on a case-by-case basis when evaluating the significance of positive wipe sampling results.
   c) Consider the toxicity, contribution of skin absorption and/or gastrointestinal absorption to the total dose. Other factors are the ambient air concentrations, skin irritation, etc., when evaluating sample results.

6. The handbook, lists substances which represent a potential for ingestion toxicity, skin absorption, and/or have a hazardous skin effect. Additional toxicological information concerning chronic skin absorption, dermatitis, etc. should be used in determining if the resulting exposure presents a potential employee hazard (see suggested readings at the end of this chapter).

2. Technique For Wipe Sampling

Filter Media and Solvents

Direct skin wipes should not be taken when high skin absorption of a substance is expected. Under no conditions should any solvent other than distilled water be used on skin, personal protective gear which directly contacts the skin, or surfaces which contact food or tobacco products. Generally, there are two types of filters recommended for taking wipe samples:

1) Glass fiber filters (GPF) (37 mm) are usually used for materials which are analyzed by High Performance Liquid Chromatography (HPLC), and often for substances analyzed by Gas Chromatogaphy (GC).

2) Paper filters are generally used for metals, and may be used for anything not analyzed by HPLC. For convenient usage, the Whatman smear tab (or its equivalent) is commonly used.

Preloading a group of vials with appropriate filters is a convenient method. (The Whatman smear tabs should be inserted with the tab end out.) Always wear clean rubber gloves when handling filters. Gloves should be disposable and should not be powdered.

Follow these procedures when wipe samples are taken:

a. If multiple samples are to be taken at the worksite, prepare a rough sketch of the area(s) or room(s) which are to be wipe sampled.
b. A new set of clean impervious gloves should be used with each individual sample. This avoids contamination of the filter by the hand and the subsequent possibility for false positives, and prevents contact with the substance.
c. Withdraw the filter from the vial. If a damp wipe sample is desired, moisten the filter with distilled water or other advent. Skin, personal protective equipment or surfaces which contact food or tobacco products must either be wiped dry, or wiped with distilled water, never with organic solvents. Skin wipes should not be done for materials with high skin absorption. It is recommended that hands and fingers be the only skin surfaces wiped. Before any skin wipe is taken, explain why you want the sample and ask the employee about possible skin allergies to the chemicals in the sampling filter or media.
d. Wipe a section of the surface to be sampled using a template with an opening exactly 100 cm^2.
e. For surfaces smaller than 100 cm^2 use a template of the largest size possible. Be sure to document the size of the area wiped. For curved surfaces, the wiped area should be estimated as accurately as possible and then documented.
f. Maximum pressure should be applied when wiping.
g. To insure that all portions of the partitioned area are wiped, start at the outside edge and progress toward the center making concentric squares of decreasing size.
h. If the filter dries out during the wiping procedure, discard the filter, reduce area to be wiped by half, and repeat wiping procedure with a new filter.
i. Without allowing the filter to contact any other surface, fold the filter with the exposed side in, then fold it over again. Place the filter in a sample vial, cap the vial, number it, and place a corresponding number at the sample location on a sketch. Include notes with the sketch giving any further description of the sample (e.g., "Fred-Employee's respirator, Inside"; "Lunch table"; etc.).
j. At least one blank filter treated in the same fashion, but without wiping, should be submitted for each sampled area.

Special Techniques for Wipe Sampling

Acids and Bases — When examining surfaces for contamination with strong acids or bases, (e.g., hydrochloric acid and sodium hydroxide), pH paper moistened with water may be used. However, these results should be viewed with caution due to potential interferences.

Direct Reading Instruments — For some types of surface contamination (e.g., mercury sniffer for mercury), direct reading instruments may be used.

Aromatic Amines — Screening may be done to determine the precise areas of carcinogenic aromatic amine contamination.

Special Considerations

Due to their volatile nature, most organic solvents are not suitable for wipes. If necessary, surface contamination can be judged by other means, (e.g., by use of detector tubes, photoionization analyzers, or other similar instruments). Some substances are not stable enough as samples to be wipe sampled reliably. Some substances should have solvent added to the vial as soon as the wipe sample is placed in the vial (e.g., Benzidine). Do not take surface wipe samples on skin if OSHA or ACGIH shows a "skin" notation, the substance has a skin LD_{50} of 200 mg/kg or less, or an acute oral LD_{50} of 500 mg/kg or less, or the substance is an irritant, causes dermatitis, contact sensitization, or is termed corrosive.

Screening for Carcinogenic Aromatic Amines — As in the case of routine wipe sampling, wear clean, disposable impervious gloves. Wipe an of exactly 100 cm^2 with a sheet of filter paper moistened in the center with 5 drops of methanol. After wiping the sample area, apply 3 drops of fluorescamine (a visualization reagent to the contaminated area of the filter paper. Place a drop of the visualization reagent on an area of the filter paper which has not contacted the surface. This marks a non-sample area or blank on the fitter paper adjacent to the test area. After a reaction time of 6 minutes, irradiate the fitter paper with 366 nm ultraviolet light. Compare the color development of the contacted area with the non-sample area or blank. A positive reaction will show a discoloration as a yellow color darker than the yellow color of the fluoroescamine blank. A discoloration indicates surface contamination, possible aromatic amine carcinogen. Repeat a wipe sampling of the contaminated areas using the regular surface contamination procedure. The following compounds are some of the suspected carcinogenic agents that can be detected by this screening procedure:

4,4-Methyienebls(2-chloroaniline)
Benzidine
α-Naphthylamine
β-Naphthylamine
4-Aminobiphenyl

J. Air Sampling and Personal Safety Monitoring

On and off the job, everyone is exposed to a great variety of chemical and physical agents, most of which do no harm under ordinary circumstances, but all of which have the potential for being injurious at some level and under some conditions of exposure. How a material is used is the major determinant of the hazard potential. Any substance contacting or entering the body can be injurious at some degree of exposure and will be tolerated without effect at some lower exposure.

The practice of industrial hygiene or environmental health is based on the concept that for each substance there is a safe or tolerable lower level of exposure below which significant injury, illness or discomfort will not occur. The industrial hygienist protects the health of the worker by determining this safe limit of exposure for a substance and then controlling the environmental conditions so that exposure does not exceed that limit.

The toxicity, or hazard properties, of a chemical refer generally to the capacity of the substance to injure an individual. Frequently the word poison is used to mean a substance with some capability of producing adverse reaction on the health or well-being of an individual. Whether or not any ill effects occur depends on: (1) the properties of the chemical, (2) the dose (the amount of the chemical acting on the body or system), (3) the route by which the substance enters the body, and (4) the susceptibility or resistance of the exposed individual. There are four routes of entry or means by which a substance may enter or act on the body: (1) inhalation, (2) ingestion, (3) injection and (4) contact or absorption through the skin. Of these, inhalation is the most important insofar as serious and acute industrial poisoning is concerned, but contact of the skin with corrosive or irritating chemicals is the most frequently encountered. Ingestion of toxic materials occurs only through accidental or careless procedures in the industrial environment and, while it cannot be ignored, it is seldom a significant factor in exposure. However, there are multiple routes of entry to the body for some materials. When a toxic chemical acts on the body or system, the nature and extent of the injurious response depends upon the dose received - that is, the amount of the chemical actually entering the body or system. This relationship of dose and response is shown in Figure 12. This is a generalized curve; an actual dose - response curve varies with the type of material and the response.

Response can vary widely and might be a cough, respiratory irritation, unconsciousness, or the death of an experimental animal. Typically, there would be no response up to a certain dose, then a gradually increasing

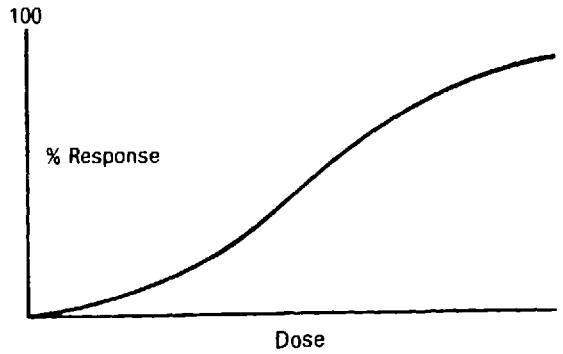


Figure 12. Illustrate the dose-response curve.

response to an increasing dose. At the upper part of the curve, the increase in response to an increase in dose would diminish, and would gradually approach 100% response in all exposed animals or individuals. However, no such curve is precise, because there is great variation in the susceptibility or resistance of individuals to a fixed dose of any material and, in addition, the biological response covers a rather wide range of effects for any given dose.

In experimental work, some accidental exposures, or in the administration of medicine, the dose may be a certain quantity of the chemical administered at one time, such as in a pill, an injection, or an accidentally swallowed poison. In industry, time is a factor in most exposures, and the dose is the result of both the concentration of the toxic agent and the duration of the exposure. In exposures by inhalation of airborne materials, the dose is the concentration multiplied by the time (CT), and is roughly a constant for any given material and specified effect. The CT value can be used to provide a rough approximation of other combinations of concentration and time which would have about the same effect. Although this concept must be used very cautiously and cannot be applied at extreme conditions of either concentration or time, it is most important in setting limits for airborne contaminants and physical agents in respect to environmental exposures. The worker is exposed for various periods of time, day after day, to the materials in his environment, and the safe limits are set so that the combinations of concentrations and durations are below the levels which will produce injury.

Over the years, various individuals proposed different limits, and some states, as well as, and the American Conference of Governmental Industrial Hygienists (ACGIH) began to develop limits or standards. In 1945, W. A. Cook compiled a list of concentration limits for 150 substances. The ACGIH adopted this list and developed an active program which continues to this day.

In the early development of such limits, they were generally known as Maximum Allowable Concentrations or MAC'S, sometimes called Maximum Acceptable Concentrations, or Maximum Permissible Concentrations. The early concept was that these were values which must not be exceeded; in other words, they were truly maximum values. As the understanding of limits and the development of the philosophy for such limits grew, it was realized that short-term exposures to somewhat higher concentrations could be permitted without undue harm if the total exposure during the day was sufficiently below the maximum limit. This lead to the development of the concept of Threshold Limit Values (TLV's) by the ACGIH.

The TLV's, as recommended and published by the ACGIH, refer to concentrations of airborne contaminants or levels of physical agents, and represent the conditions to which it is believed nearly all workers may be repeatedly exposed day after day without adverse effects. TLV's are based on the results of animal experiments, limited human experiments, some industrial experience and, when possible, a combination of all three.

The basis on which the TLV's are set may differ from substance to substance. For some, such as levels for silica dust, a guiding factor is protection against impairment of health. For others, it is the comfort level of the individual, such as freedom from irritation, nuisance, or other forms of stress; for example, the TLV for sulfur dioxide is based on irritation and not on toxicity per se. The TLV list is reviewed annually resulting in some revisions in values and some additions to the list.

It is most important that TLV data be correctly used. Misuse can occur when uninformed individuals view these levels as magic numbers, below which workers are safe and above which they become ill. It should be remembered that there is wide variation in individual susceptibility to air contaminants and physical agents. Some workers may experience some discomfort from exposures at or below the TLV, and a much smaller number may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. Therefore, the TLV's as published were intended to be used only as guides in the control of health hazards and not as levels which separate safe from dangerous exposures. In addition, a TLV is not intended as a relative index of hazard or toxicity, nor to be mathematically manipulated by applying physical constants to derive a relative hazard.

Basically a TLV refers to a time-weighted averaged exposure for a 7 or 8-hour work day and a 40-hour work week. In other words, it is a level directed toward chronic (long-term) exposure and not toward acute (short-term) exposure. Generally, toxicity data for acute exposures is obtainable largely from animal experimentation, early medical data, and limited information from accidental exposures. In the use of TLV's, it is important to recognize that the levels are generally developed for normal individuals doing normal work. Under conditions of high heat, unusual humidity, heavy exertion, abnormal pressure, or other work factors which may place added stress on the body, the effects from exposure to an air contaminant at its TLV may be altered. Generally, most of these stresses act adversely to increase the toxic response to a substance, and proper downward adjustment of the level should be made.

The TLV's for airborne contaminants are based on the premise that although all chemical substances are toxic at some concentration for some period of time, a concentration exists for all substances from which no toxicity may be expected no matter how often the exposure is repeated. A similar premise holds for substances producing irritation, discomfort and nuisance. In using these limits, items such as excursion factors, ceiling values, "skin" notations, mixtures of substances, and inert material should be considered. These factors are discussed below.

Excursion Factors — Most TLV's refer to time-weighted average exposures for an 8-hour work day and a 40-hour work week. However, in calculating time-weighted average exposure, excursions above the limit are permitted provided they are compensated for by equivalent excursions below the limit during the same work day. The question here is: "How much of a fluctuation above the limit is permissible in developing the average?" These fluctuations above the limits are related to the magnitude of the TLV for the particular substance (refer to Table 8).

Table 8. Permissible Excursions for Time-Weighted Average Limits

TLV (ppm or mg/m³)	Excursion Factor
0-1	3
1-10	2
10-100	1.5
100-1000	1.25

Note: These excursions are for a duration of only 15 min. or less.

Following are two examples of the use of excursion factors:

Example 1: Carbon monoxide has a TLV of 50 ppm. Therefore, the maximum concentration permitted for a short time would be 75 ppm (50 ppm x 1.5 = 75 ppm).

Example 2: Lead has a TLV of 0.2 mg/m³. Therefore, the maximum concentration permitted for a short time would be 0.6 mg/m³ (0.2 mg/m³ x 3 = 0.6 mg/m³).

The limiting excursion factors should be considered "rule-of-thumb" guidelines for listed substances, but are not appropriate for all materials (such as those designated "C").

Ceiling "C" Values — "C" designations following the names of some substances refer to a ceiling value which should not be exceeded for that substance for any period of time. In other words, the time-weighted average exposure should fluctuate below the C value. Generally, C values are assigned to substances whose action is chiefly irritation, narcosis, or productive of serious long-term effects from a single or a few peak exposures. These are usually fast-acting substances whose TLV is more appropriately based on a ceiling value than on a time-weighted average which allows excursions above listed values.

"Skin" Notation — The designation "skin" refers to the potential contribution to the overall exposure by the cutaneous route, including mucous membranes and eyes, either by airborne, or more particularly by direct, contact with the substance. Examples of such substances are phenol (cresol and cumene), hydrogen cyanide, and mercury. The "skin" notation is intended to make known the need to prevent cutaneous absorption so that the TLV is not violated.

Mixtures — Special consideration should be given to the application of TLV's in assessing health hazards which may be associated with mixtures of two or more substances. Generally, when two or more hazardous materials are present, their combined effect rather than either individual effect should be considered. In other words, the effects of the different hazards in a mixture should be considered additive. An exception may be made when there is good reason to believe that the chief effects of the different harmful substances are not in fact additive, but independent, such as a combined exposure to silica dust and lead dust. In the determination of whether or not the additive effects are excessive, the following formula should be used:

$$\overline{C} \quad \frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots \frac{C_n}{T_n} \qquad (6)$$

where C indicates the observed concentration and T the corresponding TLV.

If the sum of the fractions exceeds unity, then the mixture should be considered as being excessive. For example:

Air contains 0.3 mg/m³ of sulfuric acid mist (TLV = 1.0 mg/m³), and 2.8 mg/m³ of hydrochloric acid gas (TLV = 7.0 mg/m³).

$$\frac{0.3}{1.0} + \frac{2.8}{7.0} \quad \frac{2.1 + 2.8}{7.0} = \frac{4.9}{7.0} = 0.7$$

The sum is less than unity and the mixture is not considered excessive.

$$\frac{75}{100} + \frac{100}{200} + \frac{75}{200} = \frac{150 + 100 + 75}{200} =$$

$$= \frac{325}{200} \quad 1.6$$

Air contains 75 ppm of perchloro-ethylene (TLV = 100 ppm), 100 ppm methylethyl ketone (TLV = 200 ppm) and 75 ppm of propyl alcohol (TLV = 200 ppm).

The sum exceeds unity and the mixture is considered excessive. If desired, the TLV of the mixture itself may be calculated by dividing the atmospheric concentration of the mixture (75 + 100 + 75 = 250) by the concentration just calculated (1.6). Here, TLV of the mixture is 250/1.6 = 154 ppm.

"Inert" or Nuisance Particulates — Some materials may be classified as "inert" or nuisance particulates. Tables 9 gives some examples.

Generally, these materials have a long history of little adverse effect on the lungs and do not produce significant organic disease or toxic effect when exposures are kept under reasonable control. However, excessive concentrations of "inert" or nuisance particulates in the work air may seriously reduce visibility (iron oxide), may cause unpleasant deposits in the eyes, ears and upper respiratory passages (e.g., Portland cement and limestone dust), or may cause injury to the skin or mucous membranes during rigorous cleaning or mechanical action. To control these effects, a TLV for particulates with less than 1% free silica has been set at 10 mg/m³ or 30 mppcf (whichever is less) of total dust. The mg/m³ refers to a gravimetric standard and the mppcf to a particle count standard. The limits do not apply to brief exposures to higher concentrations during a normal work day, nor do they apply to substances which may cause physiologic impairment at lower concentrations, for which no TLV has been indicated.

Table 9. Typical "Inert" or Nuisance Particulates

Alundum (Al_2O_3)	Kaolin
Calcium carbonate	Limestone
Cellulose (paper fiber)	Magnesite
Portland Cement	Marble
Corundum (Al_2O_3)	Pentaerythritol
Emery	Plaster of Paris
Glass, fibrous or dust	Sawdust
Glycerin Mist	Rouge
Graphite (synthetic)	Silicon Carbide
Gypsum	Starch
Vegetable oil mists (except castor cashew nut, or similar irritant oils)	Sucrose Tin Oxide Titanium Dioxide

Time-weighted average exposures for an 8-hour work shift are calculated by the following formula.

$$E = \frac{(C_1 T_1) + (C_2 T_2) + \ldots (C_n T_n)}{\textit{Daily hours of work}} \qquad (7)$$

where E = time-weighted average exposure,
C = concentration during any period of time the concentration remains constant, and
T = the duration in hours of the exposure at C.

As an example, several air samples collected during an 8-hour work shift for benzene (8-hour time-weighted average

= 10 ppm) were 3 hours at 4 ppm, 1 hour at 15 ppm, 2 hours at 6 ppm and 2 hours at 9 ppm. The employee's time-weighted average exposure would be:

$$\frac{(3\,hrs \times 4\,ppm) + (1\times 15) + (2\times 6) + (2\times 9)}{8\,hours} =$$

$$= \frac{12 + 15 + 12 + 18}{8} = \frac{57}{8} = 7\,ppm$$

This exposure is not excessive since 7 ppm is below the 8-hour time-weighted average of 10 ppm.

Mixtures of air contaminants are additive and calculated in the manner described previously; that is, the fractions (concentration divided by limit for each material) are added together and if the sum does not exceed unity, the exposure is not excessive.

The primary purpose of monitoring the air in the work environment is to determine the level of employee exposure to airborne contaminants and to protect his health. Generally, where employees may be overexposed to potential health hazards, such sampling or measurements is performed on a routine basis. In addition to the above, sampling for air contaminants may be performed for one or more of the following reasons: (1) to determine the magnitude of employee exposure at the start-up of a new process or a change in a process or material used; (2) to determine the justification of employee grievances concerning an alleged health hazard; (3) to determine the performance or effectiveness of engineering control measures; (4) for research purposes, such as to determine the chemical and/or physical characteristics of contaminants, or (5) to investigate a potential health problem on a corporate wide basis. However, the majority of the sampling with which plant personnel will be concerned will be performed because of local or federal regulations. Those health standards under the Occupational Safety and Health Act (OSHA) require monitoring, on a periodic basis, of all employees who are exposed to harmful materials.

While the concept of air sampling and the use of air monitoring devices may appear to be simple, the details of a good monitoring program may be misunderstood unless the person engaged in sampling is adequately trained and technical supervision is provided by a professional industrial hygienist. Consequently, misapplication of techniques, errors in instrument performance, and errors in interpretation of sampling data are common when monitoring is conducted by those individuals whose training is limited solely to undertaking the monitoring required by federal and state regulations without the essential professional guidance. The major problems arise from accepting an instrument reading as reliable without determining its calibration and the reproducibility of its response; and in not obtaining representative tests. Plant personnel must have some experience with and knowledge of the resolution of these problems. This knowledge is also important in order to determine if air tests conducted by OSHA compliance officers are valid. For example, if threshold limit value in the health standard is an 8-hour time-weighted average, the air sample should be obtained by sampling over the entire shift in the employee's breathing zone. It cannot be measured by a few short term samples, even if spaced over the full shift unless the worker is in a relatively fixed location with no variation in his work procedure or in the process. Such an event is generally the exception rather than the rule. Unless established monitoring practices are conducted by plant personnel or the OSHA compliance officer, the results are of limited value in determining compliance with a standard, and what is more important, protecting the worker's health. The conduct of air monitoring by untrained, or poorly trained, persons relegates the program to a "numbers game" which serves no useful purpose.

A characteristic of the air contamination in most occupational environments is that there is most always a continual change in concentration with respect to time and location. This is particularly the case with respect to airborne particulates (dust, fumes and mists). Air currents within a room, process variations, changes in the work practice performed by an operator, and variation in the emission rate of contaminants are a few of the more significant factors resulting in this continual change in concentration throughout a work shift. This change in concentration will be less pronounced with gases and vapors than with particulates. However, generally speaking, marked concentration gradients can exist in most work areas which may be transient or relatively constant depending upon the contaminant sources and their number. Therefore, it is apparent that it would be most unrealistic to assume that the concentration of air contamination exists uniformly throughout a room or area.

The problem of determining the exposure of a worker to air contaminants is further complicated by the mobility of most workers who move about, in and out of, many areas

of a workroom. This mobility is characteristic of many assigned jobs. Therefore, the concentration of contaminants in each work area, and the time spent in each must be considered in determining the full shift time-weighted average concentration to which each worker is exposed. Exposure is concentration averaged over a time period, which in the general case is a full 8-hour shift. However, threshold limit values in the list published in the OSHA safety and health standards are peak concentrations or "ceiling values." Such standards indicate the maximum concentration which is allowed for any time period.

Although a single specific sampling strategy cannot be applicable for all air monitoring, general principles or considerations, which should be incorporated in such a strategy, can be developed.

There are a variety of air sampling instruments, as indicated previously, the normal variability of the concentration of air contaminants and the mobility of workers, the average full-shift exposure of a worker is a to different concentrations during a workday. This can be ascertained by determining each concentration and exposure period, which is an extremely time-consuming and costly procedure; however, a more effective procedure involves the use of a personal sampling device worn by the worker during his full working shift, or any portion thereof which may be under inquiry. It is important to recognize that no perfect instrument exists nor can any be worn by a worker or placed in a location without periodic observation if for no other purpose than to note variation in process operating conditions or work practices. Both people and instruments malfunction and environmental conditions can readily depart from normality. It is such observations which must be noted if sampling data is to be properly evaluated.

Standard sampling instruments and procedures have been developed by OSHA with the assistance of the National Institute of Occupational Safety and Health (NIOSH). These are developed to have OSHA industrial hygienists and compliance officers operate under a necessary standardized practice to determine compliance with standards. A principal consideration in their selection has been simplicity in operation and direct-reading response. Both of these requirements are important for any inspectorate as these individuals must engage in considerable travel and desire to ascertain compliance status as soon as possible. However, these OSHA sampling instruments and practices are not necessarily the optimum for individual plant use to provide the most accurate data, but a number of them can be so categorized as they have been selected from those long accepted by the industrial hygiene profession.

Air samples to be obtained generally consist of breathing zone and fixed position samples. While both have application in hazard evaluation, the former is to be recommended for general use in determining compliance with standards. The exposure of a worker can be measured most accurately by determining the concentration of the contaminant in the air which he breathes. This does not imply that the sampling instrument must be located a few inches from his nose, as such a location would be impractical and unnecessary. The instrument should be held or located as close to an employee's nose and mouth without interferring with his freedom of movement in the normal conduct of his work. While some individuals have indicated sharp concentration gradients around a contaminant source, sample locations for exposure measurement located 1-2 feet from the nose is adequately representative. Of more significance is the need for more than one full-shift sample if representative exposure data is to be obtained. Unfortunately OSHA standards for air contaminants are based upon a single 8-hour time-weighted average except where "ceiling value" standards are involved. Such a basis of determining compliance with standards for materials such as pneurno-coniosis-producing dusts do not recognize that these materials only produce long-term effects and hazard evaluation should be based on more than a single 8-hour sample. Such a single sample can be at considerable variance with the true exposure averaged over two or more days, nor is one rarely occurring excessive exposure hazardous to the employee. Nevertheless, the regulations require that samples must be based upon the sampling period prescribed in the standards.

Frequently it is desirable to obtain fixed position samples. For example, a worker may spend only a fraction of an hour in a job involving exposure to a contaminant and the remaining time in uncontaminated air. Such a breathing zone sample would collect such a small quantity of the contaminant that an accurate chemical analysis cannot be made. It would be preferable to locate a sampling instrument in a fixed position within the breathing zone of a worker when in the area and to sample for the entire shift. However, the concentration derived from such a sample must be time-weighted only for the actual time spent at the job to obtain the exposure of the worker involved. There are other instances when fixed position samples are desired, such as in control cabs, pulpits, etc., where the effectiveness of engineering controls or the

contribution of this location to the total exposure is desired. Another application for fixed position samples is to determine whether employees located at distances from an operation should be sampled. This can be readily determined by locating several fixed position samplers at different distances from a source of contamination. Still another type of fixed position sampling, although not directly a measure of employee exposure is the use of continuous fixed position sampling stations, such as commonly used in blast furnace divisions for carbon monoxide. These types of samplers may be the sequential multiple point sampler type or the single point sampler. They are generally arranged so that the sampling point is located in close proximity to points where accidental release of high concentration of gases having an acute effect may develop. Their principal use is to warn employees by means of an audible alarm to immediately leave the area. Such instruments also can provide a continuous recorded measurement of some gases or vapors which may or may not be exposure related.

Number of Samples — A reliable estimate of an employee's exposure requires replicate samples irrespective of their duration. This is basic whether or not one is concerned with 8-hour time-weighted concentrations, operational exposures or areal contamination. Differences involving a factor of five or more are not rare. Therefore, a minimum of three samples should be obtained, until experience dictates an upward or downward revision, based upon the variability so determined. One cannot emphasize too greatly that the objective of a sampling program is worker protection and not the collection of numbers. An occasional exposure to a concentration which exceeds the threshold limit values would result in a violation if the compliance officer is sampling on the day that such an exposure exists, even though the average of several daily samples obtained during the same week is within the standard. This demonstrates the difference between good evaluation techniques and the mere application of numbers.

In the development of a sampling schedule, one should remember that if an operation continues more than one shift, it may be prudent to collect samples during each shift, as exposure to airborne contaminants may be different for each shift. Furthermore, sampling should be performed during all seasons of the year (winter, spring, summer and fall). This is especially true for locations in areas where large temperature variations occur during the different seasons of the year. Generally, there is more natural ventilation in the warmer months with the buildings open, which tends to dilute air contaminants, than in the colder weather when natural ventilation may be limited due to closing of doors and windows. In summary, the minimum number and type of samples is dictated by OSHA standards. However, it would be highly desirable to obtain more than this minimum number of samples.

Duration of Samples — For a practical viewpoint the duration of samples will be dictated by the requirements in the OSHA standards. These are continuous 8-hour samples or short-term samples when the standard has a "ceiling value" or peak concentration limit. Scientifically speaking, the minimum volume of air to be sampled, or the duration of sampling, is based on the following consideration: (1) the threshold limit value (TLV) or regulatory standard; (2) the sensitivity of the analytical procedure; or (3) the estimated air concentration. Thus, the volume of sample needed may vary from a few liters, where the estimated concentration is high to several cubic meters where low concentrations are expected. Then, knowing the sensitivity of the analytical procedure, the TLV and the sampling rate of the particular instrument in use, one can determine the minimum time necessary for an adequate sample. However, the collected sample should represent some identifiable period of time — usually a complete cycle of an operation or so many minutes out of each hour. This will enable the worker's exposure on a time-weighted average basis to be calculated.

Preparation for Sampling — The successful application of any sampling program requires that one be knowledgeable of the processes involved, the potential hazards and be able to recognize hazardous work conditions. Therefore, the first step in evaluating the occupational environment is to become familiar with the operations in the plant. This is best obtained by a preliminary, or "walk-through", survey during which information is obtained on the job categories and the operations in each, the raw materials used, the process by-products, and the type of control measures afforded for the protection of the workers. This information should be recorded on an appropriate form following which the data is reviewed and the potential hazards indicated such as shown in Figure 13. Discussions should be held with supervisory personnel and industrial engineering personnel to obtain such details. It is imperative that plant personnel responsible for environmental health tests be considerably more knowledgeable of work practices and their environmental impact than one can expect from a regulatory official. Only by such experience can plant personnel determine if samples obtained are representative and accurate.

INDUSTRIAL HYGIENE SURVEY
WORK ROOM DATA

Name of Plant: Page 1 of 10
Department:

Informant's Name: Surveyed by: Work Room: 1
Date:

OCCUPATION	Number of Persons			NATURE OF JOB	RAW MATERIALS and BY PRODUCTS	CONTROL MEASURES							REMARKS & POTENTIAL HAZARDS
	M	F	T			Local Exh.	Isolation	Wet Method	Gas Mask	Respirator	Press Hel.	Other	
Machine Operators	20	-	20	Operate Screw Machines	Non-ferrous Metals Houghton #12 Oil							X	Dermatitis Oil Mist Noise
						Aprons							
Salvage Men	3	-	3	Centrifuge and Filter Spent Oil	Shavings — Non-ferrous Houghton Cutting Oil #12							X	Dermatitis Oil Mist Noise
						Aprons Gloves							
Total:													

Figure 13. Example of an industrial hygiene field survey.

Sampling for Gases and Vapors — Many gases and vapors can be sampled by devices which indicate the concentration of the substance during sampling or shortly thereafter, without the necessity for chemical analysis. These direct reading devices are convenient and useful when properly calibrated. Other substances cannot be sampled by this method, because no appropriate instrument is available, and indirect methods which require laboratory analysis of the sample must therefore be used. Such analyses are often delayed by days or weeks, depending upon laboratory schedules.

Direct reading samplers include simple devices such as colorimetric indicating tubes in which a color change indicates the presence of the contaminant in air passed through the tube, or instruments which are more or less specific for a particular substance. In the latter category are carbon monoxide indicators, combustible gas indicators (explosimeters) and mercury vapor meters, as well as a number of other instruments.

All instruments for sampling gases or vapors must be calibrated before use and their limitations and possible

sources of error must be fully understood. Every instrument has a lower limit of sensitivity which can be too high, making the instrument useless for health hazard evaluation. For example, some explosimeters are so insensitive that they show only the presence of nearly explosive mixtures of some solvent vapors, and give no response of levels which may be harmful to health. To be useful for environmental health purposes, an instrument should give a substantial reading at or near the TLV concentration and preferably should accurately indicate the presence of air contaminants as low as 10% of this concentration. Most direct reading instruments and many colorimetric indicating tubes are not sufficiently sensitive for this kind of sampling. The manufacturer's specifications should be reviewed before a sampling device is selected. But it should be remembered that specifications may be optimistic, and that it may not be possible to detect with certainty the concentration which is listed as the lower limit of detection.

Since no device is completely specific for the substances of interest, care must be taken that interferences do not invalidate the sampling results. Many common gases and vapors react with the same chemicals, or have similar physical properties, so that the instrument may give falsely high or low readings for the substance being sampled. The manufacturer's data for colorimetric indicating tubes lists those substances which may interfere with the desired determination.

If there is reason to think that interfering substances may be present, it is advisable to sample them to determine whether their concentrations are sufficiently high to actually constitute an interference.

It is very important to establish that an instrument responds properly to the substance it is designed to sample. This is generally done by calibration procedures with standard concentrations of the substance of interest. It is also desirable to spot test the instrument's response between calibrations. For this purpose, several suppliers of compressed gas prepare cylinders containing almost any desired concentration of the gas or vapor of interest. If it is not practical to keep such cylinders on hand, other procedures may be used. For example, a carbon monoxide meter can usually be checked by exposing it to a small amount of diluted automobile exhaust; a mercury meter can be checked by holding it above an open bottle of mercury; a combustible gas indicator (explosimeter) can be checked by exposing it to a solvent mixture such as gasoline, lighter fluid, or paint thinner. Although such rough checks are not quantitative, they indicate whether the meter is responding to the substance for which it is to be used. Indicating tubes cannot be tested in this way, since they are usually designed for one-time use. If there is any doubt about the response of indicating tubes, it is advisable to sacrifice one tube from the box, to be sure that the tubes in the particular batch are, in fact, responsive to the substance being sampled. In any case, it is desirable to check one tube from each batch with a calibrating gas of known concentration.

A sampling device may use one of three basic methods for collecting gaseous air contaminants. The first involves passing air through a direct reading instrument which indicates, without further analysis, the actual concentration of the substance at the time the sample is taken. The second method involves passing a known volume of air through an absorbing solution (a liquid which takes up and retains the gas or vapor), or an adsorbing medium (a solid substance which mechanically holds a solvent or vapor on its surface), to remove the desired contaminant or contaminants from the air. The absorbing solution may be a weak alkali solution (0.01% normal sodium hydroxide) in a fritted glass bubbler and the adsorbing medium may be chemically treated silica gel or activated charcoal sealed in a glass tube. In the third method, an air sample of definite volume at known temperature and pressure is collected in a container (an evacuated flask, a bottle, or a plastic bag) which is resealed immediately to prevent sample loss. It should be noted that samples collected by the second and third methods must be sent to a laboratory for analysis.

All three sampling methods should:

1. Provide an acceptable efficiency of collection for the air contaminant involved;
2. Maintain this efficiency at a specified air flow;
3. Have a high degree of reproducibility;
4. Require minimal manipulation in the field;
5. Avoid, if possible, the use of corrosive or otherwise hazardous sampling media.

The first (direct reading) method is fairly simple and results are available immediately. However, the instruments have limited sensitivity and must be recalibrated periodically.

The second (absorption in a liquid or adsorption on a medium) and third (gas container) methods are generally considered more sensitive and more accurate method for trace analysis by gas chromatographs, infra-red spectrophotometers, and similar instruments. However, because of their sophistication, both of these methods require careful handling to insure representative tests.

Direct reading instruments enable the operator to obtain immediate indications of gas or vapor concentration by reading a meter dial or by noting the length of stain on an indicator tube. This does not mean, however, that the mere reading of a meter implies a valid test. On the contrary, the operator must be thoroughly familiar with the use and limitations of the instruments and devices.

Direct Reading Instruments — Combustible Gas Explosimeters one of the most useful instruments of the direct reading type, also known as a combustible gas indicator. As the names suggest, instruments of this type were designed to detect the presence of explosive or combustible gases in the air. Safety checking is still their principal application, and many of them are suitable only for this purpose.

To understand the principle on which these instruments operate, the terms lower and upper explosive limits must be defined. When certain proportions of combustible vapor are mixed with air, ignition will produce an explosion. The range of concentrations over which this will occur is called the explosive range. It includes all concentrations in which a flash will occur or a flame will travel if the mixture is ignited. The lowest percentage at which this occurs is the lower explosive limit (LEL), and the highest percentage is the upper explosive limit (UEL). Mixtures below the LEL are too lean to ignite, and mixtures above the UEL are too rich. The relationship of gas and vapor mixtures to explosibility is shown in Figure 14.

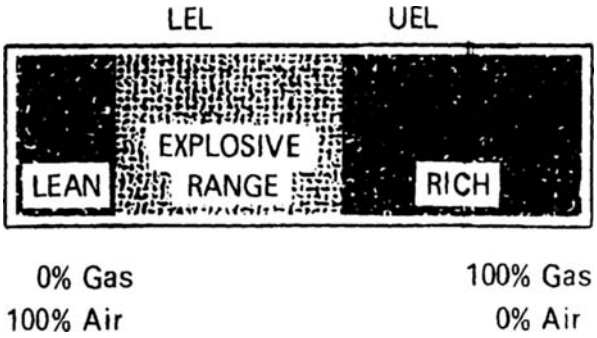


Figure 14. Illustrates flammability limits.

Explosive limits are expressed in per cent by volume of vapor in air. LEL's and UEL's have been determined in fire and safety, and health laboratories for all substances likely to be found in industry, and tables are included in this handbook. One table of such values for many solvents and gases is given in Table 10.

Table 10. Explosion Limits for Common Materials

Name	Flashpoint °F		Explosive Limits in air % by Volume		Autoignition Temp. °F	Density
	Closed Cup	Open Cup	Lower	Upper		Air = 1.0
Acetaldehyde	-36	—	4.0	55.0	365	1.52
Acetone	0	15	2.1	13.0	1000	2.00
Ammonia (Anhydrous)	Gas	Gas	15	28	1204	0.596
Amyl Acetate-n	76	80	1.1	7.5	714	4.49
Amyl Alcohol-n	91	120	1.2	—	572	3.04
Benzene	12	—	1.4	7.1	1044	2.77
Benzine	<0	—	1.4	5.9	550	2.50
Butyl Acetate-n	72	90	1.4	7.6	790	4.00
Butyl Alcohol-n	84	110	1.4	11.2	693	2.55
Camphor	150	200			871	5.24
Carbon Disulfide	-22	—	1.0	50	257	2.64
Carbon Tetrachloride	None	None				
Cellosolve	104	120	2.6	15.7	460	3.10
Chloroform	None	None	—	—		4.13
Coal Tar Oil	80-160	—	—			
Coal Tar Pitch	405	490	—	—		
O-Cresol	178	—	1.3 at 300° F	—	1038	3.72
Cyclohexanol	154	—	—		572	3.45
Denatured Alcohol — 95%	60	—	—		750	1.60

Table 10 continued.

Name	Flashpoint °F		Explosive Limits in air % by Volume		Autoignition Temp. °F	Density
	Closed Cup	Open Cup	Lower	Upper		Air = 1.0
Ethyl Acetate	24	30	2.2	11	800	3.04
Ethylene Glycol	232	240	3.2	—	775	2.14
Ethyl n-propyl ether		—	1.9	24	—	—
Formaldehyde, 37% in water	130	200	—	—	795	1.03
Fuel oil No. 1	114-185	—	0.6	5.6	445-560	—
Fuel oil No. 1-D	100 min	—	1.3	6	350-625	
Fuel oil No. 2	126-230	—	—	—	500-705	—
Fuel oil No. 2-D	100 min	—	1.3	6	490-545	—
Fuel oil No. 4	154-240	—	1	5	505	
Fuel oil No. 5	130-310	—	1	5	—	—
Fuel oil No. 6	150-430	—	1	5	765	—
Gasoline Automotive premium	-50+	—	1.3-1.4	6.0-7.6	770	3.0-4.0
Gasoline Automotive regular	-50 ±	—	1.3-1.4	6.0-7.6	700	3.0-4.0
Gasoline Aviation, commercial	-50 ±	—	1	6.0-7.6	800-880	3.0-4.0
Gasoline Aviation military	-50 ±	—	1	6.0-7,6	800-880	3.0-4.0
Hexane-n	-7	—	1.2	7.5	453	2.91
Hexane-iso	<-20	—	1	7	—	3.00
Hydrogen sulfide	Gas	Gas	4.3	45.5	500	1.18
Jet fuel JP-1	110-125	—	0.6	5.6	442-560	—
Jet fuel JP-4	26-36	—	0.8	6.2	468	—
Kerosene	110-130	—	0.6	5.6	440-560	4.5
Lacquer	0.86	—	—	—	—	—
Maleic Anhydride	218	240	—	—	890	3.38
Methyl Acetate	15	20	3.1	16	935	2.56
Mineral spirits	100 min	110	0.77@212°P	—	475	3.9
Naphtha	100-110	—	0.8	5	440-500	—
Naphtha VM&P	20-45	—	0.9	6.0	450-500	3.75
Naphthalene	174	190	0.9	5.9	979	4.42
Petroleum crude	20-90	—				—
Petroleum ether	<0	—	1.4	5.9	550	2.50
Phenol	175	185	—	—	1319	3.24
Phthalic Anhydride	305	330	1.7	10.5	1083	5.10
Pine oil	172	175	—	—	—	—
Propane	<-100	Gas	2.2	9.6	871	1.56
Propyl Acetate-n	58	70	1.7	8.0	842	3.52
Propyl Alcohol-ISO	53	60	2.5	12	750	2.07.
Quenching oil	365	405	—	—	—	—
Stoddard solvent	100-110	—	0.8	5	440-500	—
Styrene	90	—	1.1	6.1	914	3.60
Sulfur	405	440	—	—	450	—
Toluene	40	45	1.3	7.0	997	3.14
Trichloroethylene	Weakly Flammable		10 in O_2	65 in O_2	—	4.53
Turpentine	95	—	0.8	—	488	4.84
p-Xylene	77	—	1.1	7.0	984	3.66

Several manufacturers make explosimeters or combustible gas indicators. Although they differ somewhat in design and operating features, their operation is based on the fact that a measurable amount of heat is released when a combustible gas or vapor is burned. Most meters contain a battery-operated electrical circuit known as a Wheatstone bridge, which is balanced by means of controls on the outside of the instrument. A schematic illustration of the basic flow system and wiring diagram are shown in Figure 15. In one part of the bridge, the air being sampled is passed over filaments which have been brought to white heat. If the air contains a combustible gas or vapor, the heated filaments cause combustion and additional heat is released, changing the electrical resistance of the filaments.

Another part of the bridge contains similar filaments which are heated in identical fashion to those in the air stream; these cancel out all changes and resistance due to temperature variations or to characteristics of the instrument itself. The net effect is that the resistance of the filaments in the air stream changes due to the presence of combustible gases. These changes are converted into a small electrical current which is registered as "percent LEL" on the instrument's meter.

On the simplest type of instrument (an explosimeter) only one scale is provided, usually with readings from 0 to 100% LEL. However, the detectable changes produced by combustion are too small to be measured accurately in the presence of the low concentrations of contaminants usually encountered in evaluating potential health hazards. For example, the LEL of even the most explosive gas is of the order of 1%, or 10,000 ppm, which is well in excess of the toxic limit for any gas. Therefore, explosimeters or combustible gas indicators which have only a 0-to-100% LEL explosive scale are not suitable for environmental health testing in the ppm range.

More sensitive instruments, including the type used in sampling for environmental health purposes, have a dual scale, in which the second, more sensitive scale, expands the 0-to-10% LEL part of the instrument's response to full-scale reading (Figure 16). While this permits more sensitive and accurate reading of concentrations in the 0-to-10% range, this type of instrument is not sufficiently sensitive to give precise indications of concentrations at the TLV of many toxic gases and vapors. In addition, they lack specificity, do not read directly in TLV units (ppm), and are subject to interferences.

All combustible gas and vapor indicators are calibrated by the manufacturer using one specific gas or vapor such as methane, and a calibration curve is provided, in percent LEL, for the calibration gas only. Obviously, accurate concentrations of other gases or vapors cannot be indicated unless the instrument has been appropriately calibrated for each of these gases. Furthermore, the manufacturer's calibration may not be sufficiently accurate and a correction may be required.

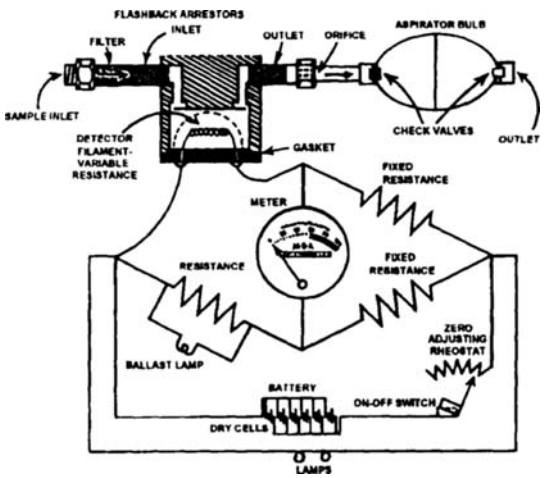


Figure 15. Schematic of standard combustible gas meter.

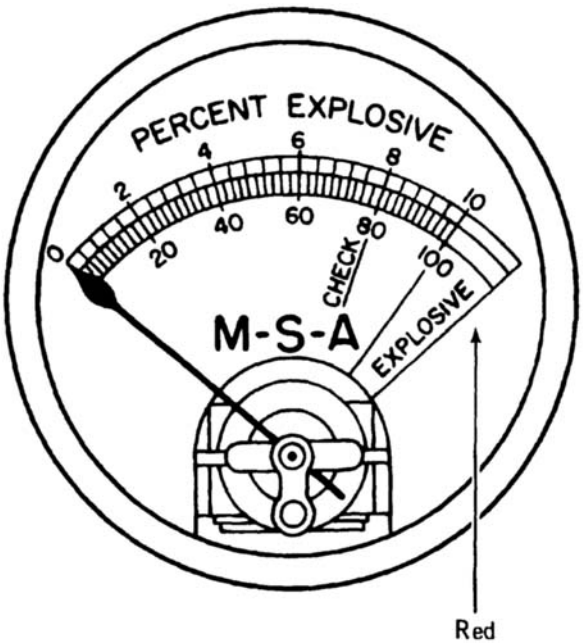


Figure 16. Scale on an explosion meter.

For example, a meter reading of 2.0 on the 0-to-10% LEL scale of one instrument would indicate, for a solvent having an LEL of 1.4%, a concentration of 280 ppm (0.02 x 14,000 ppm). Benzene, methyl isobutyl ketone (MIBK) For example, a meter reading of 2.0 on the 0-to-10% LEL scale of one instrument would indicate, for a solvent having an LEL of 1.4%, a concentration of 280 ppm (0.02 x 14,000 ppm). Benzene, methyl isobutyl ketone (MIBK) and toluene all have LEL's of 1.4%, but actual concentrations at a meter reading of 2.0 would be 294 ppm for benzene, 350 ppm for MIBK and 231 ppm for toluene. Therefore, unless the scale reading is corrected according to a calibration chart, to indicate actual ppm values, the reading can be seriously in error.

The manufacturer's instructions for operating a combustible gas indicator should be carefully reviewed before the device is used. In general, all explosimeters require a brief initial warm-up period so that the batteries can heat the filaments. Then battery strength should be checked, and the zero scale adjusted. When zero is established and the indicating needle is stable, the instrument is ready for use.

The zero adjustment must be made by taking the instrument to a source of air which does not contain combustible gases or vapors, or by passing air into it through an activated carbon filter which will remove combustible vapors and gases except methane. Since methane is not removed by activated charcoal filters, extra caution is required if the presence of methane is suspected. In addition, the filter should be changed periodically because it tends to become saturated during prolonged use and will no longer remove many of the combustible gases and vapors. If the zero adjustments are made in fresh air, care must be taken that no combustible gas or vapor is present in an amount which would influence the instrument's response.

Most combustible gas indicators are equipped with a length of sampling tubing with a metal probe at the end. The probe is held at the sampling point (usually near the breathing zone of the worker) and, a few seconds later, the response can be read on the meter. Generally, the air is drawn through the probe and meter by means of a hand-operated rubber squeeze bulb. In some instances, however, a small electrically-operated pump in the instrument case is used for this purpose. In most work areas, the concentration of combustible gas or vapor fluctuates constantly, and it is necessary to observe the instrument carefully and to make a judgment concerning average and peak readings.

Sometimes the probe of a combustible gas indicator or explosimeter is placed in a manhole or other space not normally occupied by people, to determine if there is a potentially explosive or dangerous concentration of gas present. When the instrument is used in this way, it may show a zero response for several different reasons. Assuming that the batteries are working and the instrument is functional, the absence of meter response can mean either that there is little or no combustible gas in the space being tested, or that the concentration is so high that it is above the UEL and combustion cannot occur because of lack of oxygen. A very high concentration can be identified by carefully watching the needle as the probe is moved into and withdrawn from the space being tested. At some point during entry and withdrawal, the probe must pass through the LEL concentration and enter the flammable range. At this point, the needle will jump briefly, then settle back to zero. This "chink" or jump is a clear indication that a high concentration is present. Dual scale combustible gas indicators are rugged, relatively lightweight, and portable so they are widely used for checking work operations like solvent cleaning or painting, or locations such as coal chemical areas where organic solvents are emitted. Their limitations must be realized, however, and where there is a possibility that benzene or an unknown and possibly toxic solvent may be present, they cannot be relied upon. In such cases, sampling must be performed by other means.

The user of any instrument should be thoroughly familiar with precautions to be taken in its operation; users of combustible gas indicators must also be aware of interfering gases and vapors which can create major aberrations in instrument response. One such precaution is that the 0-to-100% scale should be used first, to determine whether an explosive atmosphere exists and to prevent overloading to 0-to-10% LEL scale. For example, note the typical meter responses to methane gas shown in Figure 17, particularly those at the LEL, in the explosive range, and above the UEL. If the pointer of the meter travels into the red portion of the scale and remains there, an explosive concentration is present. However, if the pointer climbs rapidly to the red area and then falls back to zero, there is either a concentration above the UEL or a gas mixture which lacks sufficient oxygen to support combustion. Whatever the reason, if the pointer touches the red portion of the scale, the gas tester should leave the area immediately.

Interfering gases and vapors can seriously affect instrument response, and an experienced tester recognizes

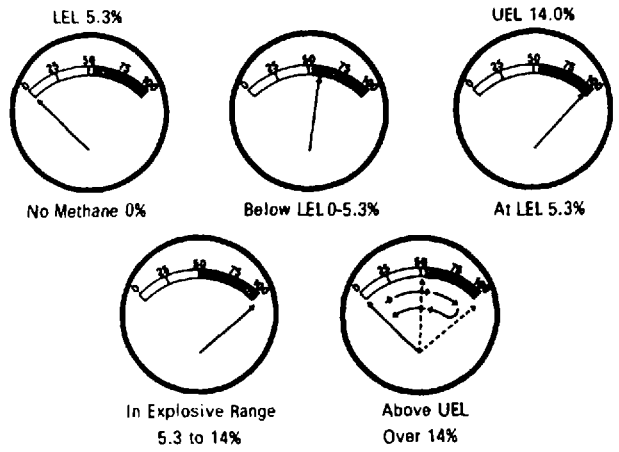


Figure 17. Examples of meter reading an explosimeter.

the indications of their presence. The manufacturer's instructions should be thoroughly understood. For example, high concentrations of chlorinated hydrocarbons (i.e., trichloroethylene) or of an acid gas (sulfur dioxide) may cause depressed meter readings when high concentrations of combustibles are also present. Trace amounts of these interferences may not affect the readings directly, but can corrode the sensitive detector elements. High molecular alcohols in the atmosphere may burn out the filaments, making the instrument inoperative. If such limitations are understood, the tester can obtain sufficiently valid results.

For calibration of the 0-to-100% LEL scale, test kits containing known concentrations of combustible gases (usually either 2.5% methane or 2.5% natural gas) are available from the instrument manufacturers. In using these kits, it should be borne in mind that the calibration is only for that specific gas and indicates only that the meter is operational on the 0-to-100% LEL scale. To calibrate to 0-to-10% scale, it is necessary to use purchased or specifically prepared known concentrations of gases in the TLV ranges.

Carbon Monoxide Testers — Carbon monoxide is one of the most commonly encountered toxic gases and may result from many industrial processes as well as from automobile or truck exhaust. Since pure CO is colorless, odorless, and tasteless, the senses cannot be relied on to give warning of its presence. Carbon monoxide may be sampled in several ways, including the use of the colorimetric indicating tubes, but for making repeated measurements over a period of time, a direct reading meter is frequently used. Such a meter is similar to a combustible gas indicator in that its operation involves combustion of the CO and measurement of the heat released by this combustion. However, both the design of the instrument and its method of measuring heat are considerably different from those in combustible gas indicators.

Carbon monoxide is combustible, but does not burn readily at low concentrations such as the present TLV of 50 ppm. However, it will burn at low concentrations in the presence of a catalyst such as hopcalite, a granular mixture originally developed for use in gas masks. A conventional meter contains one cell of inactive chemical (reference cell) and one cell of hopcalite (detector cell), each containing a number of electric wires or thermocouples which generate a small electric current when heated. The detector cell is surrounded by two thermistors (heat sensitive resistors) which are part of a Wheatstone bridge circuit. When air containing carbon monoxide is drawn through the detector cell, it is oxidized by the hopcalite. The heat created by this oxidation causes a change in the electrical resistance of the system which is registered by an upward deflection of the meter. The reference cell compensates for all temperature changes caused by the surrounding air or by variations within the instrument, so that the net reading is a measure of the concentration of CO in the air. Since the performance of the hopcalite is hampered by water vapor, the air must be dried before entering the catalyst chamber. The drying agent built into the instrument should be checked periodically, and replaced when necessary.

Oxygen Indicators — Air normally contains about 21% oxygen, and in most working places the concentration of contaminants is so low that this oxygen level remains essentially unchanged at all times. Even if there is a relatively high concentration (such as 1,000 ppm) of a vapor in the work atmosphere, there are still 999,000 ppm of air present, and for all practical purposes, this is no different from pure air insofar as its oxygen content is concerned.

In many locations, however — such as mines, manholes, tunnels, or other confined spaces — it is possible for the oxygen content to be sufficiently low that it is hazardous to life. In such situations, it is necessary to determine the oxygen content and, in addition, to sample to determine whether combustible gases are present in dangerous concentrations.

When oxygen reaches the inside of the cell, it generates a minute electric current which is converted to a voltage and is registered on a meter as a per cent of oxygen. The

instrument is basically stable, automatically compensates for temperature changes between freezing and about 100° F, and is not affected by carbon dioxide or relative humidity. It is readily calibrated by sampling ordinary air and, according to the manufacturer, this single point calibration is adequate. Complete instructions for its use, operation and maintenance are supplied by the manufacturer.

Indicator (Colorimetric) Tubes — The use of solid chemical detectors (indicating tubes) is common practice. They are simple devices to operate which tends to cause many users to ignore their limitations which must be recognized if they are to be useful in evaluating potential hazards due to air contaminants. This apparent simplicity increases the number of people who attempt to use them, which in turn results in wide variations in both individual competence and the accuracy of the data obtained.

It is essential for all users of air sampling devices to recognize that, while collecting an air sample is a simple procedure, it is only one part of the total procedure for proper evaluation of the environment. Only minimal skills are required to operate the instrument. Far greater knowledge and skill are required to recognize its limitations, to maintain and calibrate it properly, to obtain representative tests, and to know the strategy for obtaining valid data on workers' exposures. These are problems which require experienced and well-trained personnel who either are, or are under the direction of, professional industrial hygienists.

Making reliable tests with indicating tubes requires thorough knowledge of their limitations and care in their use. Experience has shown that the following measures help to minimize some errors:

1. Test each batch of tubes with a known gas concentration.
2. Read the length of stain in a well-lighted area.
3. Read the longest length of stain if stain development is not sharp or even.
4. Observe the manufacturer's expiration date closely, and discard outdated tubes.
5. Keep detector tubes in a shirt pocket or other warm place until time to start the test.
6. Refer to the manufacturer's data for a list of interfering materials.
7. Calibrate for the proper flow rate.

Indirect Sampling Devices for Gases and Vapors — As stated earlier in this chapter, not every contaminant can be sampled by a direct reading device. In such cases (or even in some situations involving contaminants which can be measured with direct reading devices) an indirect reading sampler must be used when the sample must be sent to a laboratory for analysis of the components. For this purpose, a number of glass or plastic bubblers are available, containing water or some other liquid to capture gases or dusts when air is drawn through them. Occasionally, filter papers are used, but since ordinary filter paper cannot trap gas or vapor, the paper must be treated with chemicals which will react with the substance of interest and retain it on the paper. For many purposes, gases and vapors can also be collected in bottles, in plastic bags, or in tubes which contain activated charcoal or some other adsorbent. Each of these methods is discussed below, since the person responsible for monitoring in each plant will be required to use them at some time.

Bubblers — Bubblers are ordinarily made of glass, although some are made of clear plastic. A stated amount of absorbing liquid is placed in a sample bottle which also contains the bubbler. When air is drawn through the bubbler, the contaminant is retained in the absorbing solution. The most efficient unit for sampling gases and vapors is a fritted bubbler, which is a piece of glass with thousands of small holes which disperse the air as it bubbles through the solution.

The choice of absorbing solution, the strength (normality or pH) of the solution, the sampling rate (generally 1 to 3 liters per minute), and the size of the bottle (20 cc, 50 cc, or 125 cc), are some of the variables which must be considered in using bubblers.

It should also be emphasized that the air flow calibration of bubblers should be done before field use. The calibration should be done with the same type and amount of absorbing solution as will be used in the actual testing, since absorbing solutions vary in viscosity and can directly affect the pressure drop in the sampling system. The pressure drop is also directly affected when the pores of the fritted bubbler become clogged thus lowering the efficiency of the bubbler and materially influencing the collection rate. To avoid such clogging, a filter must be used ahead of the bubbler.

Charcoal Tubes — Reference has been made earlier to adsorption, which is the property of some solid materials, such as activated charcoal, to physically retain solvent vapors on their surfaces. In environmental health testing, the adsorbed vapors are removed, generally with a solvent, in a laboratory. The solvent is then analyzed by physical methods (gas chromatography, etc.) to determine the

individual compounds whose vapors, such as benzene, were present in the sampled air.

Industrial atmospheric samples can be collected in small glass tubes (4 mm ID) packed with two sections of activated charcoal, separated and retained with fiberglass plugs. To obtain an air sample, the sealed ends of the tube are broken off, and air is drawn through the charcoal at the rate of 1 liter per minute by means of a personal sampler. After sampling, the tubes are resealed and sent to a laboratory for analysis.

Four precautions must be observed when this type of collection device is used:

1. The shorter (backup, or second) section of the charcoal tube should be inserted into the sampling line so that the air is drawn through the longer section first. When analyzed, the backup section should be void of solvent vapors - in other words, there should have been no carry-over from the first section.
2. The sampling rate must be maintained at 1 liter per minute. Sampling at a higher rate may elutriate the solvent vapors from the first section, in which case they may be adsorbed in, or even elutriated from, the second section.
3. Because of the limited adsorption capacity of the tube, the sampling period should not exceed 15 to 30 minutes. The time will depend to some degree on the expertise of the observer, since high concentrations of solvent vapors could saturate the first charcoal section in a few minutes.
4. The tubes should be carefully resealed, with the caps provided for that purpose, immediately after use.

Plastic Bags — Sometimes it is possible to sample simply by filling a bag, bottle, or other container with air from the working area and sending the container to a laboratory. Plastic bags have several advantages over bottles for this purpose. First, of course, they require little storage space and can be kept on hand at all times. In addition, they are available in relatively large sizes so that a much larger volume of air can be sampled than might be practical with a bottle. Finally, they are lightweight even when filled.

Among the materials used for these bags are Myler, Saran, and a laminated material called Scotch Pak. These bags are, in general, strong and impermeable, do not react with many of the common vapors which must be sampled, and do not themselves add contaminants to the air after it is collected. Commercially available bags come in various sizes ranging upward from 1 liter, and have built-in tubes for sampling purposes.

There are several ways to fill a sampling bag. The most common is to attach to the bag inlet a rubber bulb containing two valves, one to draw air in, the other to blow air out. If the bulb is squeezed rapidly, the bag can be filled in a very short time. If a rubber bulb is not suitable for the vapors of interest, some other means must be used to fill the bag.

Instrument Limitations — Every instrument has certain limitations which must be recognized. A number of these have already been discussed, and it is very important that they be kept in mind at all times. Otherwise, serious errors can result, rendering the tests meaningless or misleading. Following is a brief summary of limitations common to many instruments, but it must be emphasized that any given instrument may not be susceptible to any particular error:

1. All instruments are limited in specificity of response to the contaminant they are supposed to measure. Interferences may cause false readings and, as pointed out earlier, care must be taken to identify (and, if possible, compensate for) these interferences.
2. Any instrument is suitable for only a given range of contaminant concentration. This means that at certain very low levels, the instrument will not respond while, at very high levels, the reading may be grossly inaccurate or even meaningless. As discussed earlier, combustible gas indicators can even register zero in the presence of very high concentrations of vapors or gases.
3. Every instrument is likely to have a slight error, and the magnitude of this error, if it exists, must be known. It is meaningless, for example, to record an instrument reading as 51.3 ppm when in fact there is a known instrument error of $\pm$ 5%. It is also meaningless to report the average of several readings by a number which cannot be read on the instrument itself.
4. Every instrument which requires that air be passed through it, must be operated at a specific flow rate, or within a certain range of flow. Failure to sample at the correct flow rate can produce inaccurate or meaningless results.
5. A number of limitations are imposed by the construction of the instrument and its operating parts, including such factors as fully charged or new dry cell batteries, replacement of drying agents or other chemicals and, of course, how well the moving or consumable parts such as filaments have been maintained. Most instrument failures from these causes can be prevented by routine care and maintenance, and by periodic calibrations.

IV. RESPIRATORY PROTECTION

A. Anatomy and Physiology of Human Respiration

The most common complaint associated with respirators is the fatigue experienced by the user, which is caused by the added exertion to the lungs and muscular systems of the body when air is drawn through a respirator-filter mechanism. Before a person is assigned a respirator, the company must give the user a thorough physical examination. OSHA Standard 1919.134(b)(10) states "Persons should not be assigned to tasks requiring use of respirators unless it has been determined that they are physically able to perform the work and use the equipment". OSHA considers "should" as advisory in nature and "shall" as required or mandatory. Pulmonary function can be defined as a measurement of the lung's ability to exchange gases or ventilate itself by moving volumes of air in and out during breathing. Tests of lung function vary from simple measurements of vital capacity to the use of gaseous radioisotopes to determine regional ventilation and blood flow. The tests fall into two groups: (1) lung volume and air movement tests: and (2) gas exchange tests. A pulmonary function test, combined with medical history and physical examination, is the only true way to determine whether a person is physically able to wear a respirator.

The tracheobronchial system contains two types of airways: the bronchi, which consist of cartilage, and the bronchioles, which are noncartilaginous, or membraneous, airways. The primary function of the airway is to conduct air between the outside environment and the respiratory system. From the trachea downward, the airways divide progressively, similar to the branching of a tree. The branching may be symmetrical or nonsymmetrical. The total cross-sectional area of some 23 generations of airways increases, the significance being that resistance to airflow actually decreases as the air moves down from the larger airways to the bronchioles. The smaller bronchi and bronchioles less than 2 mm in diameter often are referred to as the "small airways." It is in this portion of the tracheobronchial tree that airborne substances are thought to exert their harmful effects. As these small airways contribute only 15% to total airway resistance, considerable disease must be present in them before usual spirometric tests become abnormal. The bronchioles, or noncartilaginous airways, continue to subdivide in a distinctive fashion (Figure 18) and serve mainly as conductors of air. Once the level of the respiratory bronchioles is reached, gas exchange can occur because there are respiratory tissues in their walls. The conducting airways, therefore, refer only

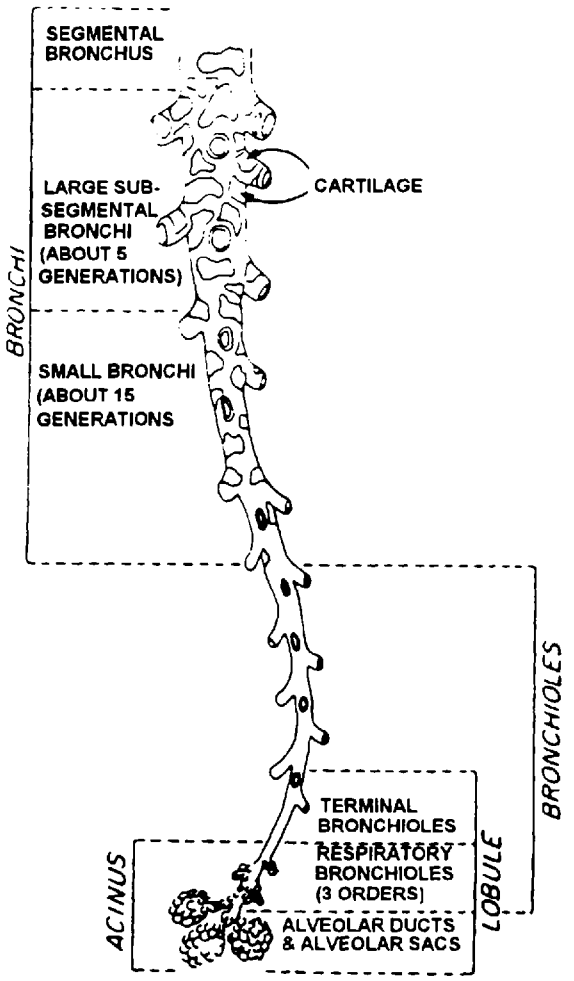


Figure 18. Progressive subdivision of the tracheobronchial tree, illustrating both conducting airways and the respiratory unit.

to the trachea, bronchi and nonrespiratory bronchioles. Gas exchange of oxygen and carbon dioxide takes place in the respiratory unit consisting of the respiratory bronchiole, alveolar duct, alveolar sac and individual alveoli. Deoxygenated blood reaches the alveoli via the pulmonary arterial system, the branching bronchi and bronchioles. This capillary plexus is in intimate proximity to the alveolar epithelium, so that red blood cells are separated from the inhaled air only by the thickness of the alveolar-capillary membrane (Figure 19). The alveoli have a surface area of about 70 m^2, providing a contact area for gas exchange equivalent to the size of a tennis court.

The lung has two separate blood supplies: one for the pulmonary circulation and the other for bronchial

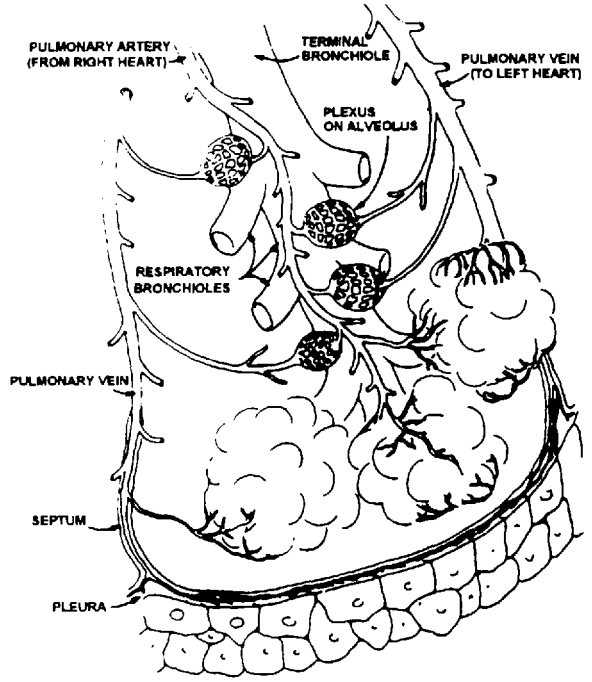


Figure 19. Pulmonary vascular system.

circulation. The pulmonary circulation handles the cardiac output, its major function being to oxygenate the blood. The bronchial circulation arising from the aorta receives only a small portion of cardiac output and contains only oxygenated blood. These bronchial arteries are the principal source of nutrient blood to the pulmonary tissue itself, including the tracheobronchial tree, pulmonary nerves, lymph tissue and the visceral pleura. Many hazardous materials are prevented from going down into the alveoli area by the lining of the airway. The lining of the airways (Figure 20) as far as the terminal bronchiole consists of two basic cell types: ciliated columnar epithelial cells and goblet cells. Goblet cells create a mucous layer that rests on top of the cilia and is swept mouthward by coordinated movement of the cilia. This mucous blanket, sometimes referred to as ciliary escalator, is an important defense mechanism for the removal of inhaled paniculate matter. Unfortunately, its efficiency may be impaired or destroyed by acids and bases or by cigarette smoke. Excessive mucous secretion, which occurs during chronic bronchitis, may impose an undue burden on cilia and contribute to plugging and narrowing of the airways. The cellular elements of the lung are supported mainly by a framework consisting of reticulin, elastin and collagen fibers. The presence of these fibers helps determine the compliance (stiffness) and the elastic recoil properties of the lung. Respiration is the utilization of oxygen and the various exchanges of gases that take place throughout the

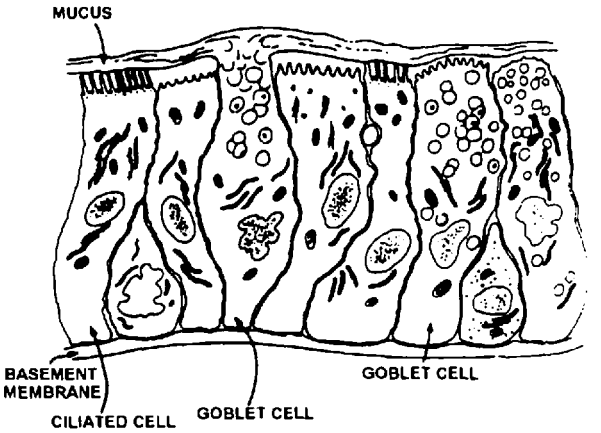


Figure 20. Illustrates lining of airway passages.

body as part of the metabolic process. The respiratory system is comprised of those parts of the body that involve breathing: the lung, the air passages leading to the lungs and the rib cage, the diaphragm and other muscles that help produce the movement of air into and out of the lungs. Figure 21 illustrates the movement of the rib cage during the breathing cycle.

Breathing is the result of a combined movement of the rib cage and the diaphragm, which increases or decreases the volume of the chest cavity. For inspiration, the ribs are raised and the diaphragm (which forms the bottom of the chest cavity) is lowered. In accordance with Boyle's law, the pressure in the chest is decreased as the volume is increased, and air from outside the body will move into the lungs because it is at a relatively higher pressure. When the rib cage is lowered and the diaphragm raised, the volume is decreased and air is forced out of the lungs.

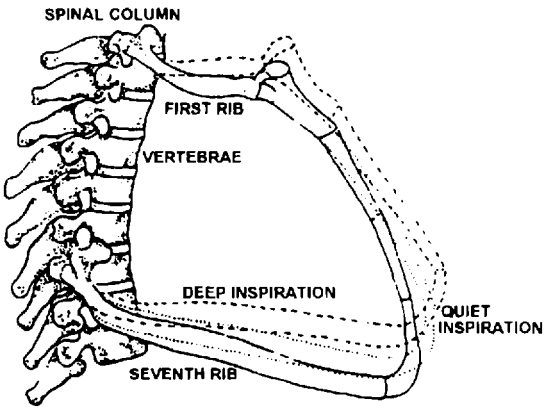


Figure 21. Rib cage movement during the breathing cycle.

However, no matter how hard a person might try, he cannot expel all the air from his lungs. A residual volume of 1-1.5 liters will remain always. Later, we will examine specific lung terminology, as modified by the physician, to measure the performance of the lung during the pulmonary function testing.

Total volume is the amount of air moved in and out of the lungs during a single breathing cycle. Tidal volume may vary from breath to breath, and usually will range from about 0.5 liters, when a person is at rest and breathing easily, to more than 2 liters, when he is working and breathing heavily.

Vital capacity of the lungs is the greatest amount of air that can be moved in and out of the lungs in a single breath. It is measured starting with the largest possible inspiration and then forcing out as much of the breath as possible, leaving only the residual volume.

Respiratory rate is the number of breathing cycles in one minute. A normal rate would be between 10-20 cpm. Respiratory minute volume (RMV) is the total volume of air moved in and out of the lungs in one minute. It is computed by multiplying the tidal volume by the respiratory rate. RMV ranges from about 6 l/min to more than 100 l/min.

Inspiratory reserve volume measures the amount of air that can be added to the lungs forcibly after taking a normal breath. Similarly, expiratory reserve is the amount of air that can be expelled forcibly after a normal expiration. Vital capacity = inspiratory reserve volume + expiratory reserve.

Respiratory dead space is that fraction of a breath that does not reach the alveoli and, therefore, does not participate in the gas exchanges in the lungs. This would include air remaining in the mouth and the other air passages, whichis brought in at the end of a breath and is pushed out ahead of the "used" air. The amount of dead space usually makes up about one third of the tidal volume in normal relaxed breathing.

Compliance generally describes stiffness or distensibility of the lung. It represents the relationship between the change in volume of air within the lung and the accompanying pressure change needed to cause that volume change. When the pressure needed to change the volume is great, the lung is stiff and compliance will be low. This is a situation found in various forms of pulmonary fibrosis, such as asbestosis. In contrast, with emphysema the volume change occurs when less pressure is exerted and compliance is increased or the lung is less stiff. Dynamic compliance is measured during tidal breathing; static compliance is measured at different lung volumes. Because compliance measures the distensibility of the respiratory system, it reflects the elasticity of the lungs or, more specifically, the elastic recoil properties of the lung and chest wall. Elastic recoil refers to the tendency of the lungs to return to the relaxed state at functional residual capacity. This elastic property is given by the intrinsic qualities of the lung tissue itself, as well as a film of surface-active material that lines the lung. Elastic recoil pressure varies with the type of disease; pulmonary fibrosis demonstrates increased elastic recoil pressure, and emphysematous lungs are more distensible due to loss of supporting tissue and have less elastic recoil.

Spirometry is the measurement of the ventilatory capacity of the lungs. Forced vital capacity (FVC) is the maximum volume of air that can be exhaled forcefully after a maximum inspiration.

Forced expiratory volume in one second (FEV_1) is that volume of air that can be expelled forcibly during the first second of expiration.

Body temperature, ambient pressure, saturated with water vapor (BTPS) occurs when the person tested exhales a volume of gas at body temperature (37°C). When collected in the spirometer, this volume rapidly cools to approach the lower ambient temperature and contracts. This reduced volume must be multiplied by the appropriate BTPS conversion factor to correct it to what it should be at normal body temperature (Table 11).

Table 11. Factors Used to Convert Gas Volumes from Ambient Temperature to BTPS

Temperature (°C)	Conversion Factor	Temperature (°C)	Conversion Factor
18	1.114	28	1.057
19	1.111	29	1.051
20	1.102	30	1.045
21	1.096	31	1.039
22	1.091	32	1.032
23	1.085	33	1.026
24	1.080	34	1.020
25	1.075	35	1.014
26	1.068	36	1.007
27	1.063	37	1.000

Forced expiratory flow during the middle half of the 25-75% FVC (FEF) is the average rate of flow during the middle two quarters of the forced expiratory effort.

Before the air ever reaches the lungs, it is possible for it to be heated, moistened and cleaned of foreign particles and bacteria while being drawn across the moist mucous lining of the nasal passages. Once the air moves into the lungs, it comes into contact with the walls of the alveoli. Here, it is separated from the blood circulating in the lungs only by the membrane walls of the alveoli and the capillaries. The oxygen, driven by its relatively high partial pressure in the lung, is dissolved quickly by the moist lining of the alveoli and diffused through the membranes into the blood. The partial pressure of oxygen in the blood entering the lungs is relatively low because much of the dissolved oxygen has been consumed in the various cells. At the same time, the partial pressure of the carbon dioxide in the blood is relative to that in the lungs, and a quantity of carbon dioxide will diffuse quickly into the area of lower partial pressure in the alveoli. As an example, at atmospheric conditions the partial pressure of oxygen in the blood entering the lungs is about 40 mm of mercury (Hg), while the partial pressure of the carbon dioxide is about 46 mm Hg. The partial pressures of oxygen and carbon dioxide in the inspired air are about 158 mm Hg and 0.30 mm Hg, respectively. The partial pressure gradients of each gas are high, and diffusion into and out of the blood will proceed almost instantaneously. The partial pressures in alveolar air are almost the same as those for blood leaving the lungs because the exchange of gas takes place so rapidly that the composition of the inspired air is changed as it reaches the walls of the alveoli. This alveolar air mixes with used air in the respiratory dead spaces on the way out of the body and then becomes expired air. This has a partial pressure of about 116 mm Hg for oxygen and 28.5 mm Hg for carbon dioxide.

The concentration of oxygen and carbon dioxide in the arterial blood is relatively constant whether the body is at rest or at work. It is determined primarily by the partial pressure of the gases in the alveoli. When a working body requires greater quantities of oxygen, the additional supply is provided by an increase in the cardiac output. A corresponding increase in the RMV provides more fresh air to match the larger flow of blood moving through the lungs. Oxygen consumption indicates the amount of oxygen being taken into the system and used. Oxygen consumption may vary from 0.25 l/min for a man at rest to more than 3 l/min when doing hard work.

Abnormal cardiopulmonary physiology refers to this as chronic obstructive pulmonary disease (COPD). Airway obstruction brings about an increase in airway resistance and results in reduced expiratory flowrates and increased work of breathing. Blood pH levels are determined by the ratio of bicarbonate ion concentration to CO; concentration, normally 20:1. a ratio physiologically maintained by means of disposal of CO; by the lungs and of bicarbonate by the kidney. As impairment of alveolar ventilation increases, CO; retention appears. Generally, medical technicians obtain a microsample of blood from an ear puncture for determining the pH and other acid-base values.

The respiratory therapist and physician would be interested in the patient's respiratory acidosis, which is the excess CO; resulting from inadequate alveolar ventilation. Respiratory alkalosis is a deficit of CO_2 resulting from alveolar hypersensitivity. The area we will examine is the use of the spirometer and the accompanying charts for comparison. The medical terminology of inhalation therapy is more directed to pulmonary disease treatment, which one is attempting to prevent with the use of respirators. It should be noted that once the worker or person impairs his lungs, modern medicine cannot reinstate previous capacity. At best, present technology can only ease the pain.

Spirometry - As spirometry is the measurement of the ventilatory capacity of the lungs, one should be concerned about the validity and reproducibility of this type of test and the factors that affect these considerations.

There are several types of equipment on the market today, whose principal differences are the methods in which the recorded data are presented. Some equipment models produce an accurate graph on which calculations are made to determine values such as FEV, FVC, etc., which produce the numbers in tabulated form.

The spirometric technique test measures FVC and FEV_1. The person performing the test must blow as hard and fast as possible into the tube connected to the spirometer. The person doing the testing should advise the person doing the test to relax. Smoking or the use of an aerosolized bronchodilator can alter the accuracy of testing. The individual may sit or stand; nose clips are provided but generally are not worn. The following three graphs (Figures 22 a,b,c) are unacceptable for the reasons given.

In these situations, some people get nervous and cough; some either cheat or think they are supposed to show improvement with testing; and others do not blow hard enough. The two best FVC must be within 5% (100 ml) of each other. Figure 23 illustrates this mathematically.

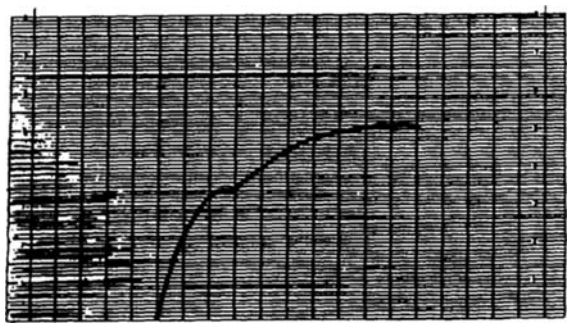


Figure 22a. Unacceptable tracing - cough.

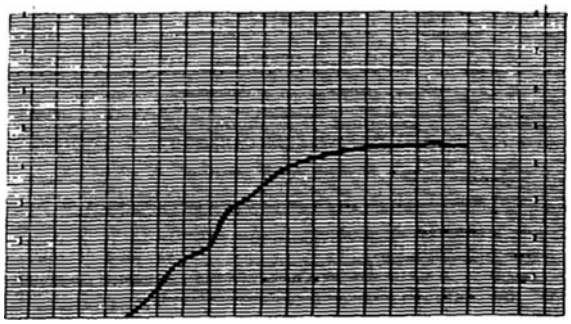


Figure 22b. Unacceptable tracing - inconsistent effort.

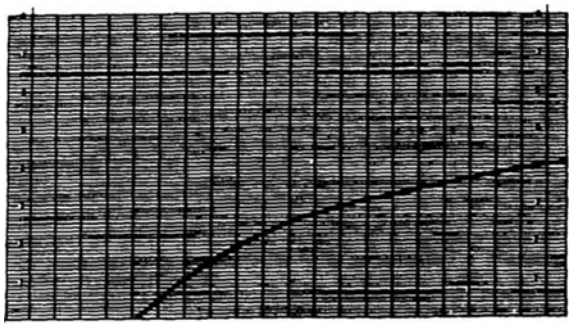


Figure 22c. Unacceptable tracing - early termination of expiration and failure to "plateau".

B. Toxicology

To select the proper respirator for use in an environment, the constituents of that environment must be determined as accurately as possible. The different types, concentrations and toxic effects of this environment must be analyzed carefully by a trained industrial hygienist, safety engineer or medical professional. These professionals depend on

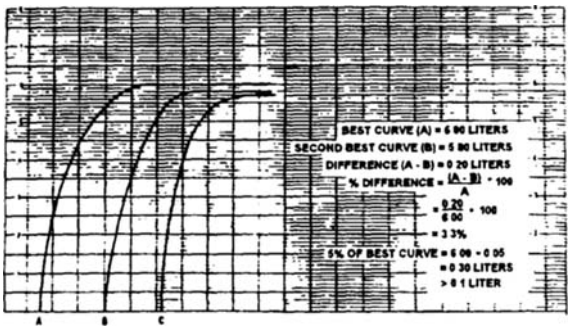


Figure 23. Valid spirogram - two best curves within 5%.

research data on various substances, and their effects on biological systems and living organisms, whether they be plants, animals or humans. This subsection presents the basic terminology of the field of toxicology to aid the user in understanding the potential hazard as it pertains to respiratory protection.

Most toxicological research falls into three main categories: environmental, economic and forensic. Environmental concerns pollution, residues and industrial hygiene. Economic areas involve drugs, food additives, pesticides and insecticides. Forensic areas include diagnosis, therapy and medical/legal aspects. The respirator user is concerned with the work done by groups such as the American Conference of Governmental Industrial Hygienists and the American Industrial Hygiene Association. As early as the 1940's, these groups began to publish lists of commonly encountered chemicals and their tolerable level of worker exposure. For the first time, groups in various segments of industry and government began to correlate these data and seek common grounds in the development of health standards. With the passage of the Occupational Safety & and Health Act (OSHA) and the creation of The National Institute of Occupational Safety & Health (NIOSH), the mechanism for implementing and enforcing the standards of employee exposure and research finally arrived at the industrial level.

Toxicology, as all sciences, has its own terminology. The most basic term is exposure. Exposure is the length of time an individual is in contact with a substance. The period of time may be short, usually referred to as being acute; or long, referred to as being chronic.

As in any investigation, the next questions concern how the individual came in contact with the material or what was the route of entry of the material into the body or system. Was it absorbed through the skin, ingested

through the gastrointestinal tract or inhaled by breathing? Of the three methods of entry, inhalation is regarded as the most important because it is probably the most frequent point of entry. Substances suspended in the air in the form of fumes, mist or vapors, dusts (particulate) or gases are breathed in easily through the nose and mouth and can be deposited in the lungs. Some of the material passes through the alveoli directly into the blood. Other materials may be acted on by the gastrointestinal tract or the lymphatic system.

As in a chemical reaction, the rate at which the material enters the body depends on the concentration of material, the dose to which the individual is exposed and how fast the material can pass through the body's cell membranes and protective reactions.

In respiratory protection, the objective is to prevent these materials from entering the body system, but the knowledge that the material ultimately will end up in a specific organ is the only proof that a respirator is effective. If that organ is accumulating the material that the respirator is designed to protect against, another type of respirator or additional control methods must be instituted immediately.

Generally, the organs most commonly affected by chemicals in the blood are the liver and kidneys. They have a high capacity to extract many chemicals, and the liver has a high capacity to metabolize them. Two other areas of concern are bone cells and fat cells. Chemicals such as DDT usually are found in the fatty tissues of man, and more than 85% of the lead in the body is found in the skeleton (bone structure). Methods of respiratory protection are designed to protect those exposed to lead and most pesticides, so correlations are possible-between deposition of these materials in areas of the body and respiratory effectiveness.

As mentioned earlier, the body has several defense mechanisms that are important and should be examined. In the measurement of the time a substance is retained in the body, the biological half-life (the time in which one-half the compound present in the body is eliminated from the body) is of great importance. For example, caffeine has a biological half-life of four hours. Substances or chemicals that are absorbed into the body's cells sometimes are bound to a protein and removed by excretion by the kidneys. Researchers in the respiratory protection field are concerned with the excretion of carbon dioxide. The physician is concerned that the blood pH level remain normal. Blood pH level is determined by the ratio of bicarbonate ion concentration to CO_2 concentration, normally 20:1, a ratio physiologically maintained by means of disposal of CO_2; by the lungs and bicarbonate by the kidneys. Biotransformation is the ability of a cell to alter normally existing and foreign compounds, which change into more or less toxic levels than the original chemical. Drug-metabolizing enzymes, abundant in liver cells, usually are involved in the biotransformations.

Death could be the most immediate response to a toxic substance. The problem with toxic substances that cause dysfunction of an organ or system of the body is the time between exposure and onset of the disease or illness. Reuse of the organ may be partial or complete, but of major concern is the attitude of the respirator user. A common problem can be illustrated as follows: an employee is told he will become sick within 20 to 30 years if he does not wear a respirator. The employee is 50 years old and does not expect to live to be 70. At 68 years of age, another individual, who was not required to wear a respirator 18 years earlier, retires from the firm with a pension—and cancer. He sues the company for $20 million, claiming willful disregard for his health and staling that the company knew or suspected that the material he was working with could cause cancer. This type of situation keeps enrollment in law schools almost as high as the legal fees involved in settling the case. Basically, eight typical responses are observed as shown in Table 12.

Table 12. Toxic Responses

Type	Example/Response
Behavioral	Oxygen deficiencies/loss of perception Mercury/emotional problems
Biochemical	Organophosphorus insecticides/prohibit acetylcholinesterase/result in nerve tremors
Carcinogenic	Vinyl chloride/cancer of the liver
Mutagenic	DNA and gene changes in infants
Pathological	Silica/lung tissue is deformed
Physiological	Ammonia gas/decreased pulmonary function
Reproductive	Cadmium/affects the reproductive organs and their ability to function properly
Teratogenic	Thalidomide/damage to a developing offspring in a pregnant female

The respiratory tract from the nasal cavities and mouth to the lungs is lined by delicate cells covered by a moist

mucous layer. Various chemicals and their compounds can attack this lining and the lungs, producing a variety of results. The most common substances are those that are either acidic or alkaline, which irritate this area and cause inflammation. It is very difficult to distinguish a common throat irritation from inflammation caused by toxic substances in the early stages. The solubility of the material is usually a key factor. Materials that dissolve in the blood are removed. Ethyl ether, for example, is absorbed by the alveoli and does not accumulate to cause damage. Nitrogen dioxide does not dissolve, so it tends to pass onto and irritate the lungs. A common problem with welders of aluminum is that the ozone produced tends to make the walls of the alveoli less elastic, so more effort is required to breathe.

The most common of the lung and respiratory diseases is "pneumoconiosis". It generally means dust in the lung, but really describes a tissue response of the lung to inhaled dust or fibers. Dust generally causes the respirator user the greatest problems. In the past, when miners used non-automatic or pneumatic tools and drilling equipment, they claimed that the particles were larger and more easily removed by the lungs. Black lung, a type of pneumoconiosis, resulted from the use of automatic equipment. The automatic equipment removed more coal but generated more dust, winch either was not removed by ventilation or overloaded the filters used in prevailing respirators. The respirators used created too much of a pulmonary strain on lungs that already were reduced in capacity by years of working in the mines. Once clogged, the respirator strained the wearer to the point where he removed it.

Silicosis is the classic example of pneumoceniosis. The lung's protective system tries to remove the silica particles by phagocytizing or engulfing them. The silica destroys the phagocytes, and other phagocytes form layer-nodules, which usually are detected by X-rays. Foundry workers exposed to silica experienced relief when green olivine, nonsilica sands were used.

The most widely publicized lung-induced disease is asbestosis. This disease results from the chronic inhalation of asbestos, a group of chain silicates that occur in natural forms. Asbestosis may not become apparent until 5-20 years after exposure to asbestos.

The most common form of lung problem that produces immediate death is asphyxia - lack of oxygen sufficient to endanger life. Every year, firemen, utility workers, coal miners, bin and silo workers are exposed to air with concentrations of oxygen less than the normal 16-19.5% by volume. Physiologically, anoxia is the diminished availability of oxygen to the cells of the body, while asphyxia is the condition of the body due to anoxia. Table 13 provides the oxygen level versus physiological effect.

Table 13. Physiological Effects vs. Oxygen Concentration

Oxygen — Volume Percent at Sea Level	*Physiological Effect*
16-12	Increased breathing volume, accelerated heartbeat, impaired attention and thinking, impaired coordination.
14-10	Faulty judgment, very poor muscular coordination, rapid fatigue that may cause rapid heart damage.
10-6	Nausea, vomiting, inability to perform vigorous movement or loss of movement - inconsciousness.
Less than 6%	Death in minutes.

Another form of asphyxia, chemical asphyxia, is common in carbon monoxide deaths. When inhaled, carbon monoxide gas reacts with the hemoglobin, the oxygen carrier in the blood, to form carboxyhemo-globin. The individual dies of oxygen deficiency. A common symptom at low levels of exposure is headache. Higher levels of exposure are usually identified by high levels of redness of the skin.

Testing with Animals — Experimentation on animals is the accepted method for determining toxicity. As a note of caution, however, little is known about the effect of the low dose rates on animals that survive. Some state (hat there are no safe levels of carcinogens, while some agree that "feasible engineering controls" can reduce the current TLV to an acceptable OSHA level. In regard to the number of animals necessary to determine a low level response, in essence, as the magnitude of the effect (or its incidence) tends toward zero, the number of experimental subjects needed to demonstrate the effect tends toward infinity.

Experimental animals should be physically small, inexpensive, easily handled, easily fed with inexpensive food, not dangerous to man by direct attack, and (if possible) of a standardized strain of the species used. The life span of the animal is important, as well as its ability to breed easily in captivity. For special purposes, monkeys and apes are chosen. Of great importance here is that the animal be physiologically comparable to the human with regard to the site of toxic action. A classic case was the testing of the drug Thalidomide. This supposedly mild

sedative produced more than 10,000 malformed children in Germany, Japan and other parts of the world.

Subsequent studies revealed that Thalidomide caused malformations only when taken by pregnant women between days 35 and 50. Prior to, or after, that time. there was no effect on the developing child. Animals tested with the drug showed no sign of birth defects.

Another important aspect is the relative size and weight of the test animal. Table 14 compares the dosage of the substance by weight and surface area to different species. These data indicate the amount of material that must be fed to the animals.

Chamber shape and air movement are important design considerations. The inlet and exhaust are designed so concentrations of air contaminants are uniform across a horizontal cross section of the chamber. Large access doors provide for the efficient loading and unloading of the animal cages. It is suggested that toxicity is often markedly greater in animals being exercised than in sedentary animals in the same atmosphere.

2. Routes of Entry

Percutaneous Route

The various basic concepts of toxicology have been discussed. In applying them to the respirator user, we will try to correlate these basics with actual field problems. As a respirator is designed to protect the lungs and inhalation system, the skin often is neglected or disregarded. Most respirators disregard the skin and concern themselves only with about 10 square inches of skin covering the nose and mouth. Many substances such as alkaloids may pass freely through the skin. Lipid-soluble compounds such as phenol and phenolic derivatives are readily absorbed into the skin. Strychnine and nicotine, common organic compounds, also can be absorbed into the skin, as well as hormones such as estrogen and progesterone. Therefore, the respirator may offer false comfort if protective clothing is not also worn where required.

Oral exposure is also a problem for workers who do not have a lunch room, smoking area and lavatories to wash properly. The common route of exposure to body lead is often cigarettes left in an open shirt pocket and smoked with dirty hands while the respirator rubs on a shirt with lead dust.

Common in laboratory animal testing is the parenteral route of entry, which, by definition, is as follows: introduction of chemicals into the organism by means of injection of the chemical from a syringe through a hollow needle at specific sites in the animal. As animal testing is very common, the typical method of administration of the test chemical is as:

- Skin (intradermal)
- Beneath the skin (subcutaneous)
- In the muscle (intramuscular)
- Into the blood of the veins (intravenous)
- Into the spinal fluid (intrathecal)

Table 14. Comparison of Dosage by Weight and Surface Area (100 mg/kg)

Species	Weight (g)	Surface (cm^2)	Dose by Weight (mg)	Dose by Surface (cm^2)	Ratio
Mouse	20	46	2	2	1.00
Rat	200	325	20	14	1.43
Guinea Pig	400	564	40	24	165
Rabbit	1,500	1,272	150	55	2.74
Cat	2,000	1,381	200	60	3.46
Monkey	4,000	2,975	400	128	3.12
Dog	12,000	5,766	1,200	248	482
Man	70,000	18,000	7,000	776	9.08

- Into the chest fluid (intrapleural)
- Into the abdominal fluid (intraperitoneal)
- Into single cells (intracellular) — by use of micropipettes

Two common examples of workers who experience fluids injected into their skin are: (1) diesel mechanics, who put their fingers on the diesel fuel injector port, causing the fluid to be injected under the skin: and (2) painters, wh use the high-pressure (3000 psi) paint systems with solvent when cleaning the spray gun. As a large volume of the data in toxicology is acquired in studies in which animals are injected, the toxicologist should be consulted before any comparison is made to the other methods. The most important route of entry to respirator users is inhalation. Every day workers are exposed to particulates, vapors, and gases, or combinations of the three. Most normal manufacturing operations produce these when materials are added, mixed, poured, welded, machined, shaped, cleaned or painted to produce a product. Particulates generally are defined further in the following categories:

- **Mechanical dispersoid** — particulates of solid or liquid matter formed and dispersed into the air by mechanical means, such as grinding, crushing, drilling, blasting and spraying.
- **Condensation particulates** — solid or liquid matter formed and dispersed into air by reactions such as combustion.
- **Dust** — a dust dispersed phase is a solid mechanical dispersoid ranging in size from submicroscopic to visible.
- **Spray and mist** — a liquid splashed onto the surface for coating or cleaning. While droplets the size of sprays are visible, a mist droplet is not.
- **Fume** — the condensation of a liquid into a solid, typically a welding alloy. The particles are extremely small, generally less than 1 nm in diameter.
- **Fog** — a mist dense enough to obscure vision.
- **Smoke** — the products of incomplete combustion of organic substances in the form of solid and liquid panicles suspended in air and gaseous products mixed with air. It is visible and generally obscures vision.

Considering that these various physical states are inhaled easily by the operator and people in adjacent areas, the exposure can be significant.

3. Dose Response

Of major concern is the acceptable level for a particular substance. Historically, the material tested was to be used as a poison, thus pioneering the lethal dose concept. Certain species of animals are fed increasingly higher doses of a substance until the response is death. Lethal dose — the amount to kill 100% of a certain species — or LD_{100}, was born. Lethal doses for 5, 20, 30, 50, 70, and 90% also were established. With the high cost of animal testing, the LD_{50} is generally referenced most. Figure 24 shows two hypothetical dose-response curves for two chemical agents - the LD_{50} lines. That one substance is safer than another is illustrated by the two different LD_5's and LD_{50}'s on the graph. Substance D killed more animals at LD_5 than substance C, but substance C killed more animals at LD_{50} than substance D. It should be noted that different studies have arranged toxicological data to illustrate the relative safety or hazard of the substance, depending on whether the data were aimed at justifying the material or having it removed from the marketplace. Pharmacologists use the relation of lethal dose 50 to effective dose 50 to relate a margin of a drug's safety or therapeutic index. Anyone who has read a prescription drug package recently knows that warnings are numerous and specify a doctor's advice. With the thousands of substances used in the work environment, it is a wonder that more problems are not encountered.

As usually more than one substance is involved in an operation, the term "synergistic" or "combined response"

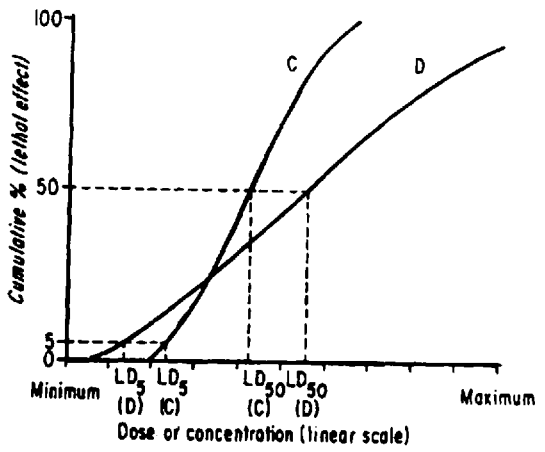


Figure 24. Hypothetical dose-response curves for two chemical agents (C and D) administered to a uniform population of biological specimens.

is used. Synergistic responses usually mean additive in nature, but research has shown that substances can combine to form less hazardous responses than when exposed to only one substance at a time. Table 15 summarizes classifications categorizing relative toxicities.

C. Respirator Filters and Chemical Cartridges

1. General Information

Particulate Filters — in OSHA Section 1910.134 (Respiratory Protection) Subpart(a)(l) (the control of those occupational diseases caused by breathing air contaminated by harmful dusts, fogs, fumes, mists, gases, smokes, sprays or vapors), the primary objective is to prevent atmospheric concentration. This is accomplished as much as is feasible, by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation and substitution of less toxic materials). When effective engineering controls are not feasible, or while they are being instituted, appropriate respirators shall be used according to specified requirements.

As discussed in earlier, the materials in question must be examined for toxicity, levels of contamination and respirable nature. Sampling must be conducted to determine whether overexposure exists. Overexposure can be defined as exposed to air contaminants at a level greater than that specified by legal OSHA standards.

Once sampling is conducted and the level of overexposure to the air contaminant determined, the type of respirator is chosen.

Mechanical Filters — mechanical filter respirators are based on the principle that particulate matter is retained when air is passed through a filter of fibrous or other material.

Some filter media can vary widely in construction and design, so the separation mechanisms must be considered carefully. The effectiveness of all separation mechanisms is related primarily to particle size.

Materials used in early respirators were of cellulose fiber. Cellulose, plastic, glass, wool and combinations of two or more of these materials are more common today. A controlling factor is cost. As the filters have a limited life span and reuse is impossible because there is no way to clean them, disposability is a key factor. Two items come into consideration at this point; resistance to flow by clogging and channeling.

Channeling is the physical occurrence in which large openings exist due to nonuniform filter media. The incoming particles take the path of least resistance and all tend to flow or channel through the opening. There are five criteria that must be considered for a filter medium to provide good filtration:

- Direct interception
- Impaction (inertial contact)
- Diffusion (Brownian motion)
- Electrostatic attraction
- Gravity

The particle size range for the respirating mechanism for each of these is shown in Table 16.

Table 15. Summary of the Classification That Places Toxicants Into Categories Related to Their Relative Toxicities

Toxicity Rating	Commonly Used Term	Probable Human Lethal Dose for a 70-kg (150-lb) Man
6	Supertoxic	< 5 mg. kg (a taste), < 7 drops
5	Extremely toxic	5-50 mg/kg. 7 drops-1 tsp.
4	Very toxic	50-500 mg/kg, 1 tsp.-1 oz
3	Moderately toxic	5-5 g/kg, 1 oz-1 pint
2	Slightly toxic	5-15 g/kg, 1 pint-1 quart
1	Practically nontoxic	>15 g/kg, >1 quart

Table 16. Particle Size Range for Separating Mechanisms

Force	Particle Size Range (μ)
Direct Interception	>1
Impaction (inertial contact)	>1
Diffusion (Brownian Motion)	<0.1 to 0.2
Electrostatic Attraction	>0.01
Gravity	>1

Direct interception of a particle occurs (Figure 25) when a particle of radius "r" approaches a fiber along a streamline that passes more closely to the fiber than the distance "v". The particle strikes the fiber and is collected. The formula is:

$$R = \frac{r}{r_v} = \frac{d_p}{d_f} \qquad (7)$$

where
R = direct interception parameter
r = particle radius (μ)
r_v = fiber radius (μ)
d_p = particle diameter (μ)
d_f = fiber diameter (μ)

The target efficiency of the interception mechanism is a function of R and the Reynolds number.

Inertial impaction occurs when a particle has sufficient mass to deviate by inertia from the line of flow as the airstream passes around the fiber. The classic inertial parameter is given by following expression:

$$\psi = \frac{C\rho v d_p^2}{18\mu d_f} \qquad (8)$$

where
ψ = inertial parameter (dimensionless)
C = Cunningham Correction Factor (dimensionless)
ρ = density of aerosol particle (g/cm^3)
v = velocity of airflow (cm/sec)
μ = viscosity of gas (air) (g/cm-sec)
d_p = particle diameter (cm)
d_f = fiber diameter (cm)

These forces are important for larger than submicron particles. Refer to Figure 25.

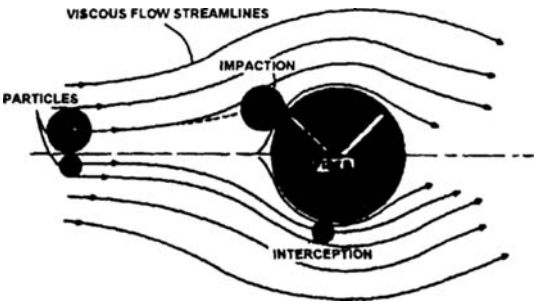


Figure 25. Particle removal by fibrous filter through mechanisms of interception and impaction.

Diffusion (Brownian motion) depends on the size of the particles being comparable to the mean free path of gas molecules (0.06 μ). Their motion is more violent, and the collisions with filter fibers are more likely to occur. The diffusion parameters is expressed as:

$$D = \frac{1}{vd_f}\left(\frac{CkT}{3\pi\mu d_p}\right) \qquad (9)$$

where
D = diffusion parameter

$\frac{CkT}{3\pi\mu d_p}$ = diffusion coefficient (sec/cm^2)

k = Boltzmann constant, 1.38×10^{-16} erg/°K
T = absolute temperature of air (°K)
v = velocity of airflow (cm/sec)
d_f = fiber diameter (cm)
d_p = particle diameter (cm)
μ = viscosity of gas (air) (g/cm-sec)

The importance of diffusion for removing fine particulates increases considerably as the velocity of the air passing through the filter decreases, as at the beginning and end of an inhalation cycle. The longer the time in the filter, the greater the chance for capture.

Electrostatic attraction of particulates has been achieved by adding a coating of resin to the fibers. Certain dielectric waxes, resins and plastics have been used to generate an electrostatic charge to attract and hold particulate matter.

Gravity, as a force for removal of particulates by a fibrous bed, is a function of terminal velocity:

$$G = \frac{u}{v} = \frac{C\rho d_p^2 g}{18\mu v} \quad (10)$$

where G = settling parameter (dimensionless)
u = terminal settling velocity of the particle (cm/sec)
v = velocity of airflow (cm/sec)
μ = viscosity of gas (air) (g/cm-sec)
ρ = density of aerosol particle (g/cm^3)
g = acceleration of gravity (cm/sec^2)

Gravitational force is usually small in nature and generally is not considered. The overall efficiencies of a filter is:

$$\eta_0 = 0.16(R+(0.5+0.8R)(\psi+D)-0.1052R(\psi+D)^2) \quad (11)$$

where η_0 = total target efficiencies
R = direct interception parameter
ψ = inertial parameter
D = diffusion parameter

The overall efficiency of a mass of fibers comprising a filter mat can be calculated from η_0, the packing density of the mat and the filter thickness.

Filter performance characteristics of a filter medium used for a respirator are efficiency and pressure drop. Efficiency is influenced by filtration velocity, fiber diameter, loading and particle size.

To increase the efficiency of small particle removal and to decrease the resistance to airflow, the velocity of air passing through the filter medium must be kept as low as possible. Velocity reduction is achieved by folding or by manipulating the slope of the filter to provide greater surface areas, resulting in a low pressure drop and a greater ability to collect or improve loading characteristics. Once the filter is used, the particles themselves act as a filter medium; however, with the vibration and pulsation of breathing, no accurate measurement of this phenomenon can be accomplished. The efficiency of collection for a filter subjected to pulsating flow is about the same as results obtained by steady-state flow. The range of velocities encountered by the wearer would cause the efficiency of collection to be increased.

Fiber size technology has increased greatly during the last few years, but probably the "HEPA" filters are the most notable advance. Loading of the filters, as with any physical screening type operation, increases filtration, but at what pressure loss? Figure 26 illustrates the effect of running time on efficiency of AEC filter paper. Figure 27 illustrates the clogging of various types of filter material. Materials such as cotton sheeting suffer a large pressure drop due to loading and are not practical as a filter medium for respirator cartridges. The key to filter design is to be sufficiently strong to be handled or, in the case of throw-away design filters, to be able to last the whole day (duration of test). Particle size is so varied in many

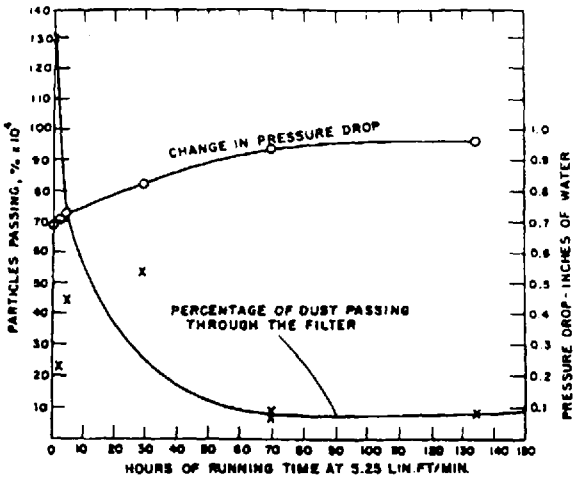


Figure 26. Effect of running time on efficiency of AEC filter paper at a flowrate of 5 linear fpm.

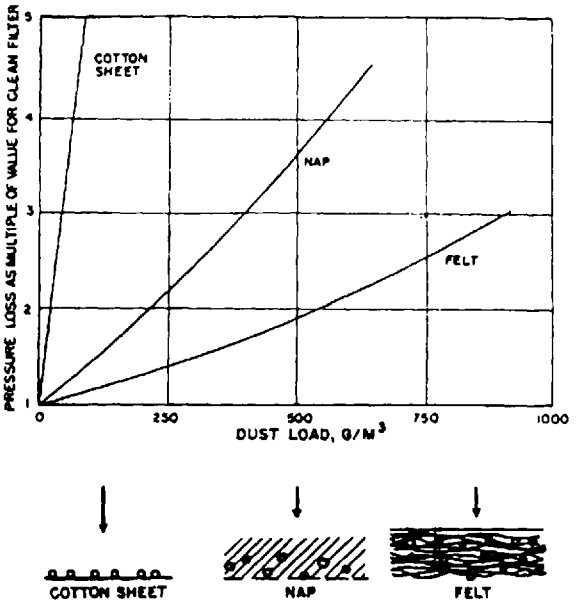


Figure 27. Clogging of various types of filter material.

operations that for any given filtration velocity there is a particle size that will penetrate a filter. For this reason, medical tests must be used to examine the effectiveness of respiratory protection.

Pressure drop is changed as the respirator filter becomes more effective or loaded with material.

Particle size, shape, density, surface characteristics, packing characteristics of deposited material, air contaminant levels and related density, and humidity all have an effect on the pressure drop.

2. Chemical Cartridge Respirators

Chemical cartridge respirators use a cartridge to remove gases and vapors from the air by sorption. Sorption is the attraction and holding to the surface of a solid as molecules of vapor and gases come into contact with that surface at room temperatures. The solid substance is the sorbent, and the gas or vapor being sorbed is the sorbate. If the molecules of the sorbate are held to the surface by physical forces, similar to condensation, the process is termed adsorption. If electron transfer takes place between the sorbate and surface of the sorbent, the phenomenon is chemisorption. In adsorption, the sorbate does not remain on the surface but enters into the solid and reacts with it chemically, changing the chemical nature of each.

One should note that odor detection is different for each individual, depending on time of the year and humidity. The subsection on quantitative and qualitative fit testing will discuss odor detection.

Adsorption Capacity — The equation for the capacity of charcoal to adsorption of a solvent vapor is based on the following:

$$A = \frac{T}{V_m} \log\left(\frac{P_5}{P}\right) \qquad (12)$$

where A = adsorption potential
T = temperature (°K)
V_m = molar volume at normal boiling point (cc/mol)
P_5 = saturation vapor pressure (torr)
P = partial pressure (torr)

As a linear expression, this equation can be modified to the following:

$$W_s = \rho W_o \exp\left(-\frac{BT^2}{\beta^2}\left(\log\left(\frac{p_s}{p}\right)^2\right)\right) \qquad (13)$$

where W_s = adsorption capacity (g solvent/g adsorbent)
ρ = solvent density (g/cc)
W_o = maximum adsorption space (cc)
B = microporosity constant
T = temperature (°K)
β = affinity coefficient
p_s = saturated vapor pressure of the solvent at temperature T (torr)
p = equilibrium partial pressure of the solvent (torr)

An expression defining how long a cartridge can be effective at a certain level of contamination is as follows:

$$t_b = \frac{W_s}{C_o Q}\left[W - \frac{\rho Q}{k}\ln\left(\frac{C_o}{C_b}\right)\right] \qquad (14)$$

where t_b = breakthrough time (min)
W_s = adsorption capacity (g/g)
C_o = input concentration (g/l)
Q = volumetric flowrate (liter/min)
W = weight of charcoal (g)
ρ = density of charcoal (g/cc)
k = adsorption rate constant (min^{-1})
C_b = breakthrough concentration (g/cc)

Humidity is another area that must be considered. The effect of moisture on the sorption of carbon tetrachloride onto charcoal is reported in the literature to be:

$$\frac{t_m}{t_d} = \frac{k}{w+k} \qquad (15)$$

where t_m = breakthrough time using moist charcoal and moist air
t_d = breakthrough time using dry charcoal and dry air
w = weight of water adsorbed
k = a constant

It is well known that storage (preconditioning) and use in humidities above 65% greatly reduce the service life of respirators. The following generalizations should be noted:

1. Both the precondition and use humidity alter the cartridge service life.
2. The use humidity has a greater effect than the preconditioning humidity.
3. The service life is approximately the same between 0 and 50% humidity.
4. Humidity has a greater effect on cartridge performance at lower concentrations of solvent vapor.

A typical organic vapor half-mask respirator cartridge is a plastic or metal case that contains approximately 25-40 g of adsorbing media. Of greatest concern to the wearer of a respirator is how effective the device is. Effectiveness can be viewed in terms of the service life of the cartridge, which is essentially the breakthrough time (i.e., the time for the cartridge to become saturated and no longer capable of sorption. Some typical literature data are reported in Figures 28 and 29, and in Table 17. Figure 28 provides plots showing cartridge break through time as a function of use relative humidity. Figure 29 shows breakthrough time as a function of concentration. Table 17 provides estimated service life data on chemical cartridge respirators for various organic vapors. This table should be viewed as a rough guideline on the effectiveness of typical chemical cartridges respirators.

Cartridge service life (the 10% breakthrough time) now can be estimated from the following empirical expression:

$$t\ 10\% = \frac{2.4 \times 10^6 W_c(a+bt)}{C^{2/3}MQ} \qquad (16)$$

where W_c = carbon weight
a, b and t = relative solvent volatility
c = concentration
M = molecular weight
Q = breathing rate

Table 18 lists maximum use concentrations for cartridges. Chemical cartridge respirators including all completely assembled respirators designed for use as respiratory protection during entry into, or escape from, atmospheres not immediately dangerous to life and health are described according to the specific gases or vapors against which they are designed to provide respiratory protection in Table 18.

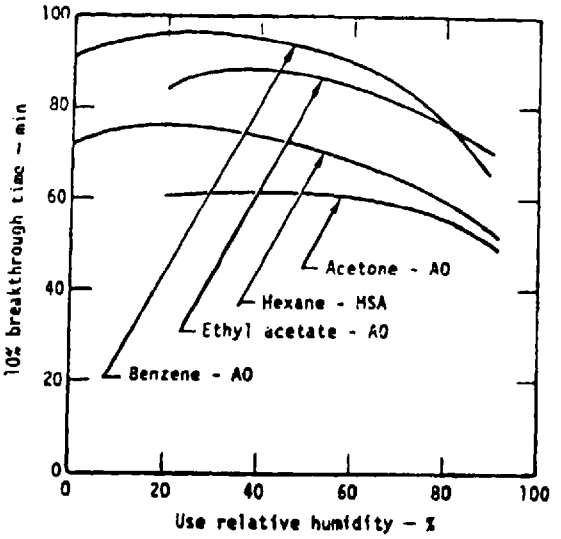


Figure 28. Service life as a function of relative humidity.

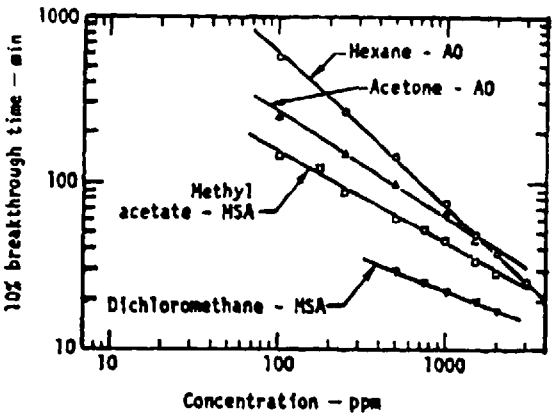


Figure 29. Service life as a function of concentration.

3. Powered Air-purifying Respirators

The idea of combining an air line portable blower respirator and a filter respirator resulted in the powered air-purifying respirator. The development of this type of respirator was based on modification of respirators requiring tight-fitting systems or an enclosure with a portable continuous-flow air supply.

The common British version of the U.S. Bureau of Mines design, developed the SMRE dust helmet, which protects head, eyes and lungs in a single comfortable unit. It combines a hard hat face shield and powered air supply in

Table 17. Estimated Service Lives of the Reusable Cartridge Against Selected Organic Vapors

	TLV (ppm)	$C_o \times 10^3$ (g/l)	w_s (g/g)	A^2	Service Life (min)*
Benzene	10	0.325	0.167	99.7	244
Toluene	100	3.83	0.387	16.7	96.1
Ethylbenzene	100	4.42	0.438	5.6	93.4
m-Xylene	100	4.41	0.438	4.9	94.5
Cumene	50	2.50	0.439	4.1	167
Mesitylene	-	4.99	0.455	0.6	86.8
p-Cymene	-	5.57	0.453	0.2	77.4
Methanol	200	1.33	0.036	240	12.9
Ethanol	1000	1.92	0.181	80.6	44.8
2-Propanol	400	2.50	0.275	40.3	105
Allyl Alcohol	2	0.048	0.063	190	624
Propanol	200	2.50	0.322	24.4	122
Sec-Butanol	150	3.08	0.365	15.7	113
Butanol	50	1.54	0.370	14.6	229
2-Pentanol	-	3.67	0.411	4.3	107
3-Methyl-1-butanol	100	3.67	0.421	1.9	109
4-Methyl-2-pentanol	25	1.07	0.386	9.4	343
Pentanol	-	3.67	0.425	1.1	110
2-Ethyl-1-butanol	-	4.25	0.437	0.6	97.8
Methyl Chloride	100	2.10	0.009	395	2.1
Vinyl Chloride	1	0.026	0.001	578	18.3
Ethyl Chloride	1000	2.68	0.080	174	14.2
2-Chloropropane	-	3.27	0.200	80.5	29.1
Allyl Chloride	1	0.032	0.027	283	402
1-Chloropropane	-	3.27	0.106	145	15.4
2-Chloro-2-methylpropane	-	3.85	0.280	46.9	69.2
1-Chlorobutane	-	3.85	0.334	33.3	82.5
2-Chloro-2-methylbutane	-	4.43	0.370	21.1	79.5
1-Chloropentane	-	4.43	0.407	13.6	87.4
Chlorobenzene	75	3.51	0.516	12.4	140
1-Chlorohexane	-	5.02	0.445	4.5	84.3
o-Chlorotoluene	50	2.63	0.547	4.6	198
1-Chloroheptane	-	5.60	0.463	0.8	78.7
Dichloromethane	200	3.53	0.145	155	19.6
t-1,2-Dichloroethylene	200	4.03	0.249	96.2	29.4
1,1-Dichloroethane	200	4.12	0.312	67.6	36.1
c-1,2-Dichloroethylene	200	4.03	0.297	80.3	35.1
1,2-Dichloroethane	50	2.06	0.330	69.2	76.0
1,2-Dichloropropane	75	3.52	0.438	32.5	118
1,4-Dichlorobutane	-	5.28	0.597	2.8	108
o-Dichlorobenzene	50	3.06	0.685	0.9	213
Chloroform	25	1.24	0.235	118	180
Methylchloroform	350	5.55	0.465	41.8	79.7
Trichloroethylene	100	5.46	0.518	39.2	90.3
1,1,3-Trichloroethane	10	0.555	0.423	57.8	725
1,2,3-Trichloropropane	50	3.06	0.707	4.4	220
Carbon Tetrachloride	10	0.640	0.334	90.7	248
Perchloroethylene	100	6.90	0.748	13.6	103
1,1,2,2-Tetrachloroethane	5	0.349	0.854	35.3	2328
Methyl Acetate	200	3.08	0.217	84.5	33.5
Vinyl Acetate	-	3.58	0.312	45.0	80.3
Ethyl Acetate	400	3.66	0.327	36.8	85.0
Isopropyl Acetate	250	4.16	0.373	20.9	85.3
Propyl Acetate	200	4.25	0.402	15.4	90.0
Butyl Acetate	150	4.83	0.443	5.4	87.3
Isopentyl Acetate	100	5.41	0.452	1.9	79.5

Table 17 Continued.

	TLV (ppm)	C_o x 10^3 (g/l)	w_s (g/g)	A^2	Service Life (min)*
Pentyl Acetate	100	5.41	0.457	1.4	80.4
Acetone	1000	2.41	0.133	112	26.2
2-Butanone	200	3.00	0.276	42.9	87.5
2-Pentanone	200	3.58	0.350	20.3	93.0
3-Pentanone	-	3.58	0.355	19.1	94.4
4-Methyl-2-pentanone	100	4.16	0.384	10.0	87.8
Mesityl Oxide	25	1.02	0.379	17.8	354
2,4-Pentanedione	-	4.16	0.478	7.3	109
2-Heptanone	100	4.75	0.424	1.4	84.9
Cyclohexanone	50	2.04	0.486	8.3	227
Peniane	600	3.00	0.197	50.5	62.5
2,3-Dimethylbulane	-	3.58	0.257	30.2	68.3
Hexane	100	3.58	0.270	25.2	71.8
Methylcyclopentane	-	3.50	0.283	32.8	76.9
Cyclohexane	300	3.50	0.302	30.7	82.1
Cyclohexene	300	3.41	0.305	33.5	85.1
2,2,4-Trimethylpentane	-	4.75	0.333	9.5	66.7
Heptane	400	4.17	0.322	11.5	73.5
Methylcyclohexane	-	4.08	0.348	15.4	81.2
Nonane	-	5.33	0.376	1.1	67.1
Methyl Iodide	5	0.295	0.033	357	53
Acrylonitrile	20	0.441	0.097	143	104
1,2-Dibromoethane	20	1.56	0.791	36.7	482
Epichlorohydrin	5	0.192	0.244	91.5	604

* Calculated from the modified Wheeler equation.

Table 18. Typical Maximum Use Concentrations

Type of Chemical Cartridge Respirator	Maximum Use Concentration (ppm)
Ammonia	300
Chlorine	10
Hydrogen Chloride	50
Methyl Amine	100
Organic Vapor	1000
Sulfur Dioxide	50
Vinyl Chloride	10

one unit. The unit is illustrated in Figure 30. The unit draws power from a portable battery that is pack-belt mounted; this powers a small battery-powered fan to force environmental air through two filters. The air then is channeled over the head of the wearer and directed behind a full face shield over the miner's face.

The air helmet is covered under Mine Safety & Health Administration Section 11.130, which concerns Dust, Fume and Mist Respirators. All the applicable parts of this system must apply to these respirators, with the added requirement that the noise level generated by the respirator measured inside the hood or helmet at maximum airflow shall not exceed 80 dBA. A second type of powered filter respirator is mounted on a belt with the complete motor and filter unit. The hose from the filter unit extends to a full-face respirator style and provides a sufficient flowrate. Powered air-purifying respirators have the advantage of mobility and can be used by people who have minor

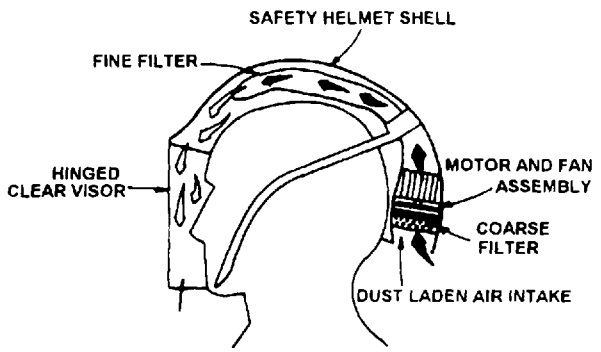


Figure 30. Schematic of Racal-Amphivox "airstream" helmet.

impairment to the respiratory system when approved by a physician. The supply of air places no strain on the lungs, and only the cost and maintenance of the unit keeps it from being used more widely.

The history of air line respirators dates back to the Assyrians (900 B.C.), who used air inhaled from inflated animal skins. The first hard-hat style diving suit (1840) is the more direct ancestor to the modern air line respirator. Most publications on respirators do not give credit to the early researchers who developed the technique of supplied air, either by lung pressure or external pump to the respirator user. The factor that makes the supplied air system of such great use is the unlimited supply of breathing air; however, it also is its greatest drawback. The method used to supply the air is a hose system, which can be tangled, tripped on and damaged. The use of supplied air respirators has increased over the years in many industrial operations for the following reasons:

1. Their cost, the cost of maintenance and powered supply of air are less than for the filter or self-contained types in many applications.
2. The use of filter type units has declined somewhat as unions and employee groups have negotiated for spirogram and lung testing programs.
3. Management in many companies have come to realize that the effort used to breathe through filter types is better spent on production.
4. Engineers faced with tough environmental and heat stress and cold weather energy problems use vortex heating-cooling devices. The cost of fan-type ventilation systems have largely been replaced by fully enclosed process systems.
5. Manufacturers are spending more to give people such comforts as AM-FM radio, heating, cooling and emerging warning lights, where distractions are permitted.
6. Legal action and lawsuits due to lung diseases contracted by non smokers has increased the desire to better protect those exposed to hazardous materials.

Before we examine the systems themselves, it is helpful to review the regulatory sections in OSHA and MSHA and explain the background of the standards. According to the OSHA Respiratory Protection Section, 1910.134(d)(l), air shall meet at least the requirements of the specifications for Grade D breathing air, as described in Compressed Gas Association Commodity Specification. Oxygen must never be used with air line respirators.

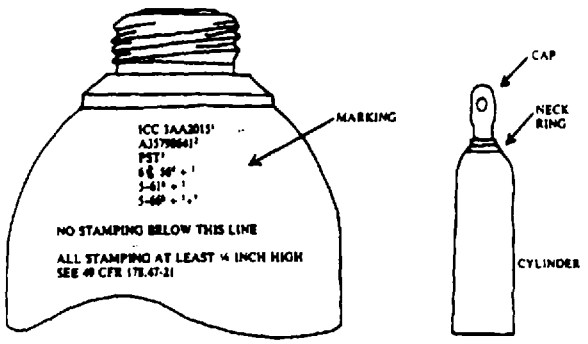
The Compressed Gas Association describes Grade D breathing air with the following limiting characteristics:

1. Percentage oxygen (v/v) balance predominantly nitrogen atm 19-23. Note that the term atm (atmospheric) denotes the oxygen content normally present in atmospheric air; the numerical values denote the oxygen limits for synthesized air.
2. The water content of compressed air required for any particular grade may vary with the intended use from saturated to very dry. If a specific water limit is required, it should be specified as a limiting dewpoint or concentration in ppm (v/v). Dewpoint is expressed in °F at 1 atm abs. (760 mm Hg).
3. Hydrocarbons (condensed) is 5 mg/m^3.
4. Carbon monoxide is 20 ppm.
5. Carbon dioxide is 1000 ppm.
6. Odor - reference is made to.

Specific measurements of odor in Type 1 air are impractical. Air normally may have a slight odor. However, presence of a pronounced odor should render the air unsatisfactory for breathing.

There are nine grades of breathing air - A to J - referred to as Type I. In Type II, or the liquid state, there are two types - A and B. Atmospheric air is naturally occurring, and it is impractical to set limits for trace elements. That oxygen must never be used with air line respirators is placed in the standards because if a welder or worker had a slight burn in his uniform, for example, the oxygen could turn him into a ball of fire. In Section (d)(2), breathing air may be supplied to respirators from cylinders or air compressors. Cylinders shall be tested and maintained as prescribed in the Shipping Container Specification Regulations of the Department of Transportation (49CFR Part 178). Figure 31 shows the typical markings for a cylinder display. The importance of this section in the regulation is that the materials for a certain size cylinder must be safely contained by the cylinder, and proper labeling must be followed by the supplier. A standard cylinder contains more than 2000 psi of air and, if knocked over, can rocket through a brick wall or kill someone.

Section (d)(2)(ii) deals with compressors used to supply breathing air through an air line. A breathing air-type compressor shall be used. Compressors shall be constructed and situated to avoid entry of contaminated air into the system, and suitable inline air-purifying sorbent beds and filters installed to further assure breathing air quality. A receiver of sufficient capacity to enable the respirator wearer to escape from a contaminated atmosphere in the event of compressor failure, as well as alarms to indicate compressor failure and overheating.



1. DOT or ICC marking may appear - new manufacture must read "DOT"
   "3AA" indicates spec in 49CFR173.37.
   "2015" is the marked service pressure
2. Serial number - no duplicates permitted with any particular symbol-serial number combination.
3. Symbol of manufacturer, user or purchaser.
4. "6 56" date of manufacture. Month and year.
   "L" desinterested inspector's official mark.
5. Plus mark (+) indicates cylinder may be 10% overcharged per 49CFR173.302(C).
6. Retest dates.
7. 5 pointed star indicates ten year retest interval. 49CFR173.34(e)(15).

Figure 31. Marking requirements for a cylinder display (from the OSHA Training Institute).

shall be installed in the system. If an oil-lubricated compressor is used, it must have a high-temperature or carbon monoxide alarm, or both.

If a high-temperature alarm is used, the air from the compressor shall be tested frequently for carbon monoxide to ensure that it meets the specification.

The CO air line monitor is an economical instrument for continuously monitoring compressed air lines for carbon monoxide in the toxic range. The air line monitor provides audible and visual alarms when a predetermined CO concentration is reached. Its features include the following:

- No pump: flow-controlled diffusion sampling
- Long-life electrochemical cell
- No humidifier or reagents
- Audible alarm
- Visual alarm
- Instrument flow failure alarm
- Adjustable alarm point
- Remote alarm relays
- Linear meter readout
- NEMA-type steel enclosure
- Simple calibration

The detector is an electrochemical, polarographic cell that oxidizes carbon monoxide in proportion to its concentration in the line being sampled. Gas from the line enters the sensor cell by diffusion, thus eliminating the need for a sampling pump. Sample flow is regulated by the instrument's flow system; no flow adjustments are required. If the flow of sample gas is stopped, the instrument flow failure alarm is activated automatically.

The OSHA standard specifying a clean area for compressors to draw air for use is based on common sense. The problem most plants face is whether to use a portable pump or tap off the existing air lines running in their plant. The concern for possible contamination in the air line is a very real one. Many plants have compressed air, but insufficient air filters, refrigeration units or dryer units to remove condensate in the line and scale from piping units. As many painters inside tanks use compressed air for the painting, they merely tap off for the respirator as well. The statement about the right type of compressor docs not specify which type is to be used. It states only that if an oil-lubricated compressor is used, a high-temperature alarm must be installed when testing the supplied air for carbon monoxide.

Rotary or centrifugal compressors are suitable for 150 psi or less. Coaxial screw-type compressors are available for up to 300 psi, and piston type, with single and dual stages, are very common for a wide range of pressures. More important problems occur with the water vapor compressed during the compression stages; this must be drained from the lines and reservoir (or receivers) constantly. Maintaining the compressors, checking the safety valves by blowing them down and being watchful for corrosion are important.

The following guide is provided to assist in the proper selection of a compressed air source.

1. For low volume and short times, bottled air is easier to locale, and no maintenance is required.
2. For average-volume jobs that require a short time period a portable compressor for one or two users provides better performance.
3. High volumes must be supplied by a compressor piping system.

In a typical air-supplied respirator, the quality of the air, impurity content and filter may not provide sufficient removal of material. One reason for this is the air temperature. When air is compressed it gets hot, and moisture or water vapor levels are raised. These problems can be eliminated for the most part by passing the air through air dryers, refrigerated air dryers or air purifiers.

Air purifiers have been used with good results for many years. The filters trap solids, oil, oil mists, water vapor,

taste or odor, water vapor and carbon monoxide in various stages. The factors that influence efficiency are:

1. type of breathing mask, helmet and full hood,
2. air pressure required,
3. air flowrate and temperature,
4. vortex cooler or heater units, and
5. section of the country (weather conditions).

MSHA Regulations — Although OSHA has a section on basic respiratory aspects, specific requirements for air line respirators are specified in Mine Safety and Health Regulations Section 11.110. There are three basic types:

Type A — This is a hose mask respirator for entry into, and escape from, atmospheres not immediately dangerous to life or health. It consists of a motor-driven or hand-operated blower that permits the free entrance of air when the blower is not operating; a strong large-diameter hose having a low resistance to airflow; a harness to which the hose and lifeline are attached; and a tight-fitting facepiece.

Type B — This is similar to Type A, the major exception being that the user draws inspired air by means of his lungs alone.

Type C — An air line respirator for entry into, and escape from, atmospheres not immediately dangerous to life or health, it consists of a source of respirable breathing air, a hose, a detachable coupling, a control valve, orifice, demand valve or pressure demand valve, an arrangement for attaching the hose to the wearer, and a facepiece, hood or helmet.

Types AE, BE and CE supplied-air respirators are primarily the same as Types A, B and C except that they have been modified with devices designed to protect the wearer's head and neck against impact and abrasion from rebounding abrasive material, and with shielding material such as plastic, glass, woven wire, sheet metal or other suitable material to protect the window(s) of facepieces, hoods and helmets. These do not interfere unduly with the wearer's vision and permit easy access to the external surface of such window(s) for cleaning.

The type of air supplied to the respirators must contain 19.5 vol % oxygen and meet the Compressed Gas Association G.7 specification. MSHA requires the following air-supply-line requirements and tests for Types A, B and C respirators.

1. Type A specifies the length of hose to be 300 feet long in 25-foot sections.
2. Type B specifies the length of hose to be 75 feet long in 25-foot sections.
3. Type C specifies the length of hose to be a maximum of 300 feet long in 25-foot sections.
4. The air-supply hose with air-regulating valve or orifice shall permit a flow of not less than 115 liters/min (4 ft^3/min) to tight-fitting, and 170 liters/min (6 ft^3/min) to loose-fitting respiratory-inlet coverings. The maximum flow shall not exceed 425 liters/min (15 ft^3/min). Other tests specify noncollapsibility, nonkinkability, strength, tightness, permeation of hose by gasoline and detachable couplings.
5. The respirators must be fit-tested with 25 feet of hose maximum length in an isoamyl acetate atmosphere containing 1% or 10,000 ppm.

4. Vortex Tubes

Vortex tubes run on compressed air and, with adjustment, can produce either cool air or warm air. Operations requiring heavy protective clothing build up the wearer's body temperature. Some workers tire from heat stress or the inability of the body to remove the heat buildup due to physical activity, lack of ventilation, radiation or all three. The standard suit provides cooling for up to 200°F, but specialty suits and different styles are sold by various manufacturers.

The way in which the air is distributed over the body is of importance and should be noted. The Vortex man cooling system uses air cooled by the vortex tube conducted into the vest at an entrance fitting located at the small of the back. The air fills the vest, causing it to puff into a swollen appearance. The inner lining of the vest has hundreds of tiny holes that allow the air to escape all over the trunk area of the body.

Figure 32 illustrates a small amount of the air leaving the vest: (1) it flows downward into the trousers and along the legs, so the legs are cooled without separate tubes running into the pants; (2) the air leaves the vest, moves upward and fills the inner jacket area at the arm holes of the vest; and (3) the elastic band seal at the bottom of the shirt prevents the air from falling out of the bottom of the jacket. As the passage of air is blocked from the bottom, the air is forced to flow out through the sleeves. It should be noted that the suit can be set up for left-handed workers as well. The man cooling systems are designed to provide

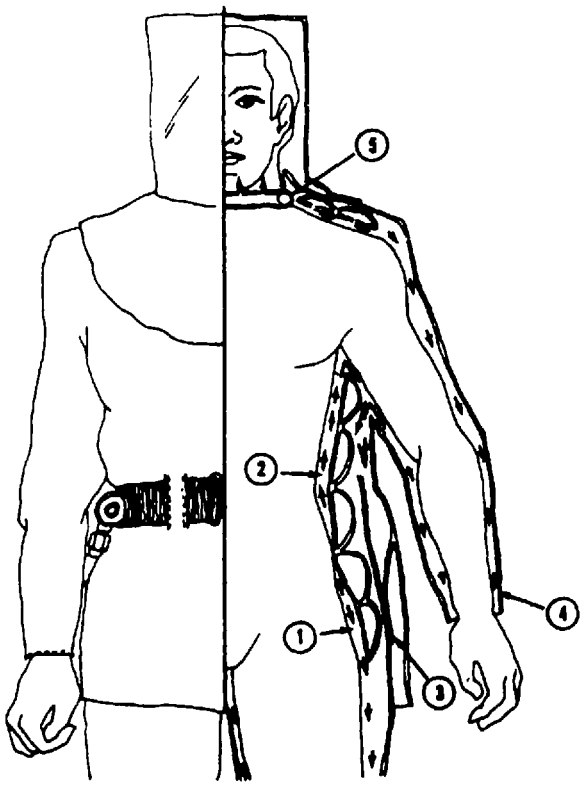


Figure 32. Airflow pattern in a man cooling system.

worker comfort and safety from heat stress in moderate-to-hot industrial environments up to 200°F. Certain systems should be used only up to about 130°F. Specifically, these are:

- Coverall systems
- Any man cooling system without head cooling
- Any system with lightweight hood

The full suit system is well designed for use up to 200°F. In selecting the proper man cooling equipment, the source of heat is as important as the amount. Whenever the heat is primarily radiant, a reflectorized system is indicated. For example, workers near furnaces, forging presses, ovens, etc., should use the reflectorized clothing. The reflective coating will reflect up to 90% of incident radiant heat. Of course, any heat reflected does not have to be offset by the vortex tube air conditioner. Systems are not intended to be used in severe heat situations, such as oven entry and fire entry applications. Highly specialized, very expensive equipment is made for these applications.

The Air Supply

Pressure — Man cooling systems are designed to use a normal shop air supply of 80-110 psig pressure. Unless pressures run considerably higher than 110 psig, one must not use a regulator to reduce the inlet pressure. Pressures higher than 200 psig must not be used. Pressures lower than 80 psig still will produce some cooling; however, the flow of air and amount of cooling reduce rapidly as supply pressure falls.

Line Sizes — For piping air up to the air purifying filter, 3/8-inch pipe or larger should be used. Runs of this pipe over 50 feet should be ½-inch in size. If the air purifying filter is to be used for two workers, the pipe supplying it should not be smaller than ½ inch in size, and it should be 3/4 inch in size for runs of 50 feet or longer. Do not use compressed air hoses longer than 50 feet on the downstream side of the air purifying filter.

Compressor Size — In most large plants, the size of the compressor is adequate to handle several man cooling systems operating simultaneously. For smaller plants, one should estimate required horsepower based on the rated capacity of the man cooling systems. Systems for body cooling only consume 15 scfm at 100 psig. Systems for body and head cooling consume 25 scfm each. It takes one horsepower to compress 4 scfm of air to 100 psig. Divide total scfm required by four to obtain compressor horsepower required.

Filters — The use of an air purifying filter, is recommended for man cooling systems. It will serve two men in full suit systems (total flow of 50 scfm). The filter contains several filter materials, including activated charcoal, and will remove mists (including oil mist), water vapor and particles (down to 0.5 μ in size) from the compressed air supply. Most important, it cleanses the air of any objectionable odor. The compressed air system should be tested for CO content.

Because the air purifying filter removes nearly all the water and dirt, it is not essential to use any other filters. If a filter separator is installed just ahead of the air purifying filter, it will act as a prefilter, and the life of the air purifying filter cartridges will be extended several times. The technique has the added advantage that water is drained automatically from the system by a float-operated valve.

Dressing Procedure (Full Suit Systems) — Full suit cooling systems are designed for use over workers' clothing. For best results, workers should wear light shirts and

pants. The vest is attached inside the jacket by means of the small patch at the back of the neck. These two garments, along with the tube air conditioner and the belt normally are kept together and handled as one assembly. This assembly is put on first, and the front closures of the vest are fastened loosely, but the front of the jacket is not closed. Next, the trousers are put on and attached by Velcro patches to the corresponding patches on the inside of the jacket. Care should be taken to make these attachments at the right height, so the entire suit is sized to the height of the man. When the trousers are fastened properly, the vest will be inside. Next, one should take the front, lower corners of the inner skirt in each hand, pull the elastic band sewn into the bottom of the inner skirt and snap the skirt together at the front. Then one should fasten the front closure of the jacket and buckle the belt. One can snap the cuffs of sleeves and trousers if desired.

The neckring now can be brought into place over the head. The high temperature hood should be placed on the head and, finally, the neckring can be held in the optimum position using the Velcro strap inside the hood. To remove the hood, just release this Velcro strap. The hood then can be rotated up or removed.

The hood, which incorporates a standard hard hat, should be adjusted to the proper hat size for the man, using the markings on the straps inside the hat as a guide. When the hat size is adjusted properly, the chin brace attached to the face shield will fit comfortably under the chin and prevent the entire hood from falling off if the worker bends over. The many small holes in the neckring face upward, but are not intended to blow directly on the face. When assembled at the factory, the neckring holes direct the air at the inside of the face shield, keeping it clear of fog. Thereafter, it is reflected off the face shield, onto the face and around the head.

The Air Distribution System — Full suit cooling systems depend on their unique design to provide even distribution of air over the entire body. In the full suit systems, all parts of the body are cooled by the combined action of several elements.

Cold air from the supply is conducted into the vest at an entrance fitting located at the small of the back. It fills the vest, causing it to puff into a quilted appearance. The inner lining of the vest has hundreds of tiny holes that allow the air to escape all over the trunk area of the body. A small amount of the air leaving the vest (1) flows downward into the trousers and along the legs, so the legs are cooled without tubes running into the trousers; (2) most of the air leaving the vest moves up along the body and spills into the inner jacket area at the armholes of the vest; (3) the air is prevented from falling out the bottom of the jacket by the elastic band seal at the bottom of the skirt; and (4) it is forced to flow out of the jacket through the sleeves, which is how the arms are cooled. At the small of the back, where the cold air enters the vest, is a small manifold. This directs some of the cold air up the tube, which runs up the center of the back of the jacket and feeds the neckring. The entire suit system can be reassembled for left-handed workers by reversing this manifold. This will place the vortex tube air conditioner with its controls conveniently at the worker's left hand.

Adjustments During Use — The vortex tube air conditioner is attached to the compressed air hose by a quick connector. The worker should familiarize himself with this connector so that he can release it easily with one hand without looking at it. In an emergency situation the worker is attached to his hose; swift disconnection is the easiest way to free oneself. One should not attempt to remove the jacket in an emergency. The valve at the hot end of the vortex tube air conditioner controls the amount of cold air and the temperatures produced. When it is screwed all the way into the tube, no air will leave the hot end. Then the air flowing into the suit will be at maximum flow, but the temperature will only be about 4°F below the compressed air line temperature. This setting, if line temperature is moderate, still will produce some cooling for the workers, because the air flowing is dry and the body's perspiration system will help.

As the control valve is opened, the flow into the suit decreases, but the air gets much colder. Maximum refrigeration is produced at about 1-1½ turns open. If the system has been operating with cold air flowing for a period of time and the valve is suddenly closed in an attempt to reduce the cooling, the air flowing into the suit will, of course, increase. Momentarily, the worker will feel even colder as the increased flow brings in the refrigeration that has been stored in the hose and vest materials. Thus, after any adjustment of the valve, the workers should allow the system a short time, perhaps a minute, to stabilize at the new setting. Initially, workers will adjust the control valve frequently, but as one becomes familiar with the system, there is a tendency to set it once and forget it.

Abrasive Blasting — One of the most common use of air-supplied respirators has been the application in abrasive blasting. In OSHA Section 1910.94, Ventilation, an abrasive-blasting respirator is defined as a continuous-flow

air line respirator constructed to cover the wearer's head, neck and shoulders to protect him from rebounding abrasives. OSHA Code 1910.134(D)(i) or Compressed Gas Association Code is used to define air for breathing.

Abrasive blast cleaning operations offer an excellent industry example of some problems that may result in respiratory hazards to workers. Dust, as generated by abrasive breakdown and pulverized surface materials, develops serious safety problems. Dense dust formed in the immediate vicinity of hand-held/operated abrasive blast nozzles reduces visibility and often obscures the work area. Production time is lost in shutdowns for dust clearance or when operations continue under adverse conditions. If enclosures are not cleared of airborne dust, blast operators may be exposed to harmful dust concentrations on removal of respirator helmets. Dust accumulations also create slippery floor conditions. Therefore, it is necessary to control generated dust through engineering controls, such as well-maintained ventilation systems, enclosing the operation for both dust control and removal. Vision impairment can be expected during such work operations, and adequate controls and protection must be provided to the worker. Operator vision tests should be conducted as part of any safety program. In addition to dust and ventilation problems, other potential problems are noise, personal injury and exposures from various machines as well as from the hazardous work location.

D. Self-Contained Breathing Apparatus (SCBA)

The first commercially practical self-contained breathing apparatus was developed by H. A. Fleuss in 1878. Designed for underwater diving, it was operated on a dosed circuit basis and used 100% oxygen for breathing. However, the improper use of oxygen caused oxygen poisoning at depths greater than 25 feet, a fact that was not known until the knowledge of underwater physiology advanced with man's desire to explore the oceans. In 1903 the First Draeger apparatus was designed and manufactured by Bernhard Draeger, of Lubeck, Germany. Self-contained (closed circuit) oxygen breathing apparatus was introduced into the United States during the summer of 1907. The first equipment was purchased by the Boston and Montana Mining and Smelting Co. (later a part of Anaconda Copper) of Butte, Montana. At this time, the Technologic Branch of the Federal Geological Survey, Pittsburgh, Pennsylvania (which later became the U.S. Bureau of Mines), purchased several Draeger units. The Westphalia unit, manufactured in Germany, was followed in 1911-12 by the Fleuss-Proto unit, manufactured by Siebe, Gorman & Co. of London, England. After the Bureau of Mines was established, it began to equip railroad cars and stations with units and train miners in their use and care as part of the campaign for greater mining safety and efficiency.

The self-contained breathing units were used in mines to fight fires. With the outbreak of World War I, the Gibbs apparatus was developed by the Bureau of Mines and the U.S. Army at Edison Laboratories, Orange, New Jersey. The rights to manufacture the apparatus were bought by Mine Safety Appliances Co. of Pittsburgh. With the outbreak of World War II, Captain Jacques-Yves Cousteau and Emile Gagnan combined an improved demand regulator and high-pressure air tanks to create the first truly efficient and safe open-circuit , self-contained underwater breathing apparatus (SCUBA) tank to the world. After the war, the aqualung was used to depths of 180 feet without significant difficulty. What is noteworthy about the apparatus, is that it was adapted successfully for use in fire fighting and worker respiratory protection, although designed and developed primarily for the diving industry.

Attempts to generate oxygen by chemical reaction led to the development of the CLEMOX, a 3/4-hour self-generating oxygen breathing apparatus. The Mine Safety Appliance Company developed it during World War II for the U.S. Navy to use in fighting ship fires.

In the general respiratory protection section 1910.134, Section (d), Air Quality, OSHA refers to the same specification for air line respirators and self-contained respirators as were discussed in the section on air line respirators. With few exceptions, it is treated as any other respirator. Section (e)(3) (Use of Respirators) states: "Written procedures shall be prepared covering safe use of respirators in dangerous atmospheres that might be encountered in normal operations or in emergencies. Personnel shall be familiar with these procedures and the available respirators." Section (f) states that self-contained breathing apparatus shall be inspected monthly. Air and oxygen cylinders shall be fully charged according to the manufacturer's instructions. It shall be determined that the regulator and warning devices function properly because OSHA considers self-contained respirators as a device used primarily for emergency situations. Fire fighting and those areas in which entry into an area may be made only for purposes of life rescue or to prevent a greater hazard from release of a product. Section 1910.1017, Vinyl Chloride is an example of such a section.

The Mine Safety and Health Administration uses Subpart H, entitled "Self-Contained Breathing Apparatus" (1), to describe the many types of equipment. There is a tremendous difference in standards due to applications. Firemen, divers and emergency personnel can leave the area or are supplied by reserves. In a mine collapse, the time period is greater between changes of supply; for example, 4 hours for an oxygen rebreathing-type apparatus to 30 minutes for a typical pressurized tank containing breathing air. MSHA defines this type of respirator as a type used during entry into, or escape from, hazardous atmospheres. There are several types designed to suit specific atmospheric conditions.

A closed-circuit apparatus is one in which the exhalation is rebreathed by the wearer after the carbon dioxide has been effectively removed. A suitable oxygen concentration is restored from sources composed of (1) compressed oxygen, (2) chemical oxygen, and (3) liquid oxygen.

An open-circuit apparatus vents the exhalation to the atmosphere and does not rebreathe it. There are two types; demand type and pressure-demand type.

The demand type apparatus is one in which the pressure inside the facepiece in relation to the immediate environment is positive during exhalation and negative during inhalation.

The pressure-demand type is an apparatus in which the pressure inside the facepiece in relation to the immediate environment is positive during both inhalation and exhalation. This style would allow no outside atmospheric contaminants into the respirator's facepiece.

The term "demand regulator" indicates that airflow is on inhalation demand, automatically regulating itself to the desired level to compensate for variations in breathing needs. The difference in the two regulators is that the pressure-demand type has additional controls on the regulator to supply positive pressure to the face mask at all times, yet still has the demand feature. The service time of the positive pressure-demand regulator would be the same as that of the demand regulator if the seal on the facepiece does not leak. Any leakage would increase air consumption, but since the pressure is positive, no contaminants seep into the respirator and decrease service time.

Demand type regulators are adequate in oxygen-deficient atmospheres; however, in hazardous atmospheres immediately dangerous to life or health, the manufacturers recommend they not be used. The mask provides a high flowrate to meet breathing demands, even during extreme exertion. The less exertion on the part of the wearer, the longer the period of service, but exertion in excess of testing standard results in shorter service life. The fast-action mask slips on quickly and adjusts in seconds. The demand regulator has a flow capacity in excess of 400 l/min, which is more than that required for hard work. The wearer opens the cylinder valve, adjusts his facepiece and breathes normally. The air mask can be used by firefighters and industrial workers in oxygen-deficient atmospheres and hazardous concentrations of toxic gases.

A pressure-demand regulator has a mask that is designed for use in atmosphere of potential toxicity so severe that a slight positive pressure in the facepiece is necessary. The MSA pressure demand unit maintains a slight positive pressure during inhalation and, through a unique pressure-balanced exhalation valve, provides low exhalation resistance. The unit is supplied with an Audi-Larm audible signal device to indicate when to leave a toxic atmosphere. Its features include:

- Single-lens Clearvue facepiece with wide visibility
- Cylinder carried comfortably with readily adjustable harness
- Standard belt-mounted demand regulator and Audi-Larm

A modified third type combination of respirators also is recognized by MSHA, mostly for industrial use during emergency entry into a hazardous atmosphere. The code states that a self-contained breathing apparatus and a Type "C" or Type "Ce" air line respirator or air line respirator approved for abrasive blasting combined with a self-contained breathing apparatus supplied by 3, 5 or 10-minutes of breathing air must be used, provided the air line supply is used during entry. A second method used is to classify the self-contained unit for a 15-minute or longer service time and not more than 20% of the rated capacity of the air supply used during entry.

In man tests, a man in a respirator performs such various functions as crawling, running, climbing and pulling various weights, reflecting the weight of the respirator apparatus and the wearer's own weight in a simulated mine rescue operation. The wearer would: (1) climb a vertical treadmill for 1 minute; (2) pull a 20-kg (45 lb) weight to 5 ft at the rate of 15 times/min; and (3) walk at 4.8 kmh (3 mph) for 1 minute. The treadmill shall be inclined 15° from vertical and operated at a speed of 30 cm/sec (1 fps) as specified by the footnote. Although MSHA requires

various types of tests for service life, manufacturers generally consider the service life to be dependent on the wearer. Testing includes:

1. degree of physical activity of the user;
2. physical condition of the user;
3. degree to which the user's breathing is increased by excitement, fear or other emotional factors;
4. degree of training or experience the user has had with this, or similar, equipment;
5. possible presence in the compressed air of carbon dioxide to increase breathing rate; and
6. atmospheric pressure; if used in a pressurized tunnel or caisson at 2 atm pressure, the duration will be one-half as long as when used at 1 atm, and, at 3 atm, will be one-third as long.

For self-contained respirators, the tests for carbon dioxide in inspired gas are considered. Open-circuit apparatus specifies that the breathing rate will be 14.5 respirations per minute, with a minute volume of 10.5 liters. Closed-circuit apparatus specify measurement of carbon dioxide at the mouth of the test dummy. Although carbon dioxide is of a low order of toxicity, the most common effect of inhaling carbon dioxide in any amount above the normal content of the atmospheric air is an increase in arterial CO_2 partial pressure. This causes breathing to become faster and deeper. Any CO_2 increase in the inhaled air also increases CO_2 in the blood. Therefore, the body sensors will detect even a small imbalance in arterial CO_2 and will trigger an increase in lung ventilation to restore equilibrium. To state it more simply, the respirator wearer will use up his air supply at a faster rate, which decreases his chances of escape or successful rescue. The Bureau of Mines (MSHA) found a disturbing factor in testing self-contained breathing apparatus - even the breath-to-breath variation of the most experienced wearer prevented accurate evaluation of the apparatus. Therefore, the Bureau of Mines developed a test method that eliminated human breathing variations.

Low-temperature factors are important because of rescue work and firefighting in winter field conditions. Tests comparing room temperature results of respirators to the apparatus being stored in a freezer provide the following recommendations were made as a result of the report.

1. Use a facepiece fitted with a nosecup.
2. If possible, avoid storing or precooling the apparatus at low temperatures.
3. Use special pans for low-temperature operations whenever necessary.
4. Additional tightening of valve packings and threaded connections may be necessary to stop high-pressure leaks.
5. Do not overtighten cold valve packings and threaded connections. This will avoid damage when brought back to room temperature.
6. Dry off exhalation valves before exposure to low temperatures to prevent them from freezing shut.
7. Do not add additional air to a cylinder after pressure in a fully charged cylinder has dropped, owing to a decrease in temperature.
8. Check the operation of the apparatus at low temperatures before using it in a dangerous atmosphere.
9. Enter toxic atmospheres cautiously. If any difficulty occurs, return to fresh air immediately and determine the cause.
10. Persons who wear apparatus should be trained thoroughly in its function, performance and limitations.

MSHA Section 11.82 - Timers; elapsed time indicators (e) states that service-life indicators or warning devices shall be provided in addition to a pressure gauge on compressed gas self-contained breathing apparatus, except that the apparatus used will be for escape only and will operate automatically without preadjustment by the wearer. Each service life indicator or warning device shall sound an alarm when the remaining service life of the apparatus is reduced within a range of 20-25% of its rated service time.

E. Fit Testing and General Respirator Selection Criteria

For respirators to provide the protection for which they were designed, users must be fit-tested. Since the OSHA Act was passed, many people responsible for respirator selection simply have handed out respirators. Users were not measured or fitted, and considerations such as glasses, speech amplification and protector factors were not considered.

This subsection considers the user's physical requirements and examines how protection factors to safeguard the user's health are determined. OSHA Section 1910.134 (e)(5)(i) states: "Every respirator wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly".

There are two types of fitting tests used: qualitative and quantitative. Qualitative tests are generally fast and

inexpensive. They rely on wearer's odor threshold or ability to smell a test substance. Isoamyl acetate, a liquid with a banana-like odor, is used widely in testing the facepiece fit for organic vapor cartridge and organic vapor canister respirators. There is presently no accepted method of vaporizing the isoamyl acetate, but either a 1.5-inch-diameter stencil brush or cotton wad is saturated for this purpose. The respirator wearer dons the respirator in an isolated area. NIOSH recommends the user perform the following:

1. The user should breathe normally.
2. The user should breathe deeply, as during heavy exertion. This should not be done long enough to cause hyperventilation.
3. Side-to-side and up-and-down head movements should be exaggerated, but should approximate those that take place on the job.
4. The user should talk, which is accomplished most easily by reading a prepared text loudly enough to be understood by someone standing nearby.
5. Other exercises, such as bending and stretching, should be done, depending on the job the wearer must perform.

The major drawback of the isoamyl acetate test is that the odor threshold varies widely among individuals. Furthermore, the sense of smell is dulled easily and may deteriorate during the test so that the wearer can detect only high vapor concentrations. If the respirator is comfortable, the wearer may say that it fits, although it has a large leak. Conversely, a wearer may claim that a particular respirator leaks, simply because it is uncomfortable.

As odor threshold is the criterion, if the odor threshold of a compound is greater than its TLV, overexposure of the respirator user is possible because breakthrough may not be detected. Individuals respond differently to the same odor. At a certain odor concentration, one person may detect the odor but not be able to recognize it; another may recognize and detect it. A third might not even sense it at all. Table 19 compares 100% recognition thresholds with TLVs for selected compounds.

The initial smoke test using stannic chloride or titanium tetrachloride as the test substance is used for fit testing the facepiece of particulate filter respirators. This test can be used both for air-purifying and atmosphere-supplying respirators, but an air-purifying respirator must have a high efficiency filter. A squeeze bulb pushes air through a tube filled with either substance, emitting a dense cloud of the irritating smoke. The user steps into a test enclosure and the irritant smoke is "sprayed" into the test hole. If the user detects any of the irritant smoke, a defective fit is indicated. The user must adjust or replace the respirator and/or filter when this happens. The irritant smoke must be applied with caution because the aerosol is highly irritating to the eyes, skin and mucous membranes. The user generally responds in a positive manner when a leak occurs by coughing or sneezing, indicating a more positive approach.

The negative and positive pressure tests use slight pressure by the lungs. They are used to give gross estimates of fit and usually are performed first. In the negative pressure test, the wearer closes off the inlet of the canister, cartridge(s) or filters by covering the breathing tube with the palm(s) or squeezing so that it does not pass air. He inhales gently so that the facepiece collapses slightly and holds his breath for about 10 seconds. If the facepiece remains slightly collapsed and no inward leakage is detected, the respirator is probably tight enough (Figure 33).

In the positive pressure test, the wearer closes off the exhalation valve and exhales gently into the facepiece. The fit is considered satisfactory if slight positive pressure can be built up inside the facepiece without any evidence of outward leakage. For some respirators, this method requires that the wearer remove the exhalation valve cover, which often disturbs the respirator fit even more than does the negative pressure test.

Other tests, such as the respirator qualitative/quantitative fit test method, refer to a Bureau of Mines technique of blowing a stream of talcum powder or coal dust directly around the face to facepiece seal. The user then would remove the respirator and the leakage would be revealed by telltale streaks of the dust or powder. This method is rarely used. Uranine (a fluorescein dye) can also be sprayed around the respirator sealing surface and, when removed, the leakage was detected by a fluorescent light source.

Quantitative respirator performance tests require the wearer to stand in an artificially generated atmosphere, in which a relatively nontoxic gas, vapor or aerosol is easily detectable. The atmosphere inside the respirator is sampled continuously through a probe in the respiratory inlet covering. The leakage is expressed as a percentage of the test atmosphere outside the respirator, called "percentage of penetration" or, simply "penetration". As the test does not rely on subjective response and the results are given numerically, the results are very accurate. This is important where facepiece leakages must be minimized in areas of highly toxic atmospheres or those immediately dangerous to life or health.

Table 19. Comparison of 100% Recognition Odor Thresholds and TLV's for Selected Compounds[a]

Group 1 - Odor Threshold and TLV approximately the same			
	Odor Threshold[b] **(ppm)**	**TLV (ppm)**	**Ratio**
Acrylonitrile	21.4	20 S	1.07
Arsine	0.21	0.05	4.20
Cyclohexene	300	300	1.00
Cyclohexanol	100	50	2.00
Epichlorhydrin	10	5 S	2.00
Ethyl Benzene	200	100	2.00
EthyleneDiamine	11.2	10	1.12
Hydrogen Chloride	10	5	2.00
Methyl Acetate	200	200	1.00
Methylamine	10	10	1.00
Methyl Chloroform	500	350	1.43
Nitrogen Dioxide	5	5	1.00
Propyl Alcohol	200	200	1.00
Styrene, Monomer	200	100	2.00
Turpentine	200	100	2.00
Group 2 - Odor Threshold from 2 to 10 times the TLV			
Acrolein	0.21	0.1	2.10
Allyl Alcohol	7	2	3.50
Carbon Tetrachloride	75	10 S	7.5
Chloroform	200	25	8.00
Croton aldehyde	7.32[c]	0.1	10.8
1,2Dichloroethylene	500	200	2.50
Dichloroethyl Ether	35	5 S	7.00
Dimethyl Acetamide	46.8	10 S	4.68
Hydrogen Selenide	0.3	0.05	6.00
Isopropyl Glycidyl Ether (IGE)	300	50	6.00
Group 3 - Odor Threshold equal to or greater then 10 times the TLV			
Bromoform	530	0.5 S	10.60
Camphor (synthetic)	1.6-200	2	0.8-100
Carbon Disulfide	[d]	20	-
a-Chloroacetophenone	1.34[c]	0.05	26.8
Chloropicrin	1.08[c]	0.1	10.8
Diglycidyl Ether (DGE)	5.0	0.5	10.0
Dimethylformamide	100	10 S	10.0
Ethylene Oxide	500	50	10.0
Mercury Vapor	[d]	0.5 mg/m^3	-
Methyl Bromide	[d]	15	-
Methyl Chloride	[d]	100	-
Methyl Formate	2000	100	20.0
Methanol	2000	200	10.0
Methyl Cyclohexanol	500	50	10.0
Phosgene	1.0	0.1	10.0
Phosphine	[d]	0.3	-
Radioactive Gases and Vapors	[d]	-	-
Toluene 2,4 Diisocyanate(TDI)	2.14	0.02	107

[a] As odor recognition threshold varies from individual to individual, this table should be used only as a rough guide.
[b] Recognition threshold, except where noted.
[c] Detection threshold.
[d] Little or no recognition threshold in range of concentration where cartridge or canister use is indicated.

The major drawback is the cost. The tests are expensive, requiring specialized equipment and highly trained operators. Each test respirator must be equipped with a sampling probe to allow continued removal of an air sample from the facepiece; therefore, the same facepiece cannot be worn in actual service because the test orifice negates the approval of the respirator.

The British Safety in Mines Research Establishment uses argon for testing full-face respirators. The wearer dons a respirator with two breathing tubes and is positioned in a transparent plastic hood sealed around the waist. Pure argon is supplied into the top of the hood from a regulated cylinder supply. The hood pressure is maintained slightly above atmospheric. Argon is used because it is inexpensive, available in pure form and physiologically inert. To

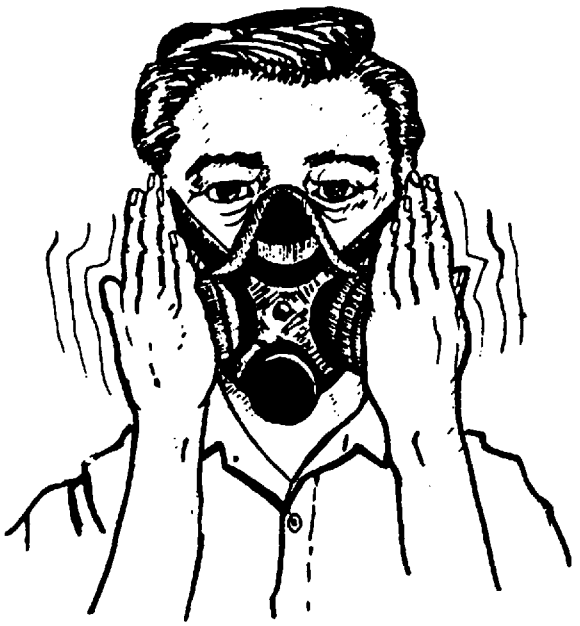


Figure 33. Negative pressure test.

implement the test, the user inhales oxygen of medical quality via a cylinder supplied and fitted with a pressure reducer and demand valve.

The oxygen breathing tube is fitted with a sampling port and a valve to control the direction of flow. A spirometer measures the volume of oxygen used. The amount of argon in the exhaled gas is measured with a mass spectrometer. This instrument can measure the differential amount of argon present in the exhaled breath to a concentration of 10 ppm. A multiway tap is connected to a mass spectrometer and the various sampling ports. Sampling is accomplished using a small suction pump. This method has been implemented to measure respirator leakage on the order of 0.001%.

National Dreager Inc., manufacturer of detector tubes and respiratory equipment, has developed two versions of the Model 80 facemask fit-test device using 2% by volume ethylene as the test gas. This method uses either a detector tube or an electronic leak detector to measure the concentration of test gas exhaled in the breath. With detector tubes, 0.5-10 ppm of ethylene leakage tests can be detected in the range of 0.0025 to 0.05%.

In the use of an electronic leak detector method, a 2% mixture of sulfur hexafluoride in air is used as the test gas. Detector sensitivity is approximately the same as the detector tube method of test. The presence of the radiation source in this detector, however, requires a special operator's license and a testing supervisor trained in handling radiation sources.

Sodium chloride as a test substance has been used in several countries and the United States. The concentration in the test hood is 15 ± 2 mg/m^3, and the particles have an MMAD of 0.66 ± 0.12 μm, with a geometric standard deviation of 2.15 ± 0.19. Calibration is done with a flame photometer using propane supplied by an external tank. The photomultiplier analyzes the flame, and the results are processed.

It is important for the testing group to be able both to make highly accurate measurements and to examine the agent's toxicity. Although the person being tested is exposed for a few minutes, the people who set up the equipment may be exposed to adverse health effects in the research, demonstration and calibration stages. Therefore, the a review of the materials used in quantitative and qualitative fit testing programs. These materials include:

- Isoamyl acetate ($C_7H_{14}O_2$) has a molecular weight of 130.21. Its lowest lethal dose is 500 mg/kg, estimated by oral administration to humans. Its TLV is 100 ppm, or 525 mg/m^3.

- Stannic chloride ($SnCl_4$) has a molecular weight of 260.49. There is no present TLV listed by ACGIH. NIOSH (28) gives 700 mg/kg as the lethal dose (LD_{50}) for rats by oral route of administration.

- Titanium tetrachlorine ($TiCl_4$) has a molecular weight of 189.7. NIOSH lists 10 mg/m^3 as the lowest lethal concentration for mice by oral route of inhalation. It is highly corrosive and presents a special hazard because it reacts violently with water to liberate heat and produce hydrochloric acid. When it comes in contact with the skin, the chemical should be wiped dry. A splash of the liquid in an eye may lead to permanent eye structure damage.

- Talcum powder is a finely pulverized hydrous magnesium silicate.

- Coal dust varies with the area of the country mined. As both talcum powder and coal dust are used rarely in present methods, they will be mentioned only briefly.

- Chloropicrin (trichloronitromethane) is used as a fumigant and tracer gas. The vapor is intensely irritating to skin, eyes, mucous membranes and

stomach. The formula is CCl_3NO_2 and its molecular weight is 164.37. ACGIH lists the TLV at 0.1 ppm and 0.7 mg/m^3 for airborne concentration.

- Uranine ($Na_2(C_{20}H_{10}O_5)$) is a disodium salt of fluorescein. Its molecular weight is 376.78. It is a commercial/medical dyestuff red-orange powder readily soluble in water. It should be noted that it causes nausea and vomiting in some cases. Clinical applications include the diagnosis of eye disorders, determination of blood circulation time and study of blood flow.

Quantitative test materials include the following:

- Argon has a molecular weight of 39.95 and is a 1% constituent of the earth's atmosphere. As it is an inert nonflammable gas, it could be a simple asphyxiant. Care in handling should be emphasized.

- Ethylene (C_2H_4) is a colorless flammable gas. The molecular weight is 28.05. The ACGIH threshold limit values list ethylene as a simple asphyxiant. NIOSH lists ethylene's lowest lethal concentration at 95,000 ppm for a 5-minute inhalation exposure to some mammals.

- Helium is a trace component of the earth's atmosphere and is used for deep diving underwater atmospheres. ACGIH lists helium as a simple asphyxiant. As it is an inert nonflammable gas, no problems have been noted with its use.

- N-Pentane (C_5H_{12}) is a flammable gas with a molecular weight of 72.17. ACGIH lists the threshold limit values for airborne concentrations at 600 ppm, or 1800 mg/m^3. NIOSH lists the lowest lethal concentration at an estimated 130,000 ppm for an inhalation exposure to a human subject.

- Sulfur hexafluoride (SF_6) is an odorless, colorless, nonflammable gas. The impurities in it are sulfur tetrafluoride and sulfur pentafluoride, which have TLVs of 0.1 ppm and 0.025 ppm, respectively. In the pure form, sulfur hexafluoride is considered pharmacologically inactive. ACGIH lists the TLVs at 1000 ppm, or 6000 mg/m^3 for airborne concentrations.

Aerosols used as fit test agents include:

- Di-2-ethylhexyl phthalate is an ester of phthalic acid and used commercially as a softener in rigid polymers like PVC. Extensive research by NIOSH basically has revealed no problems as far as inhalation is concerned. The ACGIH recommends a TLV of 5.0 mg/m^3 for DEHP in air.

- Sodium chloride (NaCl), or table salt, has a molecular weight of 58.4. The ACGIH recommends a TLV of 10 mg/m^3. This material is probably considered the safest to use, although it contributes to hypertension and may have some carcinogenic properties.

2. Simulating Work Conditions

In the fit testing of respirators, normal operations such as breathing, deep breathing, moving the head from side to side (slowly) or up and down, talking or reading a short message were discussed. OSHA section 1910.134 does not specify how well the respirator shall fit. Additions such as 1910.1017, the Vinyl Chloride Standard, used the level of atmospheric concentration the employee could be exposed to as the rationale for the respirator used. For example, if the employee were exposed to concentrations not over 10 ppm, the required apparatus could be any one of three types:

- combination Type C supplied-air respirator, demand type, with half facepiece and auxiliary self- contained air supply,
- Type C supplied-air respirator, demand type, with half facepiece; or
- any chemical cartridge respirator with an organic vapor cartridge that provides a service life of at least 1 hour for concentrations of vinyl chloride up to 10 ppm.

Unknown concentrations, or those above 3600 ppm, required an open-circuit, self-contained breathing apparatus, pressure-demand type, with full facepiece. In the Cotton Dust Standard section (1910.1043), OSHA used the level of exposure ratio to specify the type of protection required.

Example: If the ACGIH TLV were 20 ppm and the TWA concentration measured were 2000 ppm, the protection factor required would be 100. In fit testing the respirator during quantitative fit testing, the concentration of the air inside the booth, hood or test enclosure is divided by the material measured leaking into the facepiece or enclosure:

$$\textit{Protection factor} = \frac{1000 \textit{ ppm of test substance}}{1 \textit{ ppm of measured test}}$$

Based on the test substance, concentration in the booth is 1000 ppm. The amount of test material that leaked into the respirator and was drawn into the vacuum pump for analysis is 1 ppm.

NIOSH lists protection factors for different types of respirators. Table 20 gives protection factors to be noted in the use of respirators. It should be noted that this table is based on Mine Safety and Health Administration guidelines.

MSHA rules specify man tests, test conditioning and general requirements. Man tests describe the duration and sequence of specific activities. These tests will be conducted to (1) familiarize the wearer with the apparatus during use; (2) provide for a gradual increase in activity; (3) evaluate the apparatus under different types of work and physical orientation; and (4) provide information on the operating and breathing characteristics of the apparatus during actual use.

With the specific plant in mind and the current trends for various facial hair designs, the question of fit testing often arises. A classification of the various styles of facial hair are given in Figure 34.

Excessive facial hair interferes with the respirator seal, causing the degree of respirator performance to drop.

OSHA also recognizes the individual who wears glasses. Section 1910.134(e)(5)(ii) states: "Providing respiratory protection for individuals wearing corrective glasses is a serious problem. A proper seal cannot be established if the temple bars of eye glasses extend through the sealing edge of the full facepiece". Manufacturers have tried various methods of securing the glasses to the respirator. In high noise areas, hearing protection is a problem.

Wireless communication on SCBA's and respirators protect breathing only to create another problem. The wearer cannot communicate. The SCBA voice coupler comprises a miniature microphone capsule applied to the inside of the faceplate, electromagnetically coupled to a receiver module attached to the outside surface of the faceplate. The voice coupler does not violate the integrity of the faceplate. The throat microphone system utilizes a rugged dynamic-type throat microphone sealed in durable nontoxic vinyl. These systems are adapted easily to all communication systems, providing clear voice communication from within the mask.

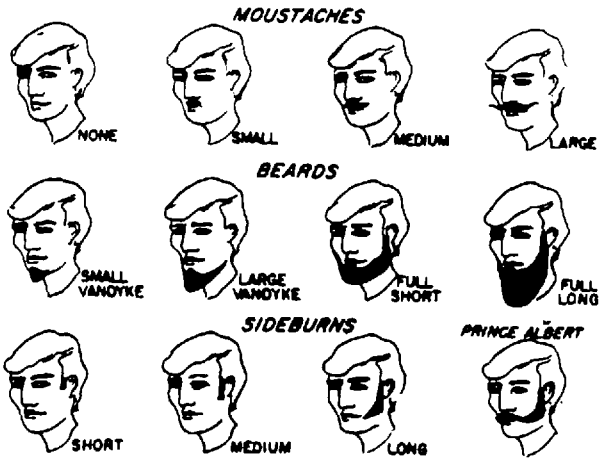


Figure 34. Classification of moustaches, beards and sideburns.

The following are general procedures for fit testing :

1. All persons being tested should be screened medically first.
2. The procedure should be explained fully and, if possible, slides should explain the process.
3. The results should be explained to the wearer and emphasis placed on the proper fit, not the fit the company or union would like.

In using booths, bags and test stands, all tube connections should be labeled. Oxygen and medical assistance shall be available as many people suffer heart attacks when being tested in hospitals, or suffer from fear of job loss.

4. If private testing is done for a large group of workers, the company should include a person dressed like a worker to ensure that the out side contractor explains all aspects to the people being tested, does all the tests and does not create a feeling of negative reaction against the company.

5. The results of individual testing should be recorded on a form such as given in Figure 35. The tests should be signed by the technician and dated, listing the equipment tested and the number of tests performed.

6. As some test methods use flammable gases such as propane in the flame photometers and ethylene, the safe handling of these gases is vital.

Proper fit testing enables specification and purchase of respiratory equipment by sizes.

Table 20. Protection Factors in the Use of Respirators

A. Protection Factors for Particulate Filter Respirators	
Protection Factor	**Permissible Respiratory Protection**
5X	Any dust and mist respirator (30 CFR 11.130)
5X	Any dust and mist respirator, except single use (30 CFR 11.130)
10X	Any dust and mist respirator, except single-use or quarter-mask respirator (30 CFR 11.130)
10X	Any fume respirator (30 CFR 11.130)
10X	Any high-efficiency particulate filter respirator (30 CFR 11.130)
50X	A high-efficiency particulate filter respirator with a full facepiece (30 CFR 11.130)
1000X	A powered air-purifying respirator with a high-efficiency particulate filter (30 CFR 11.130)
B. Protection Factors for Chemical Cartridges and Gas Masks	
Protection Factor	**Permissible Respiratory Protection**
10X	Any chemical cartridge respirator with a **Name** cartridge(s) (30 CFR 11.150)
50X	A chemical cartridge respirator with full facepiece and **Name** cartridge(s) (30 CFR 11.150)
50X	A gas mask with a full facepiece and **Name** canister (30 CFR 11.90(a))
1000X	A powered air-purifying chemical cartridge respirator with a **Name** cartridge (unlisted device)*
Escape	Any gas mask providing protection against **Name** vapors (30 CFR 11.90)
*Classes of respirators are only included in situations in which at least one device has been approved. NOTE: The approval **Name** may consist of acid gases or organic vapors as a class or specific acid gases, ammonia or organic vapors. It also may consist of combinations of acid gases, organic vapors and other gases and vapors.	
C. Protection Factors for Combination Chemical Cartridges and Particulate Filters and Gas Masks and Particulate Filters	
Protection Factors	**Permissible Respiratory Protection**
10X	Any chemical cartridge respirator with **Name** cartridge(s) and **Name** filter(s) (30 CFR 11.150 and 11.130)
50X	A chemical cartridge respirator with a full facepiece, **Name** cartridge(s) and high-efficiency filter(s) (30 CFR 11.150 and 11.130)
50X	A gas mask with a full facepiece and **Name** canister and high-efficiency filter (30 CFR 11.90(a) and 11.130)
1000X	A powered air-purifying chemical cartridge respirator with a **Name** cartridge and high-efficiency particulate filter
Escape	Any gas mask providing protection against **Name** and particulates (30 CFR 11.90 and 11.130)
Name refers to any acid gas, alkaline gas, organic vapor or other specific gas or vapor. **Type** refers to dust and mist, fume or high-efficiency particulate. NOTE: A pesticide respirator is a special type of chemical cartridge respirator or gas mask with a combination sorbent and particulate filter. Where a substance is a pesticide, the following phrase is added as a footnote to the respirator tables. "Including pesticide respirators which meet the requirements of this class."	
D. Protection Factors for Supplied-Air Respirators	
Protection Factor	**Permissible Respiratory Protection**
10X	Any supplied-air respirator (30 CFR 11. 110(a))
50X	Any supplied-air respirator with a full facepiece, helmet or hood (30 CFR 11.110(a))
1000X	*A Type C supplied-air respirator operated in pressure-demand or other positive-pressure or continuous-flow mode (30 CFR 11.110(a))
2000X	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, hood or helmet operated in continuous flow mode (30 CFR 11.110(a))
*This category is not covered fully by preceding category.	
E. Protection Factors for Self-Contained Breathing Apparatus	
Protection Factor	**Permissible Respiratory Protection**
10X	Any self-contained breathing apparatus (30 CFR 11.70 (a))
50X	Any self-contained breathing apparatus with a full facepiece (30 CFR 11.70(a))
10,000+X	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive-pressure mode (30 CFR 11.70(a))
10,000+X	A combination respirator, which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive-pressure or continuous-flow mode and auxiliary self-contained breathing apparatus operated in pressure- demand or positive pressure mode (30 CFR 11.70(b))
Escape	Any escape self-contained breathing apparatus (30 CFR 11.70(a))

DATE: _____ Location: Philadelphia, PA
NAME: _____ Soc. Sec. No. _____

Respirator: Manufacturer _____ Size: _____
Model _____ Type: _____
Approval No: TC-_____

		Pass	Fail
PRE-TEST	Positive/Negative Pressure	☐	☐
	Isoamyl Acetate/Irritant Smoke	☐	☐

AVERAGE PENETRATION (%)

	Test 1	Test 2	Test 3
Initial Upstream			
Initial Clear			
Normal Breathing			
Deep Breathing			
Side to Side			
Up and Down			
Reading			
Grimacing			
Bending			
Normal Breathing			
Final Clear			
Final Up Stream			
AVERAGE			
PROTECTION FACTOR			

REMARKS _____

TECHNICIAN _____ DATE: _____

Figure 35. Quantitative respirator fit test result.

Cleanup is a problem under normal working conditions, but for respirator users it is vital to good sanitary and health conditions. Therefore, the easiest, most efficient and safest method for management and personnel responsible for respirators is the convenient packaged cleaning system. Through education and operation, such systems can prevent skin disease and respiratory problems due to contaminated respirators, thus eliminating unnecessary absence and discomfort.

Although such systems are designed to be used by the individual worker/respirator user, management can maintain control of the respirator cleaning function more easily through inventory and inspection. Once installed as part of the respiratory protection program, these systems provide personnel and management with a simple, easy-to-learn and use method for cleaning respirators. As replacements for cleaning packets and storage bags are necessary, inventory records indicate frequency of use. Also, because the storage bags must be annotated with the name of the person who cleaned the respirators and when (and can also be inspected through the clear plastic bag), management can spot-check stored respirators to determine efficiency of the program. The use of SCBA units and similar devices has created further need for proper facemask cleaning. The Fire Service, among others, has spent thousands of dollars to ensure that their SCBA air is of the highest quality. Consequently, to pass this clean air through a dirty facemask constitutes a serious health hazard.

Probably the most important question in respiratory protection is "what is the right respirator for me?" A typical small user calls the local safety equipment supply house or places a checkmark in a box in one of the dozen publications that a typical plant may receive. Then the plant receives a visit from the local sales representative of the respirator-safety and health equipment company manufacturer. A large firm may have a safety engineer or maintenance supervisor whose responsibility it is to specify this type of equipment. A large corporation would use the medical or insurance staff or industrial hygienist to specify the type of respirator that should be worn.

The OSHA Act is a law "to assure safe and healthful working conditions for working men and women." It provides medical criteria to assure, as much as practicable, that no employee will suffer diminished health, functional capacity or life expectancy as a result of his work experience. The Act also called for the Secretary of Health, Education and Welfare to conduct research and establish methods for dealing with safety and health problems. The National Institute of Occupational Safety and Health (NIOSH) was created to perform or assist in these various functions.

OSHA specifies respiratory protection in three codes: (1) Maritime (shipbuilding), Ship Breaking, Ship Repair and Longshoring; (2) Construction, and (3) General Industry.

The Construction Codes 1926-103, Respiratory Protection, include the General Industry Code for Abrasive Blasting (1910.94) and Respiratory Protection (1910.134).

NIOSH has three basic functions vital to respirator users:

- Research and publication of studies
- Training
- Approval of respiratory apparatus

Training in respiratory protection is provided by NIOSH aimed at the individual responsible for any portion of a respirator program initiation or upgrading.

NIOSH is also responsible for the Testing and Certification Branch (TCB), Division of Safety Research. The TCB was established to assure that certain devices and instruments used for control and evaluation of occupational hazards meet minimum performance requirements necessary to protect workers' health and safety.

The following are its functions:

1. Publish certification requirements.
2. Test and certify products meeting those requirements.

3. Publish lists of certified products.
4. Survey manufacturers' plants to determine acceptability of their quality assurance programs.
5. Sample products from the open market and test them for continued conformance to certification requirements.
6. Research and development (R&D) of new test methods and requirements for product improvement, where necessary, to assure worker protection.

The NIOSH publication supplement to the NIOSH Certified Equipment List lists certification of:

- Coal mine dust personal sampler units
- Gas detector tube units
- Respiratory protection devices
- Obsolete respirators
- Sound level meter sets

Respirators are of two basic types: air filtering and air supplying. Medically speaking, respirators also are used in hospitals and inhalation therapy work for treatment of disease. We have considered respirators for industrial usage only. Respirators restrict the atmosphere inhaled into the lungs by covering the nose and the mouth. Five different devices provide this covering:

- Single-use respirator
- Quarter-mask respirator
- Half-mask respirator
- Full-face respirator
- Protective hood or garment-style full suit

The relative merits of each system will be discussed now, noting the modifications that are made for specific applications.

The Single-Use Dust Respirator — Figure 36 illustrates the single-use dust respirator. This generally is sold in hardware-paint stores by the boxful and worn to prevent irritation against a dust, mist or fumes by filtering out the irritant particulates. It generally was not taken seriously until some styles received NIOSH approval for use for various dusts. Its principal advantages are that it is inexpensive, disposable and requires no maintenance or cleaning. Its disadvantages are that it includes no method of measuring the protection factor, no method of fit testing and no method of estimating service life.

Disposable Mouth Bit Respirator — This type of disposable respirator also requires no maintenance. It is compact, lightweight, low in cost, and equipped with inhalation and exhalation valves and a one-piece polypropylene body with belt clip. It is designed for emergency escape protection against a variety of toxic gases, such as acid gas, ammonia, chlorine, organic vapors, etc., depending on the type of chemical fill used.

Depending on user preference, the respirator can be carried suspended from the neck on a neck strap or attached at the waist by means of an integral clip. Built-in inhalation and exhalation valves direct the flow of air in one direction through the chemical cartridge. This low-cost respirator requires no cleaning, sanitizing, cartridge replacement or maintenance.

The respirator contains 180 cc of chemical fill to provide the required protection. The respirator must not be used where the oxygen content of the atmosphere is less than 19.5% or in atmospheres immediately dangerous to life or health. NIOSH Certification TC-23C-55 is issued to provide respiratory protection during escape only from atmospheres containing not more than 10 ppm of chlorine gas by volume.

Quarter-Mask and Half-Mask Respirators — The quarter-mask respirator mask covers the mouth and nose. It represented a first step in providing a better seal between the wearer's face and the respirator. The respirator was improved further to the half-mask style, which includes the nose, mouth and chin. The advantage is a more secure fit, and a better sealing capacity allows the respirator to be used where more toxic material exists. The masks consist

Figure 36. Single-use respirator.

of purifying elements such as filters, chemical cartridges or canisters that can be attached directly or by use of a breathing hose, depending on the size and weight. Inhalation and exhalation valves are used to draw the air in from the filter and exhale the carbon dioxide air out.

The Full Facepiece — The full facepiece covers the entire face from chin to hairline and from ear to ear. This respirator provides added eye protection and a better seal between the respirator body and the face. Not only is better protection provided against contaminants, but this respirator can be fit-tested and secured to the face for operations such as fire fighting and rescue. This respirator offers a choice of three facepieces and two control valves, all approved by the MSHA for use in atmospheres not immediately hazardous to life or health. With this respirator, a continuous flow of breathable air is supplied to the facepiece and provides a cooling effect as it meets the respiratory requirements of the wearer.

The full-face respirator has many attachments that can be incorporated to make it more versatile. As a filter respirator, it can be equipped with filters, chemical cartridges, canisters, and powered air-purifier systems. As an air-supplied respirator, it can be equipped with an air line arrangement or a tank-supplied compressed air/oxygen system, either for closed or open operation.

A tank supplied system includes a positive-pressure self-contained breathing apparatus that features a lightweight, long-term (up to 60 minutes) oxygen/air supply. It recirculates the major portion of the user's exhaled gas, permitting the unit to be much smaller and lighter than open circuit equipment, in which all of the user's exhaled breath is vented. Properly used, the minimum duration will be 60 minutes, regardless of the user's size or level of activity. Oxygen is supplied to the breathing chamber continuously. In addition, the unit will add oxygen automatically to compensate for heavy workloads or outward mask leakage.

An emergency escape breathing device is a light-weight escape hood and life support apparatus designed to provide breathing protection from oxygen-deficient, smoke-laden or other toxic atmospheres. This device is a semiclosed-circuit, 15-minute, completely disposable emergency escape breathing device.

The hood serves as a counter lung to the user's respiratory system. Surplus system gas is vented through a protected relief valve to preclude overinflation of the hood.

F. Full Suit Styles and Protection Levels

A protective hood or garment-style full suit is the ultimate in protection for the worker exposed to hazardous chemicals and other media, such as abrasive blasting, heat, and cold, at one time. The concept is a method most companies will use to protect workers exposed to hazardous materials. It originated as the hard hat diver's suit and was modified to an abrasive blasting-airline breathing-supplied system. The design was modified further by vortex cooling tubes to produce not only ventilation but cooling as well. Further modifications of the suit protect the respirator suit wearer totally from a hostile environment. This type equipment also allows beards, spectacles and low hairlines worn by workers without problems of fitting.

The NIOSH-OSHA Standards Completion Program — Respirator Decision Logic provides guidance of the limitations of the equipment and OSHA compliance. In selecting the proper respiratory protection device, the physiology of the wearer, the toxicity of the hazards encountered by leakage or misuse and the hazard of sampling all must be considered carefully.

The purpose of the Respirator Decision Logic is to assure technical accuracy and uniformity between substances in the selection of respirators and to provide necessary criteria to support this selection. The decision logic is a step-by-step elimination of inappropriate respirators until only those that are acceptable remain. Judgment by persons knowledgeable of inhalation hazards and respiratory protection equipment is essential to ensure appropriate selection of respirators.

The primary technical criteria for what constitutes a permissible respirator is based on the technical requirements of 30 CFR Part 11 (Department of the Interior, Bureau of Mines, Respiratory Protective Devices and Tests for Permissibility). The proposed health standards will allow only respirators approved by the Bureau of Mines (or Mining Enforcement and Safety Administration (MESA)) and NIOSH under 30 CFR 11. Classes of respirators are only included when at least one device has been approved.

Protection factors are criteria used in determining what limiting concentrations are to be permitted for each respirator type that will afford adequate protection to the wearer. The referenced Subparts of 30 CFR 11 give technical descriptions concerning each type or class of respirators referenced in the decision logic. 30 CFR 11 should be used with the decision logic to properly understand the criteria for the specification of allowable respirators.

The general decision logic flowchart is based on the following:

Step 1 - Assemble Information on Substance

One must assemble necessary toxicological, safety and research information for the particular contaminant. Typically, the following are required:

1. permissible exposure limits specified in 29 CFR 1910.1000;
2. warning properties if the substance is a gas or a vapor;
3. eye irritation potential of the substance;
4. LFL (lower flammable limit) for the substance;
5. IDLH (immediately dangerous to life or health) concentration for the substance;
6. any possibility of poor sorbent efficiency at IDLH concentration and below;
7. any possibility of systemic injury or death resulting from absorbance of the substance (as a gas or vapor) through the skin;
8. any possibility of severe skin irritation resulting from contact of the skin with corrosive gases, vapors or particulates;
9. the vapor pressure of the substance (and equivalent ppm);
10. any possibility of high heat of reaction with sorbent material in cartridge or canister. and
11. any possibility of shock sensitivity of substance sorbed on sorbent of cartridge or canister.

Step 2 - Determine Physical State of Substance

One must determine the physical state(s) of the substance as it is likely to be encountered in the occupational environment. It will be either (1) gas or vapor; (2) particulate (dust, fume or mist), or (3) a combination of these.

Step 3 - Assemble a Table of Permissible Respiratory Protection for Substance

Table 21 provides a detailed logic sequence to respiratory protection for different types of air contaminants.

Personal protection requirements for protection against exposure to substances that may cause injury by absorption through the skin from materials splashed or spilled on the skin are also important considerations. Respirator selection criteria are based primarily on the inhalation hazard of the substance. A supplied-air suit may provide skin protection for extremely toxic substances, which may be absorbed through the skin, or for substances that may cause severe skin irritation or injury.

Where information is available indicating systemic injury or death resulting from absorbance of a gas or vapor through the skin or where severe skin irritation or injury may occur from exposure to a gas, corrosive vapor or particulate, the following should be noted. The use of supplied-air suit may be necessary to prevent skin contact and respiratory exposure from airborne concentrations of (specific substance). Supplied-air suits should be selected, used, and maintained under the immediate supervision of persons knowledgeable in the limitations and potential life endangering characteristics of supplied-air suits. Where supplied-air suits are used above a concentration which may be immediately dangerous to life and health, (concentration) an auxiliary positive-pressure self-contained breathing apparatus must also be worn.

Where supporting evidence exists or immediate (less than three minutes) breakthrough time at the IDLH concentration and below for a cartridge or canister sorbent, air-purifying devices shall not be allowed for any use, escape or otherwise. Where there is reason to suspect that commonly used sorbents (e.g., activated charcoal) do not provide adequate sorption efficiency against a specific contaminant, use of such sorbents shall not be allowed. However, where another sorbent material has been demonstrated to be effective against a specific contaminant, approved respirators utilizing the effective sorbent material shall be allowed.

Where there is reason to suspect that a sorbent has a high heat of reaction with a substance, use of that sorbent is not allowed. In such cases, only sorbents providing safe protection against (specific substance) may be used. For such substances, a footnote is added to the respirator table that reads as follows: "(Specific substance) is a strong oxidizer and should be kept away from oxidizable material. Some cartridges and canisters may contain activated charcoal and shall not be used to provide protection against (specific substance). Only nonoxidizable sorbents are allowed." Where the oxidizable material may be an oxidizable filter, the footnote reads: "(Specific substance) is a strong oxidizer and should be kept away from oxidizable substances. Only air-purifying respirators with nonoxidizable filters are allowed. Also, where there is reason to suspect that a substance sorbed on a sorbent of a cartridge or canister is shock sensitive, use of air-purifying respirators is disallowed.

Table 21. Logic Chart for Respiratory Protection Selection

Respiratory Protection Against Gases or Vapors	
Condition	*Selection Sequence*
Routine Use	1. Consider skin irritation and sorption of the material through the skin. 2. Poor warning properties - eliminate all air-purifying respirators. 3. Eye irritation - eliminate or restrict use of half-mask respirators. 4. IHLH or LFL - above this concentration eliminate all but positive-pressure self-contained breathing apparatus and combination positive-pressure supplied-air respirator with auxiliary positive-pressure self-contained breathing apparatus. 5. List all allowed respirators by condition of use and type.
Entry and escape from unknown concentrations	Use positive-pressure self-contained breathing apparatus or combination positive-pressure supplied-air respirator with auxiliary positive-pressure self-contained breathing apparatus.
Firefighting	Use positive-pressure self-contained breathing apparatus.
Escape	Use gas mask or escape self-contained breathing apparatus.

Respiratory Protection Against Particulates

Condition	*Selection Sequence*
Routine Use	1. Consider skin irritation or sorption of the material through the skin. 2. Eye irritation - eliminate or restrict the use of half-mask respirators. 3. Systemic poison - eliminate single-use respirators. 4. For permissible exposures less than 0.05 mg /m^3 eliminate DFM respirators, except with high-efficiency particulate filter. 5. IDLH or LFL - above this concentration eliminate all but positive-pressure self- contained breathing apparatus and combination positive-pressure supplied-air respirator with auxiliary positive-pressure self-contained breathing apparatus. 6. List all allowed respirators by condition of use and type.
Entry and escape from unknown concentration	Use positive-pressure self-contained breathing apparatus or combination positive-pressure supplied-air respirator with positive-pressure self-contained breathing apparatus.
Firefighting	Use positive pressure self-contained breathing apparatus.
Escape	Use any dust, fume or mist respirator, except single-use, or any escape self-contained breathing apparatus.

Respiratory Protection Against Combination of Gas or Vapor and Particulates

Condition	*Selection Sequence*
Routine Use	1. Consider skin irritation or sorption of the material through the skin. 2. Poor warning properties or inadequate sorbent efficiency - eliminate all air-purifying respirators. 3. Eliminate all respirators except with combination sorbent/particulate filter. 4. Eye irritation - eliminate or restrict use of half-mask respirator. 5. For permissible exposures less than 0.05 mg/m^3 eliminate all respirators except with sorbent/high-efficiency particulate filter. 6. IDLH or LFL - above this concentration eliminate all but positive-pressure self-contained breathing apparatus and combination positive-pressure supplied-air respirator with auxiliary positive-pressure self-contained breathing apparatus. 7. List all allowed respirators by condition of use and type.
Entry and escape from unknown concentration	Use-positive-pressure self-contained breathing apparatus or combination positive-pressure supplied-air respirator with auxiliary positive-pressure self-contained breathing apparatus.
Firefighting	Use positive-pressure self-contained breathing apparatus.
Escape	Use gas mask or escape self-contained breathing apparatus.

For routine work operations, any perceptible eye irritation is considered unacceptable. Therefore, only full facepiece respirators are permissible in contaminant concentrations that produce eye irritation. Note that 30 CFR 11.90(b) (note 6) specifies that eye protection may be required in certain concentrations of gases and vapors. For escape, some eye irritation is permissible if it is determined that such irritation would not inhibit escape and is reversible.

Where quantitative eye irritation data cannot be found in the literature and theoretical considerations indicate the substance should not be an eye irritant, half facepiece respirators are allowed.

IDLH — The definition of IDLH provided in 30 CFR (1) 11.3(t) is as follows:

> "Immediately dangerous to life or health" means conditions that pose an immediate threat to life or health or conditions that pose an immediate threat of severe exposure to contaminants, such as radioactive materials, which are likely to have adverse cumulative or delayed effects on health.

The purpose of establishing an IDLH exposure concentration is to ensure that the worker can escape without injury or irreversible health effects from an IDLH concentration in the event of failure of the respiratory protective equipment. The IDLH is considered a maximum concentration above which only highly reliable breathing apparatus providing maximum worker protection is permitted. As IDLH values are set conservatively, any approved respirator may be used up to its maximum use concentration below the IDLH.

In establishing the IDLH concentration the following factors are considered:

1. escape without loss of life or irreversible health effects (30 minutes is considered the maximum permissible exposure time for escape); and
2. severe eye or respiratory irritation or other reactions that would prevent escape without injury.

IDLH should be determined from the following sources:

1. specific IDLH provided in the literature, such as the AIHA Hygienic Guides;
2. human exposure data;
3. acute animal exposure data;
4. acute toxicological data from analogous substances (where such above mentioned data are lacking).

The following guidelines should be used to interpret toxicological data reported in the literature for animal species:

1. Where acute exposure animal data are available (30-minute to 4-hour exposures), the lowest exposure concentration causing death or irreversible health effects in any species is determined to be the IDLH concentration.
2. Chronic exposure data may have no relevance to the acute effects and should be used in determining the IDLH concentration only on competent toxicological judgment.
3. Where there is no toxicological evidence of an IDLH concentration, 500 times the permissible exposure limit shall determine the upper limit above which is used only highly reliable breathing apparatus providing maximum worker protection.

Lower Flammable Limit and Firefighting — Contaminant concentrations in excess of the LFL are considered to be immediately dangerous to life or health. At or above the LFL, the use of respirators is limited to those devices that provide the maximum protection, i.e., positive-pressure SCBA and the combination positive-pressure supplied-air respirators with auxiliary positive-pressure SCBA. For firefighting, the only device providing adequate protection is the positive-pressure SCBA.

V. CHEMICAL PROTECTIVE CLOTHING

A. Levels of Protection

The purpose of chemical protective clothing is to protect the wearer against the effect of toxic or corrosive/caustic products which could enter the body (inhalation, skin absorption) or cause tissue damage upon contact with the skin. These products could be in vapor, liquid, or solid form. One type of material is not compatible with every type of chemical. While it may provide excellent resistance against one chemical, the same material may provide very poor or no protection against another chemical. The levels of protection under OSHA standards are as follows:

Level D: A work uniform affording minimal protection, used for "nuisance contamination" only. This level may also include:

a. Structural fire fighting clothing with self-contained breathing apparatus (minimal skin protection against chemical attack).

b. Chemical protective clothing without respiratory protection.

Level D protection is appropriate when:

a. The atmosphere contains no known hazard.

b. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemical.

Level C: A full body splash protective (not gas tight) garment and air purifying respirator. This level provides a lesser level of respiratory protection, and a lesser level of skin protection for use when the concentration(s) and type(s) of airborne substance(s) is known, and the criteria for using air purifying respirators is met.

Level C protection is appropriate when:

a. Atmospheric contaminants, liquid splashes, or direct contact will not adversely affect or be absorbed through any exposed skin.

b. Air contaminants have been identified and measured, and can be removed by an air purifying respirator.

c. The use of air purifying respirators has been authorized by the Incident Commander.

Level B Type II: A full body splash protective (not gas tight) garment and positive pressure self contained breathing apparatus located outside the suit. This level provides the highest level of respiratory protection, but a lesser level of skin protection.

a. Advantages:

Visibility is increased due to the elimination of a separate suit face shield.

Mobility is improved as the suit is compressed by the straps on the self-contained breathing apparatus.

b. Disadvantages:

SCBA is exposed to damage and contamination.

Decontamination is more difficult due to the trapping of contamination beneath the self-contained breathing apparatus.

Level B Type I: A full body splash protective (not gas tight) garment and positive pressure self contained breathing apparatus located inside the suit. This level provides the highest level of respiratory protection, but a lesser level of skin protection.

a. Advantages:

Protects the self-contained breathing apparatus from contamination or chemical damage.

Type I garments are easier to decontaminate due to fewer places for contaminants to be trapped.

b. Disadvantages:

Type I garments tend to be more bulky (in order to be large enough to cover the wearer and self-contained breathing apparatus.

Visibility is reduces by the location and design of the face shield.

Type I suits weigh more than garments of other designs due to the greater among of fabric required.

Level B Type III: A full body splash protective (not gas tight) garment and positive pressure supplied air breathing apparatus with escape self-contained breathing apparatus. The escape self-contained breathing apparatus may be located inside or outside the suit. This level provides the highest level of respiratory protection, but a lesser level of skin protection.

a. Advantages:

Longer operating time due to uninterrupted air supply.

b. Disadvantages:

Greater duration of air supply increases the probability of heat stress.

Reduced mobility due to the use of an air line.

Entry distance limited by air supply hose (300 ft. from air supply).

Incompatibility of air hose material to hazardous material(s) may result in airline failure.

Level B protection is appropriate when:

a. Type and atmospheric concentration of substance has been identified, and requires a high degree of respiratory protection but less skin protection.

b. The atmosphere contains less then 19.5% oxygen.

c. Unidentified gases/vapors are not suspected of containing high levels of chemicals harmful to the skin, or capable of being absorbed through the skin.

d. The products involved will not harm the respiratory protective equipment used with Level B Type II and Type III (with exposed escape SCBA).

Level A: A full body, gas tight/vapor protective garment which is constructed of protective clothing material to isolate the body from direct contact with potentially dangerous gaseous or liquid chemicals and posi tive pressure self-contained breathing apparatus. Level A protection provides the highest level of respiratory and skin protection.

a. Type I: Respiratory protection inside the suit

b. Type II: Respiratory protection on outside of suit

c. Type III: Airline supplied, respiratory protection may be located inside or outside of the suit.

Level A Protection is appropriate when:

a. The hazard is identified, and requires the highest level of protection for skin, eyes, and respiratory system.

b. High concentration of gases and vapors.

c. High potential for splash, immersion, or exposure to unexpected gases/vapors/ particulate that are harmful to the skin, or are capable of being absorbed through the skin.

d. The products involved will not harm the respiratory protective equipment used with Level A Type II and Type III (with exposed escape SCBA).

Personal Protective Equipment for hazardous materials emergencies is designed primarily to protect the wearer against a chemical challenge, many other hazards may be present at an emergency incident. In addition to these hazards, there are inherent physical limitations to any protective equipment.

1. Personal Protective Equipment does not provide protection from detonation or violent container rupture.

   a. The shock wave generated as a result of the detonadon of a Class A Explosive will cause severe traumatic injury (or death) regardless of the type of protective equipment worn.

   b. A violent rupture (BLEVE) or deflagration of a Class B or C Explosive or Blasting Agent will also present a high probability of severe injury or death.

2. Exposure to gamma radiation can not be prevented without substantial shielding or remaining a great distance from the radioactive source.

   a. The lead aprons used in medical facilities is generally used for low level X-Rays or radiopharmaceuticals provide limited protection for a short time but are not practical for hazardous material response.

   b. Harm from alpha particles can be prevented by the skin if respiratory protection is worn to prevent inhalation or ingestion of the particles.

   c. In the case of beta particles normal chemical protective clothing or structural fire fighters protective clothing with adequate respiratory protection to prevent inhalation or ingestion.

3. Chemical protective clothing is not designed for firefighting operations has limited heat resistance and in many cases will burn.

   a. A limited degree of thermal protection can be obtained by covering the chemical protective ensemble with a flash cover. This does not turn the chemical protective clothing into firefighting clothing or an fire entry garment!

   b. Another option for increasing thermal protection is the use of fire resistant clothing and/or structural firefighting clothing in conjunction with chemical protective clothing.

4. Cryogenic materials present a significant hazard due to the degradation caused to protective equipment due to the extreme cold temperature of the product (< -150°F).

a. Most materials (such as protective clothing barrier fabric, boots, gloves, etc.) will become brittle at these extremely cold temperatures.

b. If the chemical protective clothing has the potential to be exposed to a cryogenic material, a nylon cryogenic cover may be used to provide a limited degree of protection from the extreme cold.

5. Exposure to ultraviolet light causes many materials to age and deteriorate. Chemical protective clothing is no exception, recognize that garments will have a limited shelf life.

6. Resistance to mechanical damage such as tears, punctures, and ripping out at seams is critical. Each barrier fabric and construction method varies in its strength.

   An additional pair of outer gloves may be used to provide additional chemical protection or to increase protection from mechanical damage.

7. Barrier fabrics should be sufficiently flexible so as not to overly impair movement.

8. It may not be possible to remove all contamination from Personal Protective Equipment. There are two options for (final) decontamination of chemical protective clothing off-site decontamination or disposal.

   a. Protective garments may be designed to be reusable after a thorough decontamination and testing. Other garments are of "limited use" design and are disposed of if they become excessively contaminated or after a limited number of uses (frequently one).

   b. When severe contamination problem (high hazard or a difficult product to remove) is anticipated, boot covers or an additional pair of outer gloves may be worn to facilitate the decontamination process.

   c. Boot covers and additional outer gloves are removed and disposed of at the start of the decontamination process.

The operational limitations of personal protective equipment include:

1. It is frequently difficult to identify and communicate with personnel working in chemical protective clothing.

   a. Chemical protective clothing can be provided with markings to assist in the identification of personnel.

   b. Effective communications with personnel operating in chemical protective clothing requires the use of radio equipment that may be worn and operated under/inside the garment.

2. Personnel may feel somewhat claustrophobic due to wearing a chemical protective garment and self-contained breathing apparatus.

3. The bulk most chemical protective ensembles makes movement more difficult.

   When multiple layers must be worn to afford the correct protection, such as working with a chemical protective suit with a flash cover movement is substantially limited.

4. Manual dexterity will also be compromised due to the multiple gloves that must be worn.

   a. OSHA regulations require double gloving.

   b. Specific work functions may require additional hand protection.

5. Peripheral vision is reduced by the facepiece of the respiratory protection, and in Type I (and possibly Type III garments) the suit face shield.

6. Heat stress and illness is a major concern when personnel are working in chemical protective clothing.

   a. The bodys principal means of cooling is through the evaporation of sweat. When personnel are working in chemical protective clothing, sweat is trapped inside the clothing and cannot evaporate. This will raise the bodys core temperature and can result in heat related illness such as: Heat Rash, Heat Cramps, Heat Exhaustion, Heat Stroke.

   b. Heat stress may be reduced by being in good physical condition, maintaining adequate

hydration, utilization of cooling garments, adequate cool down between work periods, and limiting the duration personnel work in Personal Protective Equipment.

c. Heat stress may be reduced by the use of a cooling vest or garment which slows the heating of the body through the use of a circulating fluid or replaceable cold packs.

The following are important terms related to fabric properties.

1. Penetration: The act of a chemical passing through a piece of barrier fabric at an opening such as zippers, tears, or holes in the garment.

2. Permeation: The act of a chemical passing through barrier fabric on a molecular level. The three phases of permeation are:

   a. Adsorption/Absorption begins when the challenge chemical comes in contact with the barrier fabric, sticks to, and begins to be absorbed by the protective material.

   b. Diffusion occurs as the challenge chemical migrates through the fabric from the area of contact toward the inner surface of the barrier.

   c. Desorption occurs when the challenge chemical has migrated completely through the barrier and reaches the inner surface of the protective fabric.

3. Breakthrough: When a substance permeates a barrier (such as the barrier fabric of chemical protective clothing) breakthrough occurs at the point where the substance is detected on the inside of the barrier.

4. Permeation Rate and Breakthrough Time are important factors in the selection of Personal Protective Equipment.

5. Degradation: The act of a chemical physically and visibly changing a piece of barrier fabric. For example, degradation may be observed as: Charring, a color change, a loss or gain in the weight of the barrier fabric, shrinking, swelling, or brittleness of the barrier fabric or other component of Personal Protective Equipment.

6. Degradation data may be one element used in the selection of Personal Protective Equipment. Recognize however, that the terminology used in degradation charts is qualitative (excellent, good, fair, variable).

B. Compatibility Chart for Chemical Protective Clothing

Following (Table 22) is a chart that can be used as a reference in selecting protective garment materials. The chart has been compiled from a review of company specific literature on chemical protective garments. While the author and publisher believe the chart represents reasonably accurate data, we do not guarantee its accuracy nor do we assume responsibility for its use. The reader should view the information in this chart as a general guide, and should further consult specific chemical protective clothing supplier's literature in making final selections.

The following is the rating key used in the chart: A = Recommended (little or no effect by the chemical); B = Minor to Moderate Effect; C = Conditional (Varies from moderate to severe under different conditions); X = Not Recommended (chemical has severe effect on the material); I = Insufficient Data or Information to Rate the material.

Table 22. Compatibility Chart for Selecting Chemical Protective Clothing

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Acetamide	B	X	B	A	B	A	B
Acetic Acid, Anhydrous	A	X	X	B	X	C	A
Acetic Acid, 30 %	A	X	B	B	B	B	A
Acetic Acid, Glacial	A	X	C	B	C	C	X
Acetone	C	X	X	A	X	X	B
Acetophenone	X	X	X	A	X	X	X
Acetyl Chloride	A	X	A	C	X	X	X
Acetylene	A	B	A	A	A	B	B
Acylamide	A	I	I	A	B	A	A
Acrylonitrile	I	X	X	X	X	X	C
Adipic Acid	A	A	A	A	A	A	A
Alkazene	X	X	B	X	X	X	X
Allyl Alcohol	A	C	A	A	A	A	A
Alum-NH_3-Cr-K	I	X	X	A	I	A	A

Table 22. Continued.

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Aluminum Acetate	A	X	A	A	A	B	B
Aluminum Chloride	A	B	A	A	B	A	A
Aluminum Fluoride	A	C	A	A	B	A	A
Aluminum Hydroxide	A	A	A	B	B	A	A
Aluminum Nitrate	A	C	A	A	A	A	A
Aluminum Phosphate	A	A	A	A	A	A	A
Ammonia, Anhydrous	A	X	X	A	A	B	A
Ammonia Gas (Cold)	A	C	A	A	A	A	A
Ammonia Gas (Hot)	B	X	B	B	B	X	A
Ammonium Carbonate	A	B	A	A	A	X	A
Ammonium Chloride	A	A	A	A	B	A	A
Ammonium Hydroxide	A	X	B	A	A	C	A
Ammonium Nitrate	A	X	A	A	A	A	B
Ammonium Persulfate	A	X	A	A	A	X	A
Ammonium Phosphate	A	A	A	A	A	A	A
Ammonium Salts	A	I	A	A	A	A	A
Ammonium Sulfate	A	A	A	A	A	A	A
Amyl Acetate	C	X	X	A	X	X	X
Amyl Alcohol	A	X	B	A	A	B	A
Amyl Borate	I	I	A	X	I	A	A
Amyl Chloronaphthalene	I	X	A	X	I	X	X
Aniline	B	X	C	B	X	X	X
Aniline Dyes	I	X	B	B	I	X	B
Aniline Hydrochloride	A	X	B	B	A	B	X
Animal Fats	A	B	A	B	B	A	B
Arochlor(s)	C	X	A	C	C	C	X
Arsenic Acid	A	C	A	A	A	A	A
Arsenic Trichloride	B	B	A	C	B	A	A
Askarel	C	X	A	I	B	B	X
Asphalt	A	B	A	I	B	B	C
Barium Chloride	A	A	A	A	A	A	A
Barium Hydroxide	A	A	A	A	A	A	A
Barium Sulfide	A	A	A	A	A	A	A
Benzaldehyde	C	X	X	A	X	X	X
Benzene	C	C	A	X	C	X	X
Benzene Sulfonic Acid	A	X	A	X	A	X	A
Benzoic Acid	A	X	A	X	B	X	X
Benzoyl Chloride	X	X	X	X	X	X	X
Benzyl Alcohol	A	X	A	B	X	X	B
Benzyl Benzoate	A	C	A	B	A	X	X
Benzyl Chloride	X	X	A	X	X	X	X
Berrylium	A	A	A	A	A	A	A
Black Sulfate Liquor	A	C	A	B	A	B	B

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Blast Furnace Gas	A	X	A	X	A	X	X
Bleach Solutions	A	X	A	A	A	X	C
Borax	A	A	A	A	A	B	A
Bordeaux Mixture	A	X	A	A	A	B	B
Boric Acid	A	A	A	A	A	A	A
Boron Trifluoride	C	C	C	C	B	C	C
Brine	A	B	A	A	A	A	A
Bromine	A	X	A	X	A	X	X
Butadiene	B	C	B	X	B	X	B
Butane	B	A	A	X	B	A	A
Butter	A	A	A	B	A	A	B
Butyl Acetate	X	X	X	B	X	X	X
Butyl Acetyl Ricinoleate	A	X	A	A	A	C	B
Butyl Acrylate	C	X	X	X	X	X	X
Butyl Alcohol	A	X	A	B	B	A	A
Butyl Amine	B	X	X	X	X	C	X
Butyl Benzoate	B	X	A	B	B	X	X
Butyl Carbitol	B	B	A	A	B	B	B
Butyl Cellosolve	B	X	X	A	B	C	C
Butyl Oleate	A	A	A	B	A	X	X
Butyl Stearate	B	C	A	B	B	B	X
Butylaldehyde	B	X	X	B	X	X	C
Butyric Acid	A	A	A	B	A	X	X
Calcium Acetate	A	X	X	A	A	B	B
Calcium Bisulfite	A	A	A	X	A	A	A
Calcium Chloride	A	A	A	A	A	A	A
Calcium Hydroxide	A	A	A	A	A	A	A
Calcium Hypochlorite	A	X	A	A	A	C	C
Calcium Nitrate	A	A	A	A	A	A	A
Calcium Sulfide	A	A	A	A	A	B	A
Cane Sugar Liquors	A	X	A	A	A	A	A
Carbamate	A	X	A	B	A	C	B
Carbitol	A	C	B	B	B	B	B
Carbolic Acid	A	C	A	B	A	X	C
Carbon Dioxide	A	A	A	B	A	A	B
Carbon Disulfide	X	X	X	X	X	X	X
Carbonic Acid	A	A	A	A	A	B	A
Carbon Monoxide	A	A	A	A	A	A	A
Carbon Tetrachloride	C	X	A	X	X	C	X
Castor Oil	A	A	A	B	B	A	A
Cellosolve	B	X	C	B	B	X	X
Cellosolve Acetate	B	X	X	B	B	X	X
Cellulube	A	B	A	A	B	X	X
Chlorinated Solvents	X	I	I	X	X	X	X

Table 22. Continued.

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Chlorine (Dry)	A	X	A	X	B	X	C
Chlorine (Wet)	A	X	A	C	X	X	X
Chlorine Dioxide	A	X	A	C	A	X	X
Chlorine Trifluoride	B	X	X	X	B	X	X
Chloroacetic Acid	A	X	A	B	A	X	X
Chloroacetone	X	X	X	B	X	X	B
Chlorobenzene	X	C	A	X	X	X	X
Chlorobromomethane	X	I	X	B	X	X	X
Chlorobutadiene	I	I	A	X	I	X	X
Chlorododecane	A	I	A	X	C	X	X
Choroform	X	X	A	X	X	X	X
O-Chloronaphthalene	A	X	A	X	C	X	X
1-Chloro-1-Nitro Ethane	X	X	X	X	X	X	X
Chlorox Solution	A	C	A	B	B	B	A
Chlorosulfonic Acid	A	X	C	X	A	X	X
Chlorotoluene	C	I	A	X	B	X	X
Chrome Plating Solutions	A	X	A	X	A	X	X
Chromic Acid	A	X	A	C	A	X	X
Citric Acid	A	A	A	A	A	A	A
Coal Tar Products	C	C	C	X	C	A	B
Cobalt Chloride	A	X	A	A	A	A	A
Cocoanut Oil	A	A	A	B	A	A	B
Cod Liver Oil	A	A	A	A	A	A	B
Copper Chloride	A	A	A	A	A	A	A
Copper Cyanide	A	A	A	A	A	A	A
Copper Sulfate	A	A	A	B	A	A	A
Corn Oil	A	A	A	C	A	A	C
Cottonseed Oil	A	A	A	C	A	A	B
Creosote	C	B	A	X	C	B	C
Cresol	A	X	A	X	C	X	C
Cresylic Acid	A	X	A	X	A	X	C
Cumene	B	X	A	X	B	X	X
Cyclohexane	A	B	A	X	B	A	X
Cyclohexanol	A	C	A	X	C	B	B
Cyclohexanone	X	X	X	B	X	X	X
P-Cymene	X	X	A	X	X	X	X
Decalin	C	C	A	X	C	X	X
Decane	B	B	A	X	C	B	B
Denatured Alcohol	A	X	A	A	B	A	A
Detergent Solutions	A	X	A	A	B	A	B
Developing Fluids	A	C	A	B	A	A	A
Diacetone Alcohol	A	X	I	A	C	X	B
Dibenzyl Ether	C	B	I	B	C	X	C
Dibenzyl Sebecate	C	B	B	B	C	X	X
Dibutyl Amine	A	X	X	X	B	B	B
Dibutyl Ether	A	B	C	C	X	X	C
Dibutyl Phthalate	C	C	B	C	X	X	X
Dibutyl Sebacate	B	C	B	B	X	X	X
O-Dichloro Benzene	X	C	A	X	X	X	X
Dichloro-Isopropyl Ether	C	X	C	X	C	X	X
Diesel Oil	A	A	A	X	A	A	B
Diethyl Amine	B	C	X	B	B	C	C
Diethyl Ether	A	C	X	X	C	X	C
Diethylene Glycol	A	C	A	A	B	A	A
Diethyl Sebacate	C	C	B	B	C	X	X
Diisobutylene	C	C	A	X	C	B	X
Diisopropyl Benzene	C	B	A	X	C	X	X
Diisopropyl Ketone	C	X	X	A	C	X	X
Dimethyl Aniline	C	X	X	X	C	X	X
Dimethyl Formamide	C	X	X	B	X	B	C
Dimethyl Phthalate	A	C	B	B	B	X	X
Dinitro Toluene	C	X	C	X	C	X	X
Dioctyl Phthalate	C	X	B	B	C	C	X
Dioctyl Sebacate	C	B	B	B	C	X	X
Dioxane	B	X	C	B	X	X	X
Dioxolane	C	X	X	C	C	X	X
Dry Cleaning Fluids	B	B	A	X	C	C	X
Epichlorohydrin	I	X	X	B	I	X	X
Ethane	B	B	A	X	B	A	B
Ethanolamine	A	C	X	B	A	B	B
Ethyle Acetate	B	X	X	B	X	X	C
Ethyl Acetoacetate	A	X	X	B	A	X	C
Ethyl Acrylate	B	X	X	B	X	X	X
Ethyl Alcohol	A	X	A	A	B	A	A
Ethyl Benzene	C	X	A	X	B	X	X
Ethyl Benzoate	I	X	A	B	I	X	X
Ethyl Bromide	C	I	I	X	X	B	X
Ethyl Chloride	C	B	A	A	C	A	B
Ethyl Ether	B	B	X	C	X	C	X
Ethyl Formate	A	C	A	B	B	X	B
Ethyl Mercaptan	B	C	A	X	B	X	C
Ethyl Oxalate	A	A	A	A	B	X	C
Ethyl Silicate	A	A	A	A	A	A	A
Ethylene	A	A	A	B	A	A	C
Ethylene Chloride	I	X	A	C	I	X	X
Ethylene Chlorohydrin	I	X	A	B	I	X	B

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Ethylene Diamine	B	X	X	A	B	A	A
Ethylene Dibromide	C	X	C	C	X	X	X
Ethylene Dichloride	C	X	A	C	X	X	X
Ethylene Glycol	A	B	A	A	A	A	A
Ethylene Oxide	A	X	X	C	X	X	X
Ethylene Trichloride	C	X	A	C	C	X	X
Fatty Acids	A	A	A	C	A	B	B
Ferric Chloride	A	A	A	A	A	A	A
Ferric Nitrate	A	A	A	A	A	A	A
Ferric Sulfate	A	A	A	A	A	A	A
Fish Oil	A	A	A	A	A	A	X
Fluoroboric Acid	A	A	A	A	A	A	A
Fluorine (Liquid)	X	X	B	C	X	X	X
Fluorocarbon Oils	A	A	B	A	A	A	B
Fluorolube	A	A	B	A	A	A	A
Fluorosilicic Acid	A	A	B	B	C	A	A
Formaldehyde	A	C	A	A	A	C	B
Formic Acid	A	C	C	A	B	B	A
Freon 11	C	X	A	X	C	B	C
Freon 12	A	A	B	B	A	A	A
Freon 13	A	A	A	A	A	A	A
Freon 31	I	I	X	A	I	X	A
Freon 32	I	I	C	A	I	A	A
Freon 112	I	B	A	I	I	B	X
Freon 113	B	B	B	B	B	A	A
Freon 114	B	A	B	A	B	A	A
Freon 115	B	B	B	A	B	A	A
Freon 142B	B	I	X	A	I	A	A
Freon 152A	I	I	X	A	I	A	A
Freon 218	B	A	A	A	B	A	A
Freon C316	B	B	A	A	B	A	A
Freon C318	B	B	A	A	B	A	A
Freon 114B2	I	C	B	X	I	B	B
Freon 502	I	C	B	A	I	B	A
Freon TA	B	A	B	A	B	A	A
Freon TC	B	A	B	A	B	A	A
Freon TF	C	A	A	X	C	A	A
Freon TMC	C	B	A	B	C	B	B
Freon T-P35	B	A	A	A	B	A	A
Freon T-WD602	B	A	A	A	B	B	B
Freon BF	I	I	I	X	I	B	B
Freon MF	I	I	I	X	I	A	C
Fuel Oil	B	A	A	X	B	A	B
Fumaric Acid	A	I	A	X	A	A	B

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Furan	A	I	X	X	A	X	X
Furfural	A	C	X	B	X	X	C
Gallic Acid	A	X	A	B	B	B	B
Gasoline	B	A	A	X	C	A	B
Glucose	A	A	A	A	A	A	A
Glue (Water Base)	A	A	A	A	A	A	A
Glycerine	A	B	A	A	A	A	A
Glycols	A	B	A	A	A	A	A
Green Sulfate Liquor	A	A	A	A	A	B	B
Halowax Oil	A	A	A	X	A	X	X
N-Hexaldehyde	C	I	I	B	C	X	A
Hexane	A	A	A	X	B	A	B
N-Hexene-1	I	B	A	X	I	B	B
Hexyl Alcohol	A	X	A	C	B	A	B
Hexylene Glycol	A	I	A	A	B	B	B
Hydraulic Oil	C	A	A	X	C	A	B
Hydrazine	X	X	I	A	I	C	C
Hydrobromic Acid	A	X	A	A	A	X	B
(37%) Hydrochloric Acid (Hot)	A	X	A	C	A	X	X
(37%) Hydrochloric Acid (Cold)	A	X	A	A	A	B	B
Hydrofluoric Acid (Hot)	A	X	B	X	A	X	X
Hydrofluoric Acid (Cold)	A	C	A	B	A	X	B
Hydrogen Gas	A	A	A	A	A	A	A
Hydrogen Peroxide (90%)	A	I	B	C	A	X	X
Hydrogen Sulfide(Cold)	A	A	X	A	A	X	A
Hydrogen Sulfide (Hot)	A	I	X	A	A	X	B
Hydroquinone	A	C	X	X	A	C	X
Iodine	A	A	A	B	A	B	X
Isobutyl Alcohol	A	X	A	A	B	B	A
Isooctane	A	B	A	X	B	A	B
Isophorone	C	C	X	A	X	X	X
Isopropyl Acetate	C	X	X	B	X	X	X
Isopropyl Alcohol	A	C	A	A	A	B	B
Isopropyl Chloride	A	X	A	X	A	X	X
Isopropyl Ether	A	C	X	X	A	B	C
Kerosene	A	A	A	X	B	A	C
Lactic Acid	A	X	A	A	A	A	A
Lard	A	A	A	X	A	A	C
Lead Acetate	A	X	A	A	A	B	B
Lead Nitrate	A	A	A	A	A	A	A
Lead Sulfamate	A	A	A	A	A	B	A

Table 22. Continued.

Chemical	Claropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Lime Bleach	A	A	A	A	A	A	B
Lime Sulfur	A	A	A	A	A	X	A
Lindol	C	X	B	A	C	X	X
Linoleic Acid	A	A	B	X	A	B	X
Linseed Oil	A	B	A	C	B	A	B
Liquified Petroleum Gas	A	A	A	X	A	A	B
Lubricating Oils	A	A	A	X	B	A	B
Lye	A	X	B	A	A	B	B
Magnesium Chloride	A	A	A	A	A	A	A
Magnesium Hydroxide	A	X	A	A	A	B	A
Magnesium Sulfate	A	A	A	A	A	A	A
Malathion	C	I	I	X	B	B	B
Maleic Acid	A	A	A	C	A	X	X
Maleic Anhydride	A	A	A	C	A	X	X
Mercury	A	A	A	A	A	A	A
Mesityl Oxide	C	X	X	B	X	X	X
Methane	A	C	A	X	A	A	B
Methyl Acetate	A	X	X	B	X	X	B
Methyl Alcohol	A	X	C	A	A	A	A
Methyl Acetate	C	X	X	B	C	X	B
Methylacrylate Acid	B	X	B	B	B	X	B
Methyl Bromide	I	I	A	X	I	B	X
Methyl Butyl Ketone	I	X	X	A	I	X	X
Methyl Cellosolve	A	X	X	B	A	B	B
Methyl Chloride	C	X	A	C	C	X	X
Methyl Ethyl Ketone	C	X	X	A	X	X	X
Methyl Methacrylate	C	X	X	X	X	X	X
Methylene Chloride	C	X	B	X	X	X	X
Methyl Formate	B	X	I	B	B	X	B
Methyl Isobutyl Ketone	C	X	X	C	X	X	X
Methyl Oleate	A	A	A	B	A	X	X
Methyl Salicylate	I	I	I	B	I	X	X
Milk	A	B	A	A	A	A	A
Mineral Oil	A	A	A	X	A	A	B
Monochlorobenzene	C	X	A	X	C	X	X
Monomethyl Aniline	C	X	B	B	C	X	X
Monoethanol Amine	I	X	X	B	I	X	X
Monomethyl Ether	B	B	B	A	B	A	A
Monovinyl Acetylene	C	B	A	A	C	A	B
Mustard Gas	A	X	I	A	A	A	A
Naptha	A	B	A	X	C	C	C
Naphthalene	A	B	A	X	X	X	X
Natural Gas	A	B	A	X	A	A	A
Neville Acid	A	I	A	B	A	X	X

Chemical	Claropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Nickel Acetate	A	X	X	A	A	B	B
Nickel Chloride	A	C	A	A	A	A	A
Nickel Sulfate	A	C	A	A	A	A	A
Nitric Acid - Conc.	X	X	A	C	X	X	X
Nitric Acid - Dilute	A	C	A	B	B	X	A
Nitric Acid - Red Fuming	X	X	C	X	X	X	X
Nitrobenzene	C	X	B	C	X	X	X
Nitroethane	A	X	X	B	X	X	C
Nitromethane	I	X	X	B	I	X	C
Nitrogen	A	A	A	A	A	A	A
Nitrogen Tetroxide	C	X	X	C	C	X	X
Octadecane	A	A	A	X	C	A	B
N-Octane	A	A	A	X	C	A	B
Oleic Acid	A	B	B	B	A	C	C
Oleum Spirits	A	C	A	B	A	B	C
Olive Oil	A	A	A	B	A	A	B
Oxalic Acid	A	A	A	A	A	B	B
Oxygen - Cold	A	A	A	A	A	B	A
Oxygen - 200 ~ 400 °F	X	X	B	A	I	X	X
Ozone	A	A	A	B	B	X	C
Paint Thinner	C	X	B	X	C	X	X
Palmitic Acid	A	A	A	B	A	A	B
Peanut Oil	A	A	A	C	B	A	B
Perchloric Acid	I	X	A	B	I	X	B
Perchloroethylene	C	B	A	X	X	C	X
Petroleum - Below 250 °F	A	A	A	X	C	A	B
Petroleum - Above 250 °F	X	X	B	X	X	C	X
Phenol	A	C	A	B	C	X	C
Phenyl Benzene	B	X	A	X	B	X	X
Phenyl Ethyl Ether	B	X	B	X	B	X	X
Phenyl Hydrazine	I	I	I	X	I	X	X
Phorone	I	X	I	B	I	X	X
Phosphorous Trichloride	A	A	A	A	A	X	X
Pickling Solution	A	X	B	C	A	X	X
Picric Acid	A	B	A	B	A	B	A
Pinene	B	B	A	X	B	B	C
Pine Oil	B	B	A	X	B	B	X
Piperidene	C	X	X	X	C	X	X
Polyvinyl Acetate Emulsion	A	B	A	A	A	A	B
Potassium Acetate	A	I	I	A	A	B	B
Potassium Chloride	A	A	A	A	A	A	A

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Potassium Cupro Cyanide	A	A	A	A	A	A	A
Potassium Cyanide	A	A	A	A	A	A	A
Potassium Dichromate	A	B	A	A	A	A	A
Potassium Hydroxide	A	B	B	A	A	B	B
Potassium Nitrate	A	A	A	A	A	A	A
Potassium Sulfate	A	A	A	A	A	A	A
Propane	C	C	A	X	C	A	B
Propyl Acetate	C	X	X	B	C	X	X
Propyl Alcohol	A	B	A	A	A	A	A
N-Propyl Acetate	B	X	X	A	B	X	X
Propyl Acetone	B	X	X	A	B	X	X
Propylene	A	I	A	X	A	X	X
Propylene Oxide	I	X	I	B	I	X	X
Pyranol	C	B	A	X	C	A	X
Pyridine	C	X	X	B	C	X	X
Pyrrole	C	I	I	X	C	X	X
Radiation	B	A	X	X	B	C	B
Rape Seed Oil	A	B	A	A	A	B	B
Red Oil	A	B	A	X	B	A	B
Salicylic Acid	A	A	A	A	A	B	A
Salt Water	A	B	A	A	A	A	A
Sewage	A	B	A	B	A	A	B
Silicate Esters	C	A	A	X	C	B	A
Silicone Greases	A	A	A	A	A	A	A
Silicone Oils	A	A	A	A	A	A	A
Silver Nitrate	A	A	A	A	A	B	A
Soap Solutions	A	A	A	A	A	A	A
Soda Ash	A	A	A	A	A	A	A
Sodium Bicarbonate	A	A	A	A	A	A	A
Sodium Acetate	A	I	I	A	A	B	I
Sodium Bisulfite	A	A	A	A	A	A	A
Sodium Borate	A	A	A	A	A	A	A
Sodium Carbonate	A	A	A	A	A	A	A
Sodium Chloride	A	A	A	A	A	A	A
Sodium Cyanide	A	A	A	A	A	A	A
Sodium Hydroxide	A	X	B	A	B	B	A
Sodium Hypochlorite	A	X	A	B	B	B	B
Sodium Metaphosphate	A	A	A	A	A	A	B
Sodium Nitrate	A	A	A	A	A	B	B
Sodium Perborate	A	A	A	A	A	B	B
Sodium Peroxide	A	A	A	A	A	B	B
Sodium Phosphate	A	A	A	A	A	A	A
Sodium Silicate	A	A	A	A	A	A	A

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Sodium Sulfate	A	A	A	A	A	A	A
Sodium Sulfide	A	A	A	A	A	A	A
Sodium Sulfite	A	A	A	A	A	A	A
Sodium Thiosulfate	A	A	A	A	A	B	A
Soybean Oil	A	B	A	C	A	A	B
Stannic Chloride	A	A	A	B	A	A	A
Steam - Under 300 °F	X	X	B	B	X	X	C
Steam - Over 300 °F	X	X	B	C	X	X	X
Styrene	C	C	B	X	X	X	X
Sucrose Solution	A	A	A	A	A	A	B
Sulfite Liquors	A	A	A	B	A	B	B
Sulfur	A	A	A	A	A	X	A
Sulfur Chloride	A	A	A	X	A	C	C
Sulfur Dioxide	A	A	A	B	A	X	C
Sulfur Hexachloride	A	A	A	A	A	B	A
Sulfur Trioxide	A	I	A	B	A	X	X
Sulfuric Acid (20 % Oleum)	B	X	A	X	B	X	X
Sulfuric Acid, Dilute	A	C	A	B	A	X	B
Sulfuric Acid, Conc.	B	X	A	X	B	X	X
Sulfurous Acid	A	X	A	B	B	B	B
Tannic Acid	A	A	A	A	A	A	A
Tar, Bituminous	A	A	A	X	A	B	C
Tartaric Acid	A	A	A	B	A	A	B
Terpineol	A	B	A	C	A	B	X
Tertiary Butyl Alcohol	B	X	A	B	B	B	B
Tertiary Butyl Catechol	A	X	A	B	A	X	B
Tertiary Butyl Mercaptan	B	X	A	X	B	X	X
Tetrahydrofuran	C	X	X	B	X	X	X
Tetralin	B	B	A	X	B	X	X
Thionyl Chloride	A	A	A	X	A	X	X
Titanium Tetrachloride	A	X	A	X	A	C	X
Toluene	C	B	A	X	X	C	X
Toluene Diisocyanate	C	C	B	B	C	X	X
Transformer Oil	A	A	A	X	C	A	B
Transmission Fluid A	A	A	A	X	C	A	B
Triacetin	A	X	X	A	A	B	B
Tributoxy Ethyl Phosphate	C	C	A	A	C	X	X
Tributyl Phosphate	C	C	X	A	X	X	X
Tributyl Mercaptan	C	C	A	X	C	X	X
Trichloroethylene	C	B	A	X	X	C	X
Trichloroethane	C	C	A	X	C	X	X

Table 22. Continued.

Chemical	Cloropel	F.R. Urethane	Viton	Butyl	Vinyl	Nitrile	Neoprene
Trichloroacetic Acid	A	X	C	B	A	B	X
Tricresyl Phosphate	A	C	B	A	C	X	C
Triethanol Amine	A	X	X	B	B	C	A
Triethyl Aluminum	A	X	B	C	A	X	X
Triethyl Borane	A	X	A	C	A	X	X
Trinitrotoluene	A	I	B	X	C	X	B
Trioctyl Phosphate	C	X	B	A	C	X	X
Triaryl Phosphate	C	X	A	A	C	X	X
Tung Oil	A	C	A	C	C	A	B
Turbine Oil	A	A	A	X	C	B	X
Turpentine	B	A	A	X	C	A	X
Urea	A	A	A	A	A	A	A
UDMH	C	X	X	A	C	B	B
Varnish	A	A	A	X	C	B	X
Vegetable Oils	A	A	A	C	C	A	C
Versilube	A	A	A	A	C	A	A
Vinegar	A	X	A	A	A	B	B
Vinyl Acetate	A	A	A	C	X	A	A
Vinyl Chloride	B	B	A	X	X	X	X
Vinyl Halides	C	C	C	C	X	C	C
Xylene	X	A	A	X	X	X	X
Xylidene	C	X	X	X	X	C	X
Xylol	B	B	B	X	B	X	X
Zeolites	A	A	A	A	A	A	A
Zinc Acetate	A	X	X	A	A	B	B
Zinc Chloride	A	A	A	A	A	A	A
Zinc Oxide	A	A	A	A	A	A	A
Zinc Sulfate	A	A	A	A	A	A	A

The materials highlighted in this chart are the following:

- Chlorinated Polyethylene - Sold under the brand name Cloropel™, a product of ILC Dover Company, this material has reduced flammability and increased resistance to oil, ozone, and many chemicals. It has good to excellent resistance to aliphatic hydrocarbons, phenols, ketones, esters, acids, and is impermeable to most gases. Much of the data compiled in the compatibility was derived from ILC Dover literature.
- Flame Retardant Urethane - Polyurethanes are fairly resistant to many chemicals such as aliphatic solvents, alcohols, ethers, certain fuels, and oils.
- Viton - This is a specialty fluoroelastomer. Generally it has excellent resistance to oils, fuels, lubricants. most mineral acids, hydraulic fluids, and aliphatic and aromatic hydrocarbons.
- Butyl - Butyl rubber is not resistant to oil or flame. It does have good resistance to ketones, esters, most acids and bases, and organic salts. Butyl has excellent impermeability to gases.
- Vinyl (PVC) - Polyvinyl Chloride has good to excellent resistance to amines and aromatics, inorganic acids, bases and salts. However, this low-cost elastomer has poor resistance to halogenated hydrocarbons, ketones and esters.
- Nitrile (NBR) - Nitrile polymers are practically unaffected by alkaline solutions, saturated salt solutions and aliphatic hydrocarbons, both saturated and unsaturated. They are affected little by fatty acids found in vegetable fats and oils or by aliphatic alcohols, glycols or glycerols. Nitrile rubber is not recommended, generally, for use in the presence of strong oxidizing agents, ketones, and a few other chemicals.
- Neoprene - In general, neoprene compounds have excellent resistance to all straight-chain hydrocarbons, all aliphatic hydroxy compounds such as methyl and ethyl alcohols and ethylene glycol, animal and vegetable fats and oils, and fluorinated hydrocarbons such as Freon refrigerants.

C. Types of Heat Illnesses

Heat stress and illness is a major concern when personnel are working in chemical protective clothing. The body's principal means of cooling is through the evaporation of sweat When personnel are working in chemical protective clothing, sweat is trapped inside the clothing and can not evaporate. This will raise the body's core temperature and can result in heat related illness.

1. Heat Rash: This is the least severe reaction to heat stress and results in an inflammation of the skin. This is due to prolonged exposure to heat and humid air. The rash is aggravated by chafing clothing and results in discomfort and a decreased tolerance to heat.

2. Heat Cramps: Cramping in the lower extremities and the lower abdomen. Cramps are frequently accompanies by weakness, moist warm skin and profuse sweating.

   If untreated, heat cramps can progress into heat exhaustion. Listen to your body!

3. Heat Exhaustion: This is a mild form of shock caused by the loss of fluid and salt. Blood pools in the skin

as the body attempts to rid itself of excess heat. Symptoms include overall weakness, headache, nausea, breathing is rapid and shallow, pulse is rapid and weak, the victim will be perspiring profusely and will have cold clammy skin. Heat exhaustion may result in a loss of consciousness.

If untreated, heat exhaustion will progress into heat stroke. Listen to your body (it is not fooling)!

4. Heat Stroke: **This is a true emergency!** Heat stroke is a failure of the body's heat regulating mechanism. **Heat stroke has a high rate of mortality!** Symptoms include overall weakness, deep respirations (getting more shallow as heat stress continues), a full and rapid pulse, **hot dry skin with little or no perspiration**, and frequently unconsciousness. **If untreated, heat stroke can progress into DEATH!**

Prevention is a much more effective way to deal with heat stress than treatment of heat related illness after it occurs.

1. Physical conditioning is a critical component in the battle against heat stress. An individual in good physical condition can more readily stand the insult of increased heat.

2. Maintaining hydrarion is critical to sustain the body's cooling mechanism. Thirst is not an adequate indicator of the need for fluid as it is approximately two quarts behind the body's actual requirements.

   When working in a hot environment additional water should be consumed with meals and during breaks.

3. In order to sustain continuous work, individuals working in chemical protective clothing require breaks in order to rehydrate and cool down. Based on conditions the time out of chemical protective clothing may need to exceed the time working.
4. Rotate personnel on a regular basis to minimize heat stress. Continuous operations may require a substantial number of personnel.

Physical conditioning is the most important preventative mea sure for preventing heat stress. The frequency of breaks is also important. Proper hydration of personnel can be a major help as heat loading of the body demands additional fluid be used to cool the organs via the blood. Cooling garments can also help in the battle against heat stress.

The following are field survey instruments required based on the anticipated hazards to be encountered:

1. Field survey instruments are used to identify and/or quantify hazards.

   Control zone boundaries that have initially been defined by estimation of potential hazards must be defined and monitored using field survey instruments.

2. Flammable/explosive atmosphere. When the concentration of flammable vapor in air is between the LEL and the UEL the atmosphere is flammable.

   a. A Combustible Gas Indicator provides a reading of the percentage of the lower explosive limit of a specific flammable vapor or gas in air (frequently methane).

   b. A flammable atmosphere is identified when any reading (% of LEL) is obtained on a combustible gas indicator.

   c. The Hot Zone line is established at a point where there is no reading on the Combustible Gas Indicator (0% of LEL).

3. Oxygen deficient or enriched atmosphere. Increased or decreased oxygen levels have an impact on respiratory protection requirements and the behavior of many hazardous materials (such as flammables).

   a. An Oxygen Meter provides a direct reading of the percentage of oxygen that is present.

   b. An alternative to the use of an Oxygen Meter would be the use of a Colorimetric Tube for oxygen. This would also provide a reading in percent oxygen in air.
   c. An oxygen deficient atmosphere is defined (by OSHA) as having $< 19.5\%$ oxygen.

   d. An oxygen enriched atmosphere is defined (by OSHA) as having $< 23\%$ oxygen.

   e. The Hot Zone line must be established where the oxygen concentration exceeds 19.5%.

4. Corrosive Products. The presence of corrosive materials may impact on the selection of the Level and Type of Personal Protective Equipment as well as product control methodology.

a. pH Paper provides a simple method for determining corrosivity.

b. Another alternative would be the use of a pH meter or pen which provides a direct reading of the pH of liquid products.

c. Colorimetric tubes can provide an indication of the concentration of a corrosive vapor in air.

d. The Hot Zone line must be established at a point where the concentration of vapor in air is less than the TLV/TWA.

5. Toxic conditions. Personal protective equipment requirements (including respiratory protection) are based in part on the concentration of toxic vapor or gas in the air. A toxic atmosphere is defined (by OSHA) as having a concentration which exceeds permissible or published exposure limits (such as the TLV or PEL)

   a. Colorimetric Tubes provide a means to identify unknown products or to determine the concentration of an identified product.

   b. The TLV is frequently a more conservative figure than the PEL.

   c. The Hot Zone line must be established at a point where the concentration of vapor in air is less than the TLV/TWA.

6. Radiation. Protection from radiation hazards are based on minimizing the time of exposure and maximizing both distance from the source and the amount of shielding. The instruments used will depend on the type of radiation.

   a. Alpha Particles

   b. Beta Particles

   c. Gamma Rays

   d. The Hot Zone must be established at a point where the radiation level is less than twice background radiation level.

One should identify the field survey instruments required for reconnaissance operations when dealing with an unknown product as follows:

1. When performing initial reconnaissance operations involving an unknown substance, the product hazards of the greatest concern are those that may compromise your protection.

   a. Flammable Atmosphere: Any positive reading on a Combustible Gas Indicator.

   b. Corrosive Product.

2. Personal Protective Equipment providing adequate protection from chemical hazards is not designed to provide protection against fire exposure.

   Flash protection or the use of structural firefighting equipment in addition to chemical protective clothing may provide **survivability** but not necessarily an effective working ensemble.

3. Corrosive atmospheres or products may attack Personal Protective Equipment and the tools required for product control.

4. Field Survey Instruments to detect flammable atmospheres and corrosives should always be carried by personnel involved in reconnaissance operations.

Flammability and corrosivity may not be the only hazards presented. It is important to keep in mind the potential for multiple hazards when dealing with hazardous materials.

The guidelines for preparing decontamination solutions are:

I. <u>When Dealing with Unknowns Under Emergency Conditions</u>.
Decontamination solutions are normally solutions of water and chemical compounds designed to react with and neutralize specific contaminants. The temperature of the liquid and contact time should be given consideration to be sure complete neutralization has taken place. In some cases hazardous materials workers may be faced with an unknown hazardous materials and will require decontamination after leaving the "hot zone." The following solutions should be used for unknowns since they are effective for a variety of contaminants.

<u>Decon Solution A</u> - A solution containing 5% Sodium Carbonate (Na_2CO_3) and 5% Trisodium Phosphate (Na_3PO_4). Mix four pounds commercial grade Na_3PO_4

and four pounds of Na_2CO_3 with each (ten) gallons of water. These chemicals are available in most hardware stores.

Decon Solution B - A solution containing 10% Calcium Hypochlorite ($Ca(ClO_2)_2$). Mix eight pounds of ($Ca(ClO_2)_2$) with each (ten) gallons of water. Calcium Hypochlorite is commonly known as HTH and is available from swimming pool supply stores. Make sure you purchase HTH in plastic containers or transfer it from cardboard drums into clean plastic buckets marked "oxidizer".

A general purpose rinse solution for both decon solutions is a 5% solution of Trisodium Phosphate. To prepare the rinse mix 4 pounds of Na_3PO_4 with each ten gallons of water.

II. Decon Using Degradation Chemicals for Known Materials

Five general purpose decon solutions are available for ten basic hazard classes. These are:

Decon Solution A - A solution containing 5% sodium carbonate (Na_2CO_3) and 5% trisodium phosphate (Na_3PO_4).

Decon Solution B - A solution containing 10% calcium hypochlorite ($Ca(ClO_2)_2$).

Decon Solution C - A solution containing 5% trisodium phosphate (Na_3PO_4). This solution can also be used as a general purpose rinse.

Decon Solution D - A dilute solution of hydrochloric acid (HCl). Mix one pint of concentrated HCl into 10 gallons of water. Stir with a wooden or plastic stirrer.

Decon Solution E - A concentrated solution of Tide or other detergent and water. Mix into a paste and scrub with a brush. Rinse with water.

3

CHEMICAL CLASSIFICATION GUIDE

I. INTRODUCTION

Within the context of safety, the classification of chemicals is academic, simply because all chemicals are potentially dangerous. It is the degree of hazard that we are concerned with however, or perhaps more accurately stated, the degree of risk posed to human health and the environment when handling any one or a combination of chemicals. Specific emergency response actions to spills, leaks and fires, safe handling and storing practices, hazardous site cleanup operations, the safe applications of chemicals, and indeed their synthesis and manufacturing, all depend on the particular properties of the chemicals involved and the degree of risk they pose. The purpose of this handbook is to try and provide some of the technical information and data that will enable the user to make a risk assessment for the chemicals she or he is responsible for.

There are numerous epidemiological studies reported by various industry sectors, as well as a library of electronic data bases available providing information on toxicological properties, chemical stability and fire safety. These are essential references that should be consulted if the basic information required cannot be obtained from this handbook. In all cases, the reader needs to determine how best to access the required information in an expedient manner. On any one chemical, a separate and extensive treatise can be (and probably has been) compiled, but it is particularly true when responding to a hazard materials incident, that only the most crucial and pertinent data is needed in order to formulate a safe and effective initial response. An attempt to organize safety information based on risk category (i.e., fire hazard, chemical stability, and health risk) has been made in the handbook; hence the user may refer to specific data tables and information sections in various chapters dealing with separate risk categories. This is not necessarily ideal because very often a primary risk factor such as fire may have serious secondary risks or may pose other primary risk factors such as inhalation exposure to first responders. For this reason, the author has intentionally repeated some data/information in different chapters and sections of the handbook, and where appropriate, provided cross-reference between sections.

This still leaves us with the question of how best to extract information pertinent to any one chemical. The reader is given two options, with this chapter providing a starting basis for researching information from the handbook. In this chapter an index of synonyms to common chemical compound names is given. Second, the USDOT listing of chemicals according to shipping number designation is provided in Chapter 6. The information in Chapter 6 is an alternative way to identify a chemical compound because it provides the proper or common shipping name recognized in international and North American shipments along with the 4-digit shipping number designation. In subsequent chapters (particularly in Chapters 4 and 5), a chemical is most often identified by its most common chemical name.

II. INDEX OF SYNONYMS

Following is an index of synonyms corresponding to common chemical compound names. Data sections of the handbook that provide information on the hazardous properties of chemicals, reference the chemical by its most common compound name. This index should be used to identify a common name if the synonym is known.

Synonym	*Compound Name*
Aatrex Herbicide	Atrazine
Acetaldehyde	Acetaldehyde
Acetic Acid	Acetic Acid
Acetic Acid, Ammonium Salt	Ammonium Acetate
Acetic Acid, Butyl Ester	n-Butyl Acetate
Acetic Acid, Cupric Salt	Copper Acetate
Acetic Acid, Dimethylamide	Dimethylacetamide
Acetic Acid, Ethyl Ester	Ethyl Acetate
Acetic Acid, Isobutyl Ester	Isobutyl Acetate
Acetic Acid, Isopropyl Ester	Isopropyl Acetate
Acetic Acid, Methyl Ester	Methyl Acetate
Acetic Acid, Nickel (II) Salt	Nickel Acetate
Acetic Acid, Propyl Ester	n-Propyl Acetate
Acetic Acid, Sec-Butyl Ester	Sec-Butyl Acetate
Acetic Acid, Zinc Salt	Zinc Acetate
Acetic Aldehyde	Acetaldehyde
Acetic Anhydride	Acetic Anhydride
Acetic Ester	Ethyl Acetate
Acetic Ether	Ethyl Acetate
Acetoacetic Acid, Ethyl Ester	Ethyl Acetoacetate
Acetoacetic Ester	Ethyl Acetoacetate
Acetone	Acetone
Acetone Cyanohydrin	Acetone Cyanohydrin
Acetonitrile	Acetonitrile
Acetophenone	Acetophenone
Acetylacetone	Acetylacetone
Acetylbenzene	Acetophenone
Acetyl Bromide	Acetyl Bromide
Acetyl Chloride	Acetyl Chloride
Acetylene	Acetylene
Acetylene Dichloride	1,2-Dichloroethylene
Acetylene Tetrachloride	Tetrachloroethane
Acetylenogen	Calcium Carbide
Acetyl Hydroperoxide	Peracetic Acid
Acetyl Peroxide Solution	Acetyl Peroxide Solution
Acid Ammonium Carbonate	Ammonium Bicarbonate
Acid Ammonium Fluoride	Ammonium Bifluoride
Acid Calcium Phosphate	Calcium Phosphate
Acraldehyde	Acrolein
Acridine	Acridine
Acrolein	Acrolein
Acrylaldehyde	Acrolein
Acrylamide	Acrylamide
Acrylic Acid	Acrylic Acid
Acrylic Acid, Butyl Ester	N-Butyl Acrylate
Acrylic Acid, Ethyl Ester	Ethyl Acrylate
Acrylic Acid, 2-Ethylhexyl Ester	Ethylhexyl Acrylate, Inhibited
Acrylic Acid, Isobutyl Ester	Iso-Butyl Acrylate
Acrylic Acid, Methyl Ester	Methyl Acrylate
Acrylic Aldehyde	Acrolein
Acrylic Amide, 50 %	Acrylamide
Acrylonitrile	Acrylonitrile
Activated Charcoal	Charcoal
Adacene-12	1-Dodecene
Adipic Acid	Adipic Acid
Adipic Acid, Bis(2-Ethylhexyl) Ester	Dioctyl Adipate
Adipinic Acid	Adipic Acid
Adipol 2 EH	Dioctyl Adipate
Adiponitrile	Adiponitrile
Adronal	Cyclohexanol
Aerosol Surfactant	Dioctyl Sodium Sulfosuccinate
Aerothene	Trichloroethane
Aficide	Benzene Hexachloride
Agrocide	Benzene Hexachloride
Albone	Hydrogen Peroxide
Albus	Mercuric Ammonium Chloride
Alcohol	Ethyl Alcohol
Alcohol C -10	N-Decyl Alcohol
Alcohol C-8	Octanol
Aldehyde C -10	Decaldehyde
Aldehyde-Collidine	Methylethylpyridine
Aldehydine	Methylethylpyridine
Aldifen	2.4-Dinitrophenol
Aldrin	Aldrin
Algylen	Trichloroethylene
Alkylbenzenesulfonic Acids	Alkylbenzenesulfonic Acids
Alkylbenzenesulfonic Acid, Sodium Salt	Sodium Alkylbenzene-sulfonates
Allene-Methylacetylene Mixture	Methylacetylene-Propadiene Mixture
Allomaleic Acid	Fumaric Acid

Synonym	*Compound Name*
Allyl Alcohol	Allyl Alcohol
Allyl Bromide	Allyl Bromide
Allyl Chloride	Allyl Chloride
Allyl Chlorocarbonate	Allyl Chloroformate
Allyl Chloroformate	Allyl Chloroformate
Allylsilicone Trichloride	Allyltrichlorosilane
Allyl Trichlorosilane	Allyltrichlorosilane
Aluminum Chloride	Aluminum Chloride
Aluminum Ethyl Dichloride EADC	Ethylaluminum Dichloride
Aluminum Ethyl Dichloride	Ethylaluminum Dichloride
Aluminum Fluoride	Aluminum Fluoride
Aluminum Nitrate	Aluminum Nitrate
Aluminum Nitrate Nonahydrate	Aluminum Nitrate
Aluminum Sulfate	Aluminum Sulfate
Aluminum Triethyl	Triethylaluminum
Aluminum Triisobutyl	Triisobutylaluminum
Amchlor	Ammonium Chloride
Aminobenzene	Aniline
1-Aminobutane	N-Butylamine
Aminocaproic Lactam	Caprolactam, Liquid
1-Amino-4-Chlorobenzene	P-Chloroaniline
2-Amino-5-Chlorotoluene	4-Chloro-O-Toluidine
Aminocyclohexane	Cyclohexylamine
Aminoethane	Ethylamine
2-Aminoethanol	Monoethanolamine
Beta-Aminoethyl Alcohol	Monoethanolamine
2-((2-Aminoethyl) Amino)Ethanol	Aminoethylethanolamine
N-(2-Aminoethyl)Ethanolamine	Aminoethylethanolamine
Aminoethylethanolamine	Aminoethylethanolamine
Aminoform	Hexamethylenetetramine
2-Aminoisobutane	Tert-Butylamine
Aminomercuric Chloride	Mercuric Ammonium Chloride
Aminomethane	Methylamine
2-Amino-1-Methylbenzene	O-Toluidine
1-Amino-2-Methylpropane	Isobutylamine
2-Amino-2-Methylpropane	Tert-Butylamine
1-Aminonaphthalene	1-Naphthylamine
1-Amino-2-Nitrobenzene	2-Nitroaniline
1-Amino-4-Nitrobenzene	4-Nitroaniline
2-Aminopropane	Isopropylamine

Synonym	*Compound Name*
1-Amino-2-Propanol	Monoisopropanolamine
2-Aminotoluene	O-Toluidine
Alpha-Aminotoluene	Benzylamine
Ammate	Ammonium Sulfamate
Ammoform	Hexamethylenetetramine
Ammoneric	Ammonium Chloride
Ammonia Anhydrous	Ammonia Anhydrous
Ammonia Soap	Ammonium Oleate
Ammoniated Mercury	Mercuric Ammonium Chloride
Ammonia Water	Ammonium Hydroxide
Amfonioformaldehyde	Hexamethylenetetramine
Ammonium Acetate	Ammonium Acetate
Ammonium Acid Fluoride	Ammonium Bifluoride
Ammonium Amidosulfonate	Ammonium Sulfamate
Ammonium Amidosulphate	Ammonium Sulfamate
Ammonium Benzoate	Ammonium Benzoate
Ammonium Bicarbonate	Ammonium Bicarbonate
Ammonium Bichromate	Ammonium Dichromate
Ammonium Bifluoride	Ammonium Bifluoride
Ammonium Carbonate	Ammonium Carbonate
Ammonium Chloride	Ammonium Chloride
Ammonium Citrate	Ammonium Citrate
Ammonium Citrate, Dibasic	Ammonium Citrate
Ammonium Decaborate Octahydrate	Ammonium Pentaborate
Ammonium Dichromate	Ammonium Dichromate
Ammonium Disulfate-Nickelate (II)	Nickel Ammonium Sulfate
Ammonium Ferric Citrate	Ferric Ammonium Citrate
Ammonium Ferric Oxalate Trihydrate	Ferric Ammonium Oxalate
Ammonium Ferrous Sulfate	Ferrous Ammonium Sulfate
Ammonium Fluoride	Ammonium Fluoride
Ammonium Fluosilicate	Ammonium Silicofluoride
Ammonium Formate	Ammonium Formate
Ammonium Gluconate	Ammonium Gluconate
Ammonium Hydrogen Carbonate	Ammonium Bicarbonate

Synonym	*Compound Name*
Ammonium Hydrogen Fluoride	Ammonium Bifluoride
Ammonium Hydrogen Sulfide Solution	Ammonium Sulfide
Ammonium Hydroxide	Ammonium Hydroxide
Ammonium Hypo	Ammonium Thiosulfate
Ammonium Hyposulfite	Ammonium Thiosulfate
Ammonium Iodide	Ammonium Iodide
Ammonium Iron Sulfate	Ferrous Ammonium Sulfate
Ammonium Lactate	Ammonium Lactate
Ammonium Lactate Syrup	Ammonium Lactate
Ammonium Lauryl Sulfate	Ammonium Lauryl Sulfate
Ammonium Molybdate	Ammonium Molybdate
Ammonium Muriate	Ammonium Chloride
Ammonium Nickel Sulfate	Nickel Ammonium Sulfate
Ammonium Nitrate	Ammonium Nitrate
Ammonium Nitrate-Urea Solution	Ammonium Nitrate-Urea Solution
Ammonium Oleate	Ammonium Oleate
Ammonium Oxalate	Ammonium Oxalate
Ammonium Oxalate Hydrate	Ammonium Oxalate
Ammonium Pentaborate	Ammonium Pentaborate
Ammonium Pentaborate Tetrahydrate	Ammonium Pentaborate
Ammonium Pentachlorozincate	Zinc Ammonium Chloride
Ammonium Perchlorate	Ammonium Perchlorate
Ammonium Peroxydisulfate	Ammonium Persulfate
Ammonium Persulfate	Ammonium Persulfate
Ammonium Phosphate	Ammonium Phosphate
Ammonium Phosphate, Dibasic	Ammonium Phosphate
Ammonium Rhodanate	Ammonium Thiocyanate
Ammonium Rhodanide	Ammonium Thiocyanate
Ammonium Silicofluoride	Ammonium Silicofluoride
Ammonium Stearate	Ammonium Stearate
Ammonium Sulfamate	Ammonium Sulfamate
Ammonium Sulfate	Ammonium Sulfate
Ammonium Sulfhydrate Solution	Ammonium Sulfide
Ammonium Sulfide	Ammonium Sulfide
Ammonium Sulfide Solution	Ammonium Sulfide
Ammonium Sulfite	Ammonium Sulfite
Ammonium Sulfocyanate	Ammonium Thiocyanate
Ammonium Sulfocyanide	Ammonium Thiocyanate
Ammonium Tartrate	Ammonium Tartrate
Ammonium Thiocyanate	Ammonium Thiocyanate
Ammonium Thiosulfate	Ammonium Thiosulfate
Ammonium Zinc Chloride	Zinc Ammonium Chloride
Amorphous Phosphorus	Phosphorus, Red
AMS	Ammonium Sulfamate
Amyl Acetate	Amyl Acetate
Amyl Acetates, Mixed Isomers	Amyl Acetate
N-Amyl Alcohol	N-Amyl Alcohol
1-Amyl Alcohol	N-Amyl Alcohol
Amyl Aldehyde	Valeraldehyde
Amyl Carbinol	Hexanol
Amyl Chloride	N-Amyl Chloride
N-Amyl Chloride	N-Amyl Chloride
Alpha-N-Amylene	1-Pentene
Amyl Hydrosulfide	N-Amyl Mercaptan
N-Amyl Mercaptan	N-Amyl Mercaptan
N-Amyl MethylKetone	N-Amyl Methyl Ketone
N-Amyl Nitrate	N-Amyl Nitrate
Amyl Nitrite	Iso-Amyl Nitrite
Iso-Amyl Nitrite	Iso-Amyl Nitrite
Amyl Sulfhydrate	N-Amyl Mercaptan
Amyl Thioalcohol	N-Amyl Mercaptan
N-Amyltrichlorosilane	N-Amyltrichlorosilane
Anesthesia Ether	Ethyl Ether
Anhydrone	Magnesium Perchlorate
Anhydrous Aluminum Chloride	Aluminum Chloride
Aniline	Aniline
Aniline Oil	Aniline
Anilinobenzene	Diphenylamine
Anilinomethane	N-Methylaniline
Animal Carbon	Charcoal
Animal Charcoal	Charcoal
Anisoyl Chloride	Anisoyl Chloride
P-Ansoyl Chloride	Anisoyl Chloride
ANOL	Cyclohexanol
Anone	Cyclohexanone
Ansar	Cacodylic Acid
Ansul Ether 121	Ethylene Glycol Dimethyl Ether
Anthracene	Anthracene

Synonym	*Compound Name*
Anthracin	Anthracene
Antimony Butter	Antimony Trichloride
Antimony (III) Chloride	Antimony Trichloride
Antimony (V) Chloride	Antimony Pentachloride
Antimony Pentachloride	Antimony Pentachloride
Antimony Pentafluoride	Antimony Pentafluoride
Antimony Perchloride	Antimony Pentachloride
Antimony Potassium Tartrate	Antimony Potassium Tartarate
Antimony Trichloride	Antimony Trichloride
Antimony Trifluoride	Antimony Trifluoride
Antimony Trioxide	Antimony Trioxide
Aparasin	Benzene Hexachloride
Aphtiria	Benzene Hexachloride
APO	Tris(Aziridinyl) Phosphine Oxide
Aqueous Ammonia	Ammonium Hydroxide
Arasan	Thiram
Argentous Fluoride	Silver Fluoride
Argentous Oxide	Silver Oxide
Arochlor	Polychlorinated Biphenyl (PCB)
Arsecodile	Sodium Cacodylate
Arsenic Acid	Arsenic Acid
Arsenic Chloride	Arsenic Trichloride
Arsenic Disulfide	Arsenic Disulfide
Arsenic Pentoxide	Arsenic Acid
Arsenic Sesquioxide	Arsenic Trioxide
Arsenic Trichloride	Arsenic Trichloride
Arsenic (III) Trichloride	Arsenic Trichloride
Arsenic Trioxide	Arsenic Trioxide
Arsenic T risulfide	Arsenic Trisulfide
Arsenic Yellow	Arsenic Trisulfide
Arsenious Chloride	Arsenic Trichloride
Arsenous Acid	Arsenic Trioxide
Arsenous Acid Anhydride	Arsenic Trioxide
Arsenous Chloride	Arsenic Trichloride
Arsenous Oxide	Arsenic Trioxide
Arsicodile	Sodium Cacodylate
Arsycodile	Sodium Cacodylate
Artic	Methyl Chloride
Artificial Cinnabar	Mercuric Sulfide
Asphalt	Asphalt
Asphalt Cements	Asphalt
Asphaltic Bitumen	Asphalt
Asphaltum Oil	Asphalt Blending
ATE	Triethylaluminum
Atrazine	Atrazine
10-Azaanthracene	Acridine
Azacycloheptane	Hexamethyleneimine
1-Azanaphthalene	Quinoline
Azinphosmethyl	Azinphosmethyl
Azirane	Ethyleneinine
Aziridine	Ethyleneimine
Barium Binoxide	Barium Peroxide
Barium Carbonate	Barium Carbonate
Barium Chlorate	Barium Chlorate
Barium Chlorate Monohydrate	Barium Chlorate
Barium Dioxide	Barium Peroxide
Barium Nitrate	Barium Nitrate
Barium Perchlorate	Barium Perchlorate
Barium Perchlorate Trihydrate	Barium Perchlorate
Barium Permanganate	Barium Permanganate
Barium Peroxide	Barium Peroxide
Barium Superoxide	Barium Peroxide
Basic Bismuth Chloride	Bismuth Oxychloride
Basic Zirconium Chloride	Zirconium Oxychloride
Battery Acid	Sulfuric Acid
BBH	Benzene Hexachloride
Bearing Oil	Oil: Spindle
Beet Sugar	Sucrose
Ben-Hex	Benzene Hexachloride
Benzaldehyde	Benzaldehyde
1-Benzazine	Quinoline
Benzene	Benzene
Benzene, Mixture of Toluene/Xylene	Naphtha Coal Tar
Benzenecarbinol	Benzyl Alcohol
Benzenecarbonyl Chloride	Benzoyl Chloride
Benzenecarboxylic Acid	Benzoic Acid
1,2-Benzenedicarboxylic Acid	AnhydridePhthalic Anhydride
1,2-Benzenedicarboxylic Acid, Diethyl	Diethyl Phthalate Ester
Benzene Chloride	Chlorobenzene
Benzene-1,3-Dicarboxylic Acid	Isophthalic Acid
1,4-Benzenediol	Hydroquinone

Synonym	*Compound Name*
1,3-Benzenediol	Resorcinol
1,2-Benzenediol	Catechol
Benzene Hexachloride	Benzene Hexachloride
Benzene Phosphorus Dichloride	Benzene Phosphorus Dichloride
Benzene Phosphorus Thiodichloride	Benzene Phosphorus Thiodichloride
Benzenethiophosphonyl Chloride	Benzene Phosphorus Thiodichloride
1,2,3-Benzenetriol	Pyrogallic Acid
Benzinoform	Carbon Tetrachloride
Benzoic Acid	Benzoic Acid
Benzoic Acid, Ammonium Salt	Ammonium Benzoate
Benzoic Acid Nitrile	Benzonitrile
Benzoic Aldehyde	Benzaldehyde
Benzol	Benzene
Benzole	Benzene
Benzonitrile	Benzonitrile
Benzophenone	Benzophenone
Benzo(B) Pyridine	Quinoline
Benzo (B) Quinoline	Acridine
Benzoylbenzene	Benzophenone
Benzoyl Chloride	Benzoyl Chloride
Benzoyl Peroxide	Dibenzoyl Peroxide
Benzoyl Superoxide	Dibenzoyl Peroxide
Benzyl Alcohol	Benzyl Alcohol
Benzylamine	Benzylamine
Benzyl Bromide	Benzyl Bromide
Benzyl N-Butyl Phthalate	Benzyl N-Butyl Phthalate
Benzylcarbonyl Chloride	Benzyl Chloroformate
Benzyl Chloride	Benzyl Chloride
Benzyl Chlorocarbonate	Benzyl Chloroformate
Benzyl Chloroformate	Benzyl Chloroformate
Benzyltrimethylammonium Chloride	Benzyltrimethylammonium Chloride
Beryllia	Beryllium Oxide
Beryllium Chloride	Beryllium Chloride
Beryllium Fluoride	Beryllium Fluoride
Beryllium, Metallic	Beryllium, Metallic
Beryllium Nitrate	Beryllium Nitrate
Beryllium Nitrate Trihydrate	Beryllium Nitrate
Beryllium Oxide	Beryllium Oxide
Beryllium Sulfate	Beryllium Sulfate
Beryllium Sulfate Tetrahydrate	Beryllium Sulfate
Betaprone	Beta-Propiolactone
BHC	Benzene Hexachloride
Bichrome	Potassium Dichromate
Bicyclo (4,4,0) Decane	Decahydronaphthalene
Bieberite	Cobalt Sulfate
Biethylene	Butadiene, Inhibited
Biformal	Glyoxal, 40%Solution
Biformyl	Glyoxal, 40% Solution
Biphenyl-Diphenyl Ether	Dowtherm
Bis(Acetato)Dioxouranium	Uranyl Acetate
Bis(2-Aminoethyl)Amine	Diethylenetriamine
N,N-Bis(2-Aminoethyl) Ethylenediamine	Triethylenetetramine
Bis(P-Chlorobenzoyl) Peroxide	01-(P-Chlorobenzoyl) Peroxide
Bis(2-Chloroethyl) Ether	Dichloroethyl Ether
Bis(2-Chloroethyl) Ether	Dichloroethyl Ether
Bis(Dimethylthiocarbamyl) Disulfide	Thiram
Bis(Dimethylthiocarbamyl) Disulfide	Thiram
Bis(2-Ethylhexyl) Hydrogen Phosphate	Di-(2-Ethylhexyl) Phosphoric Acid
Bis-(2-Ethylhexyl)Hydrogen Phosphate	Di-(2-Ethylhexyl) Phosphoric Acid
Bis(2-Ethylhexyl) Phthalate	Dioctyl Phthalate
Bis(2-Ethylhexyl)Sodium Sulfosuccinate	Dioctyl Sodium Sulfosuccinate
Bis(2-(2-Hydroxyethoxy)-Ethyl) Ether	Tetraethylene Glycol
Bis(2-Hydroxyethyl)Amine	Diethanolamine
Bis(2-Hydroxyethyl)Ether	Diethylene Glycol
2,2-Bis(4-Hydroxyphenyl) Propane	Bisphenol A
Bis(2-Methoxyethyl) ether	Diethylene Glycol Dimethyl Ether
2,2-Bis(P-Methoxyphenyl)-1,1,1 Trichloroethane	Methoxychlor
Bismuth Chloride Oxide	Bismuth Oxychloride
Bismuth Oxychloride	Bismuth Oxychloride
Bismuth Subchloride	Bismuth Oxychloride
Bismuthyl Chloride	Bismuth Oxychloride
Bisphenol A	Bisphenol A
Bisphenol A Diglycidyl Ether	Bisphehol A Diglycidyl Ether

Synonym	*Compound Name*
Bisphenol A Epichlorohydrin Condensate	Bisp henol A Diglycidyl Ether
Bitumen	Asphalt
Bivinyl	Butadiene, Inhibited
Black Leaf 40 (40 % Water Solution)	Nicotine Sulfate
Black Oil	Asphalt Blending Stock: Roofers Flux
Bladan	Tetraethyl Pyrophosphate
Blue Oil	Aniline
Blue Vitriol	Copper Sulfate
Boiler Compound, Liquid	Boiler Compound: Liquid
Boletic Acid	Fumaric Acid
Boracic Acid	Boric Acid
Borax, Anhydrous	Sodium Borate
Boric Acid	Boric Acid
Boron Chloride	Boron Trichloride
Boron Tribromide	Boron Tribromide
Boron Trichloride	Boron Trichloride
Bottled Gas	Liquefied Petroleum Gas
Box Toe cum	Collodion
BP	Dibenzoyl Peroxide
BPO	Dibenzoyl Peroxide
Brimstone (Liquid)	Sulfur(Liquid)
Brocide	Ethylene Dichloride
Bromallylene	Allyl Bromide
Bromellite	Beryllium Oxide
Bromine	Bromine
Bromine Pentafluoride	Bromine Pentafluoride
Bromine Trifluoride	Bromine Trifluoride
Bromobenzene	Bromobenzene
Bromobenzol	Bromobenzene
Bromofume	Ethylene Dibromide
Bromomethane	Methyl Bromide
3-Bromopropene	Allyl Bromide
3-Bromopropylene	Allyl Bromide
Alpha-bromotoluene	Benzyl Bromide
Bromotoluene, Alpha	Benzyl Bromide
Omega-Bromotoluene	Benzyl Bromide
Brucine	Brucine
Brucine Dihydrate	Brucine
BTMAC	Benzyltrimethylammonium Chloride
Bunker C Oil	Fuel Oil: 6
1,3-Butadiene	Butadiene, Inhibited
Butadiene, Inhibited	Butadiene, Inhibited
Butal	N-butyraldehyde
Butaldehyde	N-butyraldehyde
Butanal	N-butyraldehyde
I-Butanamine, N-butyl	Di-N-Butylamine
Butane	Butane
N-Butane	Butane
1,4-Butanedicarboxylic Acid	Adipic Acid
1,4-Butanediol	1,4-Butanediol, Butanediol
1-butanethiol	N-butyl Mercaptan
Butanic Acid	N-Butyric Acid
Butanoic Acid	N-Butyric Acid
Butanol	N-butyl Alcohol
1-Butanol	N-Butyl Alcohol
2-Butanol	Sec-Butyl Alcohol
2-Butanone	Methyl Ethyl Ketone
Trans-2-Butenal	Crotonalcehyde
1-Butene	Butylene
Cis-Butenedioic Acid	Maleic Acid
Trans-Butenedioic Acid	Fumaric Acid
Cis-Butenedioic Anhydride	Maleic Anhydride
1,4-Butenediol	1,4-Butenediol
Cis-2-Butene-1,4-Diol	1,4-Butenediol
3-Buten-2-One	Methyl Vinyl Ketone
1-Butene Oxide	Butylene Oxide
Butene Resins	Polybutene
1-Butoxybutane	Di-N-Butyl Ether
Butoxydiethylene Glycol	Diethylene Glycol Monobutyl Ether
Butoxydiclycol	Diethylene Glycol Mohobutyl Ether
2-Butoxyethanol	Ethylene Glycol Monobutyl Ether
2-Butoxyethanol, Acetate	Ethylene Glycol Monobutyl Ether Acetate
2-(2-Butoxyethoxy)Ethyl	Diethylene Glycol Monobutyl Ether

Synonym	*Compound Name*
Acetate	Acetate
2-Butoxyethyl Acetate	Ethylene Glycol Monobutyl Ether Acetate
Butoxyethyl 2,4-Dichlorophenoxyacetate	2,4-D Esters
Butoxypropyl Trichlorophenoxyacetate	2,4,5-T(Esters)
Buttercup Yellow	Zinc Chromate
Butter of Antimony	Antimony Trichloride
Butter of Arsenic	Arsenic Trichloride
Butyl Acetate	N-Butyl Acetate
N-butyl Acetate	N-butyl Acetate
Sec-Butyl Acetate	Sec-Butyl Acetate
Butyl Acrylate	N-Butyl Acrylate
Iso-Butyl Acrylate	Iso-Butyl Acrylate
N-butyl Acrylate	N-Butyl Acrylate
Butyl Alcohol	N-butyl Alcohol
N-butyl Alcohol	N-Butyl Alcohol
Sec-Butyl Alcohol	Sec-Butyl Alcohol
Tert-butyl Alcohol	Tert-butyl Alcohol
Butyl Aldehyde	N-Butyraldehyde
N-Butyl Alpha-Methyl Acrylate	N-butyl Methacrylate
Butylamine	N-Butylamine
N-Butylamine	N-Butylamine
Sec-Butylamine	Sec-Butylamine
Tert-Butylamine	Tert-Butylamine
Butyl Benzyl Phthalate	Benzyl N-butyl Phthalate
N-Butylcarbinol	N-Amyl Alcohol
N-Butylcarbinyl Chloride	N-Amyl Chloride
Butyl Carbinol	Diethylene Glycol Monobutyl Ether
Butyl Carbinol Acetate	Diethylene Glycol Monobutyl Ether Acetate
Butyl Cellosolve	Ethylene Glycol Monobutyl Ether
Butyl (Cellosolve) Acetate	Ethylene Glycol Monobutyl Ether Acetate
Butyl2,4-Dichlorophenoxyacetate	2,4-D Esters
Butylene	Butylene
2-Butylene Dichloride	Dichlorobutene
Butylene Hydrate	Sec-butyl Alcohol
Butylene Oxide	Butylene Oxide
Alpha-Butylene Oxide	Butylene Oxide
I,2-Butylene Oxide	Butylene Oxide
Butyl Ethanoate	N-Butyl Acetate
Butyl Ether	Di-N-Butyl Ether
N-Butylether	Di-N-Butyl Ether
Butylethylacetaldehyde	Ethylhexaldehyde
Tert-Butyl Hydroperoxide	Tert-Butyl Hydroperoxide
N-Butyl Mercaptan	N-Butyl Mercaptan
Butyl Methacrylate	N-butyl Methacrylate
N-butyl Methacrylate	N-Butyl Methacrylate
Butyl 2-methacrylate	N-Butyl Methacrylate
N-butyl Methyl Ketone	Methyl N-Butyl Ketone
Butyl 2-Methyl-2-Propenoate	N-Butyl Methacrylate
P-Tert-Butylphenol	P-Tert-Butylphenol
Butyl Phthalate	Dibutyl Phthalate
Butyl 2-Propenoate	N-Butyl Acrylate
Butyl Titanate	Tetrabutyl Titanate
Butyl Titanate Monomer	Tetrabutyl Titanate
Butyl 2,4,5-Trichlorophenoxyacetate	2,4,5-T(Esters)
Butyltrichlorosilane	Butyltrichlorosilane
N-butyltrichlorosilane	Butyltrichlorosilane
1,4-Butynediol	1,4-Butynediol
2-butyne-1,4-Diol	1,4-Butynediol
Butyral	N-Butyraldehyde
Butyraldehyde	N-butyraldehyde
Iso-Butyraldehyde	Iso-Butyraldehyde
N-Butyraldehyde	N-butyraldehyde
Butyric Acid	N-Butyric Acid
N-Butyric Acid	N-Butyric Acid
Butyric Acid, Ethyl Ester	Ethyl Butyrate
Butyric Aldehyde	N-butyraldehyde
Butyric Ether	Ethyl Butyrate
Cacodylic Acid	Cacodylic Acid
Cadmium Acetate	Cadmium Acetate
Cadmium Acetate Dihydrate	Cadmium Acetate
Cadmium Bromide	Cadmium Bromide
Cadmium Bromide Tetrahydrate	Cadmium Bromide
Cadmium Chloride	Cadmium Chloride
Cadmium Fluoborate	Cadmium Fluoroborate

Synonym	*Compound Name*
Cadmium Fluoroborate	Cadmium Fluoroborate
Cadmium Fume	Cadmium Oxide
Cadmium Nitrate	Cadmium Nitrate
Cadmium Nitrate Tetrahydrate	Cadmium Nitrate
Cadmium Oxide	Cadmium Oxide
Cadmium Sulphate	Cadmium Sulfate
Cadox HDP	Cyclohexanone Peroxide
Cadox PS	DI-(p-Chlorobenzoyl) Peroxide
Cadox TBH	Tert-Butyl Hydroperoxide
Cake Alum	Aluminum Sulfate
Calcium	Calcium Phosphate
Calcium Abietate	Calcium Resinate
Calcium Alkylbenzenesulfonate	Dodecylbenzenesulfonic Acid, Calcium Salt
Calcium Arsenate	Calcium Arsenate
Calcium Biphosphate	Calcium Phosphate
Calcium Carbide	Calcium Carbide
Calcium Chlorate	Calcium Chlorate
Calcium Chloride	Calcium Chloride
Calcium Chloride Hydrates	Calcium Chloride
Calcium Chloride, Anhydrous	Calcium Chloride
Calcium Chromate	Calcium Chromate
Calcium Chromate Dihydrate	Calcium Chromate
Calcium Chromate (VI)	Calcium Chromate
Calcium Cyanide	Calcium Cyanide
Calcium Dioxide	Calcium Peroxide
Calcium Fluoride	Calcium Fluoride
Calcium Hydroxide	Calcium Hydroxide
Calcium Hypochlorite	Calcium Hypochlorite
Calcium Monohydrogen Phosphate	Calcium Phosphate
Calcium, Metallic	Calcium, Metallic
Calcium Nitrate	Calcium Nitrate
Calcium Nitrate Tetrahydrate	Calcium Nitrate
Calcium Oxide	Calcium Oxide
Calcium Peroxide	Calcium Peroxide
Calcium Phosphate	Calcium Phosphate
Calcium	Calcium Phosphate
Calcium Phosphide	Calcium Phosphide
Calcium Resinate	Calcium Resinate
Calcium Resinate, Fused	Calcium Resinate
Calcium Rosin	Calcium Resinate
Calcium Superphosphate	Calcium Phosphate
Calochlor	Mercuric Chloride
Calomel	Mercurous Chloride
Camphene	Camphene
Camphor Oil	Camphor Oil
Cane Sugar	Sucrose
Capraldehyde	Decaldehyde
Capric Alcohol	N-Decyl Alcohol
Capric Aldehyde	Decaldehyde
Caproaldehyde	N-Hexaldehyde
Caproic Aldehyde	N-Hexaldehyde
Epsilon-caprolactam	Caprolactam, Liquid
Caprolactam, Liquid	Caprolactam, Liquid
Capronaldehyde	N-Hexaldehyde
N-Caproylaldehyde	N-Hexaldehyde
Caprylene	1-Octene
Captan	Captan
Carbamide	Urea
Carbamide Peroxide	Urea Peroxide
Carbaryl	Carbaryl
Carbide	Calcium Carbide
Carbinol	Methyl Alcohol
Carbitol	Diethylene Glycol Monoethyl Ether
Carbobenzoxy Chloride	Benzyl Chloroformate
Carbolic Acid	Phenol
Carbolic Oil	Carbolic Oil
Carbon Bisulfide	Carbon Bisulfide
Carbon Dioxide	Carbon Dioxide
Carbon Disulfide	Carbon Bisulfide
Carbonic Acid Diethyl Ester	Diethyl Carbonate
Carbonic Acid Gas	Carbon Dioxide
Carbonic Acid,Monoammonium Salt	Ammonium Bicarbonate
Carbonic Anhydride	Carbon Dioxide
Carbon Monoxide	Carbon Monoxide
Carbon Tetrachloride	Carbon Tetrachloride
Carbonyl Chloride	Phosgene
Carbonyldiamide	Urea
Carbonyl Diamine Peroxide	Urea Peroxide
Carboxybenzene	Benzoic Acid
Carene	Carene
3-Carene	Carene

Synonym	*Compound Name*
Carpeting Material	Arsenic Acid
Carpeting Medium	Asphalt Blend Stock: Straight Run Residue
Carthamus Tinctorius Oil	Oils Edible: Safflower
Carwinate 125m	Diphenylmethanediisocy anate (MDI)
Catechin	Catechol
Catechol	Catechol
Caustic Arsenic Chloride	Arsenic Trichloride
Caustic Oil of Arsenic	Arsenic Trichloride
Caustic Potash	Potassium Hydroxide
Caustic Potash Solution	Caustic Potash Solution
Caustic Soda	Sodium Hydroxide
Caustic Soda Solution	Caustic Soda Solution
CD-68	Chlordane
Cellosolve	Ethylene Glycol Monoethyl Ether
Cellosolve Acetate	Ethylene Glycol Monoethyl Ether Acetate
Cellulose Nitrate Solution	Collodion
Cetyl Sodium Sulfate	Hexadecyl Sulfate, Sodium Salt
Chamber Acid	Sulfuric Acid
Charcoal	Charcoal
Chem BAM	NABAM
Chinese Tannin	Tannic Acid
Chinoline	Quinoline
Chloracetic Acid	Monochloroacetic Acid
Chloracetyl Chloride	Chloroacetyl Chloride
Chlorate of Potash	Potassium Chlorate
Chlorate of Potassium	Potassium Chlorate
Chlorate of Soda	Sodium Chlorate
Chlordan	Chlordane
Chlordane	Chlordane
2-Chlorethanol	Ethylene Chlorohydrin
Chlorex	Dichloroethyl Ether
Chloride of Amyl	N-Amyl Chloride
Chlorinated Biphenyl	Polychlorinated Biphenyl (PCB)
Chlorine	Chlorine
Chlorine Trifluoride	Chlorine Trifluoride
Chlordacetic Acid	Monochloroacetic Acid
Chloroacetic Acid, Ethyl Ester	Ethyl Chloroacetate
Chloroacetophenone	Chloroacetophenone
Alpha-chloroacetophenone	Chloroacetophenone
Omega-chloroacetophenone	Chloroacetophenone
Chloroacetyl Chloride	Chloroacetyl Chloride
5-Chloro-2-Aminotoluene	4-Chloro-o-Toluidine
4-Chloroaniline	P-Chloroaniline
P-Chloroaniline	P-Chloroaniline
Chlorobenzene	Chlorobenzene
P-Chlorobenzoyl Peroxide	Di-(P-Chlorobenzoyl) Peroxide
Di-(4-chlorobenzoyl) Peroxide	Di-(P-Chlorobenzoyl) Peroxide
4-Chlorobutyronitrile	4-Chlorobutyronitrile
4-Chlorobutyronitrile (Practical, Mixture with 4-Bromobutyronitrile)	4-Chlorobutyronitrile
Chlorocarbonic Acid, Methyl Ester	Methyl Chloroformate
Chlorodifluoromethane	Monochlorodifluoromet hane
1-Chloro-2?,3-Epoxypropane	Epichlorohydrin
Chloroethane	Ethyl Chloride
2-Chloroethanol	Ethylene Chlorohydrin
Chloroethene	Vinyl Chloride
2-Chloroethyl Alcohol	Ethylene Chlorohydrin
2-Chloro-4-Ethylamino-6-Isopropylamino-S-Triazine	Atrazene
Chloroethylene	Vinyl Chloride
Chloroform	Chloroform
Chloroformic Acid, Benzyl Ester	Benzyl Chloformate
Chloroformic Acid, Ethyl Ester	Ethyl Chloroformate
Chloroformic Acid, Methyl Ester	Methyl Chloroformate
Chloroformyl Chloride	Phosgene
Chlorohydrins (Crude)	Chlorohydrins Crude
Gamma-Chloroisobutylene	Methallyl Chloride
Chloromethane	Methyl Chloride
4-Chloro-2-Methylaniline	4-Chloro-0-Toluidine
Chloromethyl Methyl Ether	Chloromethyl Methyl Ether
Chloromethyloxirane	Epichlorohydrin

Synonym	*Compound Name*
0-(3-Chloro-4-Methyl-2-Oxo-(2H)-1-Benzopyran-7-Yl)Phosphorothioate	Coumaphos
4-Chloro-0-Toluidine	4-Chloro-0-Toluidine
Chloromethyl Phenyl Ketone	Chloroacetophenone
3-Chloro-2-Methylpropene	Methallyl Chloride
1-Chloropentane	N-Amyl Chloride
4-Chlorophenol	P-Chlorophenol
P-Chlorophenol	P-Chlorophenol
4-Chlorophenylamine	P-Chloroaniline
Di-(P-Chlorophenyl) Trichloromethylcarbinol	4,4-Dichloro-Alpha-Trichloromethylbenzhydrol
Chloropicrin, Liquid	Chloropicrin, Liquid
3-Chloropropene	Allyl Chloride
3-Chloropropylene	Allyl Chloride
Gamma-Chloropropylene Oxide	Epichlorohydrin
3-Chloro-1,2-Propylene Oxide	Epichlorohydrin
Chlorosulfonic Acid	Chlorosulfonic Acid
Chlorothene	Trichloroethane
Chlorotoluene, Alpha	Benzyl Chloride
Alpha-Chlorotoluene	Benzyl Chloride
Omega-Chlorotoluene	Benzyl Chloride
Chlorotrifluoroethylene	Trifluorochloroethylene
Chlorotrimethylsilane	Trimethylchlorosilane
Chlorsulfonic Acid	Chlorosulfonic Acid
Chlorylen	Trichloroethylene
Chp	Cumene Hydroperoxide
Chromic Acid	Chromic Anhydride
Chromic Anhydride	Chromic Anhydride
Chromic Oxide	Chromic Anhydride
Chromium (Vl) Dioxychloride	Chromyl Chloride
Chromium Oxychloride	Chromyl Chloride
Chromium Trioxide	Chromic Anhydride
Chromyl Chloride	Chromyl Chloride
Cianurina	Mercuric Cyanide
Citric Acid	Citric Acid
Citric Acid, Diammonium Salt	Ammonium Citrate
Clarified Oil	Oil: Clarified
Clorox	Sodium Hypochlorite
Cc Ral	Coumaphos
Coal Tar Oil	Oil: Coal Tar
Cobalt Acetate	Cobalt Acetate
Cobalt Acetate Tetrahydrate	Cobalt Acetate
Cobalt (II) Acetate	Cobalt Acetate
Cobalt Chloride	Cobalt Chloride
Cobalt (II) Chloride	Cobalt Chloride
Cobaltous Acetate	Cobalt Acetate
Cobaltous Chloride	Cobalt Chloride
Cobaltous Chloride Dihydrate	Cobalt Chloride
Cobaltous Chloride Hexahydrate	Cobalt Chloride
Cobaltous Nitrate	Cobalt Nitrate
Cobaltous Nitrate Hexahydrate	Cobalt Nitrate
Cobaltous Sulfate Heptahydrate	Cobalt Sulfate
Cobalt Nitrate	Cobalt Nitrate
Cobalt (II) Nitrate	Cobalt Nitrate
Cobalt Sulfate	Cobalt Sulfate
Cobalt (II) Sulfate	Cobalt Sulfate
Coconut Butter	Oils Edible: Coconut
Coconut Oil	Oils Edible: Coconut
Cocoil	Oil: Resin
Cocoil	Oil: Rozin
Collodion	Collodion
Cologne Spirit	Ethyl Alcohol
Colonial Spirit	Methyl Alcohol
Columbian Spirit	Methyl Alcohol
Combustion Improver C12	Methylcyclopentadienyl-manganese Tricarbonyl
Condensed Phosphoric Acid	Polyphosphoric Acid
Copper Acetate	Copper Acetate
Copper Acetoarsenite	Copper Acetoarsenite
Copper Arsenite	Copper Arsenite
Copperas	Ferrous Sulfate
Copper Borofluoride Solution	Copper Fluoroborate
Copper Bromide	Copper Bromide
Copper Chloride	Copper Chloride
Copper Cyanide	Copper Cyanide
Copper Fluoroborate	Copper Fluoroborate
Copper (II) Fluoborate Solution	Copper Fluoroborate
Copper Iodide	Copper Iodide
Copper Naphthenate	Copper Naphthenate
Copper Nitrate	Copper Nitrate
Copper Orthoarsenite	Copper Arsenite
Copper Oxalate	Copper Oxalate
Copper Sulfate	Copper Sulfate
Copper Sulfate Pentahydrate	Copper Sulfate

Synonym	*Compound Name*
Copra Oil	Oils Edible: Coconut
Corn Sugar Solution	Dextrose Solution
Corn Syrup	Corn Syrup
Corn Syrup Solution	Dextrose Solution
Corrosive Mercury Chloride	Mercuric Chloride
Corrosive Sublimate	Mercuric Chloride
Cottonseed Oil	Oil: Cottonseed
Coumaphos	Coumaphos
Crankcase Oil	Oil: Motor
Crankcase Oil	Oil: Lubricating
Creosote, Coal Tar	Creosote, Coal Tar
Creosote Oil	Creosote, Coal Tar
Cresol, Epoxypropyl Ether	Cresyl Glycidyl Ether
Cresols	Cresols
Cresyl Glycidyl Ether	Cresyl Glycidyl Ether
Cresylic Acid	Xylenol
Cresylic Acids	Cresols
Croplas Eh	Ethyl Hexyl Tallate
Crotenaldehyde	Crotonaldehyde
Crotonaldehyde	Crotonaldehyde
Crotonic Aldehyde	Crotonaldehyde
Crotonoel	Oils Miscellaneous: Croton
Croton Tiglium L. Oil	Oils Miscellaneous: Croton
Crude Epichlorohydrin	Chlorohydrins (Crude)
Crude Oil	Oil: Crude
Crystallized Verdigris	Copper Acetate
CTF	Chlorine Trifluoride
Cucumber Dust	Calcium Arsenate
Cumene	Cumene
Cumene Hydroperoxide	Cumene Hydroperoxide
Cumol	Cumene
Cumyl Hydroperoxide	Cumene Hydroperoxide
Cupric Acetate Monohydrate	Copper Acetate
Cupric Arsenite	Copper Arsenite
Cupric Bromide, Anhydrous	Copper Bromide
Cupric Chloride Dihydrate	Copper Chloride
Cupric Fluoborate Solution	Copper Fluoroborate
Cupric Green	Copper Arsenite
Cupricin	Copper Cyanide
Cupric Nitrate Trihydrate	Copper Nitrate
Cupric Oxalate Hemihydrate	Copper Oxalate
Cupric Sulfate	Copper Sulfate
Cupriethylenediamine Solution	Cupriethylenediamine Solution
Cupriethylenediamine Hydroxide Solution	Cupriethylenediamine Solution
Cuprous Cyanide	Copper Cyanide
Cuprous Iodide	Copper Iodide
Cyanacetic Acid	Cyanoacetic Acid
Cyanide	Potassium Cyanide
Cyanide of Calcium	Calcium Cyanide
Cyanoacetic Acid	Cyanoacetic Acid
Cyanobenzene	Benzonitrile
2-Cyanoethanol	Ethylene Cyanohydrin
Cyanoethylene	Acrylonitrile
Cyanogas A-Dust	Calcium Cyanide
Cyanogas G-Fumigant	Calcium Cyanide
Cyanogen	Cyanogen
Cyanogen Bromide	Cyanogen Bromide
Cyanogen Chloride	Cyanogen Chloride
Cyanomethane	Acetonitrile
Cyclohexane	Cyclohexane
Cyclohexanol	Cyclohexanol
Cyclohexanone	Cyclohexanone
Cyclohexanone Peroxide	Cyclohexanone Peroxide
Cyclohexenyltrichlorosilane	Cyclohexenyltrichloro silane
Cyclohexyl Alcohol	Cyclohexanol
Cyclohexylamine	Cyclohexylamine
Cyclohexyl Ketone	Cyclohexanone
Cyclopentane	Cyclopentane
Cyclopentane, Methyl	Methylcyclopentane
Cyclopropane	Cyclopropane
P-Cymene	P-Cymene
Cymol	P-Cymene
Cystogen	Hexamethylenetetramine
Cythion Insecticide	Malathion
2,4-D	2,4-Dichlorophenoxyacetic Acid
Dalapon	Dalapon
DBP	Dibutyl Phthalate
DCEE	Dichloroethyl Ether
DCP	Calcium Phosphate
DDD	DDD
DDT	DDT

Synonym	*Compound Name*
P.P -DDT	DDT
D.D. Turpentine	Turpentine
Dea	Diethanolamine
Dead Oil	Creosote, Coal Tar
Dec	Decahydronaphthalene
Decaborane	Decaborane
Decahydronaphthalene	Decahydronaphthalene
Cis-or Trans-Decahydronaphthalene	Decahydronaphthalene
Decaldehyde	Decaldehyde
Decalin	Decahydronaphthalene
Decanal	Decaldehyde
1-Decanol	N-Decyl Alcohol
1-Decene	L-Decene
Alpha-Decene	1-Decene
N-Decyl Alcohol	K-Decyl Alcohol
N-Decyl Aldehyde	Decaldehyde
Decylbenzene	N-Decylbenzene
N-Decylbenzene	N-Decylbenzene
DEG	Diethylene Glycol
Dehd	Dioctyl Phthalate
DEHPA	Di-(2-Ethylhexyl) Phosphoric Acid
Dehydrite	Magnesium Perchlorate
De Kalin	Decahydronaphthalene
DEN	Diethylamine
Denatured Alcohol	Ethyl Alcohol
2,4-D Esters	2,4-D Esters
Detergent Alkylate = 2	Dodecylbenzene
Dextrose Solution	Dextrose Solution
Diacetic Ether	Ethyl Acetoacetate
Diacetone	Diacetone Alcohol
Diacetone Alcohol	Diacetone Alcohol
Diacetylmethane	Acetylacetone
Diacetyl Peroxide Solution	Acetyl Peroxide Solution
1,2-Diaminoethane	Ethylenediamine
2,2 -Diaminodiethylamine	Diethylenetriamine
1,6-Diaminohexane	Hexamethylenediamine
1,11-Diamino-3,6,9-Triazaundecane	Tetraethylenepentamine
Diammonium Citrate	Ammonium Citrate
Diammonium Hydrogen Phosphate	Ammonium Phosphate
Diammonium Orthophosphate	Ammonium Phosphate
Diammonium Oxalate	Ammonium Oxalate
Diamyl Phthalate	Di-N-Amyl Phthalate
Di-N-Amyl Phthalate	Di-N-Amyl Phthalate
2,2-Di-(P-Anisyl)-1,1,1-Trichloroethane	Methoxychlor
Diantimony Trioxide	Antimony Trioxide
Diazinon	Diazinon
Dibasic Calcium Phosphate	Calcium Phosphate
Dibenzo (B,E) Pyridine	Acridine
Dibenzoyl Peroxide	Dibenzoyl Peroxide
DIBK	Diisobutyl Ketone
1,2-Dibromoethane	Ethylene Dibromide
Sym-Dibromoethane	Ethylene Dibromide
Dibutylamine	Di-N-Butylamine
Di-N-Butylamine	Di-N-Butylamine
Dibutyl Ether	Di-N-Butyl Ether
N-Dibutyl Ether	Di-N-Butyl Ether
Di-N-Butyl Ether	Di-N-Butyl Ether
Di-N-Butyl Ketone	Di-N-Butyl Ketone
Dibutyl Oxide	Di-N-Butyl Ether
Dibutylphenol	Dibutylphenol
2,6-Di-Tert-Butylphenol	Dibutylphenol
Dibutyl Phthalate	Dibutyl Phthalate
Dicalcium Phosphate (Anhydrous or Dihydrate)	Calcium Phosphate
S-(1,2-Dicarbethoxyethyl)-0,0-Dimethyl Dithiophosphate	Malathion
Dicarbomethoxyzinc	Zinc Acetate
Dichloricide	P-Dichlorobenzene
1,2-Dichlorobenzene	O-Dichlorobenzene
O-Dichlorobenzene	O-Dichlorobenzene
P-Dichlorobenzene	P-Dichlorobenzene
Di-(P-Chlorobenzoyl) Peroxide	Di-(P-Chlorobenzoyl) Peroxide
Di-(4-Chlorobenzoyl) Peroxide	Di-(P-Chlorobenzoyl) Peroxide
P,P-Dichlorobenzoyl Peroxide	Di-(P-Chlorobenzoyl) Peroxide
1,1-Dichloro-2,2-Bis(P-Chlorophenyl) Ethane	DDD
Dichlorobutene	Dichlorobutene
1,4-Dichloro-2-Butene	Dichlorobutene
Cis-1,4-Dichloro-2-Butene	Dichlorobutene

Synonym	*Compound Name*
Trans-1,4-Dichloro-2-Butene	Dichlorobutene
1,4-Dichloro-2-Butylene	Dichlorobutene
Dichlorodiethyl Ether	Dichloroethyl Ether
Dichlorodifluoromethane	Dichlorodifluoro methane
Dichlorodiphenyldichloro-ethane	DDD
Dichlorodiphenylsilane	Diphenyldichlorosilane
Dichlorodiphenylsilicane	Diphenyldichlorosilane
Dichlorodiphenyltrichloro ethane	DDT
1,2-Dichloroethane	Ethylene Dichloride
Di-(2-Chloroethyl) Ether	Dichloroethyl Ether
Di-(2-Chloroethyl) Ether	Dichloroethyl Ether
Dichloroethyl Ether	Dichloroethyl Ether
1,1-Dichloroethylene	Vinylidenechloride, Inhibited
1,2-Dichloroethylene	1,2-Dichloroethylene
Sym-Dichloroethylene	1,2-Dichloroethylene
Unsym-Dichloroethylene	Vinylidenechloride, Inhibited
Cis-or Trans-1,2-Dichloroethylene	1,2-Dichloroethylene
2,2 -Dichloroethyl Ether	2,2 -Dichloroethyl Ether
Beta, Beta-Dichloroethyl Ether	Dichloroethyl Ether
Dichloromethane	Dichloromethane
2,4-Dichlorophenol	2,4-Dichlorophenol
2,4-Dichlorophenoxyacetic Acid	2,4-Dichlorophenoxyacetic Acid
2,4-Dichlorophenoxyacetic Acid, Butoxyethyl Ester	2,4-D Esters
2,4-Dichlorophenoxyacetic Acid, Butyl Ester	2,4-D Esters
2,4-Dichlorophenoxyacetic Acid, Isopropyl Ester	2,4-D Esters
Dichlorophenylphosphine	Benzene Phosphorus Dichloride
Di-(P-Chlorophenyl) Trichloromethylcarbinol	4,4-Dichloro-Alpha-Trichloromethylbenzhydrol
1,2-Dichloropropane	Dichloropropane
Dichloropropane	Dichloropropane
2,2-Dichloropropanoic Acid	Dalapon
Alpha, Alpha - Dichloropropionic Acid	Dalapon
1,3-Dichloropropene	Dichloropropene
Dichloropropene	Dichloropropene
2.2-Dichloropropionic Acid	Dalapon
4,4-Dichloro-Alpha-Trichloromethylbenzhydrol	4,4-Dichloro-Alpha-Trichloromethylbenz-hydrol
Dicofol	4,4-Dichloro-Alpha-Trichloromethylbenz-hydrol
Dicy	Dicyclopentadiene
Dicyan	Cyanogen
1,4-Dicyanobutane	Adiponitrile
Dicyanogen	Cyanogen
Dicyclohexanone Diperoxide	Cyclohexanone Peroxide
Dicyclopentadiene	Dicyclopentadiene
Dieldrin	Dieldrin
Diesel Ignition Improver	N-Amyl Nitrate
Diesel Oil, Light	Fuel Oil: I-D
Diesel Oil, Medium	Fuel Oil: 2-D
Diethanolamine	Diethanolamine
Diethanolamine, Lauryl Sulfate Solution - Lauryl Sulfate, Diethanolamine Salt Solution	Dodecyl Sulfate, Diethanolamine Salt
Diethanolamine Lauryl Sulfate Solution Lauryl Sulfate, Diethanolamine Salt	Dodecyl Sulfate, Diethanolamine Salt
1,2-Diethoxyethane	Ethylene Glycol Diethyl Ether
Diethylamine	Diethylamine
Diethylbenzene	Diethylbenzene
Diethyl Carbonate	Diethyl Carbonate
Diethyl Cellosolve	Ethylene Glycol Diethyl Ether
0,0-Diethyl-0-(3-Chloro-4-Methyl-2-Oxo-(2H)-1-Benzopyran-7-Yl) Phosphorothioate	Coumaphos
Diethylenediamine	Piperazine
Diethylene Glycol	Diethylene Glycol
Diethylene Glycol Dimethyl Ether	Diethylene Glycol Dimethyl Ether
Diethylene Glycol Ethyl Ether	Diethylehe Glycol Monoethyl Ether

Synonym	*Compound Name*
Diethylene Glycol Methyl Ether	Diethylene Glycol Monomethyl Ether
Diethylene Glycol Monobutyl Ether Acetate	Diethylene Glycol Monobutyl Ether Acetate
Diethylene Glycol Monoethyl Ether	Diethylene Glycol Monoethyl Ether
Diethylene Glycol Monomethyl Ether	Diethylene Glycol Monomethyl Ether
Diethyleneimide Oxide	Morpholine
Diethylene Imidoxide	Morpholine
Di(Ethylene Oxide)	1,4-Dioxane
Diethylene Oximide	Morpholine
Diethylenetriamine	Diethylenetriamine
Diethyl Ether	Ethyl Ether
Di-(2-Ethylhexyl)Acid Phosphate	Di-(2-Ethylhexyl) Phosphoric Acid
Di-(2 Ethylhexyl)Adipate	Dioctyl Adipate
Di-(2-Ethylhexyl)Phosphate	Di-(2-Ethylhexyl) Phosphoric Acid
Di-(2-Ethylhexyl)Phosphoric Acid	Di-(2-Ethylhexyl) Phosphoric Acid
Di(2-Ethylhexyl) Phthalate	Dioctyl Phthalate
Di-(2-Ethylhexyl)Sulfosuccinate Sodium Salt	Dioctyl Sodium Sulfosuccinate
0,0-Diethyl 0-(2-Isopropyl-6-Methyl -4-Pyrimidinyl)Phosphorothioate	Diazinon
0,0-Diethyl-0-(2-Isopropyl-6-Methyl-4-Pyrimidinyl) Phosphorothioate	Diazinon
0,0-Diethyl-0-2-Isopropyl-4-Methyl-6-Pyrimidyl Thio-Phosphate	Diazinon
0,0-Diethyl-0-(2-Isopropyl-6-Methyl-4-Pyrimidinyl)Thio-Phosphate	Diazinon
Diethyl 2-Isopropyl-4-Methyl-6-Pyrimidyl	Diazinon
0,0-Diethyl 0-(P-Nitrophenyl) Phosphorothioate	Parathion, Liquid
0,0-Diethyl 0-(P-Nitrophenyl) Thiophosphate	Parathion, Liquid
0,0-Diethyl-0(and S-)(I-Ethylthio) Ethyl)Phosphorothioates	Demeton
Diethyl Oxide	Ethyl Ether
Diethyl Phthalate	Diethyl Phthalate
Diethylzinc	Diethylzinc
1,1-Difluoroethane	1,1-Difluoroethane
Difluorophosphorus Acid	Difluorophosphoric Acid, Anhydrous
Difluorophosphoric Acid, Anhydrous	Difluorophosphoric Acid, Anhydrous
Diformyl	Glyoxal, 40% Solution
Diglycol	Diethylene Glycol
Diglycol Monobutyl Ether	Diethylene Glycol Monobutyl Ether
Diglycol Monobutyl Ether Acetate	Diethylene Glycol Monobutyl Ether Acetate
Diglyme	Diethylene Glycol Dimethyl Ether
Diheptyl Phthalate	Diheptyl Phthalate
Dihydrate	Cadmium Acetate
2,5-Dihydroperoxy-2,5-Dimethylhexane	Dimethylhexane Dihydroperoxide, Wet
1,2-Dihydro-3,6-Pyridazinedione	Maleic Hydrazide
1,2-Dihydroxybenzene	Catechol
1,3-Dihydroxybenzene	Resorcinol
M-Dihydroxybenzene	Resorcinol
P-Dihydroxybenzene	Hydroquinone
Dihydroxybenzol	Resorcinol
1,4-Dihydroxybutane	1,4-Butanediol
I,4-Dihydroxy-2-Butene	1.4-Butenediol
I,4-Dihydroxy-2-Butyne	1.4-Butynediol
2,2-Dihydroxydiethyl Amine	Diethanolamine
Beta, Beta-Dihydroxydiethyl Ether	Diethylene Glycol
P,P-Dihydroxydiphenyldimethyl-methane	Bisphenol A
2,2-Dihydroxydipropylamine	Diisopropanolamine
1,2-Dihydroxyethane	Ethylene Glycol
Di-Beta-Hydroxyethoxyethane	Triethylene Glycol
Di(2-Hydroxyethyl)Amine	Diethanolamine
Dihydroxyethyl Ether	Diethylene Glycol

Synonym	*Compound Name*
1,2-Dihydroxypropane	Propylene Glycol
Diisobutylene	Diisobutylene
Diisobutylcarbinol	Diisobutylcarbinol
Diisobutyl Ketone	Diisobutyl Ketone
1.J-Diisocyanatotoluene	Toluene 2,4-Diisocyanate (TDI)
Diisodecyl Phthalate	Diisodecyl Phthalate
Diisopropanolamine	Diisopropanolamine
Diisopropyl Ether	Isopropyl Ether
Diisopropyl Oxide	Isopropyl Ether
Diisopropyl Percarbonate	Isopropyl Percarbonate
Diisopropyl Peroxydicarbonate	Isopropyl Percarbonate
Sym-Diisopropylacetone	Diisobutyl Ketone
Diisopropylamine	Diisopropylamine
Diisopropylbenzene Hydroperoxide	Diisopropylbenzene Hydroperoxide
Dilauroyl Peroxide	Lauroyl Peroxide
Dimazine	1,1-Dimethylhydrazine
5,8-Dimethanonaphthalene	Endrin
1.2-Dimethoxyethane	Ethylene Glycol Dimethyl Ether
Dimethoxymethane	Methyl Formal
10,11-Dimethoxystrychnine	Brucine
Dimethylacetamide	Dimethylacetamide
N,N-Dimethylacetamide	Dimethylacetamide
Dimethylacetamide Acetic Acid, Dimethylamide	Dimethylacetamide
Dimethylacetic Acid	Isobutyric Acid
Dimethylamine	Dimethylamine
Dimethylarsinic Acid	Cacodylic Acid
1,3-Dimethylbenzene	M-Xylene
1,4-Dimethylbenzene	P-Xylene
1,2-Dimethylbenzene	O-Xylene
Alpha, Alpha-Dimethylbenzene Hydroperoxide	Cumene Hydroperoxide
Dimethylbenzyl Hydroperoxide	Cumene Hydroperoxide
Dimethylbenzyl-octadecylammonium Chloride	Benzyldimethuloctadecylammonium Chloride
2,2-Dimethylbutane	Neohexane
Dimethylcarbinol	Isopropyl Alcohol
Dimethyl Cellosolve	Ethylene Glycol Dimethyl Ether
Dimethyldichlorosilane	Dimethyldichlorosilane
Dimethyl Ether	Dimethyl Ether
1,1-Dimethylethylamine	Tert-Butylamine
Dimethylformal	Methyl Formal
Dimethylformamide	Dimethylformamide
N,N-Dimethylformamide	N,N-Dimethylformamide
2,6-Dimethyl-4-Heptanone	Diisobutyl Ketone
2,6-Dimethyl-4-Heptanol	Diisobutylcarbinol
Dimethylhexanals	Isooctaldehyde
Dimethylhexane	Dimethylhexane
Dihydroperoxide, Wet	Dihydroperoxide, Wet
2,5-Dimethylhexane-2,5-Dihydroperoxide, Wet	Dimethylhexane Dihydroperoxide, Wet
Dimethyl-1-Hexanols	Isooctyl Alcohol
1,1-Dimethylhydrazine	1,1-Dimethylhydrazine
Unsym-Dimethylhydrazine	1,1-Dimethylhydrazine
Dimethyl Ketone	Acetone
Dimethylmethane	Propane
2,2-Dimethyl-3-Methylenenorborman	Camphene
3,3-dimethyl-2-Methylenenorcamphane	Camphene
Dimethyloctadecylbenzyl-ammonium Chloride	Benzyldimethyloctadecylammonium Chloride
0,0-Dimethyl-0-(P-Nitrophenyl)phosphorothioate	Methyl Parathion
0,0-Dimethyl-0-(P-Nitrophenyl)Thiophosphate	Methyl Parathion
0,0-Dimethyl S-\\4—Oxo-1,2,3-Benzotriazine-3\4H'-Yl'Methyl Phosphorodithioate	Azinphosmethyl
2,6-Dimethylphenol	Xylenol
Dimethyl Polysiloxane	Dimethyl Polysiloxane
Dimethyl Silicone Fluids	Dimethyl Polysiloxane
Dimethylsilicone Oil	Dimethyl Polysiloxane
Dimethyl Sulfate	Dimethyl Sulfate
Dimethyl Sulfide	Dimethyl Sulfide
Dimethyl Sulfoxide	Dimethyl Sulfoxide
Dimethyl Terephthalate	Dimethyl Terephthalate
Dimethylzinc	Dimethylzinc
2,4-Dinitraniline	2,4-Dinitroaniline
2,4-Dinitroaniline	2,4-Dinitroaniline
1,3-Dinitrobenzene	M-Dinitrobenzene
M-Dinitrobenzene	M-Dinitrobenzene
Meta-Dinitrobenzene	M-Dinitrobenzene
Dinitrobenzol	M-Dinitrobenzene

Synonym	*Compound Name*
1,3-Dinitrobenzol	M-Dinitrobenzene
Dinitrocresols	Dinitrocresols
3.5-Dinitro-0-Cresol	Dinitrocresols
4,6-Dinitro-0-Cresol	Dinitrocresols
2,6-Dinitro-P-Cresol	Dinitrocresols
2,6-Dinitro-N,N-Dipropyl-4-Trifluoromethylaniline	Trifluralin
2,6-Dinitro-N,N-Dipropyl-Alpha, Alpha,Alpha-Trifluoro-P-Toluidine	Trifluralin
Dinitrogen Monoxide	Nitrous Oxide
Dinitrogen Tetroxide	Nitrogen Tetroxide
Alpha-Dinitrophenol	2,4-Dinitrophenol
2,4-Dinitrophenol	2,4-Dinitrophenol
2,4-Dinitrotoluene	2,4-Dinitrotoluene
2,4-Dinitrotoluol	2,4-Dinitrotoluene
Dioctyl Adipate	Dioctyl Adipate
Dioctyl Phthalate	Dioctyl Phthalate
Dioctyl Sodium Sulfosuccinate	Dioctyl Sodium Sulfosuccinate
Dioform	1,2-Dichloroethylene
Dioxan	1,4-Dioxane
1,4-Dioxane	1,4-Dioxane
P-Dioxane	1,4-Dioxane
Dioxonium Perchlorate Solution	Perchloric Acid
1,3-Dioxophthalan	Phthalic Anhydride
Dipentene	Dipentene
Dipentyl Phthalate	Di-N-Amyl Phthalate
Diphenylamine	Diphenylamine
Diphenyldichlorosilane	Diphenyldichlorosilane
Diphenyl Ether	Diphenyl Ether
Diphenyl Ketone	Benzophenone
Diphenylmethanediisocyanate (MDI)	Diphenylmethanediisocyanate (MDI)
Diphenylmethannone-4,4-Diisocyanate	Diphenylmethanediisocyanate (MDI)
Diphenyl Methanone	Benzophenone
Diphenyl Oxide	Diphenyl Ether
Diphenylsilicon Dichloride	Diphenyldichlorosilane
Di-N-Propylamine	Di-N-Propylamine
N,N-Dipropyl-2,6-Dinitro-4-Trifluoro-Methylaniline	Trifluralin
Dipropylene Glycol	Dipropylene Glycol
Disodium Arsenate Heptahydrate	Sodium Arsenate
Disodium Ethylenebis (Dithiocarbamate)	Nabam
Disodium Methanearsonate	Methanearsonic Acid, Sodium Salts
Disodium Methyl Arsonate	Methanearsonic Acid, Sodium Salts
Disodium Nitrilotriacetate	Nitrilotriacetic Acid and Salts
Distillate: Flashed Feed Stocks	Distillate: Flashed Feed Stocks
Distillate: Straight Run	Distillate: Straight Run
Disulfatozirconic Acid	Zirconium Sulfate
Dithane	Nabam
Dithiopyrophosphoric Acid, 0,0,0,0-Tetraethyl Ester	Tetraethyl Dithiopyrophosphate
Divinyl	Butadiene, Inhibited
DMDT	Methoxychlor
DMF	Dimethylformamide
DMS	Dimethyl Sulfide
DMSO	Dimethyl Sulfoxide
DNT	2,4-Dinitrotoluene
DOA	Dioctyl Adipate
1-Dodecanethiol	Lauryl Mercaptan
Dodecanol	Linear Alcohols (12-15 Carbons)
Dodecanol	Dodecanol
Dodecanol Peroxide	Lauroyl Peroxide
Dodecene	Dodecene
1-Dodecene	1-Dodecene
Dodecene (Non-Linear)	Propylene Tetramer
Dodecene (Non-Linear)	Dodecene
Dodecyl Alcohol	Dodecanol
Dodecylbenzene	Dodecylbenzene
N-Dodecylbenzene	Dodecylbenzene
Docecylbenzenesulfonic Acid	Alkylbenzenesulfonic Acids
Dodecylbenzene (Linear)	Dodecylbenzene
Dodecylbenzenesulfonic Acid, Calcium Salt	Dodecylbenzenesulfonic Acid, Calcium Salt
Dodecylbenzenesulfonic Acid, Isopropylamine Salt	Dodecylbenzenesulfonic Acid, Isopropylamine Salt

Synonym	*Compound Name*
Dodecylbenzenesulfonic Acid, Triethanolamine Salt	Dodecylbenzenesulfonic Acid, Triethanolamine Salt
Alpha-Dodecylene	1-Dodecene
Dodecylethylene	1-Tetradecene
Dodecyl Mercaptan	Lauryl Mercaptan
Dodecyl Sulfate, Ammonium Salt	Ammonium Lauryl Sulfate
Dodecyl Sulfate, Diethanolamine Salt	Dodecyl Sulfate, Diethanolamine Salt
Dodecyl Sulfate, Magnesium Salt	Dodecyl Sulfate, Magnesium Salt
Dodecyl Sulfate, Sodium Salt	Dodecyl Sulfate, Sodium Salt
Dodecyl Sulfate, Triethanolamine Salt	Dodecyl Sulfate, Triethanolamine Salt
Dodecyltrichlorosilane	Dodecyltrichlorosilane
DOP	Dioctyl Phthalate
Dormant Oil	Oil: Spray
Dowanol DB	Diethylene Glycol Monobutyl Ether
Dowanol DE	Diethylene Glycol Monoethyl Ether
Dowanol DM	Diethylene Glycol Monomethyl Ether
Dowanol EB	Diethylene Glycol Monobutyl Ether
Dowanol EE	Diethylene Glycol Monoethyl Ether
Dowanol EM	Diethylene Glycol Monoethyl Ether
Dowanol PM	Propylene Glycol Methyl Ether
Dowanol TE	Ethoxy Triglycol
Dowanol 33B	Propylene Glycol Methyl Ether
Dowfume 40, W-10, W-15, W-40	Ethylene Dibromide
Dowicide 2	Trichlorophenol
Dowicide 7	Pentachlorophenol
Dowtherm	Dowtherm
Dowtherm E	O-Dichlorobenzene
Dracyclic Acid	Benzoic Acid
Drycleaners Naphtha	Naphtha Stoddard Solvent
Drying Oil Epoxides	Epoxidized Vegetable Oils
DSMA	Methanearsonic Acid, Sodium Salt
Dust-Laying Oil	Asphalt Blending Stock: Roofers Flux
Dutch Liquid	Ethylene Dichloride
Dytol S-91	K-Decyl Alcohol
E 3314	Heptachlor
EAA	Ethyl Acetoacetate
EADC	Ethylaluminum Dichloride
EASC	Ethylaluminum Sesquichloride
EB	Ethylbenzene
EBDC, Sodium Salt	Nabam
EDC	Ethylene Dichloride
Edible Tallow	Tallow
EDTA	Ethylenediamine Tetracetic Acid
Ektasolve DB Acetate	Diethylene Glycol Monobutyl Ether Acetate
Electrical Insulating Oil	Oil: Transformer
Embafume	Methyl Bromide
Enanthic Alcohol	Heptanol
Endrate	Ethylenediamine Tetracetic Acid
Endrin	Endrin
Epichlorohydrin	Epichlorohydrin
Epoxidized Drying Oils	Epoxidized Vegetable Oils
Epoxidized Oils	Epoxidized Vegetable Oils
Epoxidized Tall Oil, Octyl Ester	Octyl Epoxy Tallate
Epoxidized Vegetable Oils	Epoxidized Vegetable Oils
1,2-Epoxybutane	Butylene Oxide
1,2-Epoxyethane	Ethylene Oxide
1,2-Epoxypropane	Propylene Oxide
Erinitrit	Sodium Nitrite
Eriochalcite (Anhydrous)	Copper Chloride
Eskimon 11	Trichlorofluoromethane
Eskimon 12	Dichlordifluoromethane
Eskimon 22	Monochlorodifluoro-methane

Synonym	*Compound Name*
Essence of Mirbane	Nitrobenzene
Ethanal	Acetaldehyde
Ethane	Ethane
Ethanecarboxylic Acid	Propionic Acid
Ethanedial	Glyoxal, 40% Solution
1,2-Ethanediamine	Ethylenediamine
Ethanedinitrile	Cyanogen
Ethanedioic Acid	Oxalic Acid
Ethanedioic Acid, Disodium Salt	Sodium Oxalate
1,2-Ethanediol	Ethylene Glycol
Ethanenitrile	Acetonitrile
Ethanethiol	Ethyl Mercaptan
Ethanoic Acid	Acetic Acid
Ethanoic Anhydride	Acetic Anhydride
Ethanol	Ethyl Alcohol
Ethanolamine	Monoethanolamine
Ethene	Ethylene
Ether	Ethyl Ether
Ethine	Acetylene
Ethoxydihydropyran	Ethoxydihydropyran
Z-2-Ethoxy-3,4-Dihydro-2H-Pyran	Ethoxydihydropyran
Ethoxyethane	Ethyl Ether
2-Ethoxyethanol	Ethylene Glycol Monoethyl Ether
2-Ethoxyethanol, Acetate	Ethylene Glycol Monoethyl Ether Acetate
2-(2-Ethoxyethoxy)Ethanol	Diethylene Glycol Monoethyl Ether
2-Ethoxyethyl Acetate	Ethylene Glycol Monoethyl Ether
Ethoxy Diglycol	Diethylene Glycol Momoethyl Ether
Ethoxylated Dodecanol	Ethoxylated Dodecanol
Ethoxylated Dodecyl Alcohol	Ethoxylated Lauryl Alcohol
Ethoxylated Myristyl Alcohol	Ethoxylated Tetradecanol
Ethoxylated Nonylphenol	Ethoxylated Nonylphenol
Ethoxylate Pentadecanol	Ethoxylated Pentadecanol
Ethoxylated Pentadecyl Alcohol	Ethoxylated Pentadecanol
Ethoxylated Tetradecanol	Ethoxylated Tetradecanol
Ethoxylated Tetradecyl Alcohol	Ethoxylated Tetradecanol
Ethoxylated Tridecanol	Ethoxylated Tridecanol
Ethoxylated Tridecyl Alcohol	Ethoxylated Tridecanol
Ethoxytriethylene Glycol	Ethoxy Triglycol
Ethoxy Triglycol	Ethoxy Triglycol
Ethyl Acetate	Ethyl Acetate
Ethylacetic Acid	N-Butyric Acid
Ethyl Acetoacetate	Ethyl Acetoacetate
Ethyl Acrylate	Ethyl Acrylate
Ethyl Alcohol	Ethyl Alcohol
Ethyl Aldehyde	Acetaldehyde
Ethylaluminum Dichloride	Ethylaluminum Dichloride
Ethylaluminum Sesquichloride	Ethylaluminum Sesquichloride
Ethylamine	Ethylamine
Ethylbenzene	Ethylbenzene
Ethyl Butanoate	Ethyl Butyrate
Ethyl Butanol	Ethyl Butanol
2-Ethyl-1-Butanol	Ethyl Butanol
2-Ethylbutyl Alcohol	Ethyl Butanol
Ethyl Butyrate	Ethyl Butyrate
2-Ethylcaproaldehyde	Ethylhexaldehyde
Ethylcarbinol	N-Propyl Alcohol
Ethyl Carbonate	Diethyl Carbonate
Ethyl Chloracetate	Ethyl Chloracetate
Ethyl Chloride	Ethyl Chloride
Ethyl Chloroacetate	Ethyl Chloroacetate
Ethyl Chlorocarbonate	Ethyl Chloroformate
Ethyl Chloroethanoate	Ethyl Chloroacetate
Ethyl Chloroformate	Ethyl Chloroacetate
Ethyl Dichlorophosphate	Ethyl Phosphorodichloridate
Ethyldichlorosilane	Ethyldichlorosilane
Ethylene	Ethylene
Ethylene Acetate	Ethylene Glycol Diacetate
Ethylene Bromide	Ethylene Dibromide
Ethylene Chlorhydrin	Ethylene Chlorohydrin

Synonym	*Compound Name*
Ethylene Chloride	Ethylene Dichloride
Ethylene Chlorchydrin	Ethylene Chlorohydrin
Ethylene Cyanohydrin	Ethylene Cyanohydrin
Ethylene Diacetate	Ethylene Glycol Diacetate
Ethylenediamine	Ethylenediamine
Ethylenediamine Tetracetic Acid	Ethylenediamine Tetracetic Acid
Ethylene Dibromide	Ethylene Dibromide
Cis-1,2-Ethylenedicarboxylic Acid	Maleic Acid
Trans-1,2-Ethylenedicarboxylic Acid	Fumaric Acid
Ethylene Dichloride	Ethylene Dichloride
Ethylene Diglycol	Diethylene Glycol
Ethylene Dihydrate	Ethylene Glycol
(Ethylenedinitrilo)Tetraacetic Acid	Ethylenediamine Tetracetic Acid
Ethylene Glycol	Ethylene Glycol
Ethylene Glycol Diacetate	Ethylene Glycol Diacetate
Ethylene Glycol Diethyl Ether	Ethylene Glycol Diethyl Ether
Ethylene Glycol Dihydroxydiethyl Ether	Triethylene Glycol
Ethylene Glycol Dimethyl Ether	Ethylene Glycol Dimethyl Ether
Ethylene Glycol Ethyl Ether	Ethylene Glycol Monoethyl Ether
Ethylene Glycol Monobutyl Ether	Ethylene Glycol Monobutyl Ether
Ethylene Glycol Monobutyl Ether Acetate	Ethylene Glycol Monobutyl Ether Acetate
Ethylene Glycol Monoethyl Ether	Ethylene Glycol Monoethyl Ether
Ethylene Glycol Monoethyl Ether Acetate	Ethylene Glycol Monoethyl Ether Acetate
Ethylene Glycol Monomethyl Ether	Ethylene Glycol Monoethyl Ether
Ethyleneimine	Ethyleneimine
Ethylenebis(Iminodiacetic Acid)	Ethylene Diamine Tetracetic Acid
Ethylene Oxide	Ethylene Oxide

Synonym	*Compound Name*
Ethyl Ethanoate	Ethyl Acetate
Ethyl Ether	Ethyl Ether
Ethyl Formate	Ethyl Formate
Ethyl Formic Ester	Ethyl Formate
Ethylhexaldehyde	Ethylhexaldehyde
2-Ethylhexaldehyde	Ethylhexaldehyde
2-Ethylhexanal	Ethylhexaldehyde
2-Ethyl Hexanol	2-Ethyl Hexanol
2-Ethyl-1-Hexanol	2-Ethyl Hexanol
2-Ethyl-2-Hexenal	2-Ethyl-3-Propylacbolein
2-Ethylhexyl Acrylate, Inhibited	2-Ethylhexyl Acrylate, Inhibited
2-Ethylhexyl Alcohol	2-Ethyl Hexanol
2-Ethylhexyl 2-Propenoate	2-Ethylhexyl Acrylate, Inhibited
Ethyl Hexyl Tallate	Ethyl Hexyl Tallate
2-Ethylhexyl Trichlorophenoxyacetate	2,4,5-T(esters)
Ethyl 2-Hydroxypropanoate	Ethyl Lactate
Ethyl Alpha-Hydroxy-Propionate	Ethyl Lactate
5-Ethylidenebicyclo(2,2,1)-Hept-2-Ene	Ethylidenenorbornene
Ethylidene Difluoride	1,1-Difluoroethane
Ethylidene Fluoride	1,1-Difluoroethane
Ethylidenenorbornene	Ethylidenenorbornene
Ethylidenenorbornylene	Ethylidenenorbornene
Ethylidenenorcamphene	Ethylidenenorbornene
Ethyl Di-Lactate	Ethyl Lactate
Ethyl Lactate	Ethyl Lactate
Ethyl Mercaptan	Ethyl Mercaptan
Ethyl Methacrylate	Ethyl Methacrylate
Ethyl 2-Methacrylate	Ethyl Methacrylate
Ethyl Methacrylate, Inhibited	Ethyl Methacrylate
Ethyl Methanoate	Ethyl Formate
Ethyl Methyl Ketone	Methyl Ethyl Ketone
Ethyl Alphamethyl-methacrylate	Ethyl Methacrylate
Ethyl 2-Methyl-2-Propenoate	Ethyl Methacrylate
5-Ethyl-2-Methylpyridine	Methylethylpyridine
Ethyl Nitrile	Acetonitrile
Ethyl Nitrite	Ethyl Nitrite
Ethyl Orthosilicate	Ethyl Silicate
Ethyl Oxide	Ethyl Ether

Synonym	*Compound Name*
Ethyl 3-Oxobutanoate	Ethyl Acetoacetate
Ethyl Parathion	Parathion, Liquid
Ethyl Phenyldichlorosilane	Ethyl Phenyldichlorosilane
Ethyl Phosphonothioic Dichloride, Anhydrous	Ethyl Phosphonothioic Dichloride, Anhydrous
Ethyl Phosphorudichlorido-Thionate	Ethyl Phosphonothioic Dichloride, Anhydrous
Ethyl Phosphorodichloridate	Ethyl Phosphorodichloridate
Ethyl Phthalate	Diethyl Phthalate
5-Ethyl-2-Picoline	Methylethylpyridine
Ethyl 2-Propenoate	Ethyl Acrylate
2-Ethyl-3-Propylacrolein	2-Ethyl-3-Propylacrolein
2-Ethyl-3-Propylacrylaldehyde	2-Ethyl-3-Propylacrolein
Ethyl Pyrophosphate	Tetraethyl Pyrophosphate
Ethyl Silicate	Ethyl Silicate
Ethyl Silicate Condensed	Ethyl Silicate
Ethyl Silicate 40	Ethyl Silicate
Ethyl Silicon Trichloride	Ethyltrichlorosilane
Ethyl Silicone Trichloride	Ethyltrichlorosilane
Ethyl Sulfhydrate	Ethyl Mercaptan
Ethyl Thionophosphonyl Dichloride	Ethyl Phosphonothioic Dichloride Anhydrous
Ethyltrichlorosilane	Ethyltrichlorosilane
Ethyl Zinc	Diethylzinc
Ethyne	Acetylene
Eufin	Diethyl Carbonate
Exitelite	Antimony Trioxide
Fermentation Alcohol	Ethyl Alcohol
Fermentation Amyl Alcohol	Isoamyl Alcohol
Fermentation Butyl Alcohol	Isobutyl Alcohol
Ferric Ammonium Citrate	Ferric Ammonium Citrate
Ferric Ammonium Citrate, Brown	Ferric Ammonium Citrate
Ferric Ammonium Citrate, Green	Ferric Ammonium Citrate
Ferric Ammonium Oxalate	Ferric Ammonium Oxalate
Ferric Chloride	Ferric Chloride
Ferric Chloride, Anhydrous	Ferric Chloride
Ferric Chloride, Hexahydrate	Ferric Chloride
Ferric Glycerophosphate	Ferric Glycerophosphate
Ferric Nitrate	Ferric Nitrate
Ferric Nitrate Nonahydrate	Ferric Nitrate
Ferric Sulfate	Ferric Sulfate
Ferrous Ammonium Sulfate	Ferrous Ammonium Sulfate
Ferrous Ammonium Sulfate Hexahydrate	Ferrous Ammonium Sulfate
Ferrous Borofluoride	Ferrous Fluoroborate
Ferrous Chloride	Ferrous Chloride
Ferrous Chloride Tetrahydrate	Ferrous Chloride
Ferrous Fluoroborate	Ferrous Fluoroborate
Ferrous Oxalate	Ferrous Oxalate
Ferrous Oxalate Dihydrate	Ferrous Oxalate
Ferrous Sulfate	Ferrous Sulfate
Ferrox	Ferrous Oxalate
Fertilizer Acid	Sulfuric Acid
Filmerine	Sodium Nitrite
Fish Oil	Oil = Fish
Flaxseed Oil	Oils Miscellaneous: Linseed
Flowers of Antimony	Antimony Trioxide
Fluorine	Fluorine
Fluoroethylene	Vinyl Fluoride, Inhibited
Fluorosilicic Acid	Fluosilicic Acid
Fluorosulfonic Acid	Fluosulfonic Acid
Fluorosulfuric Acid	Fluosulfonic Acid
Fluorspar	Calcium Fluoride
Fluosilicic Acid	Fluosilicic Acid
Fluospar	Calcium Fluoride
Fluosulfonic Acid	Fluosulfonic Acid
Fluxing Oil	Asphalt Blending Stock, Roofers Flux
Flux Oil	Asphalt Blending Stock, Roofers Flux
Foliage Oil	Oil Spray
Formaldehyde Dimethylacetal	Methyl Formal
Formaldehyde Polymer	Paraformaldehyde
Formaldehyde Solution	Formaldehyde Solution
Formalin	Formaldehyde Solution

Synonym	*Compound Name*
Formalith	Formaldehyde Solution
Formic Acid	Formic Acid
Formic Acid, Ammonium Salt	Ammonium Formate
Formic Acid, Ethyl Ester	Ethyl Formate
Formic Acid, Methyl Ester	Methyl Formate
Formic Aldehyde	Formaldehyde Solution
Formic Ether	Ethyl Formate
Formin	Hexamethylenetetramine
Formylic Acid	Formic Acid
Freon 11	Trichlorofluoromethane
Freon 12	Dichlorodifluoro methane
Freon 22	Monochlorodifluoro methane
Frigen 11	Trichlorofluoromethane
Frigen 12	Dichlorodifluoro methane
No. 1 Fuel Oil	Kerosene
Fumigrain	Acrylonitrile
Fuming Liquid Arsenic	Arsenic Trichloride
Fuming Sulfuric Acid	Oleum
Fural	Furfural
2-Furaldehyde	Furfural
2-Furancarbinol	Furfuryl Alcohol
2,5-Furanedione	Maleic Anhydride
Furfural	Furfural
Furfuralcohol	Furfuryl Alcohol
Furfuraldehyde	Furfural
Furfurole	Furfural
Furfuryl Alcohol	Furfuryl Alcohol
2-Furylcarbinol	Furfuryl Alcohol
Alpha-Furylcarbinol	Furfuryl Alcohol
Fusel Oil	Isoamyl Alcohol
Fyde	Formaldehyde Solution
Gallic Acid	Gallic Acid
Gallic Acid Monohydrate	Gallic Acid
Gallotannic Acid	Tannic Acid
Gallotannin	Tannic Acid
Gammexane	Benzene Hexachloride
Gas Oil: Cracked	Gas Oil: Cracked
Gerhardite	Copper Nitrate
Gexane	Benzene Hexachloride
Glacial Acetic Acid	Acetic Acid
D-Glucitol	Sorbitol
Glucose Solution	Dextrose Solution
Glutaraldehyde Solution	Glutaraldehyde Solution
Glycerine	Glycerine
Glycerite	Tannic Acid
Glycerol	Glycerine
Glycroyl Methacrylate	Glycidyl Methacrylate
Glycidyl Alpha-Methyl Acrylate	Glycidyl Methacrylate
Glycol	Ethylene Glycol
Glycol Butyl Ether	Ethylene Glycol Monobutyl Ether
Glycol Chlorohydrin	Ethylene Chlorohydrin
Glycol Cyanohydrin	Ethylene Cyanohydrin
Glycol Diacetate	Ethylene Glycol Diacetate
Glycol Diblromide	Ethylene Dibromide
Glycol Dichloride	Ethylene Dichloride
Glycol Ethyl Ether	Ethylene
Glycol Monobutyl Ether Acetate	Ethylene Glycol Monobutyl Ether Acetate
Glycol Monoethyl Ether	Ethylene Glycol Monoethyl Ether
Glycol Monomethyl Ether	Ethylene Glycol Monomethyl Ether
Glycol Monoethyl Ether Acetate	Ethylene Glycol Monoethyl Ether Acetate
Glyoxal, 40% Solution	Glyoxal, 40% Solution
Grain Alcohol	Ethyl Alcohol
Grape Sugar Solution	Dextrose Solution
Green Oil	Anthracene
Green Vitriol	Ferrous Sulfate
Gremalgene	Trichloroethylene
Gum Turpentine	Turpentine
Gusathion Insecticide	Azinphosmethyl
Guthion Insecticide	Azinphosmethyl
Halogenated Waxes	Polychlorinated Biphehyl (PCB)
Halon 122	Dichlordifluoromethane
Hartshorn	Ammonium Carbonate
HCH	Benzene Hexachloride
Hendecanoic Alcohol	Undecanol
1-Hendecanol	Undecanol
N-Hendecyclenic Alcohol	Undecanol
Heptachlor	Heptachlor

Synonym	*Compound Name*
1-Heptadecanecarboxylic Acid	Stearic Acid
Cis-8-Heptadecylene-Carboxylic Acid	Oleic Acid
Heptane	Heptane
N-Heptane	Heptane
Heptanol	Heptanol
1-Heptanol	Heptanol
2-Heptanone	N-Amyl Methyl Ketone
1-Heptene	1-Heptene
Heptyl Alcohol	Heptanol
Heptylcarbinol	Octanol
Heptylene	1-Heptene
N-Heptylethylene	1-Hepten
Hexadecyl Sulfate, Sodium Salt	Hexadecyl Sulfate, Sodium Salt
Hexadecylbenzenesulfonic Acid	Alkylbenzenesulfonic Acids
Hexadrin	Endrin
Hexafluosilicic Acid	Fluosilicic Acid
Hexahydric Alcohol	Sorbitol
Hexahydroaniline	Cyclohexylamine
Hexahydro-2H-Azepin-2-One	Caprolactam, Liquid
Hexahydroazepine	Hexamethyleneimine
Hexahydrobenzene	Cyclohexane
Hexahydrophenol	Cyclohexanol
Hexahydropyrazine	Piperazine
N-Hexaldehyde	N-Hexaldehyde
Hexalin	Cyclohexanol
Hexamethylene	Cyclohexane
Hexamethyleneamine	Hexamethylenetertamine
Hexamethylenediamine	Hexahethylenediamine
Hexametpyleneimine	Hexamethyleneimine
Hexamethylenetetramine	Hexahethylenetetramine
Hexamine	Hexahethylenetetramine
Hexanal	N-Hexaldehyde
Hexanaphthene	Cyclohexane
Hexane	Hexane
1,6-Hexanediamine	Hexamethylenediamine
Hexanedioic Acid	Adipic Acid
Hexanol	Hexanol
1-Hexanol	Hexanol
2-Hexanone	Methyl N-Butyl Ketone
Alpha-Hexene	1-Hexene
1-Hexene	1-Hexene
Hexone	Methyl Isobutyl Ketone
Hexyl Acetate	Methyl Amyl Acetate
Hexyl Alcohol	Hexanol
Sec-Hexyl Alcohol	Ethyl Butanol
Hexylene Glycol	Hexylehe Glycol
HGI	Benzene Hexachloride
HHDN	Aldrin
Home Heating Oil	Fuel Oil No. 2
Homopiperidine	Hexamethyleneimine
Household Ammonia	Ammonium Hydroxide
Hydracrylic Acid, Beta-Lactone	Beta-Prop Iolactone
Alpha-Hydroxytoluene	Benzyl Alcohol
Beta-Hydroxytricarballylic Acid	Citric Acid
Beta-hyoroxytricarboxylic Acid	Citric Acid
2-Hydroxy-M-Xylene	Xylemol
Illuminating Oil	Kerosene
2,2-Iminodiethanol	Diethanolamine
1,1-Iminodi-2-Propanol	Diisopropanolmine
Imperial Green	Copper Acetoarsenite
Inedible Tallow	Tallow
Insulating Oil	Oil, Transforuer
Iron Ahhoniuu Slilpate	Ferrous Ammonium Sulfate
Iron (1111 Chloride)	Febric Chloride
Iron Dichloride	Ferric Chloride
Iron(ous)sulfate	Ferrous Sulfate
Iron Perchlomde	Ferric Chloride
Iron Protochloride	Ferrous Chloride
Iron Protoxalate	Ferrous Oxalate
Iron Sesouisulfate	Ferric Sulfate
Iron (1111 Sulfate)	Ferric Sulfate
Iron Tersulfate	Ferric Sulfate
Iron Trichloride	Ferric Chloride
Iron Vitriol	Ferrous Sulfate
Isceon Ii	Trichlorofluoromethane
Isoamyl Alcohol	Isoamyl Alcohol
Isobutane	Isobutane
Isobutanol	Isobutyl Alcohol
Isobutene	Isobutylene
Isobutenyl Hethyl Ketone	Mesityl Oxide
Isobutyl Acetate	Isobutyl Acetate
Isobutyl Alcohol	Isobutyl Alcohol

Synonym	*Compound Name*
Isobutylaldehyde	Iso-Butyraldehyde
Iso-butylamine	Isobutylamine
Isobutylamine	Isobutylamine
Isobutylcarbinol	Isoamyl Alcohol
Iscbutylene	Isobutylene
Isobutyl Hethyl Carbinol	Methyl Isobutyl Carbinol
Isobutylhethyl Carbinol	Methyl Amyl Alcohol
Isobutyl Hethyl Ketone	Methyl Isobutyl Ketone
Isobutylhethylmethanol	Methyl Amyl Alcohol
Isobutyraloehyde	Iso-Butyraldehyde
Isobutyric Acid	Isobutyric Acid
Isobutyric Aloehyde	Iso-Butyraldehyde
Isobutyronitrile	Isobutyronitrile
Isocyanic Acid, 4-Methyl-N-Phenylene	Toluene 2,4-Diiscoyanate (TDI)Ester
Isodecaldehyde	Isodecaldehyde
Isodecaldehyde, Mixed Isomers	Isodecaldehyde
Iso-Decyl Acrylate	Isodecyl Acrylate, Inhibited
Isodecyl Acrylate, Inhibited	Isodecyl Acrylate, Inhibited
Isodecyl Alcohol	Isodecyl Alcohol
Isodiprene	Carene
Isohexane	Isohexane
Isonitropropane	2-Nitropropane
Isooctaldehyde	Isooctaldehyde
Isooctyl Alcohol	Isooctyl Alcohol
Isooctyl Aldehyde	Isooctaldehyde
Isooctyl Trichlorophenoxyacetate	2,4,5-T(Esters)
Isopentane	Isopentane
Isopentyl Alcohol	Isoamyl Alcohol
Isopentyl Nitrite	Iso-Amyl Nitrite
Isophorone	Isophorone
Isophthalic Acid	Isophthalic Acid
Isoprene	Isoprene
Isopropanol	Isopropyl Alcohol
Isopropanolamine	Monoisopropanolamine
Isopropenylbenzene	Alpha-Methylstyrene
Isopropenyl Methyl Ketone	Methyl Isopropeuyl Ketone, Inhibited
2- Isopropoxypropane	Isopropyl Ether
Isopropyl Acetate	Isopropyl Acetate
Isopropylacetone	Ethyl Isobutyl Ketone
Isopropyl Alcohol	Isopropyl Alcohol
Iso-Propylamine	Isopropylamine
Isopropylamine	Isopropylamine
Isopropylbenzene	Cumene
Isopropylbenzene Hydroperoxide	Cumene Hydroperoxide
Isopropylcarbinol	Isobutyl Alcohol
Isopropylcumyl Hydroperoxide	Diisopropylbenzene Hydroperoxide
Isopropyl Cyanide	Isobutyronitrile
Isopropyl 2,4-Dichlorophenoxy Acetate	2,4-D Esters
Isopropyl Ether	Isopropyl Ether
Isopropylformic Acid	Isobutyric Acid
Isopropylideneacetone	Mesityl Oxide
4,4 -Isopropylidenediphenol	Bisphenol A
4,4-Isopropylidene-diphenolepichlorohydrin	Bisphehol A Diglycidyl Ether Resin
Isopropyl Mercaptan	Isopropyl Mercaptan
Isopropyl Percarbonate	Isopbopyl Percarbonate
Isopropyl Peroxydicarbonate	Isopropyl Percarbonate
P-Isopropyltoluene	P-Cymene
Isopropyltoluol	P-Cymene
Isotridecanol	Tridecanol
Isotridecyl Alcohol	Tridecanol
Isotron 11	Trichlorofluoromethane
Isotron 12	Dichlorodifluoro-methane
Isotron 22	Monochlorodifluoro-methane
Isovaleral	Isovaleraldehyde
Isovaleraldehyde	Isovaleraldehyde
Isovaleric Aldehyde	Isovaleraldehyde
Isovalerone	Diisobutyl Ketone
Jocutin	Benzene Hexachloride
Kerosene	Oil, Range
Kerosene	Jet Fuel, JP-1 (Kerosene)
Kerosene	Fuel Oil: No.1 (Kerosene)
Kerosene	Kerosene
Kerosene, Heavy	Jet Fuel: JP-5 (Kerosene, Heavy)
Kerosene. Heavy	Oil: Spray

Synonym	*Compound Name*
Kerosine	Kerosene
Kerosine	Oil, Range
Kerosine	Fuel Oil: No 1 (Kerosene)
Kerosine	Jet Fuel: JP-1 (Kerosene)
2-Ketoheptane	N-Amyl Methyl Ketone
2-Ketohexamethylenimine	Caprolactam, Liquid
Kettle-Rendered Lard	Oils Edible, Lard
Killax	Tetraethyl Pyrophosphate
Kings Gold	Arsenic Trisulfide
Kings Green	Copper Acetoarsenite
Kings Yellow	Arsenic Trisulfide
Kwell	Benzene Hexachloride
Lactic Acid	Lactic Acid
Dl-Lactic Acid, Ammonium Salt	Ammonium Lactate
Lactic Acid, Ethyl Ester	Ethyl Lactate
LAH	Lithium Aluminum Hydride
Latex, Liquid Synthetic	Latex, Liquid Synthetic
Laughing Gas	Nitrous Oxide
Lauroyl Peroxide	Lauroyl Peroxide
Lauryl Alcohol	Dodecanol
Lauryl Ammonium Sulfate	Ammonium Lauryl Sulfate
Lauryl Benzene	Dodecylbenzene
Lauryl Magnesium Sulfate	Dodecyl Sulfate, Magnesium Salt
Lauryl Mercaptan	Lauryl Mercaptan
Lauryl Sodium Sulfate	Dodecyl Sulfate, Sodium Salt
Lauryl Sulfate, Magnesium Salt	Dodecyl Sulfate, Magnesium Salt
Lauryl Sulfate, Sodium Salt	Dodecyl Sulfate, Sodium Salt
Lauryl Sulfate, Triethanolamine Salt	Docecyl Sulfate, Triethianolamine Salt
Lead (IV) Acetate	Lead Tetraacetate
Lead Acetate	Lead Acetate
Lead Acetate Trihydrate	Lead Acetate
Lead Arsenate	Lead Arsenate
Lead Arsenate, Acid	Lead Arsenate
Lead Difluoride	Lead Fluoride
Lead Fluoborate	Lead Fluoroborate
Lead Fluoride	Lead Fluoride
Lead Fluoroborate	Lead Fluoroborate
Lead Fluoroborate Solution	Lead Fluoroborate
Lead Iodide	Lead Iodide
Lead Monoxide	Litharge
Lead Nitrate	Lead Nitrate
Lead Oxide. Yellow	Litharge
Lead Protoxide	Litharge
Lead Sulfocyanate	Lead Thiocyanate
Lead Tetraacetate	Lead Tetraacetate
Lead Tetraethyl	Tetraethyl Lead
Lead Tetramethyl	Tetramethyl Lead
Lead Thiocyanate	Lead Thiocyanate
Leaf Lard	Oils Edible, Lard
Leucol	Quinoline
Lichenic Acid	Fumaric Acid
Light Naphtha	Naphtha Solvent
Light Naphtha	Naptha VM + P (75 % Naptha)
Light Oil	Oil: Coal Tar
Limed Wood Rosin	Calcium Resinate
Limonene	Dipentene
Lindane	Benzene Hexachloride
Linear Alcohols (12-15 Carbons)	Linear Alcohols (12-15 Carbons)
Liquefied Natural Gas (LNG)	Liquefied Natural Gas (LNG)
Liquefied Petroleum Gas (LPG)	Liquefied Petroleum Gas (LPG)
Liquid Ammonia	Ammonia Anhydrous
Liquid Asphalt	Asphalt Blending Stocks
Liquid Asphalt	Oil , Road
Liquid Bleach	Sodium Hypochlorite
Liquid Gum Camphor	Camphor Oil
Liquid Hydrogen	Hydrogen, Liquefied
Liquid Impure Camphor	Camphor Oil
Liquid Nitrogen	Nitrogen, Liquefied
Liquid Nitrogen Dioxide	Nitrogen Tetroxide
Liquid Oxygen	Oxygen, Liquefied
Liquid Petrolatum	Oil: Mineral
Liquified Phenol	Carbolic Oil

Synonym	*Compound Name*
Litharge	Litharge
Lithium Aluminum Hydride	Lithium Aluminum Hydride
Lithium Hydride	Lithium Hydride
Lithium, Metallic	Lithium, Metallic
LNG	Liquefied Natural Gas (LNG)
Long-Time Burning Oil	Benzene Hexachloride
Long-Time Burning Oil	Oil: Mineral Seal
Lorol-22	N-Decyl Alcohol
LOX	Oxygen, Liquefied
LPG	Liquefied Petroleum Gas (LPG)
Lubricating Oil	Oil, Motor
Lucidol-70	Dibenzoyl Peroxide
Lumbrical	Piperazine
Lunar Caustic	Silver Nitrate
Lye	Caustic Soda Solution
Lye	Caustic Potash Solution
MAAC	Methyl Amyl Acetate
Macouers Salt	Potassium Arsenate
M-B-C Fumigant	Methyl Bromide
M-DNB	M-Dinitrobenzene
Magnesium	Magnesium
Magnesium Dodecyl Sulfate	Dodecyl Sulfate, Magnesium Salt
Magnesium Lauryl Sulfate	Dodecyl Sulfate, Magnesium Salt
Magnesium Perchlorate	Magnesium Perchlorate
Magnesium Perchlorate, Anhydrous	Magnesium Perchlorate
Magnesium Perchlorate Hexahydrate	Magnesium Perchlorate
Malathion	Malathion
Malazide	Maleic Hydrazide
Maleic Acid	Maleic Acid
Maleic Acid Hydrazide	Maleic Hydrazide
Maleic Anhydride	Maleic Anhydride
Maleic Hydrazide	Maleic Hydrazide
Maleinic Acid	Maleic Acid
Malenic Acid	Maleic Acid
Malonic Mononitrile	Cyanoacetic Acid
MAOH	Methyl Isobutyl Carbinol
MAOH	Methyl Amyl Alcohol
Mapp Gas	Methylacetylene - Propadiene Mixture
Marlate 50	Methoxychlor
Marsh Gas	Methane
Marshite	Copper Iodide
Massicot	Litharge
MCB	Chlorobenzene
MCP	Calcium Phosphate
MDI	Diphenylmethanediiso-cyanate (MDI)
Meadow Green	Copper Acetoarsenite
ME CB	Diethylene Glycol Momomethyl Ether
MEK	Methyl Ethyl Ketone
Mendrin	Endrin
MEP	Pethylethylpyridine
Mercaptoethane	Ethyl Mercaptan
Mercaptomethane	Methyl Mercaptan
Mercaptosuccinic Acid, S-Ester with 0,0-Dimethyl Dithiophosphate	Malathion
Mercurialin	Methylamine
Mercuric Acetate	Mercuric Acetate
Mercuric Ammonium Chloride	Mercuric Ammonium Chloride
Mercuric Chloride	Mercuric Chloride
Mercuric Chloride, Ammoniated	Mercuric Ammonium Chloride
Mercuric Cyanide	Mercuric Cyanide
Mercuric Iodide	Mecuric Iodide
Mercuric Iodide, Red	Mercuric Iodide
Mercuric Nitrate	Mercuric Iodide
Mercubic Nitrate Monohydrate	Mercuric Nitrate
Mercuric Oxide	Mercuric Oxide
Mercuric Oxide, Red (Red Precipitate)	Mercuric Oxide
Mercuric Oxide, Yellow (Yellow Precipitate)	Mercuric Oxide
Mercuric Sulfide	Mercuric Sulfide
Mercuric Sulfide, Black (Ethiops Mineral)	Mercuric Sulfide
Mercuric Sulfide, Red (Vermillion,Artificial Cinnabar, Chinese Red)	Mercuric Sulfide
Mercurous Chloride	Mercurous Chloride

Synonym	*Compound Name*
Mercurous Nitrate	Mercurous Nitrate
Mercurous Nitrate Monohydrate	Mercurous Nitrate
Mercury	Mercury
Mercury Ammonium Chloride	Mercuric Ammonium Chloride
Mercury Bichloride	Mercuric Chloride
Nercury Biniodide	Mercuric Iodide
Mercury (II) Chloride	Mercuric Chloride
Mercury (II) Chloride Ammonobasic	Mercuric Ammonium Chloride
Mercury Cyanide	Mercuric Cyanide
Mercury (II) Cyanide	Mercuric Cyanide
Mercury Monochloride	Mercuric Chloride
Mercuby (II) Nitrate	Mercuric Nitrate
Mercury Oxide	Mercuric Oxide
Mercury Perchloride	Mercuric Chloride
Mercury Pernitrate	Mercuric Nitrate
Mercury Protochloride	Mercurous Chloride
Mercury Protonitrate	Mercurous Nitrate
Mercury Subchloride	Mercurous Chloride
Mesityl Oxide	Mesityl Oxide
Metallic Resinate	Calcium Resinate
Methacrylate Monomer	Methyl Methacrylate
Methacrylic Acid, Butyl Ester	N-Butyl Methacrylate
Methacrylic Acid,2.3-Epoxypropyl Ester	Glycidyl Methacrylate
Methacrylic Acid, Ethyl Ester	Ethyl Methacrylate
Methacrylic Acid, Methyl Ester	Methyl Methacrylate
Beta-Methallyl Chloride	Methallyl Chloride
Methallyl Chloride	Methallyl Chloride
Methanal	Formaldehyde Solution
Methane	Methane
Methanearsonic Acid, Sodium Salts	Methanearsonic Acid, Sodium Salts
2-Methoxyethanol	Ethylene Glycol, Monomethyl Ether
2-(2-Methoxyethoxy)Ethanol	Diethylene Glycol Monomethyl Ether
Methoxyethylene	Vinyl Methyl Ether, Inhibited
1-Methoxy-2-Propanol	Propylene Glycol Methyl Ether
Methylacetaldehyde	Propionaldehyde
Methyl Acetate	Methyl Acetate
Methylacetic Acid	Propionic Acid
Methylacetic Anhydride	Propionic Anhydride
Methanethiol	Methyl Mercaptan
Methanethiomethane	Dimethyl Sulfide
Methanoic Acid	Formic Acid
Methanol	Methyl Alcohol
Metheneamine	Hexamethylenetetramine
Methoxychlor	Methoxychlor
Methoxy-DDT	Methoxychlor
Methoxydiglycol	Diethylebe Glycol Monomethyl Ether
Methylacetylene-Allene Mixture	Methylacetylene-Propadiene Mixture
Methylacetylene - Propadiene Mixture	Methylacetylene-Propadiene Mixture
Beta-Methylacrolein	Crotonaldehyde
Methyl Acrylate	Methyl Acrylate
Methylal	Methyl Formal
Methyl Alcohol	Methyl Alcohol
Beta-Methylallyl Chloride	Methallyl Chloride
Methylamine	Methylamine
N-Methylaminobenzene	N-Methylaniline
Methyl Amyl Acetate	Methyl Amyl Acetate
Methyl Amyl Alcohol	Methyl Amyl Alcohol
Methylamyl Alcohol	Methyl Isobutyl Carbinol
Methyl Amyl Ketone	N-Amyl Methyl Ketone
O-Methylaniline	O-Toluidine
2-Methylaniline	O-Toluidine
N-Methylamiline	N-Methylaniline
Methylamiline (Mono)	N-Methylaniline
2-Methylaziridine	Propyleneimime, Inhibited
Methylbenzene	Toluene
Methylbenzenesulfonic Acid	P-Toluenesulfonic Acid
Methylbenzol	Toluene
Beta-Methylbivinyl	Isoprene
Methyl Bromide	Methyl Bromide
2-Methyl-1,3-Butadiene	Isoprene
3-Methylbutanal	Isovaleraldehyde
2-Methylbutane	Isopentane
3-Methyl-1-Butanol	Isoamyl Alcohol
2-Methyl-1-Butene-3-One	Methyl Isopropenyl Ketone, Inhibited

Synonym	*Compound Name*
Methyl N-Butyl Ketone	Methyl N-Butyl Ketone
3-Methylbutyl Nitrite	Iso-Amyl Nitrite
3-Methylbutyraldehyde	Isovaleraldehyde
Methyl Carbitol	Diethylene Glycol Monomethyl Ether
Methyl Cellosolve	Ethylene Glycol Momomethyl Ether
Methyl Chloride	Methyl Chloride
Methyl Chlorocarbonate	Methyl Chloroformate
Methyl Chloroform	Trichloroethane
Methyl Chloroformate	Methyl Chloroformate
Methyl Chloromethyl Ether, Anhydrous	Chloromethyl Methyl Ether
Methyl Cyanide	Acetonitrile
Methylcyclopentadienyl-manganese	Methylcyclopehtadienyl-manganese
Tricarbonyl	Tricarbonyl
Methylcyclopentane	Methylcyclopentane
Methyldichlorosilane	Methyldichlorosilane
1-Methyl-2,4-Dinitrobenzene	2,4-Dinitrotoluene
Methylene Chloride	Dichloromethane
Methylene Dichloride	Dichloromethane
Methylene Dimethyl Ether	Methyl Formal
Methylenebis-(4-Phenyl Isocyanate)	Diphenylmethane-diisocyanate (MDI)
Methyl Ether	Dimethyl Ether
Methyl Ether: Wood Ether	Dimethyl Ether
Methylethylcarbinol	Sec-Butyl Alcohol
Methylethylene	Propylene
Methylethylene Glycol	Propylene Gylcol
2-Methylethylenimine	Propyleneimine, Inhibited
Methyl Ethyl Ketone	Methyl Ethyl Ketone
Methylethylpyridine	Methylethylpyridine
Methyl Formal	Methyl Formal
Methyl Formate	Methyl Formate
6-Methyl-1-Heptanal	Isooctaldehyde
6-Methyl-1-Heptanol	Isooctyl Alochol
Methylhydrazine	Methylhydrazine
Methyl Isobutenyl Ketone	Mesityl Oxide
Methylisobutyl Carbinol	Methyl Amyl Alcohol
Methyl Isobutyl Carbinol	Methyl Isobutyl Carbinol
Methylisobutylcarbinyl Acetate	Methyl Amyl Acetate
Methyl Isobutyl Ketone	Methyl Isobutyl Ketone
Methyl Isopropenyl Ketone, Inhibited	Methyl Isopropenyl Ketone, Inhibited
1-Methyl-4-Isopropyl-Benzene	P-Cymene
2-Methyllactonitrile	Acetone Cyanohydrin
Methyl Mercaptan	Methyl Mercaptan
Methyl Methacrylate	Methyl Methacrylate
Methyl Alpha-Methacrylate	Methyl Methacrylate
Methylmethane	Ethane
Methyl 2-Methyl-2-Propenoate	Methyl Methacrylate
Methyl Oxirane	Propylene Oxide
Methyl Parathion	Methyl Parathion
2-Methylpentane	Isohexane
2-Methyl-2,4-Pentanediol	Hexylene Glycol
4-Methyl-2-Pentanol	Methyl Amyl Alcohol
4-Methyl-2-Pentanol	Methyl Isobutyl Carbinol
4-Methyl-2-Pentanol, Acetate	Methyl Akyl Acetate
2-Methyl-2-Pentanone	Methyl Isobutyl Ketone
4-Methyl-3-Pentene-2-One	Mesityl Oxide
4-Methyl-2-Pentyl Acetate	Methyl Amyl Acetate
1-Methyl-1-Phenylethylene	Alpha-Methylstyrene
Methyl Pentyl Ketone	N-Amyl Methyl Ketone
Methylphenols	Cresols
Methylphenylamine	N-Methylaniline
Methyl Phenyl Ketone	Acetophenone
Methyl Phosphonothioic Dichloride(Anhydrous)	Methyl Phosphonothioic Dichloride(Anhydrous)
2-Methylpropanal	Iso-Butyraldehyde
2-Methylpropane	Isobutane
2-Methylpropanenitrile	Isobutyronitrile
2-Methylpropanoic Acid	Isobutyric Acid
2-Methyl-1-Propanol	Isobutyl Alcohol
2-Methyl-2-Propanol	Tert-Butyl Alcohol
2-Methylpropene	Isobutylene
Methyl 2-Propendate	Methyl Acrylate
Alpha-Methylpropionic Acid	Isobutyric Acid
2-Methylpropionitrile	Isobutyronitrile
2-Methyl-1-Propyl Acetate	Isobutyl Acetate
Methyl Propyl Benzene	P-Cymene
Beta-Methylpropyl Ethanoate	Isobutyl Acetate
1-Methyl-2-(3-Pyridyl) Pyrrolidine	Nicotine

Synonym	*Compound Name*
I-Methyl-2-(3-Pyridyl) Pyrrolidine-3-(1-Methyl-2-Pyrrolidyl) Pyridine	Nicotine
N-Methylpyrrolidinone	1-Methylpyrrolidone
1-Methyloyrrolidone	1-Methylpyrrolidone
N-Methyl-Pyrrolidone	1-Methylpyrrolidone
1-Methyl-2-Pyrrolidinone	1-Methylpyrrolidone
N-Methyl-Alpha-Pyrrolidone	1-Methylpyrrolidone
3-(2-Methyl-2-Pyrrolidyl)Pyridine	Nicotine
Methylstyrene	Vinyltoluene
Alpha-Methylstyrene	Alpha-Methylstyrene
Methyl Sulfhydrate	Methyl Mercaptan
Methyl Sulfide	Dimethyl Sulfide
4-(Methylsulfonyl)-2,6-Dinitro-N,N-Dipropylaniline	Thiram
Methyl Sulfoxide	Dimethyl Sulfoxide
Methyl Thiram	Thiram
Methyltrichlorosilane	Methyltrichlorosilane
Methyl Tuads	Thiram
Methyl Vinyl Ether	Vinyl Methyl Ether, Inhibited
Methyl Vinyl Ketone	Methyl Vinyl Ketone
Methyl Zinc	Dimethylzinc
MH	Maleic Hydrazide
MIBC	Methyl Amyl Alcohol
MIBC	Methyl Isobutyl Carbinol
MIBK	Methyl Isobutyl Ketone
MIC	Methyl Amyl Alcohol
MIC	Methyl Isobutyl Carbinol
Middle Oil	Carboli Oil
MIK	Methyl Isobutyl Ketone
Mild Mercury Chloride	Mercurous Chloride
Milk Acid	Lactic Acid
Mineral Carbon	Charcoal
Mineral Charcoal	Charcoal
Mineral Colza Oil	Oil, Mineral Seal
Mineral Oil	Oil, Mineral
Mineral Seal Oil	Oils, Mineral Seal
Mineral Spirits	Mineral Spirits
Mitis Green	Copper Acetoarsenite
Mixed Primary Amyl Nitrates	N-Amyl Nitrate
Mixture of Benzene, Toluene, and Xylenes	Naphtha Coal Tar
MMH	Methylhydrazine
Mohrs Salt	Ferrous Ammonium Sulfate
Molybdenum Trioxide	Molybdic Trioxide
Molybdic Acid, 85 %	Ammonium Molybcate
Molybdic Anhydride	Molybdic Trioxide
Holybdic Trioxide	Molybdic Trioxide
Mondur TDS	Toluene 2,4-Diisocyanate (TDI)
Monoammonium Orthophosphate	Ammonium Phosphate
Monobromobenzene	Bromobenzene
Moncbromomethane	Methyl Bromide
Mono-N-Butylamine	N-Butylamime
Monocalcium Phosphate, Monohydrate	Calcium Phosphate
Monochloracetic Acid, Ethyl Ester	Ethyl Chloroacetate
Monochlorethane	Ethyl Chloride
Monochlorethanoic Acid, Ethyl Ester	Ethyl Chloroacetate
Monochloroacetic Acid	Monochloroacetic Acid
Monochlorobenzene	Chlorobenzene
Monochlorodifluoromethane	Monochlorodifluoro-methane
Monochloromethyl Ether	Chloromethyl Methyl Ether
Monoethanolamine	Monoethanolamine
Monoethylamine	Ethylamine
Monoethylene Glycol	Ethylene Glycol
Monofluoro Ethylene	Vinyl Fluoride
Monoglyme	Ethylene Glycol
Monohydrate	Calcium Phosphate
Monoisobutylamine	Isobutylamine
Monoisopropanolamine	Monoisopropanolamine
Monoisopropylamine	Isopropylamine
Monomethylamine, Anhydrous	Methylamne
Monomethylhydrazine	Methylcrazine
Mononitrogen Monoxide	Nitric Oxide
Mono PE	Pentaerythritol
Monosodium Methanearsonate	Methanearsonic Acid, Sodium Salts

Synonym	*Compound Name*
Monosodium Methyl Arsonate	Methanearsonic Acid, Sodium Salts
Monoxide	Carbon Monoxide
Morpholine	Morpholine
Mortopal	Tetraethyl Pyrophosphate
Moss Green	Copper Acetoarsenite
Motor Oil	Oil, Lubricating
MPT	Methyl Parathion
MPTD	Methyl Phosphonothioic Dichloride (Anhydrous)
MSMA	Methanearsonic Acid, Sodium Salts
Muriatic Acid	Hydrochloric Acid
Myristic Alcohol	Tetradecanol
Myristyl Alcohol	Tetradecanol
Naphtha	Mineral Spirits
Naphtha Coal Tar	Naphtha Coal Tar
Naphtha Solvent	Naphtha Solvent
Naphtha Stodord Solvent	Naphtha Stodard Solvent
Naptha VM + P (75% Naptha)	Naptha VM + P (75% Naptha)
Naphthalane	Decahydronaphthalene
Naphthalene, Molten	Naphthalene, Molten
Naphthalin	Naphthalene, Molten
Naphthane	Decahydronaphthalene
Napthenic Acids	Napthenic Acids
Alpha-naphthylamine	1-Naphthylamine
1-naphthylahine	1-Naphthylamine
I-naphthyl N-methylcarbamate	Carbaryl
Natural Gasoline	Gasoline: Casinghead
Neatsfoot Oil	Oil: Neatsfoot
Necatorina	Carbon Tetrachloride
Nechexane	Neohexane
Neutral Ahhonium Pluoride	Ammonium Fluoride
Neutral Anhydrous Calcium Hypochlcrite	Calcium Hypochlorite
Neutral Lead Acetate	Lead Acetate
Neutral Nicotine Sulfate	Nicotine Sulfate
Neutral Potassium Chromate	Potassium Chromate
Neutral Sodium Chromatetanhydrous	Sodium Chromate
Neutral Verdigris	Copper Acetate
Nickel Acetate	Nickel Acetate
Nickel Acetate Tetrahyorate	Nickel Acetate
Nickel Ammonium Sulfate	Nickel Ammonium Sulfate
Nickel Ammonium Sulfate Hexahydrate	Nickel Ammonium Sulfate
Nickel Bromide	Nickel Bromide
Nickel Bromide Trihydrate	Nickel Bromide
Nickel Carbonyl	Nickel Carbonyl
Nickel Chloride	Nickel Chloride
Nickel Chloride	Nickel Chloride
Nickel Cyanide	Nickel Cyanide
Nickel Iiu Fluoborate	Nickel Fluoroborate
Nickel Fluoroborate Solution	Nickel Fluoroborate
Nickel Fluoroborate	Nickel Fluoroborate
Nickel Formate	Nickel Formate
Nickel Formate Dihyorate	Nickel Formate
Nickel Nitrate	Nickel Nitrate
Nickel Nitrate Hexahydrate	Nickel Nitrate
Nickel Sulfate	Nickel Sulfate
Nickel Tetracarbokyl	Nickel Carbonyl
Nickelous Acetate	Nickel Acetate
Nickelous Sulfate	Nickel Sulfate
Nicotine	Nicotine
Nicotine Sulfate	Nicotine Sulfate
Nifos	Tetraethyl Pyrophosphate
Nitralin	Nitralin
Nitram	Ammonium Nitrate
O-Nitraniline	2-Nitroaniline
P-Nitraniline	4-Nitroaniline
Nitric Acid	Nitric Acid
Nitric Acid, Aluminum Salt	Aluminum Nitrate
Nitric Acid, Iron (111) Salt	Ferric Nitrate
Nitric Acid, Lead (ll) Salt	Lead Nitrate
Nitric Oxide	Nitric Oxide
Nitrilotriacetic Acid and Salts	Nitrilotriacetic Acid and Salts
2,2,2-Nitrilotriethanol	Triethanolamine
O-Nitroaniline	2-Nitroaniline
4-Nitroaniline	4-Nitroaniline
P-Nitroaniline	4-Nitroaniline
2-Nitroaniline	2-Nitroaniline
Nitrobenzene	Nitrobenzene
Nitrobenzol	Nitrobenzene

Synonym	*Compound Name*
Nitrocarbol	Nitromethane
Nitrocellulose Gum	Collodion
Nitrocellulose Solution	Collodion
Nitrochloroform	Chloropicrin, Liquid
Nitroethane	Nitoethane
Nitrogen Dioxide	Nitrogen Tetroxide
Nitrogen, Liquefied	Nitrogengen, Liquefied
Nitrogen Monoxide	Nitric Oxide
Nitrogen Peroxide	Nitrogen Tetroxide
Nitrogen Tetroxide	Nitrogen Tetroxide
Nitromethane	Nitromethane
O-Nitrophenol	2-Nitophenol
2-Nitrophenol	2-Nitophenol
P-Nitrophenol	4-Nitophenol
4-Nitrophenol	4-Nitophenol
Sec-Nitropropane	2-Nitropropane
2-Nitropropane	2-Nitropropane
Nitrosyl Chloride	Nitosyl Chloride
Nitrotrichloromethane	Chloropicrin, Liquid
Nitrous Ether	Ethyl Nitrite
Nitrous Oxide	Nitrous Oxide
N-Nonane	Nonane
Nonane	Nonane
Nonanol	Nonanol
1-Nonanol	Nonanol
5-Nonanone	Di-N-Butyl Ketone
Nonene	Nonene
1-Nonene	1-Nonene
Nonene (Non-linear)	Nonene
Nonyl Alcohol	Nonanol
Nonylcarbinol	N-Decyl Alcohol
1-Nonylene	1-Nonene
Nonylphenol	Nonylphenol
Normal Amyl Alochol	N-Amyl Alcohol
Normal Butyl Acetate	N-Butyl Acetate
Normal Butyl Acrylate	N-Butyl Acrylate
Normal Butyl Alcohol	N-Butyl Alcohol
Normal Butyraldehyde	N-Butyraldehyde
Normal Decyl Alcohol	N-Decyl Alcohol
Normal Lead Acetate	Lead Acetate
Normal Propyl Acetate	N-Propyl Acetate
Normal Propyl Alochol	N-Propyl Alcohol
Norvalamine	N-Butylamine
2-NP	2-Nitropropane

Synonym	*Compound Name*
NTA	Nitrilotriacetic Acid and Salts
1,2,4,5,6,7,,8-Octachloro-2,3,3a,4,7,7a-Hexahydro-4,7-Methanoindene	Chlordane
Octachlorocamphene	Toxaphene
Octadecanoic Acid	Stearic Acid
Cis-9-Octadecenoic Acid	Oleic Acid
Chloride	Chloride
Cis-Octadecylenic Acid	Oleic Acid
Cis-(Delta 9)-Octadecylenic Acid	Oleic Acid
N-Octadecylic Acid	Stearic Acid
Octane	Octane
Octa-Klor	Chlordane
N-Octane	Octane
Octanol	Octanol
1-Octanol	Octanol
1-Octene	1-Octene
Octochlorocamphene	Toxaphene
Octoil	Diootyl Phthalate
Octyl Alcohol	Octanol
Octyl Aldehyde	Ethylhexaldehyde
Octyl Carbinol	Nonanol
Alpha-Octylene	1-Octene
Oil: Castor	Oil: Castor
Oil: Clarified	Oil: Clarified
Oil: Coal Tar	Oil: Coal Tar
Oil: Cottonseed	Oil: Cottonseed
Oil: Crude	Oil: Crude
Oil: Diesel	Oil: Diesel
Oil: Fish	Oil: Fish
Oil: Lubricating	Oil: Lubricating
Oil: Mineral	Oil: Mineral
Oil: Mineral Seal	Oil: Mineral Seal
Oil: Motor	Oil: Motor
Oil: Neatsfoot	Oil: Neatsfoot
Oil of Bitter Almond	Benzaldehyde
Oil of Merbane	Nitrobenzene
Oil of Vitriol	Sulfuric Acid
Oil: Olive	Oil: Olive
Oil: Peanut	Oil: Peanut
Oil: Penetrating	Oil: Penetrating
Oil: Range	Oil: Range

Synonym	*Compound Name*
Oil: Resin	Oil: Resin
Oil: Road	Oil: Road
Oil: Rosin	Oil: Rosin
Oil. Tanners	Oil, Tanners
Oils Edible, Coconut	Oils Edible, Coconut
Oils Edible, Lard	Oils Edible, Lard
Oils Edible, Palm	Oils Edible, Palp
Oils Edible, Safflower	Oils Ediblel, Safflower
Oils Edible, Tucum	Oils Edible, Tucum
Oils Miscellaneous: Croton	Oils Miscellaneous: Croton
Oils Miscellaneous: Linseed	Oils Miscellaneous: Linseed
Oils Miscellaneous: Turbine	Oils Miscellaneoss: Turbine
Oil: Soya Bean	Oil: Soya Bean
Oil: Sperm	Oil: Sperm
Oil: Spindle	Oil: Spindle
Oil: Spray	Oil: Spray
Oil: Tall	Oil: Tall
Oil: Transformer	Oil: Trausformer
Oil: Vegetable	Oil: Vegetable
Olefiant Gas	Ethylene
Oleic Acid	Oleic Acid
Oleic Acid, Ammonium Salt	Ammonium Oleate
Oleic Acid, Potassium Salt	Oleic Acid, Potassium Salt
Oleic Acid, Sodium Salt	Oleic Acid, Sodium Salt
Oleum	Oleum
Olive Oil	Oil: Olive
Orpiment	Arsenic Trisulfide
Orthoarsenic Acid	Arsenic Acid
Orthoboric Acid	Boric Acid
Orthocide	Captan
Orthodichlorobenzene	O-Dichlorobenzene
Ortho-Dihydroxybenzene	Catechol
Orthophosphoric Acid	Phosphoric Acid
Orthotitanic Acid, Tetrabutyl Ester	Tetrabutyl Titanate
Orthoxylene	O-Xylene
Oxal	Glyoxal, 40 % Solution
Oxaldehyde	Glyoxal, 40 % Solution
Oxalic Acid	Oxalic Acid
Oxalic Acid, Diammonium Salt	Ammonium Oxalate
Oxalic Acid Dinitrile	Cyanogen
Oxalic Acid, Ferrous Salt	Ferrous Oxalate
Oxalonitrile	Cyanogen
Oxammonium Sulfate	Hydroxylamine Sulfate
3-Oxa-1,5-Pentanediol	Diethylene Glycol
2-Oxetanone	Beta-Propiolactone
Oxides of Nitrogen	Nitrogen Tetroxide
Oxirane	Ethylene Oxide
Alpha-Oxodiphenylmethane	Benzophenone
Alpha-Oxoditane	Benzophenone
2,2 Oxybisethanol	Diethylene Glycol
Oxygen, Liquefied	Oxygen, Liquefied
Oxylite	Dibenzoyl Peroxide
Oxyphenic Acid	Catechol
Oxytoluenes	Cresols
Paint Drier	Copper Naphthenate
Palm Butter	Oils Edible, Palp
Palm Fruit Oil	Oils Edible, Palp
Palm Seed Oil	Oils Edible, Tucup
PAN	Phthalic Anhydride
PAPI	Polymethylene Polyphenyl Isocyanate
Paradi	P-Dichlorobenzene
Paradichlorobenzene	P-Dichlorobenzene
Paradow	P-Dichlorobenzene
Paraformaldehyde	Paraformaldehyde
Para Hydrogen	Hydrogen, Liquefied
Para-Mentha-1,8-Diene	Cipentene
Paramoth	P-Dichlorobenzene
Paranaphthalene	Anthracene
Parathion, Liquid	Parathion, Liquid
Parathion-Methyl	Methyl Parathion
Paraxylene	P-Xylene
Paris Green	Copper Acetoarsenite
Parrot Green	Copper Acetoarsenite
Patent Alum	Aluminum Sulfate
PCB	Polychlorinated Biphenyl (PCB)
PE	Pentaerythritol
Peanut Oil	Oil, Peanut
Pearl White	Bismuth Oxychloride
Pelargonic Alcohol	Nonanol
Penetrating Oil	Oil, Penetrating
Penta	Pentachlorophenol

Synonym	*Compound Name*
Pentaborane	Pentaborane
(9)-Pentaboron Nonahydride	Pentaborane
Pentachlorophenol	Pentachlorophenol
Pentadecanol	Pentadecanol
1-Pentadecanol	Pentadecanol
Pentadecanol	Linear Alcohcls (12-15 Carbons)
Pentadecyl Alcohol	Pentadecanol
Pentadecylbenzenesulfonic Acid	Alkylbenzenesulfonic Acids
Pentaerythrite	Pentaerythritol
Pentaerythritol	Pentaerythritol
Pentamethylene	Cyclopentane
Pentanal	Valeraldehyde
Pentane	Pentane
1,5-Pentanedial Solution	Glutaraldehyde Solution
2,4-Pentanedione	Acetylacetone
1-Pentanethiol	N-Amyl Mercaptan
1-Pentanol	N-Amyl Alcohol
Pentek	Pentaerythritol
1-Pentene	1-Pentene
Pentyl Acetates	Amyl Acetate
Pentyl Alcohol	N-Amyl Alcohol
Sec-Pentyl Carbinol	Ethyl Butanol
1-Pentyl Chloride	N-Amyl Chloride
Pentyl Methyl Ketone	N-Amyl Methyl Ketone
Pentylsilicon Trichloride	N-Amyltrochlorosilane
Peracetic Acid	Peracetic Acid
Percarbamide	Urea Peroxide
Perchloric Acid	Perchloric Acid
Perchloric Acid Solution	Perchloric Acid
Perchlorocyclopentadiene	Hexachlorocyclopenta-diene
Perchloroethylene	Tetrachloroethylene
Perchloromethane	Carbon Tetrachloride
Perchloromethyl Mercaptan	Perchloromethyl Mercaptan
Perclene	Tetrachloroethylene
Perhydrol-Urea	Urea Peroxide
Perhydronaphthalene	Decahydronaphthalene
Perk	Tetrachloroethylene
Peroxide	Hydrogen Peroxide
Peroxyacetic Acid	Peracetic Acid
Peroxydicarbonic Acid, Diisopropyl	Isopropyl Pebcarbonate Ester
Peroxy-Dicarbonic Acid, Bis(1-Methylethyl) Ester	Isopbopyl Percarbonate
Peroxy-Dicarbonic Acid, Bis (1-Methylethyl) Ester	Isopropyl Percarbonate
Peroxydisulfuric Acid, Diammonium Salt	Ammonium Persulfate
Petrohol	Isopropyl Alcohohl
Petrolatum	Petrolatum
Petrolatum Jelly	Petrolatum
Petroleum	Oil: Cruce
Petroleum Asphalt	Asphalt Blend Stock
Petroleum Asphalt	Oils, Road
Petroleum Asphalt	Asphalt
Petroleum Distillate	Distillate, Flashed Feed Stocks
Petroleum Distillate	Distillate' Straight Run
Petroleum Insulating Oil	Oil; Transformer
Petroleum Jelly	Petroleum
Petroleum Naphtha	Petroleum Naphtha
Petroleum Pitch	Asphalt Blend Stock
Petroleum Residue	Asphalt Blend Stock
Petroleum Solvent	Naphtha Solvent
Petroleum Solvent	Naphtha Stoddard Solvent
Petroleum Solvent	Naphtha VP + P (75% Naphtha)
Petroleum Solvent	Petroleum Naphtha
Petroleum Spirits	Mineral Spirits
Petroleum Tailings	Asphalt Blending Stock: Roofers Flux
Petroleum Wax	Waxes, Paraffin
Phellandrene	Dipentene
Phenachlor	Trichlorophenol
Phenacyl Chloride	Chloroacetophenone
Phenethylene	Styrene
Phenic Agio	Phenol
Phenol	Phenol
Phenoxybenzene	Diphehyl Ether
Phenylamine	Aniline
N-Phenylaniline	Diphenylamine
Phenylarsenic Dichloride	Phenyldichloroarsine, Liquid
Phenyl Bromide	Bromobenzene

Synonym	*Compound Name*
Phenylcarbinol	Benzyl Alcohol
Phenyl Chloride	Chlorobenzene
Phenyl Chloromethyl Ketone	Chloroacetophenone
Phenylcyanide	Benzonitrile
1-Phenyldecane	N-Decylbenzene
Phenyldichloroarsine, Liquid	Phenyldichloroarsine, Liquid
1-Phenyldodecane	Dodecylbenzene
Phenylethane	Ethylbenzene
Phenylethylene	Styrene
Phenyl Ether	Diphenyl Ether
Phenylhydrazine Hydrochloride	Phenylhydrazine Hydrochloride
Phenylhydrazinium Chloride	Phenylhydrazine Hydrochloride
Phenyl Hydroxide	Phenol
Phenylmethanol	Benzyl Alcohcl
Phenylmethyl Alcohol	Benzyl Alcohcl
Phenylmethyl Amine	Benzylamine
Phenylphosphine Dichloride	Benzene Phosphorus Dichloride
Phenylphosphine Thiodichloride	Benzene Phosphorus Thiodichloride
Phenylphosphonothioic Dichloride	Benzene Phosphorus Thiodichloride
Phenyl Phosphonous Dichloride	Benzene Phosphorus Dichloride
Phenylpropylene	Alpha-Methylstyrene
1-Phenyltetradecane	Tetradecylbenzene
1-Phenylundecane	N-Undecylbenzene
Phosgene	Phosgene
Phosphoric Acid	Phosphoric Acid
Phosphoric Sulfide	Phosphorus Pentasulfide
Phcsphorodichloridic Acid, Ethyl Ester	Ethyl Phosphorodichloridate
Phosphorothioic Acid, 0,0-Diethyl Ester	Cemeton
Phosphorothioic Acid, 0,0-Diethyl O-P-Nitrophenyl Ester	Parathion, Liquid
Phosphorus Bromide	Phosphorus Tribromide
Phosphorus Oxychloride	Phosphorus Oxychloride
Phosphorus Pentasulfide	Phosphorus Pentasulfide
Phosphorus Persulfide	Phosphorus Pentasulfide
Phosphorus Tribromide	Phosphorus Tribromide
Phosphorus Trichloride	Phosphorus Trichloride
Phosphorus, Red	Phosphorus, Red
Phosphorus, White	Phosphorus, White
Phosphoryl Chloride	Phosphorus Oxychloride
Phosphoryl Chloride	Phosphorus Oxychloride
Photophor	Calcium Phosphide
Phthalandione	Phthalic Anhydride
M-Phthalic Acid	Isophthalic Acid
Phthalic Acid Anhydride	Phthalic Anhydride
Phthalic Acid, Benzyl Butyl Ester	Benzyl N-Butyl Phthalate
Phthalic Acid, Diamyl Ester	Di-N-Amyl Phthalate
Phthalic Acid, Dibutyl Ester	Dibutyl Phthalate
Phthalic Acid. Diethyl Ester	Diethyl Phthalate
Phthalic Acid, Diheptyl Ester	Diheptyl Phthalate
Phthalic Acid, Diisodecyl Ester	Diiscoecyl Phthalate
Phthalic Acid, Dipentyl Ester	Di-N-Amyl Phthalate
Pmhalic Acid, Bis (2-Ethylhexyl)Ester	Diootyl Phthalate
Phthalic Acid, Bis (8-Methylnonyl)Ester	Diiscoedyl Phthalate
Phthalic Anhydride	Phthalic Anhydride
Picfume	Chloropicrin, Liquid
Pimelic Ketone	Cyclohexanone
Piperazidine	Piperazine
Piperazine	Piperazine
Planavin	Nitralin
Plasticizer DDP	Diisodecyl Phthalate
Plastic Latex	Latex, Liquid Synthetic
Plumbous Arsenate	Lead Arsenate
Plumbous Fluoride	Lead Fluoride
Plumbous Oxide	Litharge
Pluracol Polyol	Polypropylene Glycol
Poly (Dimethylsiloxane)	Dimethyl Polysiloxane
Polybutene	Polybutene
Polychlorinated Biphenyl (PCB)	Polychlorinated Biphenyl (PCB)
Polychloropolyphenyls	Polychlorinated Biphenyl (PCB)
Polyformaldehyde	Paraformaldehyde
Pclyisobutylene Plastics	Polybutene
Polyisobutylene Resins	Polybutene

Synonym	*Compound Name*
Polyisobutylene Waxes	Polybutene
Polyhethylene Polyphenyl Isocyanate	Polymethylene Pollphenyl Isocyanate
Polyoxpropylene Ether, PPG	Polypropylene Glycol
Poly(Oxyethyl) Dodecyl Ether	Ethoxylated Dodecanol
Pcly(Oxyethyl) Lauryl Ether	Ethoxylated Dodecanol
Poly(Oxyethyl) Myristyl Ether	Ethoxylated Tetradecanol
Poly(Oxyethyl) Pentadecyl Ether	Ethoxylated Pentadecanol
Poly(Oxyethyl) Tetradecyl Ether	Ethoxylated Tetradecanol
Poly(Oxyethyl) Tridecyl Ether	Ethoxylated Tridecanol
Polyoxymethylene	Paraformaldehyde
Polyoxymethylene Glycol	Paraformaldehyde
Polyoxypropylene Glycol	Polypropylene Glycol
Polyoxypropylene Glycol Methyl Ether	Polypropylene Glycol Methyl Ether
Polyphosphoric Acid	Polyphosphoric Acid
Polypropylene	Polypropylene
Polypropylene Glycol	Polypropylene Glycol
Polypropylene Glycol Methyl Ether	Polypropylene Glycol Methyl Ether
Potassium Chromate	Potassium Chromate
Potassium Chromate (VI)	Potassium Chromate
Potassium Cyanide	Potassium Cyanide
Potassium Dichloro-S-Triazinetrione	Potassium Dichloro-S-Triazinetrione
Potassium Dichromate	Potassium Dichromate
Potassium Hydroxide Solution	Caustic Potash Solution
Potassium Iodide	Potassium Iodide
Potassium Dihyorogen Arsenate	Potassium Arsenate
Potassium Hydroxide	Potassium Hydroxide
Potassium, Metallic	Potassium, Metallic
Potassium Oleate	Oleic Acid, Potassium Salt
Potassium Oxalate	Potassium Oxalate
Potassium Oxalate Monohydrate	Potassium Oxalate
Potassium Permanganate	Potassium Permanganate
Potassium Peroxide	Potassium Peroxide
Potassium Superoxide	Potassium Peroxide
Potatospirit Oil	Isoamyl Alcohol
Poterate	Potassium Chlorate
Preservative Oil	Oil: Penetrating
Primary Calcium Phosphate	Calcium Phosphate
Prime Steam Lard	Oils Edible, Lard
Propaldehyde	Propionaldehyde
Propanal	Propionaldehyde
Propane	Propane
Propane-Butane-(Propylene)	Liquefied Petroleum Gas (LPG)
Propane-2-Carboxylic Acid	Isobutyric Acid
Propanecarboxylic Acid	N-Butyric Acid
1,2-Propanediol	Propylene Gylcol
1,2-Propanediol 1-Acrylate	Hydroxypropyl Acrylate
1-Propanethiol	N-Propyl Mercaptan
2-Propanethiol	Isopropyl Mercaptan
Propane-1-Thiol	N-Propyl Mercaptan
Propane-2-Thiol	Isopropyl Mercaptan
1,2,3-Propanetriol	Glycerine
Propanoic Acid	Propionic Acic
Propanoic Anhydride	Propionic Anhydride
1-Propanol	N-Propyl Alcohol
2-Propanol	Isopropyl Alcohol
Propanolide	Beta-Propiolactone
2-Propanone	Acetone
2-Propenal	Acrolein
2-Propen-1-Ol	Allyl Alcohol
Propenamide 50%	Acrylamide
Propene	Propylene
Propene Oxide	Propylene Oxide
Propene Polymer	Polypropylene
Propenoic Acid	Acrylic Acid
Beta-Propiolactone	Beta-Propiolactone
Propionaldehyde	Propionaldehyde
Propionic Acid	Propionic Acid
Propionic Aldehyde	Propionaldehyde
Propionic Anhydride	Propionic Anhydride
Beta-Propionolactone	Beta-Propiolactone
Propionyl Oxide	Propionic Anhydride
N-Propyl Acetate	N-Propyl Acetate
2-Propyl Acetate	Isopropyl Acetate
Propyl Alcohol	N-Propyl Alcohol
Sec-Propyl Alcohol	Isopropyl Alcohol
N-Propyl Alcohol	N-Propyl Alcohol
Propyl Aldehyde	Propionaldehyde
N-Propylcarbinol	N-Butyl Alcohol

Synonym	*Compound Name*
Propylene	Propylene
Propylene Butylene Polymer	Propylene Butylene Polymer
Propylene Dichloride	Dichloropropane
Propylene Glycol Methyl Ether	Propylene Glycol Methyl Ether
Propylene Glycol Mono-acrylate	Hydroxypropyl Acrylate
Propylene Glycol Monomethacrylate	Hydroxypropyl Methacrylate
Propylene Glycol	Propylene Glycol
Propylenimine	Propyleneimine Inhibited
Propylene Oxide	Propylene Oxide
Propylene Tetramer	Propylene Tetramer
Propylene Tetramer	Dodecene
Propylene Trimer	Nonene
Propyleneimine, Inhibited	Propyleneimine, Inhibited
Propylethylene	1-Pentene
N-Propyl Mercaptan	N-Propyl Mercaptan
N-N-Propyl-L-Propanamine	Ci-N-Propylamide
Prussic Acid	Hydrogen Cyanide
Pseudohexyl Alcohol	Ethyl Butanol
Pyrazine Hexahydride	Piperazine
Pyridine	Pyridine
Pyrocatechin	Catechol
Pyrocatechinic Acid	Catechol
Pyrocatechol	Catechol
Pyrocatechuic Acid	Catechol
Pyrofax	Liquefied Petroleum Gas (LPG)
Pyrogallic Acid	Pyrogallic Acid
Pyrogallol	Pyrogallic Acid
Pyrogentisic Acid	Hydroquinone
Pyromucic Aldehyde	Furfural
Pyroxylic Spirit	Methyl Alcohol
Pyroxylic Solution	Collodion
Quicklime	Calcium Oxide
Quicksilver	Mercury
Quinol	Hydroquinone
Quinoline	Quinoline
Racemic Lactic Acid	Lactic Acid
Range Oil	Fuel Oil: No (Kerosene)
Range Oil	Kerosene
Range Oil	Jet Fuel: JP-(Kerosene)
Raw Linseed Oil	Oils Miscellaneous Linseed
RC Plasticizer DBP	Dibutyl Phthalate
RC Plasticizer DBP	Dioctyl Phthalate
Realgar	Arsenic Disulfide
Red Arsenic Glass	Arsenic Disulfide
Red Arsenic Sulfide	Arsenic Disulfide
Red Oil	Cleic Acid
Red Opriment	Arsenic Disulfide
Red Oxide of Nitrogen	Nitrogen Tetroxide
Red TR Base	4-Chloro-O-Toluidine
Residual Oil	Asphalt Blending Stock
Resin Oil	Oil: Rosin
Resorcin	Resorcinol
Resorcinol	Resorcinol
Retarder W	Salicylic Acid
Retinol	Oil: Resin
Retinol	Oil: Rosin
Rhodanate	Sodium Thiocyanate
Road Binder	Asphalt Blend Stock: Straight Run
Residue Road Oil	Asphalt
Blending Stock: Roofers Flux Rosin Oil	Oil: Resin
Rosinol	Oil: Rosin
Rosinol	Oil: Resin
Rubbing Alcohol	Isopropyl Alcohol
Ruby Arsenic	Arsenic Disulfide
Saccharose	Sucrose
Saccharum	Sucrose
Safflower Seed Oil	Oils Edible: Safflower
Sal Acetosella	Potassium Binoxalate
Sal Ammoniac	Ammonium Chloride
Salicylic Acid	Salicylic Acid
Salmiac	Ammonium Chloride
Salt of Saturn	Lead Acetate
Salt of Sorrel	Potassium Binoxalate
Salufer	Sodium Silicofluoride
Sal Volatile	Ammonium Carbonate
Sand Acid	Fluocilicic Acid
Santachlor	P-Dichlorobenzene

Synonym	*Compound Name*
Secondary Ammonium Phosphate	Ammonium Phosphate
Secondary Butyl Acetate	Sec-Butyl Acetate
Secondary Butyl Alcohol	Sec-Butyl Alcohol
Secondary Calcium Phosphate	Calcium Phosphate
Selenic Anhydride	Selenium Trioxide
Selenious Anhydride	Selenium Dioxide
Selenium Dioxide	Selenium Dioxide
Selenium Oxide	Selenium Dioxide
Selenium Trioxide	Selenium Trioxide
Senarmontite	Antimony Trioxide
Sentry	Calcium Hypochlorite
Sevin	Carbaryl
Sextone	Cyclohexanone
Shell Charcoal	Charcoal
Signal Oil	Oil: Mineral Seal
Silibond	Ethyl Silicate
Silicochloroform	Trichlorosilane
Silicofluoric Acid	Fluosilicic Acid
Silicon Chloride	Silicon Tetrachloride
Silicone Fluids	Dimethyl Polysiloxahe
Silicon Tetrachloride	Silicon Tetrachloride
Silver Acetate	Silver Acetate
Silver Carbonate	Silver Carbonate
Silver Fluoride	Silver Fluoride
Silver Iodate	Silver Iodate
Silver Monofluoride	Silver Fluoride
Silver Nitrate	Silver Nitrate
Silver Oxide	Silver Oxide
Silver Sulfate	Silver Sulfate
Silvisar 510	Cacodylic Acid
Slaked Lime	Calcium Hydroxide
Slow-Curing Asphalt	Oil: Road
Sodamide	Sodium Amide
Sodium	Sodium
Sodium Acid Sulfite	Sodium Bisulfite
Sodium Alkylbenzene-sulfonates	Sodium Alkylbenzene-sulfonates
Sodium Alkyl Sulfates	Sodium Alkyl Sulfates
Sodium Amide	Sodium Amide
Sodium Arsenate	Sodium Arsenate
Sodium Arsenate, Dibasic	Sodium Arsenate
Sodium Arsenite	Sodium Arsenite
Sodium Azide	Sodium Azide
Socius Biborate	Sodium Borate
Sodium Bisulfide	Sodium Hydrosulfide Solution
Sodium Bisulfite	Sodium Bisulfite
Sodium Borate	Sodium Borate
Sodium Borohydrade	Sodium Borohydride
Sodium Cacodylate	Sodium Cacodylate
Sodium Cetyl Sulfate Solution	Hexadecyl Sulfite, Sodium Salt
Sodium Chlorate	Sodium Chlorate
Sodium Chromate	Sodium Chromate
Sodium Chromate(VI)	Sodium Chromate
Sodium Cyanide	Sodium Cyanide
Sodium Dichloroisocyanurate	Sodium Dichloro-S-Triazinetrione
Sodium Dichloro-S-Triazinetrione	Sodium Dichloro-S-Triazinetrione
Sodium Dichromate	Sodium Dichromate
Sodium Dimethylarsonate	Sodium Cacodylate
Sodium Dioctyl Sulfosuccinate	Dioctyl Sodium Sulfosuccinate
Sodium Dodecyl Sulfate	Dodecyl Sulfate, Sodium Salt
Sodium Ferrocyanide	Sodium Ferrocyanide
Sodium Fluoride	Sodium Fluoride
Sodium Fluosilicate	Sodium Silicofluoride
Sodium Hexafluorosilicate	Sodium Silicofluoride
Sodium Hydride	Sodium Hydride
Sodium Hydrogen Alkyl Sulfate	Sodium Alkyl Sulfates
Sodium Hydrogen Sulfide	Sodium Hydrosulfide Solution
Sodium Hydrosulfide Solution	Sodium Hydrosulfide Solution
Sodium Hydroxide	Sodium Hydroxide
Sodium Hydroxide Solution	Caustic Soda Solution
Sodium Hypochlorite	Sodium Hypochlorite
Sodium Lauryl Sulfate	Dodecyl Sulfate: Sodium Salt
Sodium Metaarsenite	Sodium Arsenite
Sodium Metabisulfite	Sodium Bisulfite
Sodium Methoxide	Sodium Methylate
Sodium Methylate	Sodium Methylate
Sodium Nitrite	Sodium Nitrite
Sodium Oleate	Oleic Acid, Sodium Salt

Synonym	*Compound Name*
Sodium Orthoarsenite	Sodium Arsenite
Sodium Oxalate	Sodium Oxalate
Sodium Phosphate	Sodium Phosphate
Sodium Pyroborate	Sodium Borate
Sodium Pyrosulfite	Sodium Bisulfite
Sodium Rhodanide	Sodium Thiocyanate
Sodium Silicate	Sodium Silicate
Sodium Silicofluoride	Sodium Silicofluoride
Sodium Sulfhydrate	Sodium Hydrosulfide Solution
Sodium Sulfide	Sodium Sulfide
Sodium Sulfite	Sodium Sulfite
Sodium Sulfocyanate	Sodium Thiocyanate
Sodium Tetraborate, Anhydrous	Sodium Borate
Sodium Thiocyanate	Sodium Thiocyanate
Solar Nitrogen Solutions	Ammonium Nitrate-Urea Solution
Soluble Glass	Sodium Silicate
Sorbit	Sorbinol
Sorbitol	Sorbitol
Sorbo	Sorbitol
Sorbol	Sorbitol
Soybean Oil	Oil: Soya Bean
Sperm Oil	Oil: Sperm
Spindle Oil	Oil: Spindle
Spirit	Ethyl Alcohol
Spirit of Ether Nitrite	Ethyl Nitrite
Spirits of Turpentine	Turpentine
Spirits of Wine	Ethyl Alcohol
Spotting Naphtha	Naphtha Stoddard Solvent
Spray Oil	Oil: Spray
Steam Turbine Lube Oil	Oils Miscellaneous: Turbine
Steam Turbine Oil	Oils Miscellaneous: Turbine
Stearic Acid	Stearic Acid
Stearic Acid, Ammonium Salt	Ammonium Stearate
Stearophanic Acid	Stearic Acid
Stearyl Alcohol, Crude	Tallow Fatty Alcohol
Steinbuhl Yellow	Calcium Chromate
Streunex	Benzene
Styrene	Styrene
Styrol	Styrene
Styrolene	Styrene
Sucrose	Sucrose
Sugar	Sucrose
Sugar of Lead	Lead Acetate
Sulfamic Acid, Monoammonium Salt	Ammonium Sulfate
Sulfated Neatsfoot Oil, Sodium Salt	Oil, Tanners
Sulfate of Copper	Copper Sulfate
Sulfate Turpentine	Turpentine
Sulfolane	Sulfolane
Sulfolane-W	Sulfolane
Sulfonated Alkylbenzene, Sodium Salt	Sodium Alkylbenzenesulfolates
Sulfur Dioxide	Sulfur Dioxide
Sulfuretted Hydrogen	Hydrogen Sulfide
Sulfuric Acid	Sulfuric Acid
Sulfuric Acid, Spent	Sulfuric Acid, Spent
Sulfuric Ether	Ethyl Ether
Sulfur (Liquid)	Sulfur (Liquid)
Sulfur Monochloride	Sulfur Monochloride
Sulfuryl Chloride	Sulfuryl Chloride
Sulphur (Liquid)	Sulfur(Liquid)
Sulphuretted Hydrogen	Hydrogen Sulfide
Superoxol	Hydrogen Peroxide
Swedish Green	Copper Arsenite
Sweet Spirit of Nitre	Ethyl Nitrite
Synthetic Rubber Latex	Latex, Liquid Synthetic
Tall Oil	Oil: Tall
Tallow	Tallow
Tallow Fatty Alcohol	Tallow Fatty Alcohol
Tallow Oil	Tallow
Tanners Oil	Oil, Tanners
Tannic Acid	Tannic Acid
Tannin	Tannic Acid
Tar Acids	Cresols
Tar Camphor	Naphthalene, Molten
Tartar Emetic	Antimony Potassium Tartrate
L-Tartaric Acid, Ammonium Salt	Ammonium Tartrate
Tartarized Antimony	Antimony Potassium Tartrate

Synonym	*Compound Name*
Tartrated Antimony	Antimony Potassium Tartrate
TBA	Tert-Butylamine
TCP	Tricresyl Phosphate
TCP	Calcium Phosphate
TCE	DDD
TOI	Toluene 2,4-Diisocyanate (TDI)
TEA	Triethylaluminum
Tear Gas	Chloroacetophenone
Teflon Monomer	Tetrafluoroethylene, Inhibited
TEG	Triethylene Glycol
TEL	Tetraethyl Lead
Telone	Dichloropropene
TEN	Triethylamine
Tep	Tetraethyl Pyrophosphate
Tepp	Tetraethyl Pyrophosphate
Terephthalic Acid, Dimethyl Ester	Dimethyl Terephthalate
Tergitol 3-A-B Nonionic	Ethoxylated Tridecanol
Tergitol Nonionic 45-S-10	Ethoxylated Pentadecanol
Tergitol Nonionic 45-S-10	Ethoxylated Tetradecanol
Tergitol Nonionic TMN	Ethoxylated Dodecanol
Terpinene	Dipentene
Delta-1,8-Terpodiene	Dipentene
Teriary Butyl Alcohol	Tert-Butyl Alcohol
Tertiary Butyl Hydroperoxide	Tert-Butyl Hydroperoxide
2,4,5-T(Esters)	2,4,5-T(Esters)
Teta	Triethylenetetramine
Tetrabutyl Titanate	Tetrabutyl Titanate
1,1,2,2-Tetrachloroethane	Tetrachloroethane
Tetrachloroethane	Tetrachloroethane
Tetrachloroethylene	Tetrachloroethylene
Tetrachloromethane	Carbon Tetrachloride
1-Tetradecanol	Tetradecanol
Tetradecanol	Tetradecanol
Tetradecanol	Linear Alcohols (12-15 Carbons)
1-Tetradecene	1-Tetradecene
N-Tetradecyl Alcohol	Tetradecanol
Tetradecylbenzene	Tetradecylbenzene
Tetradecylbenzenesulfonic Acid	Alkylbenzenesulfonic Acids
Tetraethyl Dithionopyrophosphate	Tetraethyl Dithiopyrophosphate
Tetraethyl Dithiopyrophosphate	Tetraethyl Dithiopyrophosphate
Tetraethyl Lead	Tetraethyl Lead
Tetraethyl Orthosilicate	Ethyl Silicate
Tetraethyl Pyrophosphate	Tetraethyl Pyrophosphate
0,0,0,0-Tetraethyl Pyrophosphorodithionate	Tetraethyl Dithiopyrophosphate
Tetraethylene Glycol	Tetraethylene Glycol
Tetraethylenepentamine	Tetraethylenepentamine
Tetraethyl Silicate	Ethyl Silicate
Tetrafluoroethylene Inhibited	Tetrafluoroethylene, Inhibited
Tetrahydrofuran	Tetrahydrofuran
Tetrahydronaphthalene	Tetrahydronaphthalene
Tetrahydro-P-Oxazine	Morpholine
Tetrahydro-2H-1,4-Oxazine	Morpholine
Tetrahydrothiophene-1,1-Dioxide	Sulfolane
Tetrahydroxymethylmethane	Pentaerythritol
Tetralin	Tetrahydronaphthalene
Tetramethyleneglycol	1,4-Butanediol
Tetramethylene Oxide	Tetrahydrofuran
Tetramethylene Sulfone	Sulfolane
Tetramethyl Lead	Tetramethyl Lead
Tetramethylolmethane	Pentaerythritol
Tetramethylthiuram Disulfide	Thiram
Tetranap	Tetrahydronaphthalene
Tetrapropylene	Propylene Tetramer
Tetrapropylene	Dodecene
Tetrine Acid	Ethylediamine Tetracetic Acid
Tetron	Tetraethyl Pyrophosphate
Thanol PPG	Polypropylene Glycol
THF	Tetrahydrofuran
2-Thiapropane	Dimethyl Sulfide
Thiobutyl Alcohol	N-Butyl Mercaptan
Thiocarbonyl Chloride	Thiophosgene

Synonym	*Compound Name*
Thiocyanic Acid, Ammonium Salt	Ammonium Thiocyanate
Thioethyl Alcohol	Ethyl Mercaptan
Thiomethyl Alcohol	Methyl Mercaptan
Thiophosgene	Thiophosgene
Thiophosphoric Anhydride	Phosphorus Pentasulfide
Thiram	Thiram
Thiuram	Thiram
Thorium Nitrate	Thorium Nitrate
Thorium Nitrate Tetrahydrate	Thorium Nitrate
Threthylene	Trichloroethylene
TIBA	Triisobutylaluminum
Tibal	Triisobutylaluminum
Titanium Butoxide	Tetrabutyl Titanate
Titanium Tetrabutoxide	Tetrabutyl Titanate
Titanium Tetrachloride	Titanium Tetrachloride
Toluene	Toluene
2,4-Toluene Diisocyanate	Toluene 2,4-Diisocyanate (TDI)
Toluene 2,4-Diisocyanate (TDI)	Toluene 2,4-Diisocyanate (TDI)
P-Toluenesulfonic Acid	P-Toluenesulfonic Acid
O-Toluidine	O-Toluidine
Toluol	Toluene
N-Tolylene Diisocyanate	Toluene 2,4-Diisocyanate (TDI)
2,4-Tolylene Diisocyanate	Toluene 2,4-Diisocyanate (TDI)
Tolyl Epoxypropyl Ether	Cresyl Glycidyl Ether
Tolyl Glycidyl Ether	Cresyl Glycidyl Ether
Tosic Acid	P-Toluenesulfonic Acid
Toxaphene	Toxaphene
Toxichlor	Chloroane
Toxilic Acid	Maleic Acid
Toxilic Anhydride	Maleic Anhydride
Transformer Oil	Oil: Transformer
Transmission Oil	Oil: Motor
Transmission Oil	Oil: Lubricating
Treflan	Trifluralin
Trethylene	Trichloroethylene
TRI	Trichloroethylene
Tri-6	Benzene Hexachloride
Tricalcium Arsenate	Calcium Arsenate
Tricalcium Orthoarsenate	Calcium Arsenate
Trichloran	Trichloroethylene
Trichloroamylsilane	H-Amyltrichlorosilane
1,1,1-Trichloro-2,2-Bis (P-Chlorophenyl)Ethane	DDT
1,1,1-Trichloroethane	Trichloroethane
Trichloroethane	Trichloroethane
Trichloroethene	Trichloroethylene
Trichloroethylene	Trichloroethylene
Trichloroethylsilane	Ethyltrichlorosilane
Trichloroethylsilicane	Ethyltrichlorosilane
Trichlorofluoromethane	Trichlorofluoromethane
Trichloroiminoisocyanuric Acid	Trichloro-S-Triazinetrione
Trichloroisocyanuric Acid	Trichloro-S-Triazinetrione
Trichloromethane	Chloroform
Trichloromethane	Calcium Fluoride
Trichloromethane Sulphuryl Chloride	Perchloromethyl Mercaptan
Trichloromethanesulfenyl Chloride	Perchloromethyl Mercaptan
Trichloromethyl Sulpho-chloride	Perchloromethyl Mercaptan
Trichloromethylsilane	Methyltrichlorosilane
Trichloromethylsulfur Chloride	Perchloromethyl Mercaptan
N-Trichloromethylthio-Cis-Cyclohexene-1,2-Dicarboximide	Captan
Trichloromonosilane	Trichlorosilane
Trichloronitromethane	Chloropicrin, Liquid
Trichlorooxo Vanadium	Vanadium Oxytrichloride
N-Tolylene Diisocyanate	Toluene 2,4-Diisocyanate (TDI)
2,4-Tolylene Diisocyanate	Toluene 2,4-Diisocyanate (TDI)
Tolyl Epoxypropyl Ether	Cresyl Glycidyl Ether
Tolyl Glycidyl Ether	Cresyl Glycidyl Ether
Tosic Acid	P-Toluenesulfonic Acid
Toxaphene	Toxaphene
Toxichlor	Chloroane
Toxilic Acid	Maleic Acid
Toxilic Anhydride	Maleic Anhydride
Transformer Oil	Oil: Transformer

Synonym	*Compound Name*
Transmission Oil	Oil: Motor
Transmission Oil	Oil: Lubricating
Treflan	Trifluralin
Trethylene	Trichloroethylene
TRI	Trichloroethylene
Tri-6	Benzene Hexachloride
Tricalcium Arsenate	Calcium Arsenate
Tricalcium Orthoarsenate	Calcium Arsenate
Trichloran	Trichloroethylene
Trichloroamylsilane	H-Amyltrichlorosilane
1,1,1-Trichloro-2,2-Bis (P-Chlorophenyl)Ethane	DDT
1,1,1-Trichloroethane	Trichloroethane
Trichloroethane	Trichloroethane
Trichloroethene	Trichloroethylene
Trichloroethylene	Trichloroethylene
Trichloroethylsilane	Ethyltrichlorosilane
Trichloroethylsilicane	Ethyltrichlorosilane
Trichlorofluoromethane	Trichlorofluoromethane
Trichloroiminoisocyanuric Acid	Trichloro-S-Triazinetrione
Trichloroisocyanuric Acid	Trichloro-S-Triazinetrione
Trichloromethane	Chloroform
Trichloromethane	Calcium Fluoride
Trichloromethane Sulphuryl Chloride	Perchloromethyl Mercaptan
Trichloromethane	Calcium Fluoride
Trichloromethane Sulphuryl Chloride	Perchloromethyl Mercaptan
Trichloromethanesulfenyl Chloride	Perchloromethyl Mercaptan
Trichloromethyl Sulphochloride	Perchloromethyl Mercaptan
Trichloromethylsilane	Methyltrichlorosilane
Trichloromethylsulfur Chloride	Perchloromethyl Mercaptan
N-Trichloromethylthio-Cis-Cyclohexene-1,2-Dicarboximide	Captan
Trichloromonosilane	Trichlorosilane
Trichloronitromethane	Chloropicrin, Liquid
Trichlorooxo Vanadium	Vanadium Oxytrichloride
Trichloropentylsilane	N-Amyltrichlorosilane
Trichlorophenol	Trichlorophenol
2,4,5-Trichlorophenol	Trichlorophenol
Trichlorosilane	Trichlorosilane
Trichloro-S-Triazinetrione	Trichloro-S-Triazinetrione
Trichlorotriazinetrione	Trichloro-S-Triazinetrione
Trichloro-S-Triazine-2,4,6-(1H,3H,5H)-Trione	Trichloro-S-Triazinetrione
Trichlorovinyl Silicane	Vinyltrichlorosilane
Trichlorovinylsilane	Vinyltrichlorosilane
Triclene	Trichlorethylene
Tri-Clene	Trichlorethylene
Tricresyl Phosphate	Tricresyl Phosphate
Tri-P-Cresyl Phosphate	Tricresyl Phosphate
1-Tridecanol	Tridecanol
Tridecanol	Tridecanol
Tridecanol	Linear Alcohols (12-15 Carbons)
1-Tridecene	1-Tridecene
Tridecylbenzenesulfonic Acid	Alkylbenzenesulfonic Acids
Trielene	Trichloroethylene
Trien	Triethylenetetramine
Triethanolamine	Triethanolamine
Triethanolamine	Dodecylbenzenesulfonic Acid
Dodecylbenzenesulfonate	Triethanolamine Salt
Triethanolamine Lauryl Sulfate	Dodecyl Sulfate, Triethanolamine Salt
Triethylaluminum	Triethylaluminum
Triethylamine	Triethylamine
Triethylbenzene	Triethylbenzene
Sym-Triethylbenzene	Triethylbenzene
1,3,5-Triethylbenzene	Triethylbenzene
Triethylene Glycol	Triethylene Glycol
Triethylene Glycol Monoethyl Ether	Ethoxy Triglycol
Triethylenephosphoramide	Tris(Aziridinyl) Phosphine Oxide
Triethylenetetramine	Triethylenetetramine
Triethylolamine	Triethanolamine
Trifluorochloroethylene	Trifluorochloro-ethylene

Synonym	*Compound Name*
Trifluoromonochloroethylene	Trifluorochloroethylene
Trifluorovinyl Chloride	Trifluorochloroethylene
Trifluralin	Trifluralin
Triglycine	Nitrilotriacetic Acid and Salts
Triglycol	Triethylene Glycol
Triglycol Monoethyl Ether	Ethoxy Triglycol
1,2,3-Trihydroxybenzene	Pyrogallic Acid
3,4,5-Trihydroxybenzoic Acid	Gallic Acid
1,2,3-Trihydroxypropane	Glycerine
Trihydroxytriethylamine	Triethanolamine
Trilsobutylaluminum	Trilsobutylaluminum
Trilene	Trichloroethylene
Triline	Trichloroethylene
Trimar	Trichloroethylene
Trimethylamine	Trimethylamine
Trimethylaminomethane	Tert-Butylamine
Trimethylbenzylammonium Chloride	Benzyltrimethyl ammonium Chloride
3,7,7-Trimethylbicyclo(0,1,4)Hept-3-Ene	Carene
Trimethylcarbinol	Tert-Butyl Alcohol
Trimethylchlorosilane	Trimethylchlorosilane
3,5,5-Trimethyl-2-Cyclohene-1-One	Isophorone
Trimethylene	Cyclopropane
Trimethylheptanals	Isodecaldehyde
4,7,7-Trimethyl-3-Norcarene	Carene
2,4,4-Trimethyl-1-Pentene	Diisobutylene
Trimethylsilyl Chloride	Trimethylchlorosilane
3,6,9-Trioxaundecan-1,11-Diol	Tetraethylene Glycol
Tripropylene	Nonene
Tripropylene Glycol	Tripropylene Glycol
Tris(Aziridinyl)Phosphine Oxide	Tris(Aziridinyl)Phosphine Oxide
Tris (Hydroxyethyl)Amine	Triethanolamine
Trisodium Nitrilotriacetate	Nitrilotriacetic Acid and Salts
Tri-P-Tolyl Phosphate	Tricresyl Phosphate
P-TSA	P-Toluenesulfonic Acid
Turpentine	Turpentine
Turps	Turpentine
Tyranton	Diacetone Alcohol
Ucane Alkylate 12	Dodecylbenzene
Ucar Bisphenol Hp	Bisphenol A
Ucon 11	Trichlorofluoromethane
Ucon 12	Dichlorodifuoromethane
Ucon 22	Monochlorodifluoromethane
Monochlorodifluoromethane	1,1-Dimethylhydrazine
UDMF	
Undecanol	Undecanol
1-Undecanol	Undecanol
1-Undecene	1-Undecene
Undecyl Alcohol	Undecanol
N-Undecylbenzene	N-Undecylbenzene
Undecylbenzenesulfonic Acid	Alkylbenzenesulfonic Acids
Undecylethylene	1-Tridecene
Undecylic Alcohol	Undecanol
Unslaked Lime	Calcium Oxide
Uranium Acetate	Uranyl Acetate
Uranium Acetate Dihydrate	Uranyl Acetate
Uranium Nitrate	Uranyl Nitrate
Uranium Oxyacetate Dihydrate	Uranyl Acetate
Uranium Sulfate	Uranyl Sulfate
Uranium Sulfate Trihydrate	Uranyl Sulfate
Uranyl Acetate	Chloroform
Uranyl Acetate Dihydrate	Uranyl Acetate
Uranyl Nitrate	Uranyl Nitrate
Uranyl Sulfate	Uranyl Sulfate
Uranyl Sulfate Trihydrate	Uranyl Sulfate
Urea	Urea
Urea Hydrogen Peroxide	Urea Peroxide
Urea Peroxide	Urea Peroxide
Uritone	Hexamethylenetetramine
Urotropin	Hexamethylenetetramine
Valentinite	Antimony Trioxide
Valeral	Valeraldehyde
Valeraldehyde	Valeraldehyde
Valeric Aldehyde	Valeraldehyde
Vam	Vinyl Acetate
Vanadic Anhydride	Vanadium Pentoxide
Vanadium Oxysulfate	Vanadyl Sulfate
Vanadium Oxytrichloride	Vanadium Oxytrichloride
Vanadium Pentaoxide	Vanadium Pentoxide
Vanadium Pentoxide	Vanadium Pentoxide

Synonym	*Compound Name*
Vanadyl Chloride	Vanadium Oxytrichloride
Vanadyl Sulfate	Vanadyl Sulfate
Vanadyl Sulfate Dihydrate	Vanadyl Sulfate
Vanadyl Trichloride	Vanadium Oxytrichloride
Vanicide	Captan
Vapotone	Tetraethyl Pyrophosphate
Vaseline	Petrolatum
VC	Vinyl Chloride
VCL	Vinyl Chloride
VCH	Vinyl Chloride
Vegetable Carbon	Charcoal
Vegetable Charcoal	Charcoal
Vegetable Oil	Oil: Vegetable
Velsicol	Heptachlor
Velsicol 1068	Chlordane
Vemtox	Acrylonitrile
Versene Acid	Ethylenediamine Tetracetic Acid
Vic-M-Xylenol	Xylenol
Vienna Green	Copper Acetoarsenite
Vilrathane 4300	Diphenylmethane-diisocyanate (MDI)
Vinegar Acid	Acetic Acid
Vinyl Acetate	Vinyl Acetate
Vinyl A Monomer	Vinyl Acetate
Vinylbenzene	Styrene
Vinylcarbinol	Allyl Alcohol
Vinyl Chloride	Vinyl Chloride
Vinyl C Monomer	Vinyl Chloride
Vinyl Cyanide	Acrylonitrile
Vinylethylene	Butadiene, Inhibited
Vinyl Fluoride, Inhibited	Vinyl Fluoride, Inhibited
Vinylidenechloride, Inhibited	Vinylidenechloride, Inhibited
Vinyl Methyl Ether, Inhibited	Vinyl Methyl Ether, Inhibited
Vinylsilicon Trichloride	Vinyltrichlorosilane
Vinyltoluene	Vinyltoluene
Vinyltrichlorosilane	Vinyltrichlorosilane
Vyac	Vinyl Acetate
Water Displacing Oil	Oil: Penetrating
Water Glass	Sodium Silicate
Waxes: Carnauba	Waxes: Carnauba
Waxes: Paraffin	Waxes: Paraffin
Weisspiessglanz	Antimony Trioxide
White Arsenic	Arsenic Trioxide
White Oil	Oil: Mineral
White Vitriol	Zinc Sulfate
Witcizer 300	Dibutyl Phthalate
Witcizer 312	Dioctyl Phthalate
Wood Alcohol	Methyl Alcohol
Wood Charcoal	Charcoal
Wood Ether	Dimethyl Ether
Wood Naphtha	Methyl Alcohol
Wood Spirit	Methyl Alcohol
Wood Turpentine	Turpentine
Meta-Xylene	M-Xylene
P-Xylene	P-Xylene
O-Xylene	O-Xylene
M-Xylene	M-Xylene
Xylenes, Mixture with Benzene and Toluene	Naphtha Coal Tar
Xylenol	Xylenol
2,6-Xylenol	Xylenol
Xylol	M-Xylene
Yellow Arsenic Sulfide	Arsenic Trisulfide
Yellow Petrolatum	Petrolatum
Yellow Phosphorus	Phosphorus, White
Zinc Acetate	Zinc Acetate
Zinc Acetate Dihydrate	Zinc Acetate
Zinc Ammonium Chloride	Zinc Ammonium Chloride
Zinc Arsenate	Zinc Arsenate
Zinc Borate	Zinc Borate
Zinc Bromide	Zinc Bromide
Zinc 0,0-Di-N-Butylphosphorodithioate	Zinc Dialkyldithio-phosphate
Zinc Chloride	Zinc Chloride
Zinc Chromate	Zinc Chromate
Zinc Chromate(VI)Hydroxide	Zinc Chromate
Zinc Diacetate	Zinc Acetate
Zinc Dialkyldithiophosphate	Zinc Dialkyldithio-phosphate
Zinc Diethyl	Diethylzinc

Synonym	*Compound Name*
Zinc Dihexyldithiophosphate	Zinc Dialkyldithio phosphate
Zinc Dihexylphosphorodithioate	Zinc Dialkyldithio-phosphate
Zinc Dimethyl	Dimethylzinc
Zinc Ethyl	Diethylzinc
Zinc Fluoborate Solution	Zinc Fluoroborate
Zinc Fluoroborate	Zinc Fluoroborate
Zinc Fluosilicate	Zinc Sulicofluoride
Zinc Hexafluorosilicate	Zinc Silicofluoride
Zinc Methyl	Dimethylzinc
Zinc Nitrate	Zinc Nitrate
Zinc Nitrate Hexahydrate	Zinc Nitrate
Zinc P-Phenolsulfonate	Zinc Phenolsulfonate
Zinc Phenolsulfonate	Zinc Phenolsulfonate
Zinc Phenolsulfonate Octahydrate	Zinc Phenolsulfonate
Zinc Phosphide	Zinc Phosphide
Zinc Silicofluoride	Zinc Silicofluoride
Zinc Silicofluoride Hexahydrate	Zinc Silicoflouoride
Zinc Sulfate	Zinc Sulfate
Zinc Sulfate Heptahydrate	Zinc Sulfate
Zinc Sulfocarbolate	Zinc Phenolsulfonate
Zinc Sulfophenate	Zinc Phenolsulfonate
Zinc Vitriol	Zinc Sulfate
Zinc Yellow	Zinc Chromate
Zirconium Acetate	Zirconium Acetate
Zirconium Acetate Solution	Zirconium Acetate
Zirconium Nitrate	Zirconium Nitrate
Zirconium Nitrate Pentahydrate	Zirconium Nitrate
Zirconium Oxide Chloride	Zirconium Oxychloride
Zirconium Oxychloride	Zirconium Oxychloride
Zirconium Oxychloride Hydrate	Zirconium Oxychloride
Zirconium Sulfate	Zirconium Sulfate
Zirconium Sulfate Tetrahydrate	Zirconium Sulfate
Zirconyl Chloride	Zirconium Oxychloride

4

GUIDE TO CHEMICAL REACTIVITY, FIRE AND EXPLOSION

I. INTRODUCTION

This chapter is organized into three major subsections. The first section covers theory and practical information concerning hydrocarbon fires. Both the chemistry and pertinent data concerning this important class of chemicals are discussed from a fire safety standpoint. The second subsection provides a guide to chemical reactivity for incompatible binary mixtures. The third subsection provides extensive data tables and information on the flammability and chemical compatibility of commercial chemicals.

II. PROPERTIES AND FLAMMABILITY OF HYDROCARBONS

A. Chemistry Fundamentals

Hydrocarbons are compounds containing only hydrogen and carbon atoms. Since a hydrocarbon is a chemical combination of hydrogen and carbons, both of which are non-metals, hydrocarbons are covalently bonded. Hydrogen has only one electron in the outer ring and, therefore, will form only one bond, by donating one electron to the bond. Carbon, on the other hand, occupies a unique position in the Periodic Table, being halfway to stability with its four electrons in the outer ring. None of these electrons are paired, so carbon uses all of them to form covalent bonds. Carbon's unique structure makes it the basis of organic chemistry.

Carbon not only combines covalently with other non-metals, but also with itself. Oxygen also reacts with itself to form O_2, hydrogen reacts with itself to form H_2, nitrogen reacts with itself to form N_2, fluorine reacts with itself to form F_2, and chlorine reacts with itself to form Cl_2. Forming diatomic molecules, however, is the extent of the self-reaction of the elemental gases, while carbon has the ability to combine with itself almost indefinitely. Although the elemental gases form molecules when they combine with themselves, the carbon-to-carbon combination must include another element or elements, generally hydrogen. This combination of carbon with itself (plus hydrogen) forms a larger molecule with every carbon atom that is added to the chain. When the chain is strictly carbon-to-carbon with no branching, the resulting hydrocarbon is referred to as a straight-chain hydrocarbon. Where there are carbon atoms joined to carbon atoms to form side branches off the straight chain, the resulting compound is known as a branched hydrocarbon, or an isomer.

The carbon-to-hydrogen bond is always a single bond. While the resulting bond between carbon and hydrogen is always a single bond, carbon does have the capability to form double and triple bonds between itself and other carbon atoms, and/or any other atom that has the ability to form more than one bond. When a hydrocarbon contains only single bonds between carbon atoms, it is known as a saturated hydrocarbon; when there is at least one double or triple bond between two carbon atoms anywhere in the molecule, it is an unsaturated hydrocarbon. When determining the saturation or unsaturation of a hydrocarbon, only the carbon-to-carbon bonds are considered, since the carbon-to-hydrogen bond is always single.

This section provides an overview of the chemistry, properties and fire hazards of hydrocarbons. Hydrocarbons are among the most useful materials to mankind, but are also among the most dangerous in terms of their fire potential.

An analogous series of hydrocarbons, and one of the simplest, are the compounds known as the alkanes. In this series, the names of all the compounds end in -ane. The first compound in this series is methane. Methane's molecular formula is CH_4. Methane is a gas and is the principal ingredient in the mixture of gases known as natural gas. The next compound is this series is ethane, whose molecular formula is C_2H_6. It is also a gas present in natural gas, although in a much lower percentage than methane. The difference in the molecular formulas of methane and ethane is one carbon and two hydrogen atoms.

Propane is the next hydrocarbon in this series, and its molecular formula is C_3H_8 which is one carbon and two hydrogen atoms different from ethane. Propane is an easily liquified gas which is used as fuel.

The next hydrocarbon in the series is butane, another rather easily liquified gas used as a fuel. Together, butane and propane are known as the LP (liquified petroleum) gases. Butane's molecular formula is C_4H_{10}, which is CH_2 bigger than propane.

Hence, the series begins with a one-carbon-atom compound, methane, and proceeds to add one carbon atom to the chain for each succeeding compound. Since carbon will form four convalent bonds, it must also add two hydrogen atoms to satisfy those two unpaired electrons and allow carbon to satisfy the octet rule, thus achieving eight electrons in the outer ring. In every hydrocarbon, whether saturated or unsaturated, all atoms must reach stability. There are only two elements involved in a hydrocarbon, hydrogen and carbon; hydrogen must have two electrons in the outer ring, and carbon must have eight electrons in the outer ring. Since the carbon-hydrogen bond is always single, the rest of the bonds must be carbon-carbon, and these bonds must be single, double, or triple, depending on the compound.

Continuing in the alkane series (also called the paraffin series because the first solid hydrocarbon in the series is paraffin, or candle wax), the next compound is pentane. This name is derived from the Greek word penta, for five. As its name implies, it has five carbon atoms, and its molecular formula is C_5H_{12}.

From pentane on, the Greek prefix for the numbers five, six, seven, eight, nine, ten, and so on are used to name the alkanes, the Greek prefix corresponding to the number of carbon atoms in the molecule. The first four members of the alkane series do not use the Greek prefix method of naming, simply because their common names are so universally accepted: thus the names methane, ethane, propane, and butane.

The next six alkanes are named pentane, hexane, heptane, octane, nonane, and decane. Their molecular formulas are C_5H_{12}, C_6H_{14}, C_7H_{16}, C_8H_{18}, C_9H_{20} and $C_{10}H_{22}$. The alkanes do not stop at the ten-carbon chain however. Since these first ten represent flammable gases and liquids and most of the derivatives of these compounds comprise the vast majority of hazardous materials encountered, we have no need to go any further in the series. The general formula for the alkanes is C_nH_{2n+2}. The letter n stands for the number of carbon atoms in the molecule. The number of hydrogen atoms then becomes two more than twice the number of carbon atoms. Since there is more than one analogous series of hydrocarbons, you must remember that each series is unique; the alkanes are defined as the analogous series of saturated hydrocarbons with the general formula C_nH_{2n+2}.

1. Isomers

Within each analogous series of hydrocarbons there exist isomers of the compounds within that series. An isomer is defined as a compound with the same molecular formula as another compound but with a different structural formula. In other words, if there is a different way in which the carbon atoms can align themselves in the molecule, a different compound with different properties will exist.

Beginning with the fourth alkane, butane, we find we can draw a structural formula of a compound with four atoms and ten hydrogen atoms in two ways; the first is as the normal butane exists and the second is as shown in Figure 1, with the name isobutane. With isobutane, no matter how you count the carbon atoms in the longest chain, you will always end with three. Notice that the structural formula is different - one carbon atom attached to the other carbon atoms - while in butane (also called normal butane), the largest number of carbon atoms another carbon atom can be attached to is two. This fact does make a difference in certain properties of compounds. The molecular formulas of butane and isobutane are the same and, therefore, so are the molecular weights. However, there is a 38-degree difference in melting points, 20-degree difference in boiling points, and the 310-degree difference in ignition

temperatures. The structure of the molecule clearly plays part in the properties of the compounds.

With the five-carbon alkane, pentane, there are three ways to draw the structural formula of this compound with five carbon atoms and twelve hydrogen atoms. The isomers of normal pentane are isopentane and neopentane. The structural formulas of these compounds are shown in Figure 1, while typical properties are given in Table 1. Note the three identical molecular formulas and three identical molecular weights, but significantly different melting, boiling, and flash points and different ignition temperatures. These property differences are referred to as the "structural effect", i.e., differences in the properties of compounds exist for materials having the same molecular formulas but different structural arrangements. This particular structure effect is called the branching effect, and the isomers of all the straight-chain hydrocarbons are called branched hydrocarbons.

There is another structural effect; it is produced simply by the length of the chain formed by consecutively attached carbon atoms.

In noting the increasing length of the carbon chain from methane through decane, the difference in each succeeding alkane is that "unit" made up of one carbon atom and two hydrogen atoms; that "unit" is not a chemical compound itself, but it has a molecular weight of fourteen. Therefore, each succeeding alkane in the analogous series weighs fourteen atomic mass units more than the one before it and fourteen less than the one after it. This weight effect is the reason for the increasing melting and boiling points, the increasing flash points, and the decreasing ignition temperatures. The increasing weights of the compounds also account for the changes from the gaseous state of the first four alkanes, to the liquid state of the next thirteen alkanes, and finally to the solid state of the alkanes, starting with the 17-carbon atom alkane, heptadecane.

We may now state a very general rule of chemistry: the larger a molecule (that is, the greater the molecular weight), the greater affinity each molecule will have for each other molecule, therefore, slowing down the movement. The molecules, duly slowed from their frantic movement as gases, become liquids, and, as the molecules continue to get larger, they are further slowed from their still rapid movement as liquids and become solids.

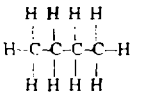
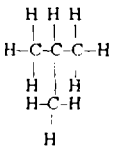
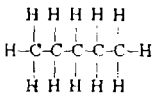
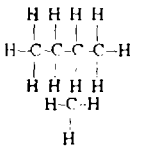
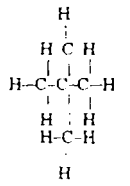
Compound	Molecular Formula	Structural Formula
Butane	C_4H_{10}	
Isobutane	C_4H_{10}	
Pentane	C_5H_{12}	
Isopentane	C_5H_{12}	
Neopentane	C_5H_{12}	

Figure 1. Illustrates the structural formulas for isomers of butane and pentane.

The straight-chain hydrocarbons represent just one group of straight-chain hydrocarbons, the saturated hydrocarbons known as the alkanes. There are other series of hydrocarbons that are unsaturated; one of those is important in the study of hazardous materials. Additionally, the first hydrocarbon in another series is the only hydrocarbon important in that series. Each of these hydrocarbon series are briefly described below.

2. Alkenes

The series of unsaturated hydrocarbons that contain just one double bond in the structural formula of each of its members is the analogous series known as the alkenes. Notice that the name of the analogous series is similar to the analogous series of saturated hydrocarbons known as

Table 1. Typical Properties of Alkanes

Compound	Formula	Atomic Weight (°F)	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temp. (°F)
Methane	CH_4	16	-296.5	-259	gas	999
Ethane	C_2H_6	30	-298	-127	gas	882
Propane	C_3H_8	44	-306	-44	gas	842
Butane	C_4H_{10}	58	-217	31	gas	550
Pentane	C_5H_{12}	72	-201.5	97	<-40	500
Hexane	C_6H_{14}	86	- 139.5	156	-7	437
Heptane	C_7H_{16}	100	-131.1	209	25	399
Octane	C_8H_{18}	114	-70.2	258	56	403
Nonane	C_9H_{20}	128	-64.5	303	88	401
Decane	$C_{10}H_{22}$	142	-21.5	345	115	410
Butane	C_4H_{10}	58	-217	31	gas	550
Isobutane	C_4H_{10}	58	-255	11	gas	860
Pentane	C_5H_{12}	72	-201.5	97	<-40	500
Isopentane	C_5H_{12}	72	-256	82	<-60	788
Neopentane	C_5H_{12}	72	2	49	<-20	842

the alkanes, but the structural formula is significantly different. Remembering that the definition of a saturated hydrocarbon is a hydrocarbon with nothing but single bonds in the structural formula and that an unsaturated hydrocarbon is a hydrogen-carbon with at least one multiple bond in the structural formula, then we would expect to find a multiple bond in the structural formulas of the alkenes. The names of all the hydrocarbons in this series end in -ene. The corresponding names for this series of hydrocarbons is similar to the alkanes, with the only difference being the above-mentioned ending. Thus, in the alkene series ethane becomes ethene, propane is propene, butane is butene; the five-carbon straight-chain hydrocarbon in the alkene series is pentene, as opposed to pentane in the alkane series, and so on.

Note that these compounds are covalently bonded compounds containing only hydrogen and carbon. The differences in their structural formulas are apparent; the alkanes have only single bonds in their structural formulas, while the alkenes have one (and only one) double bond in their structural formulas. There are different numbers of hydrogen atoms in the two analogous series. This difference is due to the octet rule that carbon must satisfy. Since one pair of carbon atoms shares a double bond, this fact reduces the number of electrons the carbons need (collectively) by two, so there are two fewer hydrogen atoms in the alkene than in the corresponding alkane.

In any hydrocarbon compound, carbon will form four covalent bonds. In saturated hydrocarbons the four bonds will all be single bonds. The definition of an unsaturated hydrocarbon, however, is a hydrocarbon with at least one multiple bond, and the alkenes are an analogous series of unsaturated hydrocarbons containing just one double bond (which is a multiple bond). The double bond must be formed with another carbon atom since hydrogen atoms can form only single bonds and, in a hydrocarbon compounds there are no other elements but hydrogen and carbon. In forming a double bond with another carbon atom and to satisfy the octet rule, the alkene must form fewer bonds with hydrogen, resulting in less hydrogen in the structural formula of each alkene than in the corresponding alkane. There are two fewer hydrogen atoms in each of the alkenes than in the alkane with the same number of carbon atoms. This is also shown by the general molecular formula of the alkenes, C_nH_{2n}, as opposed to the general molecular formula of the alkanes, which is C_nH_{2n+2}.

Note that there is no one-carbon alkene corresponding to methane, since hydrogen can never form more than one covalent bond, and there is no other carbon atom in the structural formula. Therefore, the first compound in the alkene series is ethene, while the corresponding two-carbon compound in the alkane series, ethane, is the second compound in the series, with methane the first.

Although the naming of the alkenes is the same as the alkanes, with only the ending changed from -ane to -ene, there is a problem with the names of the first three alkenes. The systematic names of hydrocarbons came a long while after the simplest (that is, the shortest chain) of the compounds in each series was known and named. In naming the alkanes, the system of using the Greek names for numbers as prefixes begins with pentane, rather than with methane. That situation occurred because methane, ethane, propane, and butane were known and named long before it was known that there was an almost infinite length to the chain that carbon could form and that a systematic naming procedure would be needed. Before the new system was adopted, the common names for the shortest-chain compounds had become so entrenched that those names survived unchanged. Therefore, not only are the first four compounds in the alkane series named differently from the rest of the series, the corresponding

two-, three-, and four-carbon compounds are not generally known as ethene, propene, and butene. Their common names are ethylene, propylene, and butylene.

As noted earlier, more than one compound may have the same molecular formula (isomers), but a structural formula is unique to one compound. In addition, there are many chemicals which possess more than one chemical name, for the same reason mentioned above. The most common organic chemicals are those that have the shortest carbon chains. This fact is also true of their derivatives. The inclusion of a double bond in the structural formula has a profound effect on the properties of a compound. Table 2 illustrates those differences through the properties of alkenes. The presence of a double bond (and, indeed, a triple bond) between two carbon atoms in a hydrocarbon increases the chemical activity of the compound tremendously over its corresponding saturated hydrocarbon. The smaller the molecule (that is, the shorter the chain), the more pronounced this activity is. A case in point is the unsaturated hydrocarbon ethylene. Disregarding the present the differences in combustion properties between it and ethane, ethylene is so chemically active that, under the proper conditions, instead of burning, polymerization, which, if it is uncontrolled, is a much more violent reaction than combustion. This tendency to polymerize is due to the presence of the double bond. The tendency to polymerize decreases as the molecule gets bigger (the chain is longer). Only the first four or five of the straight-chain hydrocarbons are important in the study of hazardous materials. Few, if any, of the isomers of the alkenes are common.

There are other hydrocarbon compounds that contain multiple bonds, however, discussion here is limited to those compounds containing just one multiple bond in their molecules. This is because the compounds containing just one multiple bond are the most valuable commercially and, therefore, the most common. There is, however, a simple way to recognize when you are dealing with a compound that may contain two double bonds; that is a name in which the Greek prefix "di-" is used. As example would be the compound butadiene. Recognize from the first part of the name ("buta-") that there are four carbon atoms in the chain, and that there is a double bond present (the ending "-ene"), however, just before the -ene ending is the prefix "di-," meaning two. Therefore, recognize that you are dealing with a four-carbon hydrocarbon with two double bonds.

As in the alkanes, it is possible for carbon atoms to align themselves in different orders to form isomers. Not only is it possible for the carbon atoms to form branches which produce isomers, but it is also possible for the double bond to be situated between different carbon atoms in different compounds. This different position of the double bond also results in different structural formulas, which, of course, are isomers. Just as in the alkanes, isomers of the alkenes have different properties. The unsaturated hydrocarbons and their derivatives are more active chemically than the saturated hydrocarbons and their derivatives.

Table 2. Typical Properties of Alkenes

Compound	Formula	Molecular Weight	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temp. (°F)
Ethylene	C_2H_4	28	-272.2	-155.0	gas	1,009
Propylene	C_3H_6	42	-301.4	-53.9	gas	927
1-Butene	C_4H_8	56	-300.0	21.7	gas	700
2-Butene	C_4H_8	56	-218.2	38.7	gas	615
1-Pentene	C_5H_{10}	70	-265.0	86.0	32	523
2-Pentene	C_5H_{10}	70	-292.0	98.6	32	NA
1-Hexene	C_6H_{12}	84	-219.6	146.4	-15	487
2-Hexene	C_6H_{12}	84	-230.8	154.4	-5	473
1-Heptene	C_7H_{14}	98	-119.2	199.9	28	500
1-Octene	C_8H_{16}	112	-152.3	250.3	70	446

NA = Not Applicable

3. Alkynes

Another analogous series of unsaturated hydrocarbons that contain just one multiple bond, but, instead of being a double bond, it is a triple bond is the alkynes. The names of all the compounds end in -yne. The only compound in this series that is at all common happens to be an extremely hazardous material. It is a highly unstable (to heat, shock, and pressure), highly flammable gas that is the first compound in the series. This two-carbon unsaturated hydrocarbon with a triple bond between its two carbon atoms is called ethyne, and indeed this is its proper name. It is, however, known by its common name, acetylene. The -ene ending could be confusing, so one must memorize the fact that acetylene is an alkyne rather than an alkene. Its molecular formula is C_2H_2. The fact that it contains this triple bond makes it extremely active chemically, that is what is meant by its instability to heat, shock, and pressure. It takes energy to start a chemical reaction, and heat, shock, and pressure are forms of energy. The fact that the triple bond contains so much energy tied up in the structure means that it will release this energy, which is the input of some slight amount of external energy. When this input energy strikes the

molecule of acetylene, the triple bond breaks, releasing the internal energy of the bonds. This produces either great amounts of heat or an explosion, depending on the way in which the external energy was applied.

There are no other alkynes that are of commercial importance, and so acetylene will be the only member of this series that is considered in fire discussions. There are other alkynes, however, along with hydrocarbons that might have one double bond and a triple bond present in the molecule.

4. Straight-Chain Hydrocarbon Nomenclature

The system for naming the straight-chain hydrocarbons is based on an agreed-upon method of retaining the first three or four common names, then using Greek prefixes that indicate the number of carbon atoms in the chain. For isomers, the same system is used, always using the name of the compound that is attached to the chain and the name of the chain.

Recall the first analogous series of hydrocarbons the alkanes, a series of saturated hydrocarbons, all ending in -ane. For these hydrocarbons and other hydrocarbons to react, a place on the hydrocarbon chain must exist for the reaction to take place. Since all the bonds from carbon to hydrogen are already used, an "opening" on one of the carbon atoms must exist for it to be able to react with something else. This "opening" occurs when one of the hydrogen atoms is removed from its bond with a carbon atom, thus causing that carbon to revert back to a condition of instability, with seven electrons in its outer ring, or, as we now state, with one unpaired electron. This one unpaired electron (or half of a covalent bond, or "dangling" bond) wants to react with something, and it will, as soon as another particle which is ready to react is brought near. This chain of carbon atoms (from one carbon to another to another, and so on) with a hydrogen atom missing is a particle that was once a compound, and its name is a radical.

Radicals are created by energy being applied to them in a chemical reaction or in a fire. Remember that a hydrocarbon compound with at least one hydrogen atom removed is no longer a compound, but a chemical particle known as a radical. Radicals have names of their own; they are derived from the name of the alkane. When a hydrogen atom is removed from the alkane hydrocarbon, the name is changed from -ane to -yl. Therefore, when a hydrogen is removed from the compound methane, the methyl radical is formed. When a hydrogen atom is removed from the compound ethane, the ethyl radical is formed. In the same manner, the propyl radical comes from propane, the butyl radical comes from butane, and so on. Similarly, isobutane will produce the isobutyl radical, and isopentane will produce the isopentyl radical. A list of hydrocarbons and the radicals produced from them when a hydrogen is removed is shown is Table 3. Note that there are only a few radicals from compounds other than the alkanes which are important.

Radicals are referred to as hydrocarbon "backbones". As an example, isobutane is more properly named methyl propane. Another isomer with a different proper name is isopentane, more properly called methyl butane. Neopentane is also named 2,2-dimethyl propane.

Table 3. A Listing of Common Radicals

Methane	CH_4	Methyl	$-CH_3$
Ethane	C_2H_6	Ethyl	$-C_2H_5$
Propane	C_3H_8	n-Propyl	$-C_3H_7$
		Isopropyl	$-C_3H_7$
Butane	C_4H_{10}	n-Butyl	$-C_4H_9$
Isobutane	C_4H_{10}	Isobutyl	$-C_4H_9$
		sec-Butyl	$-C_4H_9$
		tert-Butyl	$-C_4H_9$
Ethylene	C_2H_4	Vinyl	$-C_2H_3$
Benzene	C_6H_6	Phenyl	$-C_6H_5$

The following is a list of rules for proper nomenclature of the isomers and their derivatives.

1. Find the longest continuous chain and name it as if it were an alkane.
2. Name the side branches in the same manner.
3. Identify the number of the carbon atom on the longest chain to which the branch is attached by counting from the end of the chain nearest to the branch.
4. If it is possible that there could be any confusion as to which carbon atom is meant, put the number in front of the name of the compound, followed by a dash.
5. If there is more than one branch, you must use the numbers to identify the carbon atom to which they are attached.
6. If the branches are identical, use the prefixes di- for two, tri- for three, tetra- for four, and so on.

In this manner, the four isomers of hexane are named 2-methyl pentane, 3-methyl pentane, 2,2,-dimethyl butane, and 2,3-dimethyl butane.

5. Aromatic Hydrocarbons

The above discussions have concentrated on hydrocarbons, both saturated and unsaturated, with the unsaturated hydrocarbons containing only one multiple bond. The unsaturated hydrocarbons are the alkenes with one double bond and the alkynes with one triple bond. There are other straight-chain hydrocarbons that are unsaturated containing more than one multiple bond, some with more than one double bond, and some with a mixture of double bonds and triple bonds. The combinations and permutations are endless, but there are only a few of the highly unstable materials.

From a commercial standpoint, there is a large body of hydrocarbons that is very important and hence these are of relevance to first responders to a hazardous-materials incidents. These hydrocarbons are different in that they are not straight-chain hydrocarbons but have a structural formula that can only be called cyclical. The most common and most important hydrocarbon in this group is benzene. It is the first and simplest of the six-carbon cyclical hydrocarbons referred to as aromatic hydrocarbons.

Benzene's molecular formula is C_6H_6, but it does not behave like hexane, hexene, or any of their isomers. One would expect it to be similar to these other six-carbon hydrocarbons in its properties. Table 4 provides a comparison between benzene, hexane and 1-hexene. The table shows that there are major differences between benzene and the straight-chain hydrocarbons of the same carbon content. Hexene's ignition temperature is very near to hexane's. The flash point difference is not great, however, there are significant differences in melting points. The explanation for these differences is structure; which in the case of benzene is a cyclical form with alternating double bonds.

Table 4. Comparison Between Properties of Benzene and of Straight-Chain Hydrocarbons

Compound	Formula	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temp. (°F)	Molecular weight
Hexane	C_6H_{14}	-139.5	156.0	-7	500	86
1-Hexene	C_6H_{12}	-219.6	146.4	<-20	487	84
Benzene	C_6H_6	41.9	176.2	12	1,044	78

The alternating double bonds are illustrated in Figure 2A. Initially, it was believed that the alternating double bonds impart very different properties to benzene, however, and the fact is that they do not. The only possible way for the benzene molecule to exist is illustrated in Figure 2B, in which a circle is drawn within the hexagonal structural to show that the electrons that should form a series of alternating double bonds are really spread among all six carbon atoms. It is the only structure possible that would explain the unique properties of benzene. This structural formula suggests resonance; that is, the possibility that the electrons represented by the circle are alternating back and forth between and among the six carbon atoms.

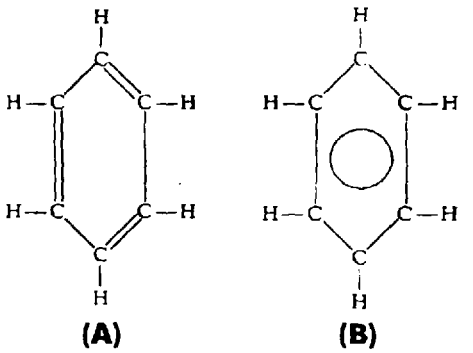


Figure 2. Illustrates the structure of benzene: (A) conventional illustration of double bonds, (B) illustration implying resonance.

This particular hexagonal structure is found throughout nature in many forms, almost always in a more complicated way, usually connected to many other "benzene rings" to form many exotic compounds. Of importance to the immediate discussions are benzene and a few of its derivatives. Benzene's derivatives include toluene and xylene, whose structural formulas are illustrated in Figure 3 along with that of benzene.

Some typical properties are given in Table 5, which illustrates the differences caused by molecular weight and structural formulas. There are other cyclical hydrocarbons,

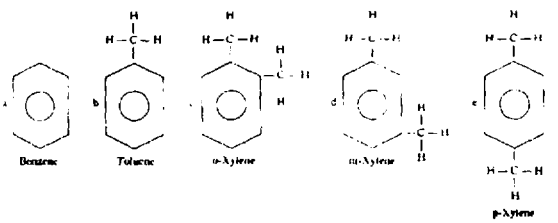


Figure 3. Illustrates the structures of benzene and some of its common derivatives.

but they do not have the structural formulas of the aromatics, unless they are benzene-based. These cyclical hydrocarbons may have three, four, five, or seven carbons in the cyclical structure, in addition to the six-carbon ring of the aromatics. None of them has the stability or the chemical properties of the aromatics.

Table 5. A Comparison of Benzene and Some of its Derivatives

Compound	Formula	Melting Point (°F)	Boiling Point (°F)	Flash Point (°F)	Ignition Temperature (°F)	Molecular Weight
Benzene	C_6H_6	41.9	176.2	12	1,044	78
Toluene	C_7H_8	-138.1	231.3	40	997	92
o-xylene	C_8H_{10}	-13.0	291.2	90	867	106
m-xylene	C_8H_{10}	-53.3	281.9	81	982	106
p-xylene	C_8H_{10}	-55.8	281.3	81	984	106

The aromatic hydrocarbons are used mainly as solvents and as feedstock chemicals for chemical processes that produce other valuable chemicals. With regard to cyclical hydrocarbons, the aromatic hydrocarbons are the only compounds discussed. These compounds all have the six-carbon benzene ring as a base, but there are also three-, four-, five-, and seven-carbon rings. These materials will be considered as we examine their occurrence as hazardous materials. After the alkanes, the aromatics are the next most common chemicals shipped and used in commerce. The short-chain olefins (alkenes) such as ethylene and propylene may be shipped in larger quantities because of their use as monomers, but for sheer numbers of different compounds, the aromatics will surpass even the alkanes in number, although not in volume.

6. *Hydrocarbon Derivatives*

A hydrocarbon derivative is a compound with a hydrocarbon backbone and a functional group attached to it chemically. A hydrocarbon backbone is defined as a molecular fragment that began as a hydrocarbon compound and has had at least one hydrogen atom removed from the molecule. Such a fragment is also known as a radical. A functional group is defined as an atom or a group of atoms, bound together, which impart specific chemical properties to a molecule; also referred to as radicals. A hydrocarbon derivative then is essentially a compound made up of two specific parts; the first part comes from a hydrocarbon, and the second may have many different origins (which includes coming from a hydrocarbon), depending on the chemical makeup of the functional group. The hydrocarbon backbone may come from an alkane, an alkene, an alkyne (indeed, any saturated or unsaturated hydrocarbon), or from an aromatic hydrocarbon or other cyclical hydrocarbon. Any hydrocarbon compound may form the hydrocarbon backbone portion of the hydrocarbon derivative, as long as it has been converted to a radical, by removal of one or more hydrogens, in preparation for the reaction. The functional group may have many origins, with chemists using as reactants any chemical compound that will produce the desired functional group. The functional groups include the halogens (fluorine, chlorine, bromine, and iodine), the hydroxyl radical, the carbonyl group, oxygen, the carboxyl group, the peroxide radical, the amine radical, and even other hydrocarbon radicals. When these functional groups are chemically attached to hydrocarbon backbones, they form compounds called hydrocarbon derivatives, and each functional group imparts a separate set of chemical and physical properties to the molecule formed by this chemical attachment.

Just as the alkanes and alkenes had general formulas, the carbon derivatives all have general formulas. The hydrocarbon backbone provides a portion of the general formula, and the functional group provides the other part. In each case, the hydrocarbon derivative is represented by the formula R-, and the hydrocarbon backbone has its own specific formula. The term "substituted hydrocarbon" is another name for hydrocarbon derivative, because the functional group is substituted for one or more hydrogen atoms in the chemical reaction.

7. *Halogenated Hydrocarbons*

A halogenated hydrocarbon is defined as a derivative of a hydrocarbon in which a hydrogen atom is replaced by a halogen atom. Since all of the halogens react similarly, and the number of hydrocarbons (including all saturated hydrocarbons, unsaturated hydrocarbons, aromatic hydrocarbons, other cyclical hydrocarbons, and all the isomers of these hydrocarbons) is large, the number of halogenated hydrocarbons can also be very large. The most common hydrocarbon derivatives are those of the first four alkanes and the first three alkenes (and, of course, the isomers of these hydrocarbons). There are some aromatic hydrocarbon derivatives, but, again, they are of the simplest structure. Whatever the hydrocarbon backbone is, it is represented in the general formula by its formula, which is R-. Therefore, the halogenated hydrocarbons will have formulas such as R-F, R-Cl, R-Br, and R-I for the respective substitution of fluorine, chlorine, bromine, and iodine on to the hydrocarbon backbone. As a rule, the general formula can be written R-X, with the R

as the hydrocarbon backbone, the X standing for the halide (any of the halogens), and the "-" the covalent bond between the hydrocarbon backbone and the halogen. R-X is read as "alkyl halide".

Radicals of the alkanes are referred to as alkyl radicals. There are two other important radicals; they are the vinyl radical, which is produced when a hydrogen atom is removed from ethylene, and the phenyl radical, which results when a hydrogen atom is removed from benzene. The term halogenated means that a halogen atom has been substituted for a hydrogen atom in a hydrocarbon molecule. The most common halogenated hydrocarbons are the chlorinated hydrocarbons. The simplest chlorinated hydrocarbon is methyl chloride, whose molecular formula is CH_3Cl. The structural formula for methyl chloride shows that one chlorine atom is substituted for one hydrogen atom. Methyl chloride has many uses, such as a herbicide, as a topical anesthetic, extractant, and low-temperature solvent, and as a catalyst carrier in low-temperature polymerization. It is a colorless gas that is easily liquified and is flammable; it is also toxic in high concentrations. Methyl chloride is the common name for this compound, while its proper name is chloromethane. Proper names are determined by the longest carbon chain in the molecule, and the corresponding hydrocarbon's name is used as the last name of the compound. Any substituted groups are named first, and a number is used to designate the carbon atom that the functional group is attached to, if applicable.

It is possible to substitute more than one chlorine atom for a hydrogen atom on a hydrocarbon molecule; such substitution is done only when the resulting compound is commercially valuable or is valuable in another chemical process. An example is methylene chloride (the common name for dichloromethane), which is made by substituting two chlorine atoms for two hydrogen atoms on the methane molecule. Its molecular formula is CH_2Cl_2. Methylene chloride is a colorless, volatile liquid with a sharp, ether-like odor. It is listed as a non-flammable liquid, but it will ignite at 1,224°F; it is narcotic at high concentrations. It is most commonly used as a stripper of paints and other finishes. It is also a good degreaser and solvent extractor and is used in some plastics processing applications.

Substituting a third chlorine on the methane molecule results in the compound whose proper name is trichloromethane (tri- for three; chloro- for chlorine; and methane, the hydrocarbon's name for the one-carbon chain). It is more commonly known as chloroform. Its molecular formula is $CHCl_3$. Chloroform is a heavy, colorless, volatile liquid with a sweet taste and characteristic odor. It is classified as non-flammable, but it will burn if exposed to high temperatures for long periods of time. It is narcotic by inhalation and toxic in high concentrations. It is an insecticide and a fumigant and is very useful in the manufacture of refrigerants.

The total chlorination of methane results in a compound whose proper name is tetrachloromethane (tetra- for four), but its common name is carbon tetrachloride (or carbon tet). This is a fire-extinguishing agent that is no longer used since it has been classified as a carcinogen. It is still present, though, and its uses include refrigerants, metal degreasing, and chlorination of organic compounds. Its molecular formula is CCl_4. It is possible to form analogues of methyl chloride, (methyl fluoride, methyl bromide, methyl iodide), methylene chloride (substitute fluoride, bromide, and iodide in this name also), chloroform (fluoroform, bromoform, and iodoform), and carbon tetrachloride (tetrafluoride, tetrabromide, and tetraiodide). Each of these halogenated hydrocarbons has some commercial value.

What was true for one hydrocarbon compound is true for most hydrocarbon compounds, particularly straight-chain hydrocarbons; that is, you may substitute a functional group at each of the bonds where a hydrogen atom is now connected to the carbon atom. Where four hydrogen atoms exist in methane, there are six hydrogen atoms in ethane; you recall that the difference in make-up from one compound to the next in an analogous series is the "unit" made up of one carbon and two hydrogens. Therefore, it is possible to substitute six functional groups on to the ethane molecule. You should also be aware that the functional groups that would be substituted for the hydrogens need not be the same, that is, you may substitute chlorine at one bond, fluorine at another, the hydroxyl radical at a third, an amine radical at a fourth, and so on.

Substituting one chlorine atom for a hydrogen atom in ethane produces ethyl chloride, a colorless, easily liquifiable gas with an ether-like odor and a burning taste, which is highly flammable and moderately toxic in high concentrations. It is used to make tetraethyl lead and other organic chemicals. Ethyl chloride is an excellent solvent and analytical reagent, as well as an anesthetic. Its molecular formula is C_2H_5Cl.

Although we are using chlorine as the functional group, it may be any of the other halogens. In addition, we are

giving the common names, while the proper names may be used on the labels and shipping papers. Ethyl chloride's proper name is chloroethane.

Substituting another chlorine produces ethylene dichloride (proper name 1,2-dichloroethane). In this case, an isomer is possible, which would be the chlorinated hydrocarbon where both chlorines attached themselves to the same carbon atom, whereby 1,1-dichloroethane is formed. These compounds have slightly different properties and different demands in the marketplace. As further chlorination of ethane occurs, we would have to use the proper name to designate which compound is being made. One of the analogues of ethylene dichloride is ethylene dibromide, a toxic material that is most efficient and popular as a grain fumigant, but it is known to be a carcinogen in test animals.

There are many uses for the halogenated hydrocarbons. Many of them are flammable; most are combustible. Some halogenated hydrocarbons are classified as neither, and a few are excellent fire-extinguishing agents (the Halons ®), but they will all decompose into smaller, more harmful molecular fragments when exposed to high temperatures for long periods of time.

B. Alcohols

The compounds formed when a hydroxyl group (-OH) is substituted for a hydrogen are called alcohols. They have the general formula R-OH. The hydroxyl radical looks exactly like the hydroxide ion, but it is not an ion. Where the hydroxide ion fits the definition of a complex ion - a chemical combination of two or more atoms that have collectively lost or (as in this case) gained one or more electrons - the hydroxide radical is a molecular fragment produced by separating the -OH from another compound, and it has no electrical charge. It does have an unpaired electron waiting to pair up with another particle having its own unpaired electron. The alcohols, as a group, are flammable liquids in the short-chain range, combustible liquids as the chain grows longer, and finally solids that will burn if exposed to high temperatures, as the chain continues to become longer. As in the case of the halogenated hydrocarbons, the most useful alcohol compounds are of the short-carbon-chain variety. Just as in the case of the halogenated hydrocarbons, the simplest alcohol is made from the simplest hydrocarbon, methane. Its name is methyl alcohol and its molecular formula is CH_3OH.

Nature produces a tremendous amount of methyl alcohol, simply by the fermentation of wood, grass, and other materials made to some degree of cellulose. In fact, methyl alcohol is known as wood alcohol, along with names such as wood spirits and methanol (its proper name; the proper names of all alcohols end in -ol). Methyl alcohol is a colorless liquid with a characteristic alcohol odor. It has a flash point of 54°F, and is highly toxic. It has too many commercial uses to list here, but among them are as a denaturant for ethyl alcohol (the addition of the toxic chemical methyl alcohol to ethyl alcohol in order to form denatured alcohol), antifreezes, gasoline additives, and solvents. No further substitution of hydroxyl radicals is performed on methyl alcohol.

The most widely known alcohol is ethyl alcohol, simply because it is the alcohol in alcoholic drinks. It is also known as grain alcohol, or by its proper name, ethanol. Ethyl alcohol is a colorless, volatile liquid with a characteristic odor and a pungent taste. It has a flash point of 55°F, is classified as a depressant drug, and is toxic when ingested in large quantities. Its molecular formula is C_2H_5OH. In addition to its presence in alcoholic beverages, ethyl alcohol has many industrial and medical uses, such as a solvent in many manufacturing processes, as antifreeze, antiseptics, and cosmetics.

The substitution of one hydroxyl radical for a hydrogen atom in propane produces propyl alcohol, or propanol, which has several uses. Its molecular formula is C_3H_7OH. Propyl alcohol has a flash point of 77°F and, like all the alcohols, burns with a pale blue flame. More commonly known is the isomer of propyl alcohol, isopropyl alcohol. Since it is an isomer, it has the same molecular formula as propyl alcohol but a different structural formula. Isopropyl alcohol has a flash point of 53°F. Its ignition temperature is 850°F, while propyl alcohol's ignition temperature is 700°F, another effect of the different structure. Isopropyl alcohol, or 2-propanol (its proper name) is used in the manufacture of many different chemicals, but is best known as rubbing alcohol.

The above-mentioned alcohols are by far the most common. Butyl alcohol is not as commonly used as the first four in the series, but it is used. Secondary butyl alcohol and tertiary butyl alcohol, so named because of the type of carbon atom in the molecule to which the hydroxyl radical is attached, must be mentioned because they are flammable liquids, while isobutyl alcohol has a flash point of 100°F. All of the alcohols of the first four carbon atoms in the alkanes, therefore, are extremely hazardous because of their combustion characteristics.

Whenever a hydrocarbon backbone has two hydroxyl radicals attached to it, it becomes a special type of alcohol known as a glycol. The simplest of the glycols, and the most important, is ethylene glycol, whose molecular formula $C_2H_4(OH)_2$. The molecular formula can also be written CH_2OHCH_2OH and may be printed as such on some labels. Ethylene glycol is a colorless, thick liquid with a sweet taste, is toxic by ingestion and by inhalation, and among its many uses is a permanent antifreeze and coolant for automobiles. It is a combustible liquid with a flash point of 240°F.

The only other glycol that is fairly common is propylene glycol which has a molecular formula of $C_3H_6(OH)_2$. It is a combustible liquid with a flash point of 210°F, and its major use is in organic synthesis, particularly of polyester resins and cellophane.

The last group of substituted hydrocarbons produced by adding hydroxyl radicals to the hydrocarbon backbone are the compounds made when three hydroxyl radicals are substituted; these are known as glycerols. The name of the simplest of this type of compound is just glycerol. Its molecular formula is $C_3H_5(OH)_3$. Glycerol is a colorless, thick, syrupy liquid with a sweet taste, and has a flash point of 320°F, and is used to make such diverse products as candy and explosives, plus many more. Other glycerols are made, but most of them are not classified as hazardous materials.

C. Ethers

The ethers are a group of compounds with the general formula R-O-R'. The R, of course, stands for any hydrocarbon backbone, and the R' also stands for any hydrocarbon backbone, but the designation R' is used to indicate that the second hydrocarbon backbone may be different from the first. In other words, both the hydrocarbon backbones in the formula may be the same, but the "'" is used to indicate that it may also be different. R-O-R as the general formula for the ethers is also correct. The fact that there are two hydrocarbon backbones on either side of an oxygen atom means that there will be two hydrocarbon names used.

The simplest of the ethers would be ether that has the simplest hydrocarbon backbones attached; those backbones are the radicals of the simplest hydrocarbon, methane. Therefore, the simplest of the ethers is dimethyl ether, whose formula is CH_3OCH_3. Dimethyl is used because there are two methyl radicals, and "di-" is the prefix for two. This compound could also be called methyl methyl ether, or just plain methyl ether, but it is better known as dimethyl ether. It is an easily liquified gas that is extremely flammable, has a relatively low ignition temperature of 66°F, and is used as a solvent, a refrigerant, a propellant for sprays, and a polymerization stabilizer.

The next simplest ether is the ether with the simplest alkane as one of the hydrocarbon backbones and the next alkane, which is methyl ethyl ether. Its molecular formula is $CH_3OC_2H_5$. It is a colorless gas with the characteristic ether odor. It has a flash point of 31 F, and an ignition temperature of only 374°F. This property, of course, makes it an extreme fire and explosion hazard.

The next simplest ether is actually the one most commonly referredto as "ether". It is diethyl ether, whose molecular formula is $C_2H_5OC_2H_5$,sometimes written as $(C_2H_5)_2O$. This ether is the compound that was widely used as an anesthetic in many hospitals. One of the hazards of all ethers, and particularly diethyl ether because of its widespread use, is that once ethers have been exposed to air, they possess the unique capability of adding an oxygen atom to their structure and converting to a dangerously unstable and explosive organic peroxide. The peroxide-forming hazard aside, diethyl etherhas a flash point of -56°F and ignition temperature of 356 F; it is a colorless, volatile liquid with the characteristic ether odor. In addition to its use as an anesthetic, it is useful in the synthesis of many other chemicals, but it is an extremely hazardous material.

Another important ether is vinyl ether, a colorless liquid with the characteristic ether odor. Its molecular formula is $C_2H_3OC_2H_3$. Vinyl ether has a flash point of -22°F and an ignition temperature of 680 F. It is highly toxic by inhalation and is used in medicine and in the polymerization of certain plastics.

D. Ketones

The ketones are a group of compounds with the general formula R-C-R'. The -C- functional group is known as the carbonyl group or carbonyl radical; it appears in many different classes of hydrocarbon derivatives. There are only a few important ketones, and they are all extremely hazardous.

The first is the simplest, again with two methyl radicals, one on either side of the carbonyl group. Its molecular formula is CH_3COCH_3. Its proper name is propanone

(propa- because of the relationship to the three-carbon alkane, propane, and -one because it is a ketone); it could logically be called dimethyl ketone, but it is universally known by its common name, acetone. Acetone is a colorless, volatile liquid with a sweet odor, has a flash point of15° F and an ignition temperature of 1,000° F, is narcotic in high concentrations, and could be fatal by inhalation or ingestion. It is widely used in manufacturing many chemicals and is extremely popular as a solvent.

The next most common ketone is methyl ethyl ketone, commonly referred to as MEK. Its molecular formula is $CH_3COC_2H_5$. MEK has a flash point of 24°F and an ignition temperature of 960° F. It is a colorless liquid with a characteristic ketone odor. It is as widely used as acetone and is almost as hazardous.

E. Aldehydes

The aldehydes are a group of compounds with the general formula R-CHO. The aldehyde functional group is always written -CHO, even though this does not represent the aldehyde's structural formula. It is written in this way so that the aldehydes will not be confused with R-OH, the general formula of the alcohols.

The simplest of the aldehydes is formaldehyde, whose molecular formula is HCHO. The second hydrocarbon backbone of the ketone is replaced by a hydrogen atom. Formaldehyde is a gas that is extremely soluble in water; it is often sold commercially as a 50 percent solution of the gas in water. The gas itself is flammable, has an ignition temperature of 806°F and a strong, pungent odor, and is toxic by inhalation. Inhalation at low concentrations over long periods of time has produced illness in many people. Beside its use as an embalming fluid, formaldehyde is used in the production of many plastics and in the production of numerous other chemicals.

The next aldehyde is acetaldehyde, a colorless liquid with a pungent taste and a fruity odor. Its molecular formula is CH_3CHO. It has a flash point of -40°F, an ignition temperature of 340°F, and is toxic by inhalation. Acetaldehyde is used in the manufacture of many other chemicals. Other important aldehydes are propionaldehyde, butyraldehyde, and acrolein.

F. Peroxides

The peroxides are a group of compounds with the general formula R-O-O-R'. All peroxides are hazardous materials, but the organic peroxides may be the most hazardous of all.

G. Esters

The esters are a group of compounds with the general formula R-C-O-O-R'. They are not generally classified as hazardous materials, except for the acrylates, which are monomers and highly flammable. Few of the rest of the class are flammable. There are some esters that are hazardous.

H. Amines

The amines are a group of compounds with the general formula $R\text{-}NH_2$, and all the common amines are hazardous. As a class the amines pose more than one hazard, being flammable, toxic, and, in some cases, corrosive. The amines are an analogous series of compounds and follow the naming pattern of the alkyl halides and the alcohols; that is, the simplest amine is methyl amine, with the molecular formula of CH_3NH_2. Methyl amine is a colorless gas with an ammonia-like odor and an ignition temperature of 806°F. It is a tissue irritant and toxic, and it is used as an intermediate in the manufacture of many chemicals.

Ethyl amine is next in the series, followed by propyl amine, isopropyl amine, butyl amine and its isomers, and so on.

I. Flammability and Pyrolysis

Fire, or combustion is a chemical reaction, and specifically it is an oxidation reaction. Oxidation is defined as the chemical combination of oxygen with any substance. In other words, whenever oxygen (and some other materials) combines chemically with a substance, that substance is said to have been oxidized. Rust is an example of oxidized iron. In this case, the chemical reaction is very slow. The very rapid oxidation of a substance is called combustion, or fire.

There are three basic theories that are used to describe the reaction known as fire. They are: the fire triangle, the tetrahedron of fire, and the life cycle of fire. Of the three, the first is the oldest and best known, the second is accepted as more fully explaining the chemistry of fire, while the third is a more detailed version of the fire triangle. Each is briefly described below.

The first of these theories, the fire triangle, is quite simplistic and provides a basic understanding of the three

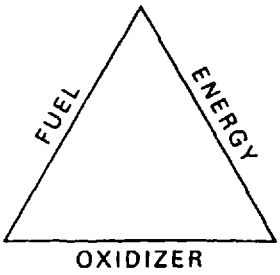


Figure 4. Illustrates the fire triangle theory.

entities that are necessary for a fire. This theory states that there are three things necessary to have a fire: fuel, oxygen (or an oxidizer), and heat (or energy). It likens these three things to the three sides of a triangle, stating that as long as the triangle is not complete, that is, the legs are not touching each other to form the closed or completed triangle, combustion cannot take place. Figure 4 illustrates the fire triangle.

The theory, as stated, is still correct. Without fuel to burn, there can be no fire. If there is no oxygen present, there can be no fire (technically, this is not correct, but we can make the fire triangle theory technically correct by changing the oxygen leg to an oxidizer leg). Finally, without heat, there can be no fire. This last statement must also be brought up to date. The fact is that heat is just one form of energy; it is really energy that is necessary to start a fire. This difference is mentioned because there are some instances where light or some other form of energy may be what is needed to start the combustion reaction. It is best to change the "heat" leg of the fire triangle to the "energy" leg. Therefore, our "updated" fire triangle now has three sides representing fuel, oxidizer, and energy.

A fuel may be defined as anything that will burn. It is important for you to grasp this definition, because most firefighters consider only flammable gases and liquids as fuels. Many others include wood, and coal as fuels, because we all recognize that they will burn, but we also tend to forget the metals, which under many circumstances are more hazardous than almost any other type of fuel. Fuels may be categorized into the following classes:

1. Elements (which include the metals, and some non-metals such as carbon, sulphur, and phosphorus)
2. Hydrocarbons
3. Carbohydrates (including mixtures that are made up partially of cellulose, like wood and paper)
4. Many covalently bonded gases (including carbon monoxide, ammonia, and hydrogen cyanide)
5. All other organic compounds

This list of materials that burn is quite long, and one must not forget that the list includes not only the pure substances such as the elements and compounds that make up the list, but mixtures of those elements and compounds. Examples of mixtures would include natural gas, which is a mixture of methane (principally), ethane, and a few other compounds, and gasoline, which is a mixture of the first six liquid alkanes (pentane, hexane, heptane, octane, nonane, and decane), plus a few other compounds. Wood (another mixture), and wood-related products, like paper, are excellent fuels, as are many polymers such as rubber, plastics, wool, silk, and the above-mentioned cellulose, which makes wood and paper the excellent fuels that they are.

The second leg of the fire triangle is oxygen, or the oxidizer leg. We changed this because oxygen, although it is the most common oxidizing agent encountered, is not the only oxidizer. Another problem with calling this second leg the oxygen leg is that most firefighters consider only oxygen from the atmosphere when they think of oxygen, and do not consider other sources. Since the greatest source of oxygen is the atmosphere, however, this has to be considered the source that must be eliminated as one of the ways to control a fire. Whatever the source, note that oxygen does not burn.

The third leg of the fire triangle is what was once called the heat leg but we have updated to call it the energy leg, so as to consider all forms capable of providing the source of energy needed to start the combustion process. This energy can be provided in one or more of several ways. The energy can be generated chemically by the combustion of some other fuel, or it can be generated by some other exothermic chemical reaction. Exothermic is defined as the emission or liberation of heat (or energy). This is the opposite of endothermic, which is defined as the taking-in or absorption of heat (or energy).

Energy may also be generated by mechanical action; that is, the application of physical force by one body upon another. Examples of this are the energy created by the friction of one matter upon another or the compression of

a gas. The force of friction in one case may produce energy that manifests itself as heat, while friction in the other case may result in a discharge of static electricity. Static electricity is created whenever molecules move over and past other molecules. This happens whether the moving molecules are in the form of a gas, a liquid, or a solid. (This is the reason why leaking natural gas under high pressure will ignite. This is also the reason why two containers must be bonded - connected by an electrical conductor - when you are pouring flammable liquids from one container to another. In any case, the amount of energy present and/or released could be more than enough to start the combustion reaction.)

A third method of generation of energy is electrical - much like the discharge of static electricity. This method may manifest itself as heat, as produced in an electrical heater, as arcing in an electrical motor or in a "short" circuit, or as the tremendous amount of energy released as lightning.

The fourth method of generation of energy is nuclear. Nuclear energy may be generated by the fission (splitting) of the atoms of certain elements and by the fusion (or joining together) of the nuclei of certain elements.

Once the energy - in many cases, heat - is generated, it must be transmitted to the fuel (the "touching" of the fuel and energy legs). This process is accomplished in three ways: conduction (the transfer of heat through a medium, such as a pan on a stove's heating element), convection (the transfer of heat with a medium, such as the heated air in a hot-air furnace), and radiation (the transfer of heat which is not dependent on any medium).

These three entities (fuel, oxidizer, an energy) make up the three legs of the fire triangle. It is a physical fact, a law of nature that cannot be repealed, that when fuel, oxidizers, and energy are brought together in the proper amounts, a fire will occur. If the three are brought together slowly, and over a long period of time, the oxidation will occur slowly, as in the rusting of iron. If the three are of a particular combination, the resulting oxidation reaction might even be an explosion. Whatever form the final release of energy takes, the thing that cannot be changed is that the chemical reaction will occur.

The second popular explanation of fire is the tetrahedron theory which is illustrated in Figure 5. This theory encompasses the three concepts in the fire triangle theory but adds a fourth "side" to the triangle, making it a pyramid, or tetrahedron; this fourth side is called the

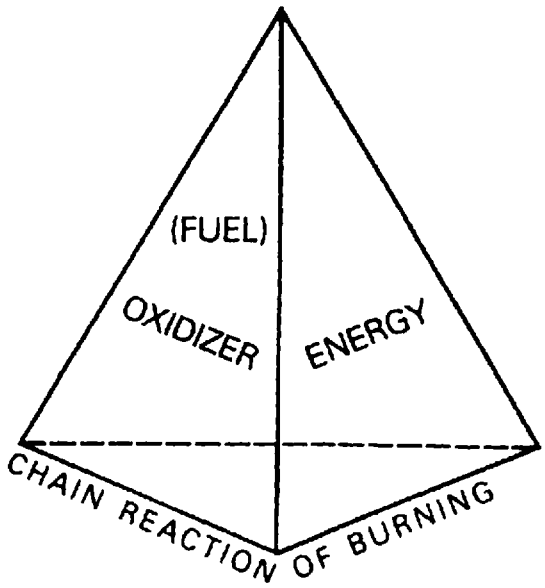


Figure 5. Illustrates the theory of the fire tetrahedron.

"chain reaction of burning". This theory states that when energy is applied to a fuel like a hydrocarbon, some of the carbon-to-carbon bonds break, leaving an unpaired electron attached to one of the molecular fragments caused by the cleavage of the bond, thus creating a free radical. This molecular fragment with the unpaired electron, or "dangling" bond, is highly reactive and will therefore seek out some other material to react with in order to satisfy the octet rule. The same energy source that provided the necessary energy to break the carbon-to-carbon bond may have also broken some carbon-to- hydrogen bonds, creating more free radicals, and also broken some oxygen-to-oxygen bonds, creating oxide radicals. This mass breaking of bonds creates the free radicals in a particular space, and in a number large enough to be near each other, so as to facilitate the recombining of these free radicals with whatever other radicals or functional groups may be nearby. The breaking of these bonds releases the energy stored in them, so that this subsequent release of energy becomes the energy source for still more bond breakage, which in turn releases more energy. Thus the fire "feeds" upon itself by continuously creating and releasing more and more energy (the chain reaction), until one of several things happens: either the fuel is consumed, the oxygen is depleted, the energy is absorbed by something other than the fuel, or this chain reaction is broken. Thus a fire usually begins as a very small amount of bond breakage by a relatively small energy (ignition)

source and builds itself up higher and higher, until it becomes a raging inferno, limited only by the fuel present (a fuel-regulated fire) or the influx of oxygen (an oxygen-regulated fire). The earlier in the process that the reaction can be interrupted, the easier the extinguishment of the fire will be. This theory claims that the propagation of all hydrocarbon fires (or fires involving hydrocarbon derivatives) depends upon the formation of the hydroxyl (-OH) radical, which is found in great quantities in all such fires.

The third theory of fire is the life cycle theory, which is illustrated in Figure 6. According to this theory, the combustion process can be categorized by six steps, rather than the three of the fire triangle or the four of the tetrahedron of fire theory. Three of the steps in this theory are the same as the only three steps in the fire triangle theory. In the life cycle of fire theory, the first step is the input heat, which is defined as the amount of heat required to produce the evolution of vapors from the solid or liquid. The input heat will also be the ignition source and must be high enough to reach the ignition temperature of the fuel; it must be continuing and self-generating and must heat enough of the fuel to produce the vapors necessary to form an ignitable mixture with the air near the source of the fuel. The second part of the life cycle of fire theory is the fuel, essentially the same as the fuel in the tetrahedron of fire and the fire triangle. It was assumed without so stating in the fire triangle theory, and is true in all three theories, that the fuel must be in the proper form to burn; that is, it must have vaporized, or, in the case of a metal, almost the entire piece must be raised to the proper temperature before it will begin to burn. The third part is oxygen in which the classical explanation of this theory only concerns itself with atmospheric oxygen, because the theory centers around the diffusion flame, which is the flame produced by a spontaneous mixture (as opposed to a pre-mixed mixture) of fuel gases or vapors and air. This theory concerns itself with air-regulated fires, so airflow is crucial to the theory; this is why only atmospheric oxygen is discussed. Ignoring oxygen and the halogens that are generated from oxidizing agents should be viewed as a flaw in this theory. The fourth part of the theory is proportioning, or the occurrence of intermolecular collisions between oxygen and the hydrocarbon molecule (the "touching" together of the oxidizer leg and the fuel leg of the fire triangle). The speed of the molecules and the number of collisions depend on the heat of the mixture of oxygen and fuel; the hotter the mixture, the higher the speed. A rule of thumb is used in chemistry that states the speed of any chemical reaction doubles for roughly every 18°F (10°C.) rise in temperature. The fifth step is mixing; that is, the ratio of fuel to oxygen must be right before ignition can occur (flammable range). Proper mixing after heat has been applied to the fuel to produce the vapors needed to burn is the reason for the "backdraft" explosion that occurs when a fresh supply of air is admitted to a room where a fire has been smoldering. The sixth step is ignition continuity, which is provided by the heat being radiated from the flame back to the surface of the fuel; this heat must be high enough to act as the input heat for the continuing cycle of fire. In a fire, chemical energy is converted to heat; if this heat is converted at a rate faster than the rate of heat loss from the fire, the heat of the fire increases; therefore, the reaction will proceed faster, producing more heat faster than it can be carried away from the fire, thus increasing the rate of reaction even more. When the rate of conversion of chemical energy falls below the rate of dissipation, the fire goes out. That is to say, the sixth step, ignition continuity, is also the first step of the next cycle, the input heat. If the rate of generation of heat is such that there is not enough energy to raise or maintain the heat of the reaction, the cycle will be broken, and the fire will go out. The life cycle of fire theory adds the concepts of flash point and ignition point (heat input) and flammable range (mixing). These terms are discussed at greater length later in this chapter.

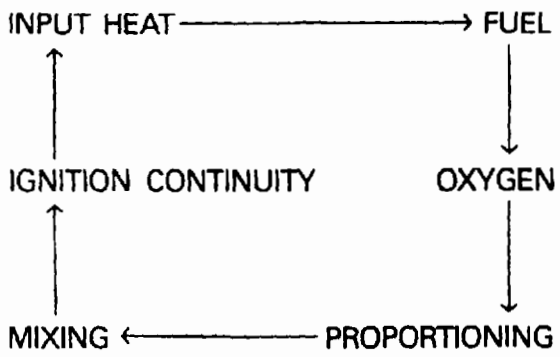


Figure 6. Illustrates the life cycle theory of fire.

J. Categories of Petroleum Liquids

Hydrocarbons are derivatives from petroleum or crude, but within the context of our immediate discussions, we shall use the terms petroleum liquids and hydrocarbon liquids as being interchangeable. From a fire standpoint, there are

flammable liquids and *combustible liquids*. Both categories of materials will burn; however, it is into which of these two categories that a liquid belongs that determines its relative fire hazard. Of the two categories, it is the flammables that are considered to be more hazardous, principally because they release ignitable vapors at lower temperatures (a concept consistent with the life cycle theory of fire).

Fire hazard is viewed from the standpoint of safety, to which in the United States, the Occupational Safety and Health Standard (OSH) is often used as the basis for classification of flammables versus a combustible material. Additionally, the U.S. Department of Transportation also has very specific definitions regarding classification of fire hazards based on safe transport of materials. For initial discussions we will adhere to the OSHA definitions, and later refer to distinctions in U.S. federal definitions which are legal standards.

For flammable liquids, the OSHA standard defines a flammable material based upon the liquid's flash point temperature. Any liquid having a flash point below 100°F is classified as being flammable. The definition for flammable liquids given by the National Fire protection Association (NFPA) includes the additional criteria that the liquid's vapor cannot exceed 40 psi at a liquid temperature of 100°F. From a practical standpoint, these criteria refer simply to the fact that any material with a flash point temperature of 100°F or less is capable of releasing vapors at a rate sufficient to be ignitable, and hence represents the greatest danger from a fire standpoint due to the possibility of spontaneous combustion. It is important to note that there are many materials that are capable of vaporizing at extremely low temperatures. A common example is gasoline whose flash point is -40°F.

The combustible liquid category are thus those liquids whose flash points are above 100°F. The category for petroleum liquids covers a range from the 100°F flash point of kerosene to the flash point of 450°F of some motor oils. Although these materials are less hazardous than flammable liquids, they still represent fire hazards and under certain conditions are as dangerous as flammables. Some typical examples of the two categories of fire hazards for petroleum liquids are given in Table 6.

The term flash point is sometimes confusing and its definition should be carefully considered. The term basically refers to the temperature that a liquid must be at before it will provide the fuel in vapor form necessary for the condition of spontaneous combustion to occur. Perhaps more accurate a definition is that it refers to the lowest temperature a liquid may be and still have the ability to liberate flammable vapor at a sufficient rate that, when mixed with the proper amounts of air, the air-fuel mixture will flash in the presence of a source of energy or ignition source. This provides a more pragmatic viewpoint on how fires occur. In essence, when a material liberates vapor, this vapor represents fuel. When it combines with oxygen in air in the proper amounts, we now have a flammable mixture, and hence all that is needed to complete the fire triangle is a source of energy. In essence then, it is the vapor (air-fuel mixture) that burns, and not the material itself. It, therefore, stands to reason that, assuming sufficient amounts of air to be present, the greater the volume of released vapor, the larger and more intense will be the fire.

Table 6. Common Examples of Flammable and Combustible Petroleum Liquids

Flammables	Flash Point, °F	Combustible	Flash Point, °F
Gasoline	-40	Kerosene	100
Ethers	-30	Fuel oils	100-140
Acetone	-4	Diesel oil	130
Methanol	52	Lubricating oil	300
Crude Oil and Naphtha	20-90	Asphalt	400

Another term that is often given attention to is the fire point. The fire point temperature refers to the temperature which the liquid must be at before released vapor is in sufficient quantity to continue to burn. With the flash point temperature, the amounts of vapor being released at the exact flash point temperature will not sustain the fire and, after flashing across the liquid surface, the flame extinguishes. For many materials the fire point is only a few degrees above the flash point, but regardless, the flash point is perhaps the more universally accepted basis of classifying a fire hazard largely because a flash fire will generally be sufficient to ignite combustible materials. Both the terms flash point and fire point (or also known as the ignition point) are discussed in greater detail later in this chapter.

K. Fire Extinguishment

Fire is an exothermic (heat-liberating) reaction. There must be a continuous feedback of energy (heat) to keep the reaction going. Also, heat is dissipated from the fire by

one or more of the methods of transferring heat: conduction, convection, and radiation. Heat energy is also fed back to the fire by radiation from the flame, and this source of heat keeps the fire going. If we could devise a way to interrupt that feedback of heat to the fuel, the continuity of the fire would be broken, and the fire would go out. Hence, a fire-extinguishing agent is needed that siphons heat energy away from the fire, reduces the temperature of the material burning, and cools the surroundings below the ignition temperature of the fuel, so that there would not be a re-ignition of flammable vapors once the fire was extinguished.

Water is the most common extinguishing agent that performs this task. Water has many disadvantages, however. Some of the drawbacks to the use of water as an extinguishing agent include its propensity to conduct electricity (which, of course, is deadly if the water is applied incorrectly), its low viscosity (which allows it to run off a wall instead of sticking there), and a high surface tension (which prevents it from penetrating tightly arranged materials). Water also allows heat to be radiated through it, freezes at a relatively high temperature, splashes about, and displaces many flammable liquids, causing them to spread rapidly, while burning all the time. This list of problems also includes the fact that water itself will violently react with many of the hazardous materials it is supposed to control.

In addition to the fact that water is relatively inexpensive and is usually available in large quantities, there are two specific properties of water that make it invaluable. Those properties are its latent heat of vaporization and its specific heat. The latent heat of vaporization of a substance is defined as the amount of heat a material must absorb when it changes from a liquid to a vapor or gas. The specific heat of a substance is defined as the ratio between the amount of heat necessary to raise the temperature of a substance and the amount of heat necessary to raise the same weight of water by the same number of degrees.

The specific heat of water is important because it is so high in relation to the specific heat of other materials; this fact means that it takes more energy to raise the temperature of water than just about any other material. Therefore, the temperature of the materials to which water has been applied will drop faster than the temperature of water will rise. The specific heat may be reported as the number of calories needed to raise the temperature of one gram of the material 1°C, or the number of British Thermal Units (BTUs) needed to raise one pound of the material, 1°F. Therefore, when water is applied to a fire, it begins absorbing heat from the fire, thereby cooling the fire down while the water heats up. For every BTU absorbed, the temperature of the water will rise 1°F per pound of water involved. The important thing to remember here is that the rise in temperature of the water is caused by heat energy absorbed from the fire. The water is siphoning the heat away from the burning material. The temperature of the water will continue to rise, as long as the fire is producing heat, until it reaches its boiling point of 212°F. At this time the latent heat of vaporization of water comes into play. At 212°F the water is still a liquid and will remain a liquid unless more energy is received from the fire. At this time, there is a phase change from liquid to vapor, with no increase in temperature; that is, wateras a liquid at 212°F converts to water vapor at 212°F. It is at this phase change that the latent heat of vaporization of water does its work, for while water will absorb 1 BTU per pound for every increase of 1°F, up to 212°F, at 212°F when the phase change occurs, 970 BTUs are absorbed per pound. That sudden, rapid, and massive withdrawal of heat energy from the fire at this time is what gives water its tremendous fire-extinguishing capabilities, which are so valuable as to overcome the previously mentioned disadvantages. Heat is withdrawn from the burning material so rapidly, and in such large quantities, that the temperature of the burning fuel drops dramatically, usually well below its ignition temperature. When this happens, of course, the fire goes out. The latent heat of vaporization also explains why steam at 212°F is hotter than boiling water at 212°F. The live steam has 970 BTU's of energy more than the boiling water.

This latent heat of vaporization also explains why materials wet with water are difficult, and sometimes impossible, to ignite. If a combustible substance has absorbed enough water to be considered wet, or just damp, this water will act as a barrier to ignition by its evaporation as it is heated. As heat is applied to the wet substance, the water begins to evaporate (go through the phase change from a liquid to a vapor). To make this phase change, the water must absorb 1 BTU for every pound of water present for every 1°F it rises until it reaches 212°F, whereupon it must absorb 970 BTUs for every pound of water present. Before any combustible material that has been wet with water can burn, the water (which has preferentially been absorbing the applied heat and thus keeping the combustible material itself from heating to its ignition temperature) must be driven off. If in the process of driving off the water enough heat energy from the potential ignition source has been used up so that there is not enough left (for example

a burnt-out match) to raise the combustible to its ignition temperature, there will be no fire.

Water, of course, does not work with all materials. There is a special class of materials that are water reactive, and hence water becomes an unacceptable extinguishing agent. For these class of materials another approach to eliminating the fire is taken. Specifically, we must remove the oxidizer leg from the fire triangle; i.e. cut off the supply of oxygen which fuels the air to fuel mixture.

L. Flammability of Petroleum Products

The following discussions are limited to petroleum liquids. From a fire standpoint, the two main categories of petroleum liquids are flammable and combustible, and are determined mainly by the liquid's flash point. Both categories of liquids will burn but it is into which of these two categories the liquid belongs that determines its relative fire hazard. As already noted, flammable liquids are generally considered the more hazardous of the two categories mainly because they release ignitable vapors.

Following OSHA definitions, a flammable material is any liquid having a flash point below 100°F. The NFPA expands this definition by including the stipulation that the vapor cannot exceed 40 psi (pounds per square inch) at a liquid temperature of 100°F, with the theory being that such liquids are capable of releasing vapor at a rate sufficient to be ignitable. Since this aspect of the definition relating to vapor pressure has little fire-ground application it is often ignored. However, it is important to note that if the heat from a fire raises the liquid temperature to a temperature above the liquid's flash point, it will automatically increase the vapor pressure inside a closed container. Any other source of sufficient heat will produce the same result.

Within the combustible liquid category are those materials with a flash point above 100°F. Combustible liquids are considered less hazardous than flammable liquids because of their higher flash points. However, this statement can be misleading since there are circumstances when it is not a valid assumption. It is possible for certain combustible liquids to be at their flash point when a hot summer sun has been striking their metal container for some time. Additionally, during the transportation of some combustible products, the product is either preheated or a heat source is maintained to make the product more fluid than it would be at atmospheric temperatures. One reason this is done is to facilitate transportation or pumping; i.e. to aid with the movement of a material that is very viscous, such as asphalt or tar. Also, some materials classed as combustible solids will be heated to their melting point. Naphthalene is one example of this treatment. Naphthalene might be heated to a temperature above its melting point, which is about 176°F. Despite its fairly high ignition temperature (almost 980°F), it would not be unreasonable to surmise that a spill of liquid naphthalene could present a serious fire hazard. Fortunately, with naphthalene, quick action with adequate amounts of water applied as spray streams should cool and solidify it, thus greatly minimizing the fire risk.

It is important to note that a combustible liquid at or above its flash point will behave in the same manner that a flammable liquid would in a similar emergency. As an example No.2 fuel oil when heated to a temperature of 150°F can be expected to act or react in the same way gasoline would at 50°F. In most instances, however, to reach this elevated temperature will require the introduction of an external heat source. Some common examples of combustible petroleum liquids are given in Table 7.

Table 7. Examples of Petroleum Liquids That are Combustible

Product	Flash Point (°F)
Kerosene	100+
Fuel Oils	100 - 140
Diesel Oil	130
Lubricating Oil	300
Asphalt	400

It is important to note that the extinguishing techniques, controlling actions, or fire-prevention activities implemented can differ greatly depending upon which of the two categories the liquid falls in. To have the ability to categorize a liquid correctly when it is not so identified, it is only necessary to know its flash point. By definition, the flash point of a liquid determines whether a liquid is flammable or combustible.

The categories of liquids are further subdivided into classes according to the flash point plus the boiling point of certain liquids. These divisions are summarized in Table 8, which shows that flammable liquids fall into Class 1, and combustible liquids into Classes 2 and 3. The products that are at the low end (100°F) of the Class 2 combustible-liquid group might be thought of as borderline cases. These could act very much like flammable liquids

if atmospheric temperatures were in the same range. It is not a common industry practice to identify either stationary or portable (mobile) liquid containers by the class of liquid it contains. The usual practice is to label either "flammable" or "combustible" and include the required U.S. Department of Transportation placard.

Table 8. Classes of Flammable and Combustible Liquids

Class	Flash Point (°F)	Boiling Point (°F)
1	Below 100	—
1A	Below 73	Below 100
1B	Below 73	At or above 100
1C	73-99	—
2	100-139	—
3	140 or above	Below 100
3A	140-199	At or above 100
3B	200 or above	—

Basically, the flash point is the temperature a liquid must be at before it will provide the fuel vapor required for a fire to ignite. A more technical definition for flash point is: The lowest temperature a liquid may be at and still have the capability of liberating flammable vapors at a sufficient rate that, when united with the proper amounts of air, the air-fuel mixture will flash if a source of ignition is presented. The amounts of vapor being released at the exact flash-point temperature will not sustain the fire and, after flashing across the liquid surface, the flame will go out. It must be remembered that at the flash-point temperature, the liquid is releasing vapors and, as with other ordinary burnable materials, it is the vapors that burn. The burning process for both ordinary combustible solids and liquids requires the material to be vaporized. It may also be in the form of a very fine mist, which will be instantly vaporized if a source of heat is introduced. It is not the actual solid or the liquid that is burning, but the vapors being emitted from it. For this reason, when we speak of a fuel we are referring to the liberated vapor. It is an accepted phenomenon, assuming sufficient amounts of air to be present, that the greater the volume of released vapor, the larger the fire will be.

The technical literature sometimes refers to the "fire point", which in most instances is just a few degrees above the flash point temperature, and is the temperature the liquid must be before the released vapor is in sufficient quantity to continue to burn, once ignited. However, because a flash fire will normally ignite any Class "A" combustible present in the path of the flash, it is reasonable to accept the flash point as being the critical liquid temperature in assessing a fire hazard. Any of the other combustibles ignited by the flash fire, that is, wood, paper, cloth, etc., once burning, could then provide the additional heat necessary to bring the liquid to its fire point.

A crucial objective upon arrival of the first responding fire forces is to determine if the liquid present is a product that is vaporizing at the time or, if it is not, and what condition may be present that is capable of providing the required heat to cause the liquid to reach its flash point. This information would have a direct influence on the selection of control and/or extinguishing activities. An emergency involving a petroleum liquid, which is equal to or above flash point, means that a fuel source consisting of flammable vapors will be present. This, in turn, means the responding fire-fighting forces will be faced with either a highly hazardous vapor cloud condition or with a fire if ignition has occurred before arriving at the scene. Conversely, if it is a liquid at a temperature below its flash point, then fuel would not be immediately available to burn.

As explained earlier by the theories of fire, a source of air or more specifically, oxygen must be present. A reduction in the amount of available air to below ideal quantities causes the fire to diminish. Moreover, reduce the fuel quantity available and the fire will also diminish in size. Almost all extinguishing techniques developed are methods of denying the fire one or both of these requirements. By cooling a material below its flash point, vapor production is halted, thus removing the fuel from the fire. When utilizing a smothering-type extinguishing agent, the principle involved consists of altering the air-fuel mixture. When the vapor is no longer in its explosive range, the fire dies, either due to insufficient fuel or a lack of oxygen. The flash point tells us the conditions under which we can expect the fuel vapor to be created, but it is the explosive range which tells us that a certain mixture of fuel vapor and air is required for the vapor to become ignitable. The terms flammable limit and combustible limit are also used to describe the explosive range. These three terms have identical meanings and can be used interchangeably. In chapter 5 the reader can find a compilation of published data that lists the explosive ranges for the various flammable liquids and gases. This information is reported as the lower explosive limits (LEL) and the upper explosive limits (UEL). The values that are reported for the LEL and UEL are given as a percentage of the total volume of the air-fuel mixture. The area between the LEL

and the UEL is what is known as the explosive range. The figures given for the amount of fuel vapor required to place a substance within its explosive range are shown as a percentage of the total air-fuel mixture. To compute how much air is required to achieve this mixture, subtract the listed percentage from 100 percent: the remainder will be the amount of air needed. Even though it is only the oxygen contained in the air that the fire consumes, flammable ranges are shown as air-fuel ratios because it is the air that is so readily available. Any air-fuel mixture in which the vapor is above the UEL, or any air-fuel mixture in which the vapor is below the LEL, will not burn. Using gasoline as an example, the explosive range can be computed as follows:

	LEL(%)	UEL (%)
Gasoline vapor	1.5	7.6
Air	98.5	92.4
Total volume	100	100

This example helps to illustrate that large volumes of air are required to burn gasoline vapors. The explosive ranges for the different grades of gasoline, or even those of most other petroleum liquids, are such that average explosive-range figures that are suitable for use by the fire fighter would be the LEL at 1 percent and the UEL at about 7 percent. The vapor content of a contaminated atmosphere may be determined through the use of a combustible gas-detecting instrument, referred to as an explosimeter.

If a fire involving a petroleum liquid does occur, an extinguishing technique that may be appropriate is the altering of the air-fuel mixture. One technique utilized will necessitate the use of an extinguishing agent such as a foam with the capability of restricting the air from uniting with the vapor. Another technique is to prevent the liquid from having the ability to generate vapor. Usually this is a cooling action and is accomplished with water spray streams. In both cases, extinguishment is accomplished as a result of altering the air-fuel mixture to a point below the LEL for the specific liquid.

We will now devote attention to the so-called ignition temperature. Consider the emergency situation where there is a spill of gasoline. We may immediately conclude that two of the requirements for a fire exist. First, the gasoline, which would be at a temperature above its flash point, will be releasing flammable vapors; thus a source of fuel will be present. Moreover, there is ample air available to unite with the fuel thus there is the potential for the mixture to be in its explosive range. The only remaining requirement needed to have a fire is a source of heat at or above the ignition temperature of gasoline. Technically speaking, all flammable vapors have an exact minimum temperature that has the capability of igniting the specific air-vapor mixture in question. This characteristic is referred to as the ignition temperature and could range from as low as 300°F for the vapor from certain naphthas to over 900°F for asphaltic material vapor. Gasoline vapor is about halfway between - at 600°F. A rule of thumb for the ignition temperature of petroleum-liquid vapors is 500°F. This figure may appear low for several of the hydrocarbon vapors, but it is higher than that of most ordinary combustibles, and is close enough to the actual ignition temperatures of the products most frequently present at emergency scenes to give a suitable margin of safety.

In emergency situations, it is best to take conservative approaches by assuming that all heat sources are of a temperature above the ignition temperature of whatever liquid may be present. This approach is not an overreaction when it is realized that almost all the normally encountered spark or heat sources are well above the ignition temperature of whatever petroleum liquid might be present. Among the more common sources of ignition would be smoking materials of any kind (cigarettes, cigars, etc.), motor vehicles, and equipment powered by internal combustion engines: also electrically operated tools or equipment, as well as open-flame devices such as torches and flares. The removal of any and all potential ignition sources from the area must be instituted immediately and methodically. The operation of any motor vehicle, including diesel-powered vehicles, must not be permitted within the immediate vicinity of either a leak or spill of a flammable liquid. The probability of a spark from one of the many possible sources on a motor vehicle is always present. Also, under no circumstances should motor vehicles be allowed to drive through a spill of a petroleum product.

Ignition sources are not necessarily an external source of heat; it could be the temperature of the liquid itself. Refineries and chemical plants frequently operate processing equipment that contains a liquid above its respective ignition temperature. Under normal operating conditions, when the involved liquid is totally contained within the equipment, no problems are presented because the container or piping is completely filled with either liquid or vapor. If full and totally enclosed, it means there can be no air present; thus an explosive or ignitable

mixture cannot be formed. If the enclosed liquid which in certain stages of its processing may be above the required ignition temperature should be released to the atmosphere, there is a possibility that a vapor-air mixture could be formed and hence, ignition could occur. This type of ignition is referred to as auto-ignition. Auto-ignition is defined as the self-ignition of the vapors emitted by a liquid heated above its ignition temperature and that, when escaping into the atmosphere, enter into their explosive range. Some typical ignition temperatures for various petroleum liquids are 600°F for gasoline, 550°F for naphtha and petroleum ethers, 410°F for kerosine, and 725°F for methanol.

From the above discussions, the important elements that are responsible for a fire are:

- Fuel in the form of a vapor that is emitted when a liquid is at or above its flash point temperature.
- Air that must combine with the vapor in the correct amounts to place the mixture in the explosive range.
- Heat, which must be at least as hot as the ignition temperature, must then be introduced.

In addition to fuel, oxygen, and energy, the tetrahedron of fire theory identifies the chemical chain reaction of the flame as a requirement for a fire to sustain itself. The fourth side of the tetrahedron is the chain reaction, however, from a practical standpoint it does not appear to have a significant influence on normal fire-control practices. It is known that when using a dry chemical, extinguishment is achieved by the interruption of the chain reaction propagating the flame rather than by a smothering action, however this knowledge doesn't really alter the practical application of this technique to fire fighting.

Petroleum liquids have certain characteristics that can exert an influence on the behavior of the liquid and/or vapor that is causing the problem. For this reason, these features may have a bearing on the choice of control practices or extinguishing agents under consideration. These characteristics include the weight of the vapor, the weight of the liquid, and whether the liquid will mix readily with water. The specific properties of importance are vapor density, specific gravity, and water solubility. Before discussing these important physical properties, let's first examine the data in Table 9 which lists the flammability limits of some common gases and liquids. Two general conclusions can be drawn. First, the lower the material's LEL, obviously the more hazardous. Also note that there are some materials that have wide explosive ranges. This aspect is also significant from a fire standpoint. As an

Table 9. Limits of Flammability of Gases and Vapors, % in Air

Gas or Vapor	LEL	UEL
Hydrogen	4.00	75.0
Carbon monoxide	12.50	74.0
Ammonia	15.50	26.60
Hydrogen sulfide	4.30	45.50
Carbon disulfide	1.25	44.0
Methane	5.30	14.0
Ethane	3.00	12.5
Propane	2.20	9.5
Butane	1.90	8.5
Iso-butane	1.80	8.4
Pentane	1.50	7.80
Iso-pentane	1.40	7.6
Hexane	1.20	7.5
Heptane	1.20	6.7
Octane	1.00	3.20
Nonane	0.83	2.90
Decane	0.67	2.60
Dodecane	0.60	...
Tetradecane	0.50	...
Ethylene	3.1	32.0
Propylene	2.4	10.3
Butadiene	2.00	11.50
Butylene	1.98	9.65
Amylene	1.65	7.70
Acetylene	2.50	81.00
Allylene	1.74	...
Benzene	1.4	7.1
Toluene	1.27	6.75
Styrene	1.10	6.10
o-Xylene	1.00	6.00
Naphthalene	0.90	...
Anthracene	0.63	...
Cyclo-propane	2.40	10.4
Cyclo-hexene	1.22	4.81
Cyclo-hexane	1.30	8.0
Methyl cyclo-hexane	1.20	...
Gasoline-regular	1.40	7.50
Gasoline-73 octane	1.50	7.40
Gasoline-92 octane	1.50	7.60
Gasoline-100 octane	1.45	7.50
Naphtha	1.10	6.00

example, comparing hydrogen sulfide to benzene, although the LEL for H_2S is more than 3 times greater, its explosive range is 7 times wider. This would suggest that H_2S is an extremely hazardous material even though its LEL is relatively high. In fact, H_2S fires are generally so dangerous that the usual practice is to contain and allow burning to go to completion rather than to fight the fire.

1. Estimating Lower Flammable Limits

The following discussion provides a plant caculation method for lower explosion limit concentrations for flare stacks or leaking valves that could ignite.

Explosivity limits for various pure components are given in Table 9. The limits of flammability (a concentration, C) for a mixture of gases can be computed from the following expression:

$$\frac{1}{C_L} = \frac{y_1}{C_{L1}} + \frac{y_2}{C_{L2}} + \cdots + \frac{y_n}{C_n} \qquad (1)$$

where: C_L = Lower explosive limit concentration of the mixture in air

y_1 = Mole fraction (or volume fraction) of component 1 in the mixture

y_n = Mole fraction of the nth component

C_{L1} = Lower explosive limit concentration of component 1 in air

C_n = Lower explosive limit of the nth component.

Equation 1 is accurate for mixtures of paraffinic gases or for mixtures of H_2, CO and CH_4. It is only approximate for mixtures of H_2 and C_2H_4, H_2 and C_2H_2, H_2S and CH_4 or CH_4 and $C_2H_2Cl_2$. It is even less accurate for mixtures of flammable gases with steam or inerts. Nevertheless, for the accuracy required here, this simple equation should be tried first in all cases. When dealing with a mixture of flammable gases and inerts, the simplest way to approximate C_L is to use the above equation with C_L taken to be equal for the inert components. This step treats the inerts as a simple diluent in an ideal mixture. It would give only a rough approximation for mixtures such as H_2 and H_2O vapor, where a component which is inert in the cold mixture nevertheless enters into the reactions taking place in the flame. In such cases, if a rough approximation of C_L is not good enough, then more accurate methods described below should be used.

Application of this procedure to inadvertently ignited safety valve discharges can involve a special problem. Certain combinations of pressure ratio and length of safety valve riser can result in choked flow, with a pressure discontinuity at the exit. The pressure of the jet then adjusts to atmospheric pressure in a system of shock waves or expansion waves over a distance of a few pipe diameters. These waves can affect the local mixing of the jet with the crosswind. Since the calculation procedure incorporates correlations for subsonic jets, it cannot be expected to be entirely accurate in this case. Nevertheless, since the wave system occupies a very small portion of the flow field influenced by the jet, the procedure can still be counted on to provide a useful approximation of the gross flame length and flame shape when the actual discharge velocity and diameter are used in the calculation.

Credit for additional height of the flame center for multiple valve installations may be taken by clustering the safety valve discharge pipes to the atmosphere. The following procedure should be used for determining equivalent diameter and exit velocity to be used in the flame center calculation. Diameter and velocity are based on the total actual area of the clustered vents.

For Equal Diameter Vents:

$$D_{jequ.} = \left[4 * (\textit{sum of vent areas})/\pi\right]^{0.50} = d * n$$

$V_{jequ.}$ = actual velocity of any one vent.

For Unequal Diameter Vents :

$$D_{jequ.} = \left[4 * (\textit{sum of vent areas})/\pi\right]^{0.50} = \sqrt{d_1^2 + d_2^2 + \cdots + d_n^2}$$

$U_{jequ.}$ = Total Gas Rate / Total Vent Area

$$= \frac{1.273 * 10^{-3} * Q}{(D_{jequ.})^2}$$

In the above expressions, the terms are defined as follows:

d, d_1, d_2, d_n = Diameter of individual vents, in meters

D_{jequ} = Equivalent vent diameter to be used in flame calculation, in meters

n = Number of vents in cluster (n > 3)

Q = Total gas rate of all valves, in dm^3/s at one atmosphere and the release temperature

$U_{jequ.}$ = Equivalent vent exit velocity to be used in flame calc., in m/s

Let's now turn attention back to the flammability limit itself. When small increments of a combustible gas are successively mixed with air, a concentration is finally attained in which a flame will propagate if a source of ignition is present. This is referred to as the Lower Flammable Limit (or lower explosion limit, LEL or LFL) of the gas in air. As further increments of the gas are added, a higher concentration of flammable gas in air will finally be attained in which a flame will fail to propagate. The concentration of gas and air just as this point is reached is referred to as the Upper Flammable Limit (UFL or upper explosion limit, UEL) of the gas in air.

Safety requires that only the most reliable experimentally determined flammable limit data be considered in purging calculations.

Below atmospheric pressure there is no effect on the limits of flammability of natural gas-air mixtures and most other gas-air mixtures. Below about 25 mm absolute pressure, carbon monoxide-air mixtures are not flammable.

From atmospheric pressure, up to 2170 kPa, the lower limit of flammability is not affected, but the upper limit rises as the pressure on the mixture is increased. This widens the limits of flammability as the pressure increases, as shown in Table 10. Above 2170 kPa the lower limit will be reduced.

It is necessary, in approaching most problems to obtain the limits of flammability of the particular gas mixture in question. Few industrial fuel gases are composed of pure gases or vapors, but are mixtures in most cases of many different gases. If the equipment and time are available, a number of mixtures of the fuel gas-air mixtures may be prepared and their flammabilities tested by ignition but it is much easier to determine the flammability limits of complex gas mixtures by calculation. Experience has shown that the results obtained are sufficiently dependable.

Table 10. Effect of Increase in Pressure on Raising the Upper Flammability Limit

Gage Pressure, kPa		0	500	1000	1500	2000	2500
Methane and Natural Gas	Approx.	15	17	20	25	31	42
Coke Oven Gas	Approx.	31	35	44	57	72	-
Multipliers*		1	1.2	1.5	2.0	2.6	3.7

* For estimating the upper limit of gases other then those given when the limits at 0 gage pressure are known, apply the multipliers indicated in the table to the present range in flammability, adding the new range to the lower limit at 0 gage pressure to find the new upper limit.

A calculation of the flammability limits of complex gas mixtures is carried out by the application of the mixture rule. Stated simply, the mixture rule is that if two limit mixtures of different gases are added together, the resulting mixture also will be a limit mixture. The mathematical statement of this law is as follows:

$$C_L = \frac{1}{\sum(y_1/C_{L1} + y_2/C_{L2} + y_3/C_{L3} + \ldots + y_n/C_n)} \qquad (2)$$

where y_1, y_2, y_3, etc. , are the proportions of each combustible gas present in the original mixture, free from air and inerts so that $y_1 + y_2 + y_3 + \ldots y_n = 100$, and C_{L1}, C_{L2}, $C_{L3} \ldots C_{ln}$, etc., are the lower limits of flammability of the mixture. A similar procedure would be applied to determine the upper limit of flammability.

An example of the application of this law is given for natural gas having the following composition:

Gas	% By Volume	%Gas in Air Lower Limit
Methane	80.0	5.00
Ethane	15.0	3.10
Propane	4.0	2.10
Butane	1.0	1.86

$$\text{Lower Limit} = \frac{100}{\frac{80.0}{5.00} + \frac{15.0}{3.10} + \frac{1.0}{1.86}} = 4.30\% \text{ Gas in Air}$$

Any oxygen contained in a mixture may be considered as though it were a part of the air required for the combustion, and the analysis of the flammable mixture should be converted to an air-free basis before the flammable limits are calculated.

When mixtures contain appreciable amounts of nitrogen and carbon dioxide, calculation of the flammability limits becomes more complicated and requires the use of an extension of the mixture rule. In this modified method, the inert gases are taken into consideration by assuming that the original mixture is composed of a number of submixtures of inert gas-combustible gas, the flammability limits of which have been experimentally determined in a similar manner as have the limits for the pure gases as given in Table 9. Figures 7, 8, and 9 provide the flammability limits of mixtures of some common gases present in fuels with CO_2, N_2 and H_2O.

An illustration of the application of this modified mixture rule is given in Table 11. In this example, a producer gas has the composition shown at the top of the table. The CO_2 and N_2 may be apportioned with the different combustibles in any of several ways, two of which are represented by calculations A and B in Table 11.

In these examples, the inerts CO_2 and N_2 are combined with the combustibles H_2 and CO and the small amount of CH_4 is taken alone. Next, the ratio of inert to combustible

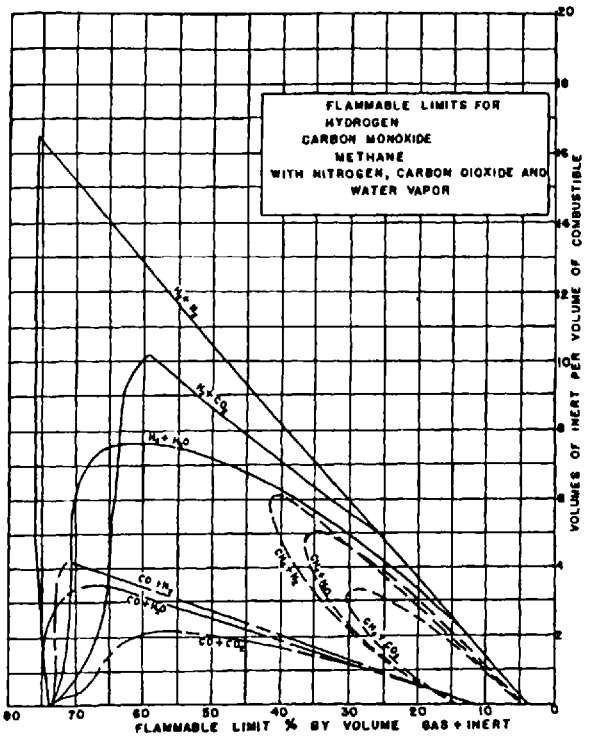


Figure 7. Flammable limits for hydrogen, carbon monoxide, methane, with nitrogen, carbon dioxide and water vapor.

is obtained for each group and the flammable limits for each such mixture are obtained from Figure 9. The mixture rule formula is now applied, using the data as just obtained, and the limits are calculated as shown in Table 10.

The summary at the bottom of Table 10 indicates the relative agreement between the calculated data and that experimentally determined for this particular producer gas. It is suggested that the difference between calculated and determined data in this case may be due more to inaccuracies in the analysis of the producer gas (particularly for methane) than to the fault of the mixture rule formula. This points up the fact that reliable gas analyses also are a necessary part of the calculated flammability limit data.

2. Vapor Density

Vapor density is a measure of the relative weight of vapor compared to the weight of air. Published data on the characteristics of petroleum products usually include the vapor density. The value of unity has been arbitrarily assigned as the weight of air. Hence any vapor that is reported to have a density of greater than 1 is heavier than air, and any vapor with a density of less than 1 is lighter than air. Vapors weighing more than 1 will usually flow like water, and those weighing less will drift readily off into the surrounding atmosphere. Even heavier-than-air flammable petroleum-liquid vapor can be carried along with very slight air currents. It may spread long distances before becoming so diluted with enough air as to place it below the lower explosive limit (LEL), at which time it would become incapable of being ignited. There are catastrophic incidences that have occurred whereby ignitable air-vapor mixtures have been detected as far as one-half mile from the vapor source. For this reason, while responding to a spill or leak, we must consider environmental and topographical features of the surroundings, such as wind direction, the slope of the ground, any natural or artificial barriers that may channel the liquid or vapors. It is critical in a non-fire incident such as a spill or leak to determine the type of petroleum liquid present and its source. Information about the material's vapor density enables us to make reasonable predictions as to the possible behavior of the emitting vapor. These factors may influence the route of approach, the positioning of firefighting apparatus and personnel, the need for and the route of evacuation, and the boundaries of the potential problem area. It is essential that no apparatus or other motor vehicles or personnel be located in the path that a vapor cloud will most likely follow.

THE CALCULATION OF FLAMMABLE LIMITS

Gas Analysis Gas Composition		Combinations Chosen	Total	Ratio Inert/Combustible	Flammable Limits (Fig. 1) Lower	Upper
H_2	12.4%	12.4 H_2 + 6.2 CO_2	18.6%	0.50	6.0	71.5
CO	27.3	27.3 CO + 53.4 N_2	80.7%	1.96	39.8	73.0
CH_4	0.7	0.7 CH_4	0.7%	0.00	5.0	15.0
CO_2	6.2					
O_2	0.0					
N_2	53.4					

CALCULATION A

$$\text{Lower Limit} = \frac{100}{\frac{18.6}{6.0} + \frac{80.7}{39.8} + \frac{0.7}{5.0}} = 19.0$$

$$\text{Upper Limit} = \frac{100}{\frac{18.6}{71.5} + \frac{80.7}{73.0} + \frac{0.7}{15.0}} = 70.8$$

Gas Analysis	12.4 H_2 + 53.4 N_2	65.8	4.31	22.0	76.0
	27.3 CO + 6.2 CO_2	33.5	0.23	15.0	71.0
	0.7 CH_4	0.7	0.7	5.0	15.0

CALCULATION B

$$\text{Lower Limit} = \frac{100}{\frac{65.8}{22.0} + \frac{33.5}{15.0} + \frac{0.7}{5.0}} = 18.7$$

$$\text{Upper Limit} = \frac{100}{\frac{65.8}{76.0} + \frac{33.5}{71.0} + \frac{0.7}{15.0}} = 71.9$$

Summary	Lower Limit		Upper Limit	
Determined	20.7		73.7	
Calculation A	19.0	use 18.7	70.8	use 73.7
Calculation B	18.7		71.9	

Table 11. The Calculation of Flammable Limits.

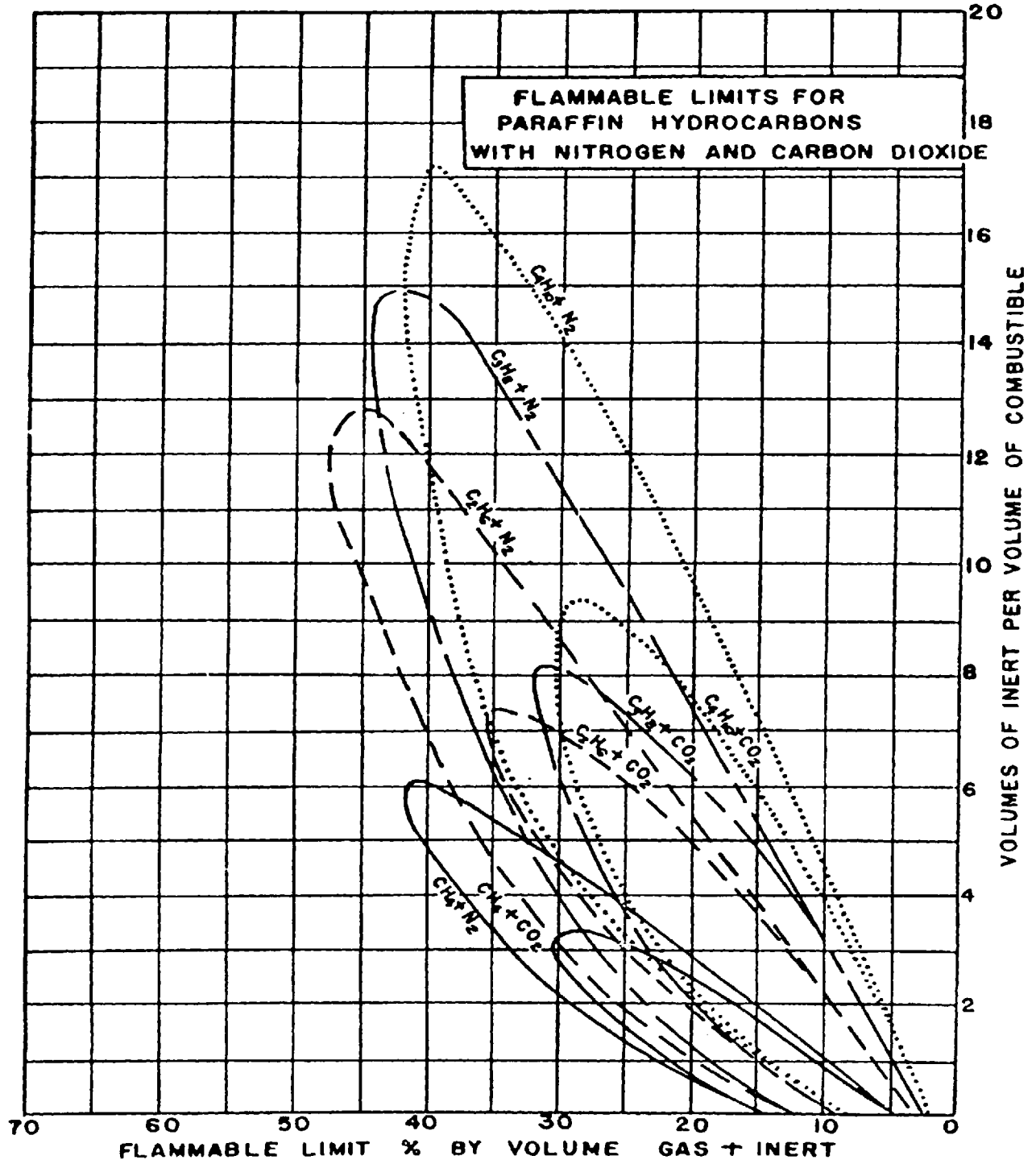


Figure 8. Flammable limits for paraffin hydrocarbons, with nitrogen and carbon dioxide.

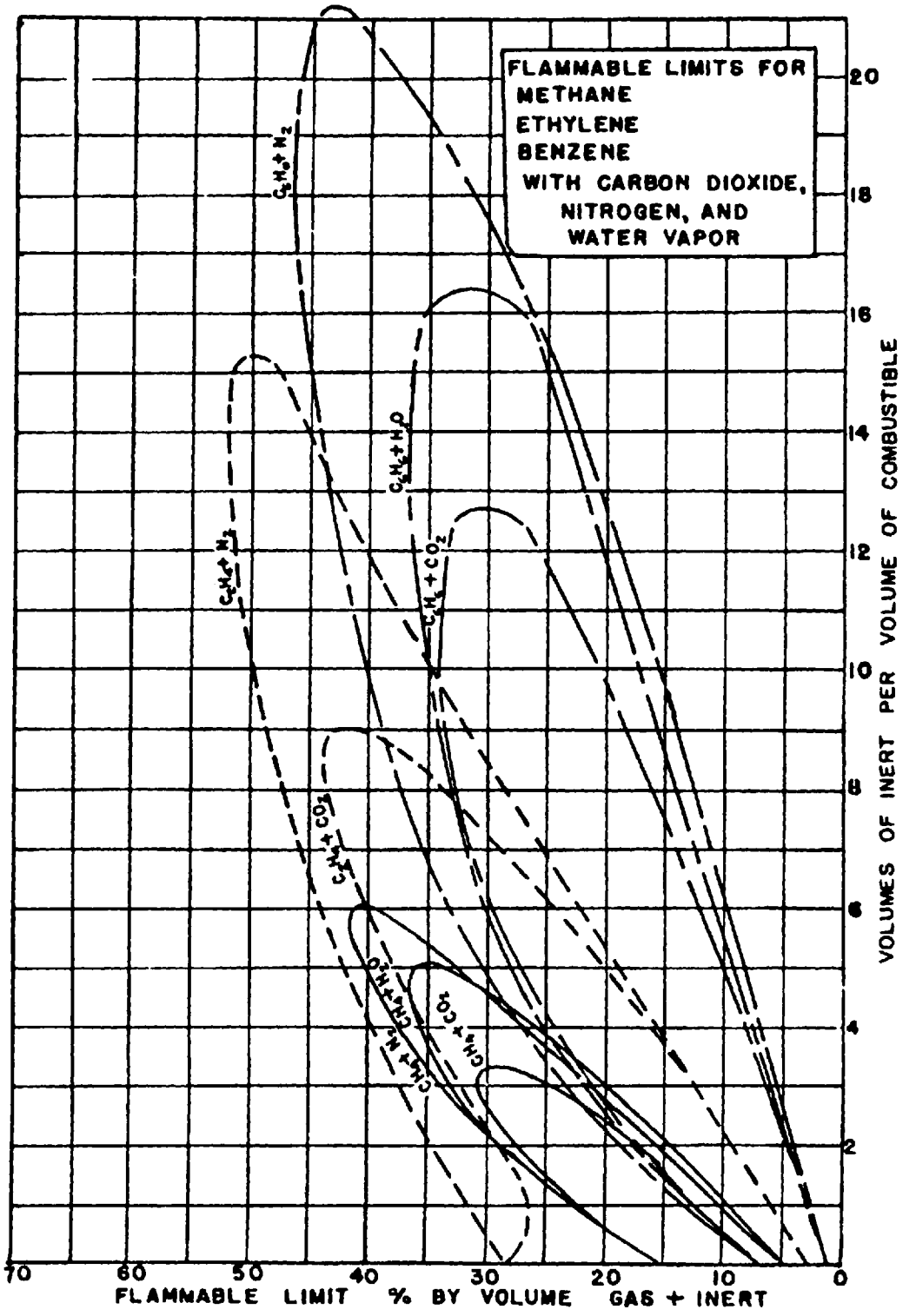


Figure 9. Flammable limits for methane, ethylene, benzene, with nitrogen, carbon dioxide and water vapor.

As a rule of thumb one should approach a hydrocarbon spill (non-fire situation) under the assumption that the liquid is vaporizing (the vapors will be invisible) and that the liberated vapors are heavier than air unless proven otherwise. The expected conduct of a heavier-than-air vapor is for it to drop and spread at or below ground level much as a liquid would. The big difference is that a liquid will be visible and its boundaries well defined. One can expect that the invisible heavier-than-air vapor will settle and collect in low spots such as ditches, basements, sewers, etc. As the vapor travels, it will be mixing with the air, thus some portions of the cloud may be too rich to burn, other sections too lean, and still others well within the explosive range. Some typical vapor densities for petroleum products are 3 to 4 for gasoline, 2.5 for naphtha, and 1.1 for methanol. For comparison, the vapor density for hydrogen gas is 0.1.

3. Specific Gravity

The property of specific gravity indicates a petroleum liquid's weight relative to the weight of an equal volume of water. The specific gravity of water is assigned the value of unity as a reference point. Hence, other liquids are evaluated relative to water; those lighter than water have a value less than unity, whereas those that are heavier have a value that is greater than unity. In general, petroleum products are lighter than water; as a result, they can be expected to float on and spread over the water's surface. The exceptions to this are thick, viscous materials such as road tars and heavy "bunker" fuel. With their low specific gravity, most petroleum liquids, if spilled onto a pool of water, have a tendency to spread quickly across the water's surface. Unless the fluid contacts an obstacle, the oil will continue to spread until it is of microscopic thickness. For this reason, a relatively small amount of oil floating on water is capable of covering a large area of the surface.In a spill situation, knowledge of the liquid's specific gravity can help determine which one of several tactics will be implemented to mitigate the spread of contamination or to eliminate a fire hazard. Knowing the specific gravity will help determine the following:

- If it will be possible to use only water, or must we apply a different agent for purposes of smothering the fire.
- How great the probability is that the burning liquid could result in the involvement of exposures because of it floating on any water that is applied.
- Can the displacement of the fuel by water be considered an effective technique to control a leak from a container.

Some specific gravities of common petroleum liquids are 1 to 1.1 for asphalt, 0.8 for gasoline, and 0.6 for naphtha.

4. Water Solubility

Another important property of petroleum liquids is water solubility, which may be described as the ability of a liquid to mix with water. Since most petroleum products are lighter than water, and even if they are well mixed with water, they will separate into a layer of water and a layer of the hydrocarbon. Exceptions to this are polar solvents such as methanol and other alcohols. These types of materials will readily mix with water and can even become diluted by it.

Information on solubility is important in an emergency situation because a petroleum fire will require the application of a regular-type foam or an alcohol-resistant--type foam for extinguishment or for vapor-suppression purposes. For use on a water-soluble liquid, a good-quality alcohol-resistant foam is generally applied.

5. General Fire Characteristics

In an emergency situation involving a flammable petroleum liquid, the product can be expected to behave as follows:

- When accidentally released from its container it almost always results in a fire response.
- If a fire does occur, flammable liquids prove to be virtually impossible to extinguish by cooling with water.
- If the liquid is contained, the confined space will consist of a vapor-rich mixture.
- After extinguishment, there is still the strong possibility for a reflash owing to the continued production of vapor.

It is important to remember that during an emergency the escaping flammable liquids are low-flash products and, as a result, are releasing vapor at the usual atmospheric temperatures. These materials are, therefore, very susceptible to ignition. Because of this, they are generally encountered as an event requiring fire-control procedures. Also, for the same reasons, and the frequent need for large quantities of chemical extinguishing agents, they can present difficult extinguishment problems. The fact that the temperature at which many flammable liquids release vapor is well below the temperature of the water that is being used for fire-control purposes means that

extinguishment by the cooling method is not feasible. This does not mean water cannot be used. In fact, the use of water serves an important function in spite of its limitations. However, to obtain extinguishment other tactics utilizing a different agent and techniques are needed. Exactly what agent and what technique will be dictated by the size of the fire, the type of storage container or processing equipment involved, and the fire-fighting resources that are available. When dealing with a low flash point flammable liquid, the probability of a reflash occurring after initial extinguishment is achieved is a high probability.

The probability of an ignitable air-fuel mixture existing inside a closed storage container of a flammable liquid is normally low. Flammable liquids have the capacity of generating vapor below the commonly encountered atmospheric temperatures; thus, the space between the tank top and the liquid surface will most usually contain a vapor-rich atmosphere (i.e., conditions will be above the UEL). As the vapor being liberated drives the air from the container, the vapor-rich mixture being above the UEL cannot be ignited; moreover, if a fire should occur outside the tank or vessel, it will not propagate a flame back into the tank. The major exceptions would be those instances where the product had a flash point temperature about the same as the prevailing atmospheric temperature. Another example would be when a tank containing a low vapor pressure product with a flash point in the same range as the prevailing atmospheric temperature is suddenly cooled. A thunderstorm accompanied by a downpour of rain could cause the tank to breathe in air if the liquid is cooled below the temperature at which it is capable of emitting vapor (the boiling point).

In contrast to flammable liquids, an emergency situation that involves a combustible liquid will have a much different behavior. The expected behavior of a combustible product would be for:

- the liquid to present no significant vapor problem,
- a fire to be readily extinguished by cooling the liquid with water,
- the atmosphere above the liquid level to be below the LEL of any confined product.

Most combustible liquids do not present a vapor problem if accidentally released into the atmosphere. The probability of a fire, therefore, is considerably less than it would be if the spill was of a flammable material. If, however, the combustible liquid is at a temperature higher than its flash point, then it can be expected to behave in the identical manner a flammable liquid. One major difference between the two in a fire situation is that the potential exists for cooling the combustible liquid below its flash point by the proper application of water (generally applied in the form of water spray). In the event the liquid is burning, and if the fire forces are successful in achieving the required reduction in liquid temperature, then vapor production will cease and the fire will be extinguished because of a lack of vapor fuel. Unless this reduction in liquid temperature can be brought about, the fire will necessitate the same control considerations a low-flash liquid fire would.

With a fire in a storage tank containing a combustible liquid, normally the application of a foam blanket is the only practical method to achieve extinguishment. This is normally done when the entire exposed surface is burning and is necessitated by the fact that the sheer size of the fire makes it very difficult to apply water spray in the amounts and at the locations needed. Also, the volume of oil that has become heated is such that the large quantities of water needed to cool the liquid would introduce the possibility of overflowing the tank. Another problem is that the water requirements for both protecting exposures and attempting extinguishment might be far greater than what is available. These factors alone would cause the emergency forces to treat all refined product tank fires alike and, regardless of the flash point of the liquid, initiate the required steps to apply a foam blanket to the liquid surface. In addition there is always concern for any reaction the water may cause when contacting an oil or hydrocarbon heated above the boiling point of water (212°F). In general, because a spill is generally shallow, spilled or splashed combustible liquids do not present the type of problems that a large storage tank does. It is reasonable to expect to be able to extinguish shallow pools or surface spills with water spray.

In the case of a storage tank with a combustible product, the atmosphere inside the container will normally consist of air. On occasion, there will be detectable odors such as that associated with fuel oil. These odors, which are a good indicator of the presence of a combustible product, are not considered fuel vapor. During a fire situation, flame impingement or radiant heat on a container could cause the liquid to become heated to the temperature at which it would emit vapors. Should this occur, and the vapors being generated then start to mix with the air already in the tank, at some instant the space in the container would then contain a mixture that was within the explosive range of the product; if ignition occurred, a

forceful internal explosion could result. The case of crude oil is somewhat unique compared to fires with refined petroleum products. Burning crude oil has the capability of developing a "heat wave". Crude oil has a composition of different fractions of petroleum products. In a manner similar to a refinery operation which distills, or heats crude oil to separate it into the various usable products - such as gasoline and asphalt, a fire accomplishes the same effect. As crude oil burns it releases the fractions that have lower flash points first, and these are burned. The heavier fractions sink down into the heated oil. This movement of light fractions up to the fire and heavier, heated fractions down into the crude produces the phenomenon known as a heat wave. Crude oil has the same basic characteristics as other flammable liquids. There are different grades of crude oil produced from various geographic locations throughout the world, with some crudes having more heavy-asphalttype material than others. Some have greater quantities of sulfur (creating the problem of poisonous hydrogen sulfide gas generation during a fire) and still others more light, gaseous fractions; however, a common characteristic among them is that all will have varying amounts of impurities and some entrained water.

When liquids of this type burn, creating a heat wave which is comprised of the higher boiling point components plus whatever impurities may be present in the product, radiant heat from the flame heats the liquid surface, the light products boil-off, thus creating the vapor that is burning. The remaining hot, heavier materials transfer their heat down into the oil. As it is formed, this heat wave, or layer of heated crude oil components, can reach temperatures as high as 600°F and spread downward at a rate of from 12 to 18 inches per hour faster than the burn-off rate of the crude oil. This would mean that with a crude oil burn-off of 1 foot per hour, at the end of two hours the heat wave would be somewhere between 24 and 36 inches thick. Once this heat wave is created, the chances of extinguishing a crude-oil tank fire, unless it is of small size, are poor, and any water or foam applied could result in a "slopover" of burning oil.

As noted earlier, crude oil normal contains some entrained water and/or an emulsion layer of water and oil. In addition, crude-oil storage tanks will have some accumulations of water on the uneven tank bottoms. In a fire, when a heat wave is formed and comes in contact with any water, a steam explosion will occur, thus agitating the hot oil above it with great force. The evolution of the steam explosion can be attributed to the reaction of water to high temperatures. When water is heated to its boiling point of 212°F, water vapor or steam is generated. Steam that is produced expands approximately 1700 times in volume over the volume of the water that boils away. If a heat wave of a temperature well above 212°F contacts any water entrained in the oil, or some of the bottom water, which is usually in larger quantities, the instantaneous generation of steam will act like a piston, causing the oil to be flung upward with considerable violence and force. This reaction is so strong that it causes the oil to overflow the tank shell. This sudden eruption is known as a boilover. When the hot oil and steam reaction takes place, the oil is made frothy, which in turn further increases its volume. The reaction resulting from the heat wave contacting entrained water can be expected to be of lesser activity than from contact with bottom water. The reason for this difference is that the quantities of water converted to steam in a given spot are usually less.

Another phenomenon associated with a crude oil fire is slopover. Basically, the same principles that are responsible for a boilover are the cause of a slopover. The fundamental difference is that in a slopover the reaction is from water that has entered the tank since the start of the fire. Usually this introduction is the result of firefighting activities. A slopover will occur at some point after the heat wave has been formed. Either the water from the hose streams or, after the bubbles collapse, the water in the foam will sink into the oil, contacting the heat wave, where it is converted to steam, and the agitation of the liquid surface spills some amount of oil over the tank rim.

6. Use of Extinguishing Agents

The proper extinguishing agents suitable for petroleum-liquid emergencies must be capable of performing the identical functions as those agents used in the combating of structural-type fires. There will be times when circumstances dictate the use of a cooling agent, whereas at other times it will be a smothering agent, and on some occasions, both agents will be necessary. There are a variety of agents capable of accomplishing each of these objectives, as well as being appropriate to combat Class B-type fires. Agents suitable for use on Class B-type fires include halon, carbon dioxide (CO_2), dry chemicals, foam, and aqueous film forming foam. A brief description of the major types of fire fighting agents is given below.

Water - Regardless whether it is a spill or a fire, or whether it involves a flammable or a combustible liquid, water is almost invariably required. Water can be used for the dissipation of vapors, for the cooling of exposed

equipment, for the protection of personnel, for control purposes, and, for actual extinguishment. For the cooling down of exposed equipment such as pipelines, pumps, or valves, it is recommended that water be applied at the minimum flow rate of 1 gallon per minute per 10 square feet of exposed surface area. Some general guidelines to consider when applying water are as follows:

- All areas of any piping, containers, etc., that are exposed to the fire's heat or flame should be kept wetted during the course of the fire.
- The use of water streams to push and move the burning liquid away from exposed equipment is recommended provided that it can be done safely.
- The rate of flow from any hose stream should not be less than 100 gal/min regardless of its purpose.
- The use of spray streams is recommended whenever possible.
- Back-up lines for lines in active service should be provided and they should be at least of the same capacity as the attack line.
- Any equipment being protected is cool enough if water applied to it no longer turns to steam.

With storage tanks or processing equipment exposed to fire or radiant heat, the cooling of any metal above the liquid level inside the vessel is critical. Metal surfaces that have a constant film of water flowing over them will not reach a surface temperature above the boiling point of water. This temperature is well below that which would subject the metal to loss of integrity because of softening.

Water flows employed to cool exposed vertical storage tanks can be calculated using as a requirement one hose line (flowing 200 gal/min) per 10 feet of tank diameter. Assuming an average tank height of 50 feet, this would give a water flow capability in excess of the recommended rate.

On the fire ground, wind conditions, personnel deficiencies (fatigue, lack of experience or training, etc.), stream feathering, and so forth have historically resulted in not all the water that is flowing actually doing its intended function. The rule of thumb of one line flowing a minimum of 200 gal/min for each 10 feet of tank diameter provides a suitable safety margin to overcome the loss of water not reaching its target. This flow is only required on the side or sides of the tank being heated; therefore, if a 100-foot-diameter tank is receiving heat on just one-half of its circumference, it would require five hose streams of 200 gal/min, each applied to the heated area for cooling purposes. It must be anticipated that these minimum flows will need to be maintained for a time period of at least 60 minutes. Tank truck incidents in which the fire burned for several hours are not unusual. It should be appreciated that a relatively minor fire on a tank truck or rail car could require in excess of 20,000 gallons of water for control and/or extinguishment. It is imperative that as early into the event as possible, an accurate assessment of water flow requirements should be made and flow rates adjusted accordingly. First responders must be constantly alert for any indication of an increase in the internal pressure of a container. Such an increase or any visible outward distortion of the tank shell would be an indication that additional water flows are required. These warning signs, which would be an indication of increased internal pressures, could justify the immediate use of unmanned monitors or hoseholders, larger size nozzles, and the pulling back of all personnel to a safe location.

In preparing emergency response plans for petroleum - liquid spills or fires, it should be taken into consideration that the required water rates could be needed for long periods of time. Built into the plans must be provisions for an uninterrupted supply at a suitable volume. The rates stipulated in the foregoing do not include amounts of water that may be needed for the protection of fire-fighting personnel who are involved in activities such as rescue work or valve closing and block off operations. If these or other water-consuming activities are required, additional water must be provided. Of equal importance to the amount of water being used is that water be used in the right place. In general, the application of water should have as its objective one or more of the following goals:

- The cooling of the shell of any container that is being subjected to high heat levels. This is most effectively accomplished by applying the water to the uppermost portions of the container and allowing it to cascade down the sides.
- The cooling of any piece of closed-in equipment containing a liquid or gas and exposed to high heat levels. This is most effectively accomplished by applying the water spray over the entire area being heated.
- The protection of any part of a container, piping, or item of processing equipment receiving direct flame contact. This is most effectively accomplished with a very narrow spray pattern or even a straight stream directed at the point of flame contact.
- The cooling of steel supports of any container or pipe rack that may be subjected to high heat levels. This is

most effectively accomplished by the application of narrow spray streams to the highest part of the support being heated and permitting the water to run down the vertical length of the support.

Foam - The application of a foam blanket is the only means available to the fire forces for the extinguishment of large petroleum storage tank fires. The foam blanket extinguishes by preventing vapor, rising from the liquid surface, from uniting with the surrounding air and forming a flammable mixture. Although the water in a foam does provide some incidental cooling action, this is considered of more importance for cooling heated metal parts, thus reducing the possibility of re-ignition, than as an extinguishing factor. A good-quality foam blanket of several inches in thickness has also been proved effective as a vapor suppressant on low flash-point liquids. Foam may also be used to suppress vapor, hence the layer of foam will be instrumental both in preventing ignition and reducing the contamination of the surrounding atmosphere. Since foam is still water, even if in a different form from that usually used, it may conduct electricity: consequently, its use on live electrical equipment is not recommended.

There are basically two methods of foam application to fires. The first involves the application of chemical foam, which is generated from the reaction of a powder with water. This type of foam has been replaced largely by a technique that involves the formation of foam bubbles when a foaming agent and water are expanded by the mechanical introduction of air. This type, which is not a chemical reaction, is referred to as mechanical foam. Another name for the same material is air-foam. There are a variety of foam concentrates designed to fit different hazards. These include regular protein-based foams, fluoroprotein foams, aqueous film forming types, alcohol-resistant types, as well as foams that are compatible with dry chemical powders and those that will not freeze at below-zero temperatures. Of the many types, the most suitable for general all-around petroleum the use would be either a good-quality fluoroprotein or a good-quality aqueous film forming foam (AFFF). Foam liquids are also available in a wide range of concentrates, from 1 percent to 10 percent. The 3 percent and 6 percent protein and fluoroprotein types are usually employed as low-expansion agents with an expansion ratio of about 8 to 1. That is, for each 100 gallons of foam solution (water/concentrate mix) to which air is properly introduced, it will then develop approximately 800 gallons of finished foam. Foam concentrates of other than 3 percent or 6 percent generally are either high-expansion (as high as 1,000 to 1) or alcohol-resistant types.

In foam applications, the manufacturer will provide a percentage rating of a concentrate, which identifies the quantity of concentrate required to be added to water to achieve a correct solution mixture. For each 100 gallons of solution flowing, a concentrate rated as 3 percent would mean 3 gallons of concentrate per 97 gallons of water, whereas a 6 percent concentrate would mix with 94 gallons of water. This readily explains why only half as much space is required to store or transport the amount of 3 percent concentrate needed to generate a given quantity of foam than would be needed for a 6 percent concentrate to make the same volume of foam.

Once the application of foam is initiated, it must be applied as gently as possible in order to develop a good vapor-tight blanket on the liquid surface. Any agitation of the foam blanket or of the burning liquid surface will serve to prolong the operation and to waste foam supplies. Water streams cannot be directed into the foam blanket or across the foam streams because the water will dilute and break down the foam. To be assured that all metal surfaces are cool enough and a good, thick (4 inches or more) blanket of foam has been applied, continue application for a minimum of five minutes after all visible fire is extinguished.

As noted earlier, one of the agents considered suitable for the extinguishment of petroleum-liquid fires is aqueous film forming foam. This is a liquid concentrate that contains a fluorocarbon surfactant to help float and spread the film across the petroleum-liquid surface and is commonly referred to as "A Triple F". AFFF concentrates of 1, 3, or 6 percent are available, all with about an eight to one expansion ratio. This material is one of the mechanical-type foaming agents. The same kind of air-aspirating nozzles and proportioners that are used for protein-based foams are usable with AFFF concentrates. The primary advantage of AFFF over other foaming agents is its ability to form a thin aqueous film that travels ahead of the usual foam bubbles. This film has the ability to flow rapidly across the burning liquid surface, thus extinguishing the fire by excluding the air as it moves across the surface. The regular foam bubbles formed and flowing behind the film have good securing qualities, which serve to prevent reflashing from occurring. As with all types of foams, care must be exercised that the foam blanket, once formed, is not disturbed. Water streams should not be directed into the foam blanket or onto the same target a foam stream is aimed at. Water will dilute the foam below the needed concentration and, simultaneously, the force of the stream will destroy the foam's blanketing effect. The blanket must be maintained

until all flames are extinguished, all heated metal surfaces cooled, and other sources of ignition removed from the vicinity.

Alcohol-Resistant Foams - Foams that are suitable for water-soluble polar solvents are formulated to produce a bubble that is stable in those fuels and tends to mix and unite with water. Fuels of this type dissolve the water contained in regular foam very rapidly resulting in the collapse of the bubbles. The breakdown is so fast and complete with regular protein or fluoroprotein based foams that unless the rate at which the foam is being applied is well above the recommended rate, the blanket will not form at all. Alcohol-type foam concentrates are most commonly available at strengths of 3 percent, 6 percent, or 10 percent. Because of the possibility of breakdown, regular foams are not considered suitable for polar solvent-type fires. The exception would be a fire in a container of fairly small diameter or a shallow spill, either of which would allow for the possibility of applying foam at sufficient rates to the point of overwhelming the fire.

High-Expansion Foams - High-expansion foam includes foaming agents with the expansion ratio between the solution and the foam bubbles of from 20 to 1 to as high as 1,000 to 1. This agent has been found suitable when combating certain types of Class A and Class B fires. Originally developed to help fight fires inside mines, it is most effective when used in confined areas. Extinguishment is accomplished both by the smothering action of the foam blanket and the cooling action obtained from the water as the bubbles break down. Light, fluffy bubbles break apart and are easily dispersed by even relatively moderate wind currents. Bubbles formed at ratios greater than about 400 to 1 are most likely to be adversely affected by regular air movement as well as the thermal updrafts created by the fire. In an effort to overcome the susceptibility of the bubbles to wind currents, medium expansion foams have been introduced, which have expansion ratios ranging from about 20:1 to 200:1. High-expansion foam concentrates require special foam generators both for proportioning the liquid with water, and aspirating the mixture. Many high-expansion foam-dispensing devices have a discharge range of only a few feet; thus, they must be operated fairly close to the area being blanketed.

Other Extinguishing Agents - Other extinguishing agents that are suitable for use on fires involving petroleum liquids include dry chemical powders, carbon dioxide gas, and halon gases. Each of these agents, while being capable of extinguishing Class B fires, usually is available in either hand-held extinguishers or the larger wheeled or trailer-mounted portable units.

In some petroleum refineries or chemical plants, an on-site fire brigade that is equipped with an apparatus capable of dispensing large volumes of dry chemical, or a vehicle with a large-capacity carbon dioxide (CO_2) cylinder is common practice.

7. Tank Cleaning and Removal Operations

A very common operation that can pose a serious fire hazard is either the cleaning and/or removal of underground storage tanks used for flammable products such as gasoline. If these operations are not performed properly, they can lead to spontaneous combustion conditions. There are two basic procedures that must be performed before a tank used for storing a flammable product can be entered either for inspection or cleaning purposes prior to its removal or repair. The first procedure is called inerting.

A vessel that has first been pumped dry of its content will have a freeboard atmosphere that is above the UEL of the flammable liquid. However, if the tank is now opened, e.g. through a manway, oxygen or air is introduced and the resulting mixture of air-vapor could easily enter within the explosive range. To avoid this dangerous situation, the tank must first be inerted. There are two common approaches to inerting, both using the same principal. The first approach involves displacing the vapor in the tank's freeboard with another fluid. The other fluid can be an inert gas like nitrogen, or with small tanks (under 10,000 gallons in capacity) by pumping in water. The use of water is generally not practiced because it becomes contaminated with residual product and sludge in the tank and can become an added expense in disposal. The second method of inerting is to use dry ice which can be introduced to a tank through a fill port. Normally a little water is also added to help dissipate the dry ice. The dry ice will melt producing carbon monoxide which then acts in the same manner as a motive fluid like N_2 or water, displacing the tank's fuel rich atmosphere. A rough guideline is to use 10 pounds of dry ice for every 1000 gallons of tank capacity.

In both inerting procedures, the flammable vapors are discharged though tank's vent line. Because in the case of gasoline vapors, vapor densities are greater than 1, the vent line should be sufficiently tall to enable vapors to be adequately diluted in the atmosphere. A general rule of

thumb is that the vent's discharge should be at least 10 feet above the tallest neighboring structure. The professional tank cleaner will use an explosimeter to monitor the LEL at the vent's exit, and hence have an exact measure of when the tank has been purged.

Once the tank has been inerted, the second operation involves purging. Purging a tank involves introducing fresh air so that the atmosphere is within a safe limit for entry by inspectors and maintenance technicians. This is a closely monitored operation requiring the use of an oxygen meter. Following OSHA standards, the minimum safe entry condition based on oxygen concentration is 18.5%. In other words, there must be a minimum of 18.5% O_2 available in the tank in order to safely send personnel in.

III. CHEMICAL COMPATIBILITY GUIDE

This subsection is based in part upon information provided to the U.S. Coast Guard by the National Academy of Sciences — U.S. Coast Guard Advisory Committee on Hazardous Materials and represents general guidelines on chemical compatibility between binary mixtures. The accidental mixing of one chemical with another can in some cases be expected to result in a vigorous and hazardous chemical reaction. The generation of toxic gases, the heating, overflow, and rupture of containers, and fire and explosion are possible consequences of such reactions. The section contains a Compatibility Chart that shows chemical combinations believed to be dangerously reactive in the case of accidental mixing. It should be recognized, however, that the Chart provides a broad grouping of chemicals with an extensive variety of possible binary combinations. Although one group, generally speaking, can be considered dangerously reactive with another group where an "X" appears on the Chart, there may exist between the groups some combinations which would not dangerously react. The Chart should therefore not be used as an infallible guide. Its original intent was to serve as aid in the safe loading of bulk chemical cargoes, with the recommendation that proper safeguards be taken to avoid accidental mixing of binary mixtures for which an "X" appears on the Chart. The chart, provided as Figure 10, however provides general enough guidance for purposes of warehouse storing and stockpiling chemical operations, and as a guide for avoiding the mixing of incompatable wastes where chemical analysis on the waste components are available. The information in this chart will also assist in applying proper safeguards which would include consideration of such factors as avoidance of the use of common cargo and vent lines and carriage in adjacent tanks having a common bulkhead in loading operations.

The following procedure explains how this section may be used as a guide in determining chemical compatibility information:

1. Determine the reactivity group of a particular product by referring to the alphabetical list in Table 12.
2. Enter the Chart (Figure 10) with the reactivity group that is listed in Table 13. Proceed across the chart. An "X" indicates a reactivity group that forms an unsafe combination with the product in question.

For example, crotonaldehyde is listed in Table 12 as belonging in Group 19 (Aldehydes). The Chart shows that chemicals in this group should be segregated from sulfuric and nitric acids, caustics, ammonia, and all types of amines (aliphatic, alkanol, and aromatic). According to note A, crotonaldehyde is also incompatible with non-oxidizing mineral acids.

It is recognized there are wide variations in the reaction rates of individual chemicals within the broad groupings shown reactive by the Compatibility Chart. Some individual materials in one group will react violently with some of the materials in another group and cause great hazard; others will react slowly, or not at all. Accordingly, a useful addition to the Guide is the identification of specific binary combinations which are found not to be dangerously reactive, even though an "X" appears on the chart for those two chemicals. A few such combinations are listed in Table 14.

Figure 10. Chemical compatibility chart.

Cargo Groups / Reactive groups	1. Non-oxidizing mineral acids	2. Sulfuric acid	3. Nitric acid	4. Organic acids	5. Caustics	6. Ammonia	7. Aliphatic amines	8. Alkanolamines	9. Aromatic amines	10. Amides	11. Organic anhydrides	12. Isocyanates	13. Vinyl acetate	14. Acrylates	15. Substituted allyls	16. Alkylene oxides	17. Epichlorohydrin	18. Ketones	19. Aldehydes	20. Alcohols, glycols	21. Phenols, Cresols	22. Caprolactam solution
1. Non-oxidizing mineral acids		×			×	×	×	×	×	×	×	×	×			×	×		A	E		
2. Sulfuric acids	×		×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
3. Nitric acid		×			×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	
4. Organic acids		×			×	×	×	×	C			×				×	×			F		
5. Caustics	×	×	×	×							×	×				×	×		×	×	×	×
6. Ammonia	×	×	×	×						×	×	×	×			×	×		×			
7. Aliphatic amines	×	×	×	×							×	×	×	×	×	×	×	×	×	×	×	×
8. Alkanolamines	×	×	×	×							×	×	×	×	×	×	×	B	×			
9. Aromatic amines	×	×	×	C							×	×							×			
10. Amides	×	×	×			×						×									×	
11. Organic anhydrides	×	×	×		×	×	×	×	×													
12. Isocyanates	×	×	×	×	×	×	×	×	×	×					D					×		×
13. Vinyl acetate	×	×	×			×	×	×														
14. Acrylates		×	×				×	×														
15. Substituted allyls		×	×				×	×				D										
16. Alkylene oxides	×	×	×	×	×	×	×	×														
17. Epichlorohydrin	×	×	×	×	×	×	×	×														
18. Ketones		×	×				×	B														
19. Aldehydes	A	×	×		×	×	×	×	×													
20. Alcohols, glycols	E	×	×	F	×		×					×										
21. Phenols, Cresols		×	×		×		×			×												
22. Caprolactam solution		×			×		×					×										
30. Olefins		×	×																			
31. Paraffins																						
32. Aromatic hydrocarbons			×																			
33. Miscellaneous hydrocarbon mixtures			×																			
34. Esters		×	×																			
35. Vinyl halides			×																			×
36. Halogenated hydrocarbons		G			H		I															
37. Nitriles		×																				
38. Carbon disulfide							×	×														
39. Sulfolane																						
40. Glycol ethers		×										×										
41. Ethers		×	×																			
42. Nitrocompounds					×	×	×	×	×													
43. Miscellaneous water solutions		×										×										

Notes to compatibility chart: reactivity differences (deviations) within chemical groups

A. Isophorone (18), and Mesityl Oxide (18) are not compatible with Group 8, Alkanolamines.
B. Acrylic Acid (4) is not compatible with Group 9, Aromatic Amines.
C. Allyl Alcohol (15) is not compatible with Group 12, Iso-cyanates.
D. Furfuryl Alcohol (20) is not compatible with Group 1, Non-oxidizing Mineral Acids.
E. Furfuryl Alcohol (20) is not compatible with Group 4, Organic Acids.
F. Dichloroethyl Ether (36) is not compatible with Group 2, Sulfuric Acid.
G. Trichloroethylene (36) is not compatible with Group 5, Caustics.
H. Ethylenediamine (7) is not compatible with Ethylene Di-chloride (36).

Table 12. Alphabetical Listing of Compounds

Name	Group No.
Acetaldehyde	19
Acetic Acid	4
Acetic Anhydride	11
Acetone	18
Acetonitrile	37
Acrolein. (inhibited)	19
Acrylic Acid (inhibited)	4
Acrylonitrile (inhibited)	15
Adiponitrile	37
Allyl Alcohol	15
Allyl Chloride	15
Aminoethylethanolanline	8
Ammonia, Anhydrous	6
Ammonium Hydroxide	6
Ammonium Nitrate, Urea,	6
Ammonium Nitrate, Urea,	43
Amyl Acetate	34
Amyl Alcohol	20
Amyl Tallate	34
Aniline	9
Asphalt	33
Asphalt Blending Stocks:	
Roofers Flux	33
Straight Run Residue	33
Benzene	32
Benzene, Toluene, Xylene (crude)	32
Butadiene (inhibited)	30
Butane	31
Butyl Acrylate (inhibited)	14
Butyl Acetate	34
Butyl Alcohol	20
Butylamine	7
Butyl Benzyl Phthalate	34
Butylene	30
1,3-Butylene Glycol	20
Butylene Oxide	16
Butyl Ether	41
Butyl Methacrylate (inhibited)	14
Butyraldehyde	19
Butyric Acid	4
Carbon Bisulfide	38
Carbon Tetrachloride	36
Caustic Potash Solution	5
Caustic Soda Solution	5
Chlorine	*
Chlorobenzene	36
Chloroform	36
Chlorosulfonic Acid	*
Corn Syrup	43
Creosote, Coal Tar	21
Cresols	21
Cresylate Spent Caustic Solution	5
Crotonaldehyde	19
Cumene	32
Cycloaliphatic Resins	31
Cyclohexane	31
Cyclohexanol	20
Cyclohexanone	18
Cyclohexylamine	7
Cymene	32
Decaldehyde	19
Decane	31
Decene	30
Decyl Alcohol	20
Decyl Acrylate (inhibited)	14
Decylbenzene	32
Dextrose Solution	43
Di-acetone Alcohol	20
Dibutylamine	7
Di-butyl Phthalate	34
Dichlorobenzene	36
Dichlorodifluoromethane	36
1,1-Dlchloroethane	36
Dichloroethyl Ether	41
Dichloroalethane	36
1,1-Dichloropropane	36
1,2-Dichloropropane	36
1,3-Dichloropropene	15
Dicyclopentadiene	30
Diethanolamine	8

Table 12 Continued

Name	Group No.
Diethylene Glycol	40
Diethylene Glycol Monobutyl Ether	40
Diethylene Glycol Monobutyl Ether	34
Diethylene Glycol Monoethyl Ether	40
Diethylene Glycol Monomethyl Ether	40
Diethylenetriamine	7
Diethylethandamine	8
Diheptyl Phthalate	34
Dilsobutylene	30
Dilsobutyl Carbinol	20
Dilsobutyl Ketone	18
Diisodecyl Phthalate	34
Diisopropanolamine	8
Diisopropylamine	7
Dimethylamine	7
Dimethylethanolamine	8
Dimethylformamide	10
Dinonyl Phthalate	34
Dioctyl Phthalate	34
1,4-Dioxane	41
Diphenyl-Diphenyl Oxide	33
Diphenylmethane Diisocyanate	12
Di-n-propylamine	7
Dipropylene Glycol	40
Distillates:	
Straight Run	33
Flashed Feed Stocks	33
Diundecyl Phthalate	34
Dodecane	31
Dodecanol	20
Dodecene	30
Dodecylbenzene	32
Epichlorohydrin	17
Ethane	31
Ethanolamine	8
Ethoxylated Alcohols C_{11}-C_{15}	40
Ethoxy Triglycol	40
Ethyl Acetate	34
Ethyl Alcohol	20
Ethyl Acrylate (inhibited)	14
Ethylamine	7
Ethyl Benzene	32
Ethyl Butanol	20
Ethyl Chloride	36
Ethylene	30
Ethylene Chlorohydrin	20
Ethylene Cyanohydrin	20
Ethylenediamine	7

Name	Group No.
Ethylene Glycol Monobutyl Ether	34
Ethylene Glycol Monoethtyl Ether	40
Ethylene Glycol Monoethtyl Ether	34
Ethylene Glycol Monomethtyl Ether	40
Ethylene Oxide	*
Ethyl Ether	40
Ethylhexaldehyde	19
2-Ethyl Hexanol	20
2-Ethylhexyl Acrylate (inhibited)	14
Ethyl Hexyl Tallate	34
Ethyl Methacrylate (inhibited)	14
2-Ethyl-3-Propyl Acrolein	19
Formaldehyde Solution (37-50%)	19
Formic Acid	4
Furfural	19
Furfuryl Alcohol	20
Gas Oil Cracked	33
Gasoline Blending Stocks:	
Alkylates	33
Reformates	33
Gasolihes:	
Casinghead (natural)	33
Automotive (containing	33
Aviation (containing not	33
Polymer	33
Straight Run	33
Glutaraldehyde Solution	19
Glycerine	20
Glycol Diacetate	34
Glyoxal Solution	19
Heptane	31
Hexamethyleneimine	7
Hexane	31
Hexanol	20
Hexene	30
Hexylene Glycol	20
Hydrochloric Acid	1
Hydrofluoric Acid	1
Isophorone	18
Isoprene (inhibited)	30
Jet Fuel s:	
JP-l (Kerosene)	33
JP-3	33
JP-4	33
JP-5 (Kerosene, Heavy)	33

Table 12 Continued

Name	Group No.
Mesityl Oxide	18
Methane	31
Methyl Acetate	34
Methyl Acetylene, Propadiene Mixture	30
Methyl Acrylate (inhibited)	14
Methyl Alcohol	20
Methyl Amyl Acetate	34
Methyl Amyl Alcohol	20
Methyl Bromide	36
3-Methyl Butyraldehyde	19
Methyl Chloride	36
Methyl Ethyl Ketone	18
2-Methyls-Ethyl Pyridine	9
Methyl Formal (Dimethyl Formal)	41
Methyl Isobutyl Ketone	18
Methyl Isobutyl Carbinol	20
Methyl Methacrylate (inhibited)	14
(alpha-) Methyl Styrene (inhibited)	30
Mineral Spirits	33
Monochlorodifluoro -methane	36
Morpholine	7
Motor Fuel Antiknock Compounds	*
Naphtha:	
Coal Tar	33
Solvent	33
Stoddard Solvent	33
Varnish Markers' and	33
Naphthalene (molten)	32
Nitric Acid (70* or less)	3
Nitric Acid (95%)	*
Nitrobenzene	43
1- or 2-Nitropropane	43
Nitrotoluene	43
Nonane	31
Nonene	30
Nonyl Alcohol	20
Nonyl Phenol	21
Nonyl Phenol (ethoxylated)	40
Octane	31
Octene	30
Octyl Alcohol	20
Octyl Aldehyde	19
Octyl Epoxytallate	34
Oils:	
Clarified	33
Coal Oil	33
No. 1-D	33
No. 2	33
No. 2-D	33
No, it	33
No. 5	33
No. 6	33
Residual	33
Road	33
Transformer	33
Edible Oils, including:	
Castor	34
Coconut	34
Cotton Seed	34
Fish	34
Lard	34
Olive	34
Palm	34
Peanut	34
Safflower	34
Soya Bean	34
Tucum	34
Vegetable	34
Miscellaneous Oils, including:	
Absorption	33
Aromatic	33
Coal Tar	33
Heartcut Distillate	33
Linseed	33
Lubricating	33
Mineral	33
Mineral Seal	33
Motor	33
Neatsfoot	33
Penetrating	33
Range	33
Resin	33
Resinous Petroleum	33
Rosin	33
Sperm	33
Spindle	33
Spray	33
Tall	34
Tanner's	33
Turbine	33
Oleum	*
Pentadecanol	22
Pentane	31
Pentene	30

Table 12 Continued

Name	Group No.
Pentyl Aldehyde	19
Perchloroethylene	36
Phenol	21
Pentachloroethane	36
Phosphoric Acid	1
Phosphorus	*
Phthalic Anhydride (molten)	11
Polybutene	30
Polyethylene Glycols	40
Polymethylene Polyphenyl-isocyanate	12
Polypropylene	30
Polypropylene Glycol Methyl Ether	40
Polypropylene Glycols	40
Propane	31
Propanolamine	8
Propionaldehyde	19
Propionic Acid	4
Propionic Anhydride	11
Propyl Acetate	34
Propyl Alcohol	20
Propylamine	7
Propylene	30
Propylene Butylene Polymer	30
Propylene Glycol	20
Propylene Oxide	16
Propylene Tetramer	30
Propyl Ether	41
Pyridine	9
Sodium Hydrosulfide Solution (45% or	5
Sorbitol	20
Styrene (inhibited)	30
Sulfolane	39
Sulfur (molten)	*
Sulfuric Acid	2
Sulfuric Acid, Spent	2
Tallow	34
Tallow Fatty Alcohol	20
1,1,2,2-Tetrachloroethane	36
Tetradecanol	20
Tetradecene	30
Tetradecylbenzene	32
Tetraethylene Glycol	40
Tetraethylenepentamine	7
Tetrahydrofuran	41
Tetrahydronaphthalene	32
Tetrasodium Salt of EDTA Solution	43
Toluene	32
Toluene Diisocyanate	12
1,2,4-Trichlorobenzene	36
Trichloroethylene	36
Tridecanol	20
Triethanolamine	8
Triethylamine	7
Triethyl Benzene	32
Triethylene Glycol	40
Triethylenetetramine	7
Tripropylene Glycol	40
Turpentine	30
Undecanol	20
Undecene	30
Undecylbenzene	32
Valeraldehyde	19
Vinyl Acetate (inhibited)	13
Vinyl Chloride (inhibited)	35
Vinylidene Chloride (inhibited)	35
Vinyl Toluene (inhibited)	30
Xylene	32

* Because of very high reactivity or unusual conditions of carriage, this product is not included in the Compatibility Chart.

Table 13. Reactivity Groups

1. Non-Oxidizing Mineral Acids
Hydrochloric Acid
Hydrofluoric Acid
Phosphoric Acid

2. Sulfuric Acids
Spent Sulfuric Acid
Sulfuric Acid (98% or less)

3. Nitric Acid
Nitric Acid (70% or less)

4. Organic Acids
Acetic Acid
Butyric Acid
Formic Acid
Proplonic Acid
Acrylic Acid (inhibited)

5. Caustics
Caustic Potash Solution
Caustic Soda Solution
Cresylate Spent Caustic Solution
Sodium Hydrosulfide Solution (45% or less)

Table 13 Continued

6. Ammonia
Ammonia, Anhydrous
Ammonium Hydroxide (28% or less)
Ammonium Nitrate, Urea, Water Solutions (containing Ammonia)

7. Aliphatic Amines
Butylamine
Cyclohexylamine
Dibutylamine
Diethylamine
Diethylenetriamine
Dilsopropylamine
Dimethylamine
Di-n-propylamine
Ethylamine
Ethylenediamine
Hexamethyleneimine
Methylamine
Morpholine
Propylamine
Tetraethylenepentamine
Triethylamine
Triethylenetetramine

8. Alkanolamines
Aminoethylethanolamine
Diethanolamine
Diethylethanolamine
Dimethylethanolamine
Ethanolamine
Propanolamine
Triethanolamine

9. Aromatic Amines
Aniline
Pyridine
2-Methyl-5-Ethylpyridine

10. Amides
Dimethyl formamide

11. Organic Anhydrides
Acetic Anhydride
Phthalic Anhydride
Propionic Anhydride

12. Isocyanates
Diphenylmethane Diisocyanate
Polyphenyl Polymethylene-isocyanate
Toluene Diisocyanate

13. Vinyl Acetate
Vinyl Acetate (inhibited)

14. Acrylates
Butyl Acrylate (inhibited)
Butyl Methacrylate (inhibited)
Decyl Acrylate (inhibited)
Ethyl Acrylate (inhibited)
2-Ethylhexyl Acrylate (inhibited)
Ethyl Methacrylate (inhibited)
Methyl Acrylate (inhibited)
Methyl Methacrylate (inhibited)

15. Substituted Allyls
Acrylonitrile (inhibited)
Allyl Alcohol
Allyl Chloride
1,3-Dichloropropene

16. Alkylene Oxides
Propylene Oxide
Butylene Oxide

17. Epichlorohydrin
Epichlorohydrin

18. Ketones
Acetone
Camphor Oil
Cyclohexanone
Diisobutyl Ketone
Isophorone
Mesityl Oxide
Methyl Ethyl Ketone
Methyl Isobutyl Ketone

19. Aldehydes
Acetaldehyde
Acrolein (inhibited)
Butyraldehyde
Decaldehyde
Ethylhexald ehyde
Formaldehyde
Glutaraldehyde Solution
Glyoxal Solution
Methylbutyraldehyde
Octyl Aldehyde

Table 13 Continued

Pentyl Aldehyde
Propionaldehyde
Valeraldehyde

20. Alcohols, Glycols
Amyl Alcohol
Butyl Alcohol
1,3-Butylene Glycol
Cyclohexanol
Decyl Alcohol
Diacetone Alcohol
Diisobutyl Carbinol
Dodecanol
Ethanol
Ethoxylated Alcohols C_{11} C_{15}
Ethyl Alcohol
Ethylbutanol
Ethylene Chlorohydrin
Ethylene Cyanohydrin
Ethylene Glycol
2-Ethyl Hexanol
Furfuryl Alcohol
Glycerin
Hexanol
Hexylene Glycol
Methanoi
Methyl Alcohol
Methylamyl Alcohol
Methylisobutyl Carbinol
Octyl Alcohol
Nonyl Alcohol
Pentadecanol
Propyl Alcohol
Propylene Glycol
Sorbitol
Tallow Fatty Alcohol
Tetradecanol
Tridecanol
Undecanol

21. Phenols, Cresols
Carbolic Oil
Creosote, Coal Tar
Cresols
Nonyl Phenol
Phenol

22. Caprolactam Solution
Caprolactam Solution

23 - 29. Unassigned

30. Olefins
Butadiene (inhibited)
Butene
Butylene
Decene
Dicyclopentadiene
Diisobutylene
Dodecene
Ethylene
Hexene
Isoprene (inhibited)
Methyl Acetylene, Propadiene Mixture (stabilized)
(alpha-) Methyl Styrene (inhibited)
Nonene
Octene
Pentene
Polybutene
Polypropylene
Propylene
Propylene Butylene Polymer
Propylene Tetramer
Styrene (inhibited)
Vinyl Toluene (inhibited)
Tetradecene
Tridecene
Turpentine
Undecene

31. Paraffins
Butane
Cycloaliphatic Resins
Cyclohexane
Decane
Dodecane
Ethane
Heptane
Hexane
Methane
Nonane
Octane
Pentane
Propane

32. Aromatic Hydrocarbons
Benzene
Benzene, Toluene, Xylene (crude)
Cumene
Cymene
Decylbenzene

Table 13 Continued

Diethylbenzene
Dodecylbenzene
Ethylbenzene
Naphthalene
Tetradecylbenzene

Tetrahydronaphthalene
Toluene
Tridecylbenzene
Triethylbenzene
Undecylbenzene
Xylene

33. Misc. Hydrocarbon Mixtures
Asphalt
Asphalt Blending Stocks
Diphenyl - Diphenyl Oxide
Distillates
Gas Oil, Cracked
Gasoline Blending Stocks
Gasolines
Jet Fuels
Kerosene
Mineral Spirits
Naphtha
Oils, Crude
Oils, Diesel
Oils, Coal
Oils, Fuel (No. 1 thru No. 6)
Oils, Residual
Oils, Road
Oils, Transformer
Petroleum
Petroleum Naphtha

34. Esters
Amyl Acetate
Amyl Tallate
Butyl Acetate
Butyl Benzyl Phthalate
Castor Oil
Coconut Oil
Cottonseed Oil
Dibutyl Phthalate
Diethylene Glycol Monobutyl Ether Acetate
Diheptyl Phthalate
Diisodecyl Phthalate
Dinonyl Phthalate
Dioctyl Phthalate
Diundecyl Phthalate
Ethyl Acetate
Ethylene Glycol Monobutyl Ether Acetate
Ethylene Glycol Monoethyl Ether Acetate
Ethylhexyl Tallate
Fish Oil
Glycol Diacetate
Lard
Methyl Acetate
Methyl Amyl Acetate
Octyl Epoxy Tallate
Olive Oil
Palm Oil
Peanut Oil
Propyl Acetate
Safflower Oil
Soybean Oil
Tallow
Tucum Oil
Vegetable Oil

35. Vinyl Halides
Vinyl Chloride (inhibited)
Vinylidene Chloride (inhibited)

36. Halogenated Hydrocarbons
Carbon Tetrachloride
Chlorobenzene
Chloroform
Dichlorobenzene
1,1-Dichloroethane
Dichloroethyl Ether
Dichloromethane
1,1-Dichloropropane
1,2-Dichloropropane
Ethyl Chloride
Ethylene Dibromide
Ethylene Bichloride
Methyl Bromide
Methyl Chloride
Pentachloroethane
Perchloroethylene
1,1,2,2-Tetrachloroethane
1,2,4-Trichlorobenzene
Trichloroethylene

37. Nitriles
Acetonitrile
Adiponitrile

38. Carbon Disulfide

Table 13 Continued

39. Sulfolane

40. Glycol Ethers
Diethylene Glycol
Diethylene Glycol Monobutyl Ether
Diethylene Glycol Monoethyl Ether
Diethylene Glycol Monomethyl Ether
Dipropylene Glycol
Ethoxy Triglycol
Ethylene Glycol Monobutyl Ether
Ethylene Glycol Monethyl Ether
Ethylene Glycol Monomethyl Ether
Nonylphenol, Ethoxylated
Polyethylene Glycols
Polypropylene Glycols
Polypropylene Glycol Methyl Ether
Soybean Oil, Epoxidized
Tetraethylene Glycol
Triethylene Glycol
Tripropylene Glycol

41. Ethers
Butyl Ether
1,4-Dioxane
Ethyl Ether
Methyl Formal (Dimethyl Formal)
Propyl Ether
Tetrahydrofuran

42. Nitrocompounds
(mono-) Nitrobenzene
1- or 2-Nitropropane
Nitrotoluene

43. Miscellaneous Water Solutions
Ammonium Nitrate, Urea, Water Solutions (not containing Ammonia)
Corn Syrup
Dextrose Solution
Latex Solutions
Tetrasodium Salt of EDTA Solution

Table 14. Combinations Not Dangerously Reactive

Acetone (8)	Caustic soda solution (3)
Acrylonitrile (inhibited) (14)	Methyl alcohol (6)
Acrylonitrile (inhibited) (14)	Niax polyol (6)*
Acrylonitrile (inhibited) (14)	Polyol 3030 (6)*
Acrylonitrile (inhibited) (14)	Propylene glycol (6)
Acrylonitrile (inhibited) (14)	Voranol CP 4100 (6)*
Benzene (10)	Phosphoric acid (1)
Butyl acetate (n-, iso-*) (13)	Caustic soda solution (3)
Butyl acrylate (inhibited) (14)	Methyl alcohol (6)
Butyl acrylate (inhibited) (14)	Voranol CP 4100 (6)*
n-Butyl alcohol (6)	Styrene (inhibited) (14)
n-Butyl alcohol (6)	Vinyl acetate (inhibited) (14)
Carbon tetrachloride (5)	Caustic soda solution (3)
Caustic soda solution (3)	Acetone (8)
Caustic soda solution (3)	Butyl acetate (iso-*, n-) (13)
Caustic soda solution (3)	Carbon tetrachloride (5)
Caustic soda solution (3)	Oils, edible: coconut (13)*
Caustic soda solution (3)	Oils, edible: cottonseed (13)
Caustic soda solution (3)	Dichloropropane (5)
Caustic soda solution (3)	Dichloropropene (5)
Caustic soda solution (3)	Diisodecyl phthalate (13)*
Caustic soda solution (3)	Di-normal-alkyl phthalate (13)*
Caustic soda solution (3)	Dioctyl phthalate (13)
Caustic soda solution (3)	Ethyl acetate (13)
Caustic soda solution (3)	Ethylene dichloride (5)
Caustic soda solution (3)	Oils, edible: fish (13)
Caustic soda solution (3)	Grease (inedible, yellow) (13)*
Caustic soda solution (3)	Lard (edible) (13)*
Caustic soda solution (3)	Linseed oil (raw) (13)*
Caustic soda solution (3)	Methylene chloride (5)*
Caustic soda solution (3)	Methyl ethyl ketone (8)
Caustic soda solution (3)	Methyl isobutyl ketone (8)
Caustic soda solution (3)	Palm oil (13)*
Caustic soda solution (3)	Perchloroethylene (5)*
Caustic soda solution (3)	Propyl acetate (iso-*, n-) (13)
Caustic soda solution (3)	Oils, edible: soya bean (13)
Caustic soda solution (3)	Oils, miscellaneous: sperm
Caustic soda solution (3)	Styrene (inhibited) (14)
Caustic soda solution (3)	Tallow (13)
Caustic soda solution (3)	Trichloroethane (5)
Dichloropropane (5)	Caustic soda solution (3)
Dichloropropene (5)	Caustic soda solution (3)
Diisodecyl phthalate (13)*	Caustic soda solution (3)
Di-normal-alkyl phthalate (13)*	Caustic soda solution (3)
Dimethylformamide (4)	Furfural (7)
Dimethylformamide (4)	Phenol (15)
Dioctyl phthalate (13)	Caustic soda solution (3)
Dioctyl phthalate (13)	Ethylenediamine (4)
Diphenylmethanediisocyanate	Ethylene dichloride (5)
Ethyl acetate (13)	Caustic soda solution (3)
Ethyl acrylate (inhibited) (14)	Ethylene glycol (6)
Ethyl acrylate (inhibited) (14)	2-Ethyl hexanol (6)
Ethyl acrylate (inhibited) (14)	Voranol CP 4100 (6)*
Ethyl alcohol (6)	Methyl methacrylate (inhibited) (14)
Ethylenediamine (4)	Dioctyl phthalate (13)

Table 14 Continued

Ethylene dichloride (5)	Caustic soda solution (3)
Ethylene dichloride (5)	Diphenylmethanediisocyanate
Ethylene glycol (6)	Ethyl acrylate (inhibited) (14)
Ethylene glycol (6)	Styrene (inhibited) (14)
Ethylene glycol (6)	Vinyl acetate (inhibited) (14)
2-Ethyl hexanol (6)	Ethyl acrylate (inhibited) (14)
2-Ethyl hexanol (6)	Styrene (inhibited) (14)
Furfural (7)	Dimethylformamide (4)
Furfural (7)	Isopropyl alcohol (6)
Furfural (7)	Methyl ethyl ketone (8)
Grease (inedible, yellow) (13)*	Caustic soda solution (3)
Isobutyl alcohol (6)	Styrene (inhibited) (14)
Isobutyl alcohol (6)	Vinyl acetate (inhibited) (14)
Isodecyl alcohol (6)	Vinyl acetate (inhibited) (14)
Isooctyl alcohol (6)	Methyl methacrylate (inhib.)(14)
Isooctyl alcohol (6)	Styrene (inhibited) (14)
Isooctyl alcohol (6)	Vinyl acetate (inhibited) (14)
Isopropyl alcohol ((?)	Furfural (7)
Isopropyl alcohol (6)	Styrene (inhibited) (14)
Isopropyl alcohol (6)	Vinyl acetate (inhibited) (14)
Lard (edible) (13)*	Caustic soda solution (3)
Linseed oil (raw) (13)*	Caustic soda solution (3)
Methyl alcohol (6)	Acrylonitrile (inhibited) (14)
Methyl alcohol (6)	Butyl acrylate (inhibited) (14)
Methyl alcohol (6)	Styrene (inhibited) (14)
Methyl alcohol (6)	Vinyl acetate (inhibited) (14)
Methylene chloride (5)*	Caustic soda solution (3)
Methyl ethyl ketone (8)	Caustic soda solution (3)
Methyl ethyl ketone (8)	Furfural (7)
Methyl isobutyl ketone (8)	Caustic soda solution (3)
Methyl methacrylate (inhibited) (14)	Ethyl alcohol (6)
Methyl methacrylate (inhibited) (14)	Isooctyl alcohol (6)
Niax polyol (6)*	Acrylonitrile (inhibited) (14)
Niax polyol (6)*	Vinyl acetate (inhibited) (14)
Oils, edible: coconut (13)*	Caustic soda solution (3)
Oils, edible: cottonseed (13)	Caustic soda solution (3)
Oils, edible: fish (13)	Caustic soda solution (3)
Oils, edible: soya bean (13)	Caustic soda solution (3)
Oils, miscellaneous: sperm	Caustic soda solution (3)
Palm oil (13)*	Caustic soda solution (3)
Perchloroethylene (5)*	Caustic soda solution (3)
Phenol (15)	Dimethyl formamide (4)
Phosphoric acid (1)	Benzene (10)
Phosphoric acid (1)	Toluene (10)
Phosphoric acid (1)	Xylene (10)
Polyol 3030 (6)*	Acrylonitrile (inhibited) (14)
Propyl acetate (iso-*, n-) (13)	Caustic soda solution (3)
Propylene glycol (6)	Acrylonitrile (inhibited) (14)
Propylene glycol (6)	Styrene (inhibited) (14)
Styrene (inhibited) (14)	n-Butyl alcohol (6)
Styrene (inhibited) (14)	Caustic soda solution (3)
Styrene (inhibited) (14)	Ethylene glycol (6)
Styrene (inhibited) (14)	2-Ethyl hexanol (6)
Styrene (inhibited) (14)	Isobutyl alcohol (6)
Styrene (inhibited) (14)	Isooctyl alcohol (6)
Styrene (inhibited) (14)	Isopropyl alcohol (6)
Styrene (inhibited) (14)	Methyl alcohol (6)
Styrene (inhibited) (14)	Propylene glycol (6)
Styrene (inhibited) (14)	Trichloroethylene (5)
Tallow (13)	Caustic soda solution (3)
Toluene (10)	Phosphoric acid (1)
Trichloroethane (5)	Caustic soda solution (3)
Trichloroethylene (5)	Styrene (inhibited) (14)
Vinyl acetate (inhibited) (14)	n-Butyl alcohol (6)
Vinyl acetate (inhibited) (14)	Ethylene glycol (6)
Vinyl acetate (inhibited) (14)	Isobutyl alcohol (6)
Vinyl acetate (inhibited) (14)	Isodecyl alcohol (6)
Vinyl acetate (inhibited) (14)	Isooctyl alcohol (6)
Vinyl acetate (inhibited) (14)	Isopropyl alcohol (6)
Vinyl acetate (inhibited) (14)	Methyl alcohol (6)
Vinyl acetate (inhibited) (14)	Niax polyol (6)*
Vinyl acetate (inhibited) (14)	VoranolCP4100(6)*
VoranolCP4100(6)*	Acrylonitrile (inhibited) (14)
VoranolCP 4100 (6)*	Butyl acrylate (inhibited) (14)
Voranol CP 4100 (6)*	Ethyl acrylate (inhibited) (14)
VoranolCP4100(6)*	Vinyl acetate (inhibited) (14)
Xylene (10)	Phosphoric acid (1)

Toluene 2,4-diisocyanate (TDI), diphenylmethanediisocyanate (MDI), and polymethylene polyphenyl isocyanate (PAPI)* are considered compatible with reactivity groups 9, 10, 11, 12, 18, and 21.

IV. CHEMICAL COMPATIBILITY AND FIRE HAZARD DATA

A. Chemical Compatibility and Explosivity Limits

This section provides technical data on the fire potential for commonly used chemicals (Table 15). The information provided includes the chemical name, the chemical's formula, common synonyms for the chemical, a list of the materials that the chemical is incompatible with in terms of fire and explosion hazard or polymerization, the chemical's flash point temperature, and the chemical's explosion

limits in terms of the lower explosion limit (LEL) and upper explosion limit (UEL). The data summarized in this chapter were derived from literature sources including published OSHA reports and the NIOSH Pocket Guidebook. Chemicals listed are in alphabetical order. Not all of these chemicals represent fire hazards, and indeed many represent toxic materials in terms of inhalation or ingestion exposure hazards. Those chemicals which are either strong oxidizers or represent potential fire hazards are highlighted (underlined) for ready identification by the reader. The criteria used for highlighting high fire hazard materials is its incompatibility with strong oxidizers, and/or low LELs. As a general rule, any chemical with a LEL below about 3% is highlighted. This does not mean that any non-highlighted chemical is not a fire or explosion hazard. The reader should carefully read the list of incompatible ingredients for the product he/she is handling and consult other references.

Note also that synonyms for each chemical are common shipping or industry names. Brand or company product names are not given. The reader should carefully examine product material safety data sheets to identify ingredients or specific components that are potentially active or toxic, and then identify the chemical ingredients in the accompanying table. The reader should also refer to the data provided in Chapter 5 on physical and chemical properties. Data in Chapter 5 also provides additional information on fire conditions such as latent heats of vaporization, heats of combustion, and heats of decomposition. The last two subsections in this chapter provide further information.

Table 15. Fire/Explosion and Chemical Compatibility Data

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
ACETALDEHYDE	CH_3CHO	Ethanal, Acetic aldehyde	Strong oxidizers, acids, bases, alcohol, ammonia, amines, phenols, ketones, HCN, hydrogen sulfide	-36	4	60
ACETIC ACID	CH_3COOH	Glacial acetic acid, Methane carboxylic acid, Ethanoic acid, Vinegar acid	Strong oxidizers, chromic acid, sodium peroxide, nitric acid, strong caustics	104	5.4	16
ACETIC ANHYDRIDE	$(CH_3CO)_2O$	Ethanoic anhydride, Acetic acid anhydride, Acetyl oxide	Water, alcohols, strong oxidizers, chromic acid, amines, strong caustics	120	2.9	10.3
ACETONE	CH_3COCH_3	2- Propanone, Dimethyl ketone, Ketone propane	Oxidizing materials, acids	1.4	2.6	12.8
ACETONITRILE	CH_3CN	Methylcyanide	Strong oxidizers	42	4.4	16
2-ACETYLAMINO-FLUORENE	$C_{15}H_{11}NO$	2-Acetamidofluorene, 2-AAF, AAF, 2-Acet-aminofluorene, N-Acetyl-2-amino-fluorene, FAA, 2-FAA, 2-Fluoroenyl-acetamide, N-2-Fluor-enylacetamide, N-Fluoren-2-acetyl-acetamide, N-Fluorenyl-2-acetamide	Not available	?	?	?
ACETYLENE TETRABROMIDE	$CHBr_2CHBr_2$	Tetrabromoethane; symmetrical tetra-bromoethane; 1,1,2,2-Tetra-bromoethane	Chemically active metals, caustics, hot iron, aluminum, zinc in presence of steam		Not combustible	
ACROLEIN	CH_2CHCHO	Acrylic aldehyde, Acryl-aldehyde, Propenal, Allyl-aldehyde	Oxidizers, acids, alkalies, ammonia	-15	2.8	31
ACRYLAMIDE	$CH_2CHCONH_2$	Propenamide, Acrylamide monomer, Acylic amide	Strong oxidizers	?	?	?
ACRYLONITRILE	CH_2CHCN	Propenenitrile, An, Vinyl cyanide	Strong oxidizers (especially bromine), strong bases, copper, copper alloys, ammonia, amines	30	3	17
ALDRIN	$C_{12}H_8Cl_6$	1,2,3,4,10,10-Hexa-chloro-1,4,4a,5,8,8a-hexahydro-endo,exo-1,4,5,8-dimenthano-naphthalene; Octalene	None hazardous		Not combustible	
ALLYL ALCOHOL	CH_2CHCH_2OH	2-Propenol, 2-Propen-1-ol, Vinyl carbinol	Strong oxidizers		2.5	18
ALLYL CHLORIDE	CH_2CHCH_2Cl	3-Chloropropene, 1-Chloro-2-propene	Strong oxidizers, acids, aluminum, zink, amines, peroxides, chlorides of iron and aluminum	-25	3.3	11

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
ALLYL GLYCIDYL ETHER	$C_6H_{10}O_2$	AGE; 1-Allyloxy-2,3-epoxy-propane	Strong oxidizers	135	?	?
4-AMINO-DIPHENYL	$C_{12}H_{11}N$	p-Aminobiphenyl; Biphenylamine; (1,1-Biphenyl)-4-amine; p-Phenyl-aniline; Xenylamine; 4-Amino-biphenyl; p-Aminobiphenyl; p-Biphenylamine; Paraminodiphenyl; 4-Biphenylamine	None	307	?	?
2-AMINO-PYRIDINE	$C_5H_6N_2$	alpha-Aminopyridine	Strong oxidizers	154	?	?
AMMONIA	NH_3	Anhydrous ammonia	Strong oxidizers, calcium, hypo-chlorite bleaches, gold, mercury, silver, halogens	NA	16	25
AMMONIUM SULFAMATE	$NH_2SO_3NH_4$	Ammate herbicide	Strong oxidizers, hot water	Not combustible		
N-AMYL ACETATE	$CH_3COOC_5H_{11}$	1-Pentanol acetate, n-Amyl acetate (mixed isomers)	Nitrates; strong oxidizers, alkalies, and acids	77	1.1	7.5
SEC-AMYL ACETATE	$C_7H_{14}O_2$	2-Pentanol acetate	Nitrates; strong oxidizers, alkalies, and acids	89	1	?
ANILINE	$C_6H_5NH_2$	Aminobenzene, Phenyl-amine, Aniline oil	Stong acids and oxidizers	158	1.3	?
ANISIDINE (O-, P-ISOMERS)	$NH_2C_6H_4OCH_3$	o-Methoxyaniline, p-Methoxyaniline	Strong oxidizers	86 para	?	?
ANTIMONY AND COMPOUNDS (AS SB)	Sb	Synonyms vary depending upon specific compound	Oxidizers, acids, halogenated acids	?	?	?
ANTU	$C_{11}H_{10}N_2S$	alpha-Naphthyl thio-urea, alpha-Napthyl thiocarbamide, n-1-Napthyl-thiourea, 1-(1-Naphthly)-2-thiourea	Strong oxidizers	?	?	?
ARSENIC AND COMPOUNDS (AS AS)	As	Synonyms vary depending upon specific compound	Not applicable	Properties vary depending upon specific compound		
ARSINE	AsH_3	Hydrogen arsenide, Arsenic trihydride	Strong oxidizers, chlorine, nitric acid	Not combustible		
ASBESTOS		Chrysotile, Amosite, Crocidolite, Tremolite, Anthophyllite, Actinolite	None	Properties vary depending upon specific compound		
AZINPHOS-METHYL	$C_{10}H_{12}N_3O_3PS_2$	Guthion; o,o-Dimethyl S-4-oxo-1,2,3-benzo-triazin-3(4H)-yl-methyl phosphoro-dithioate	Strong oxidizers	?	?	?
BARIUM (SOLUBLE COMPOUNDS AS BA)	Ba	Synonyms vary depending upon specific compound	Incompatibilities vary depending upon specific compound	Properties vary depending upon specific compound		
BENZENE	C_6H_6	Benzol, Cyclohexa-triene, Coal tar naphtha, Phenyl hydride	Strong oxidizers; chlorine, bromine with iron	12	1.3	7.1
BENZIDINE	$C_{12}H_{12}N_2$	1,1-Biphenyl-4,4-diamine; 4,4-Diamino biphenyl; 4,4-Biphenyldiamine; 4,4-Bianiline; 4,4-Diphenyl-enediamine; 4,4-Diamino-diphenyl; Azoic Diazo Component 112; Fast Corinth Base B; Biphenyl, 4,4'-diamino-p-Diamino-diphenyl	Not available	Combustible solid	?	?
BENZOYL PEROXIDE	$(C_6H_5CO)_2O_2$	Dibenzoyl peroxide	Combustible substances, wood, paper, lithium aluminum hydride; explosive at high temperatures	?	?	?
BENZYL CHLORIDE	$C_6H_5CH_2Cl$	alpha-Chlorotoluene, Benzylchloride anhydrous, Benzyl-chloride (stabilized)	Active metals: copper, aluminum, magnesium, iron, zinc, tin; strong oxidizers	140	1.1	?
BERYLLIUM AND COMPOUNDS (AS BE)	Be	Synonyms vary depending upon specific compound	None	Properties vary depending upon specific compound		

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
BORON OXIDE	B_2O_3	Anhydrous boric acid, Boric anhydride, Boric oxide	None hazardous	Not combustible		
BORON TRIFLUORIDE	BF_3	None	Reacts with alkalies, fumes in moist air, particulates reduce visibility	Not combustible		
BROMINE	Br_2	None	Combustible organics, oxidizable material, aqueous ammonia; anhydrous Br_2 reacts with aluminum, titanium, mercury, potassium; wet Br_2 reacts with other metals	Not combustible, but strong oxidizer		
BROMOFORM	$CHBr_3$	Tribromomethane	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium, strong caustics	Not combustible		
BUTADIENE	$CH_2CHCHCH_2$	1,3-Butadiene; Divinyl; Biethylene; Erythrene	Strong oxidizers, copper, copper alloys	NA	2	11.5
2-BUTANONE	$CH_3COCH_2CH_3$	Methyl ethyl ketone, MEK, Ethyl methyl ketone	Very strong oxidizers	21	2	10
2-BUTOXY ETHANOL	$C_4H_9OCH_2CH_2OH$	Butyl cellosolve, ethylene-glycol monobutylether, Dowanol EB, Butyl oxitol, Jeffersol EB, Ektasolve EB	Strong oxidizers and caustics	141	1.1	10.6
BUTYL ACETATE	$CH_3COO(CH_2)_3CH_3$	n-Butyl acetate, Butyl ethanoate, Acetic acid butyl ester	Nitrates; strong oxidizers, alkalies, and acids	72	1.7	7.6
SEC-BUTYL ACETATE	$CH_3COOCH(CH_3)C_2H_5$	1-Methylpropylacetate	Nitrates; strong oxidizers, alkalies, and acids	62	1.7	9.8
TERT-BUTYL ACETATE	$CH_3COOC(CH_3)_3$	Acetic acid tert-butyl ester	Nitrates; strong oxidizers, alkalies, and acids	62 to 72(est)	1.5	?
BUTYL ALCOHOL	$CH_3CH_2CH_2CH_2OH$	1-Butanol, Propyl-carbinol, n-Butanol, n-Butyl alcohol, NBA	Strong oxidizers	84	1.4	11.2
SEC-BUTYL ALCOHOL	$CH_3CHOHCH_2CH_3$	2-Butanol, Methyl ethyl carbinol, Butylene hydrate, 2-Hydroxybutane	Strong oxidizers	75	1.7	9.8
TERT-BUTYL ALCOHOL	$(CH_3)_3COH$	2-Methyl-2-propanol, TBA, Trimethyl-carbinol	Strong mineral acids, strong hydrochloric acid	52	2.4	8
BUTYLAMINE	$C_4H_9NH_2$	n-Butylamine, 1-Amino-butane	Strong oxidizers and acids	10	1.7	9.8
TERT-BUTYL CHROMATE (AS CRO_3)	$((CH_3)_3CO)_2CrO_2$	Chromic acid, di-tert-Butyl ester; bis (tert-Butyl) chromate	Reducing agents, moisture	?	?	?
N-BUTYL GLYCIDYL ETHER	$C_4H_9OCH_2CHOCH_2$	BGE;1,2-Epoxy-3-butoxy-propane	Strong oxidizers and caustics	130	?	?
BUTYL MERCAPTAN	$CH_3CH_2CH_2CH_2SH$	n-Butanethiol, 1-Mercapto-butane, 1-Butanethiol	Strong oxidizers, such as dry bleaches	35	?	?
P-TERT-BUTYLTOLUENE	$CH_3C_6H_4C_4H_9$	1-Methyl-4-tert-butyl-benzene	Oxidizers	155(oc)	?	?
CADMIUM DUST (AS CD)	Cd	Synonyms vary depending upon specific compounds	Strong oxidizers, elemental sulfur, selenium, tellurium	Properties vary depending upon specific compound		
CADMIUM FUME (AS CD)	Cd/CdO	Cadmium oxide fume	Not applicable	NA	NA	NA
CALCIUM ARSENATE (AS AS)	$Ca_3(AsO_4)_2$	Tricalcium arsenate; Tricalcium ortho-arsenate; Cucumber dust; arsenic acid, calcium salt (2:3)	None hazardous	Not combustible		
CALCIUM OXIDE	CaO	Quicklime, Pebble lime	Water	Not combustible		
CAMPHOR	$C_{10}H_{16}O$	2-Camphonone, Syn-thetic camphor, Gum camphor, Laurel camphor	Oxidizers, chromic anhydride	150	0.6	3.5
CARBARYL (SEVIN®)	$C_{12}H_{11}NO_2$	1-Naphthyl n-methyl-carbamate, alpha-Naphthyl n-methyl-carbamate	Strong oxidizers	?	?	?
CARBON BLACK		Channel black, Lamp black, Furnace black, Thermal black, Acetyl-ene black	Strong oxidizers, such as chlorates, bromates, nitrates	NA	?	?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
CARBON DIOXIDE	CO_2	Carbonic acid gas, Dry ice	Chemically active metals, such as sodium, potassium, hot titanium		Not combustible	
CARBON DISULFIDE	CS_2	Carbon bisulfide	Strong oxidizers; chemically active metals, such as sodium, potassium, zinc; azides, organic amines	-22	1.3	50
CARBON MONOXIDE	CO	Monoxide	Strong oxidizers	NA	12.5	74
CARBON TETRACHLORIDE	CCl_4	Tetrachloromethane	Chemically active metals, such as sodium, potassium, magnesium		Not combustible	
CHLORDANE	$C_{10}H_6Cl_8$ (approx)	1,2,4,5,6,7,8,8-Octa-chloro-3a,4,7,7a-tetra-hydro-4,7-methano-indane	Strong oxidizers		Not combustible	
CHLORINATED CAMPHENE	$C_{10}H_{10}Cl_8$	Toxaphene	Strong oxidizers	275	?	?
CHLORINATED DIPHENYL OXIDE	$C_{12}H_4Cl_6O$	Hexachlorodiphenyl oxide	Strong oxidizers	NA	?	?
CHLORINE	Cl_2	None	Combustible substances, finely divided metals	Not combustible, but strong oxidizer		
CHLORINE DIOXIDE	ClO_2	None	Combustible substances, dust, organic matter, sulfur	NA	10	?
CHLORINE TRIFLUORIDE	ClF_3	None	Combustible substances, water, sand, glass, asbestos, silicon-containing compounds	Not combustible but highly reactive		
CHLOROACET-ALDEHYDE	$ClCH_2CHO$	2-Chloroethanal, Chloro-acetaldehyde (40% aqueous)	Oxidizers, acids, water	190 (40%)	?	?
ALPHA-CHLOROACETO-PHENONE	$C_6H_5COCH_2Cl$	Phenacyl chloride, omega-Chloroaceto-phenone, Chloromethyl phenyl ketone, Phenyl chloro-methyl ketone, "tear gas", CN	Water, steam	244	NA	NA
CHLOROBENZENE	C_6H_5Cl	Monochlorobenzene, Chlorobenzol, Phenyl chloride, MCB	Strong oxidizers	84	1.3	7.1
O-CHLORO-BENZYLIDENE MALONITRILE	$C_{10}H_5ClN_2$	OCBM, CS	Strong oxidizers			
CHLOROBROMO-METHANE	CH_2BrCl	Bromochloromethane, Methylene chloro-bromide, CB, CBM, Halon 1011	Chemically active metals: calcium, powdered aluminum, zinc, magnesium		Not combustible	
CHLORODIPHENYL (42% CHLORINE)	$C_{12}H_7Cl_3$ (approx)	Polychlorinated biphenyl, PCB	Strong oxidizers	349	?	?
CHLORODIPHENYL (54% CHLORINE)	$C_{12}H_5Cl_5$ (approx)	Polychlorinated biphenyl, PCB	Strong oxidizers	432	?	?
CHLOROFORM	$CHCl_3$	Trichloromethane	Strong caustics, chemically active metals, such as aluminum, magnesium powder, sodium, potassium		Not combustible	
BIS-CHLOROMETHYL ETHER	$O(CH_2Cl)_2$	Dichloromethylether; BCME; sym-Dichloro-dimethylether; Chloro-(chloromethoxy)methane; sym-Dichloromethyl ether; Oxybis (chloro-methane); Dimethyl-1,1-dichloroether; Chloromethyl ether; Methane, oxybis (chloro-bis-CHE)	Water, unstable	?	?	?
CHLOROMETHYL METHYL ETHER	$ClCH_2OCH_3$	Methyl chloromethyl ether; Chloromethoxy-methane; CMME; Ether, dimethyl chloro; Monochlorodimethyl-ether; Dimethyl-chloroether; Chlorodi-methylether; Methyl chloromethyl ether, anhydrous (DOT)	Water, unstable	?	?	?
1-CHLORO-1-NITROPROPANE	$C_3H_6CHClNO_2$	None	Strong oxidizers	144		?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
CHLOROPICRIN	CCl_3NO_2	Nitrotrichloromethane, Trichloronitromethane, Nitrochloroform	Strong oxidizers	Not combustible, but heated material will detonate		
CHLOROPRENE	$CH_2CClCHCH_2$	2-Chloro-1,3-Buta-diene; Chlorobuta-diene; beta-Chloro-prene	Peroxides, other oxidizers	-4	4	20
CHROMIC ACID AND CHROMATES (AS CRO_3)	H_2CrO_4	Synonyms vary depending upon specific compound	Combustible, organic, or other readily oxidizable materials: paper, wood, sulfur, aluminum, plastics, etc.	Properties vary depending upon specific compound		
CHROMIUM METAL AND INSOLUBLE SALTS (AS CR)	Cr	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
CHROMIUM: SOLUBLE CHROMIC AND CHROMOUS SALTS (AS CR)	Cr	Synonyms vary depending upon specific compound	Water	Properties vary depending upon specific compound		
COAL TAR PITCH VOLATILES		Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
COBALT METAL, FUME, AND DUST (AS CO)	Co	Synonyms vary depending upon specific compound	Strong oxidizers	NA	NA	NA
COPPER DUST AND MIST (AS CU)	Cu	Synonyms vary depending upon specific compound	Acetylene gas, magnesium metal	?	?	?
COPPER FUME (AS CU)	Cu	Synonyms vary depending upon specific compound	Acetylene gas	NA	NA	NA
COTTON DUST (RAW)		None	Strong oxidizers	NA	NA	NA
CRAG® HERBICIDE	$C_8H_7Cl_3OOSO_3Na$	Sesone; Crag® herbicide No. 1; Sodium-2-(2,4-dichloro-phenoxy) ethyl sulfate	Strong oxidizers	Not combustible		
CRESOL	$CH_3C_6H_4OH$	Cresylic acid; ortho-, meta-, or para-Cresol; 2-,3-, or 4-Methyl phenol	Strong oxidizers	o-178/m-187/ p-187	?	?
CROTONALDEHYDE	$CH_3CHCHCHO$	beta-Methylacrolein, Propylene aldehyde, Crontonic aldehyde, 2-Butenal	Caustics, ammonia, organic amines, mineral acids, strong oxidizers	55	2.1	15.5
CUMENE	$C_6H_5C_3H_7$	Isopropyl benzene, 2-Phenyl propane, Cumol	Oxidizers	111	0.9	6.5
CYANIDES (AS CN)	KCN/NaCN	1) Potassium cyanide 2) Sodium cyanide	Strong oxidizers, such as nitrates, chlorates, acids, acid salts	Not combustible		
CYCLOHEXANE	C_6H_{12}	Hexahydrobenzene, Hexamethylene, Benzene hexahydride	Oxidizers	-4	1.3	8.4
CYCLOHEXANOL	$C_6H_{11}OH$	Hexalin, Hydralin, Hydroxycyclohexane, Anol, Hexahydro-phenol, Cyclohexyl alcohol	Strong oxidizers	154	2.4	?
CYCLOHEXANONE	$C_6H_{10}O$	Pimelic ketone, Cyclohexyl ketone	Oxidizing agents, nitric acid	111	1.1 (212°F)	?
CYCLOHEXENE	C_6H_{10}	Benzene tetrahydride	Strong oxidizers	10	1	5 (212°F)
CYCLOPENTADIENE	C_5H_6	1,3-Cyclopentadiene	Strong oxidizers	< 90 (oc)	?	?
2,4-D	$C_8H_6Cl_2O_3$	2,4-Dichlorophenoxy-acetic acid	Strong oxidizers	?	?	?
DDT	$C_{14}H_9Cl_5$	p,p'-DDT; 2,2-bis(p-Chlorophenyl)-1,1,1-trichloroethane; Dichloro-diphenyl-trichloroethane	Strong oxidizers	Not combustible		
DECABORANE	$B_{10}H_{14}$	None	Oxidizers, water, halogenated compounds	176	?	?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
DEMETON*	$C_8H_{19}O_3PS_2OC_2H_4S$ $C_2H_5)_2$	Systox®; o,o-Diethyl o-(2-ethylthio)ethyl phosphorothioate mixture; demeton-o	Strong oxidizers	?	?	?
DIACETONE ALCOHOL	$(CH_3)_2C(OH)CH_2COCH_3$	Diacetone, 4-Hydroxy-4-methyl-2-pentanone, 2-Methyl-2-pentanol-4-one	Strong oxidizers and alkalies	136	1.8	6.9
DIAZOMETHANE	CH_2N_2	Azimethylene, Diazirine	Alkali metals, drying agents such as calcium sulfate	NA	?	?
DIBORANE	B_2H_6	Boroethane	Air, halogenated compounds, aluminum, lithium, active metals, oxidized surfaces	?	0.8	98
DIBUTYL PHOSPHATE	$(C_4H_9O)_2(OH)PO$	Dibutyl acid o-phosphate, Di-n-butyl hydrogen phosphate, Dibutyl phosphoric acid	Strong oxidizers	?	?	?
DIBUTYLPHTHALATE	$C_6H_4(CO_2C_4H_9)_2$	DBP; Dibutyl; 1,2,-Benzene-dicarboxylate	Nitrates; strong oxidizers, alkalies, and acids	315	0.5 (at Fl.P)	?
O-DICHLORO-BENZENE	$C_6H_4Cl_2$	1,2-Dichlorobenzene; o-Dichlorobenzol	Strong oxidizers, hot aluminum or aluminum alloys	151	2.2	9.2
P-DICHLORO-BENZENE	$C_6H_4Cl_2$	1,4-Dichlorobenzene; Dichloricide; PDCB	None hazardous	150	2.5	?
3,3'-DICHLORO-BENZIDINE (AND ITS SALTS)	$C_{12}H_{10}Cl_2N_2$	Dichlorobenzidine base; o,o'-Dichloro-benzidine; 3,3'-Dichlorobiphenyl -4,4'-diamine; 3,3'-Dichloro-4,4'-biphenyl-diamine; DCB; 4,4'-Diamino-3,3'-Dichlorobiphenyl; 3,3'-Dichloro-4 4'-diaminobiphenyl	Not available	NA	NA	NA
DICHLORODI-FLUORO-METHANE	CCl_2F_2	Refrigerant 12, Freon 12, Propellant 12, Halon 122	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium		Not combustible	
1,3-DICHLORO-5,5-DIMETHYL-HYDANTOIN	$C_5H_6Cl_2N_2O_2$	Halane, Dactin	Water, strong acids, easily oxidized materials, such as ammonia salts, sulfides, etc.	346	?	?
1,1-DICHLORO-ETHANE	CH_3CHCl_2	Asymmetrical Dichloro-ethane, Ethylidene chloride; 1,1-Ethylidene dichloride	Strong oxidizers and caustics	17	6	16
1,2-DICHLORO-ETHYLENE	ClCHCHCl	Acetylene dichloride, cis-Acetylene dichloride, Dioform, trans-Acetylene dichloride, sym-Dichloro-ethylene	Strong oxidizers	36 to 39	9.7	12.8
DICHLOROETHYL ETHER	$(ClCH_2CH_2)_2O$	bis(2-Chloroethyl) ether; 2,2-Dichloro-diethytether	Strong oxidizers	131	?	?
DICHLOROMONO-FLUOROMETHANE	$CHCl_2F$	Refrigerant 21, Freon 21, Halon 112, Dichlorofluoro-methane	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium		Not combustible	
1,1-DICHLORO-1-NITROETHANE	$CH_3CCl_2NO_2$	None	Strong oxidizers	136	?	?
DICHLOROTETRA-FLUOROETHANE	$F_2ClCCClF_2$	1,2-Dichlorotetra-fluoroethane; Freon 114; Refrigerant 114; Halon 242	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium		Not combustible	
DICHLORVOS	$(CH_3O)_2POOCH$ CCl_2	DDVP; 2,2-Dichloro-vinyl dimethyl phosphate	None hazardous		Not combustible	
DIELDRIN	$C_{12}H_8Cl_6O$	1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-exo-5,8-di-methano-naphthalene	Strong oxidizers, active metals like sodium, strong acids, phenols		Not combustible	
DIETHYLAMINE	$(C_2H_5)_2NH$	None	Strong oxidizers and acids	<0	1.8	10.1
DIETHYLAMINO-ETHANOL	$(C_2H_5)_2NC_2H_4OH$	2-Diethylaminoethyl alcohol; N,N-Diethyl-ethanolamine; Diethyl-(2-hydroxy-ethyl)amine; 2-Diethylamino ethanol	Strong oxidizers and acids	126	6.7	11.7

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
DIFLUORO-DIBROMO-METHANE	CBr_2F_2	Dibromodifluoro-methane, Freon 12B2	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium		Not combustible	
DIGLYCIDYL ETHER	$C_6H_{10}O_3$	di(Epoxypropyl)ether; bis(2,3-Epoxypropyl)-ether; 2-Epoxypropyl ether; Diallyl ether dioxide; DGE	Strong oxidizers	?	?	?
DIISOBUTYL KETONE	$((CH_3)_2CHCH_2)_2CO$	2,6-Dimethyl-4-heptan-one; sym-Diisopropyl-acetone; Isovalerone; Valerone	Strong oxidizers	140	0.8	6.2
DIISOPROPYL-AMINE	$(CH_3)_2CHNHCH(CH_3)_2$	None	Strong oxidizers, strong acids	20	0.8	7.1
DIMETHYL ACETAMIDE	$CH_3CON(CH_3)_2$	N,N-Dimethyl acet-amide; DMAC	Carbon tetra-chloride; other halogenated com-pounds, when in contact with iron	150(oc)	1.8	11.5
DIMETHYLAMINE	$(CH_3)_2NH$	Dimethylamine, anhydrous	Strong oxidizers, chlorine, mercury	NA	2.8	14.4
4-DIMETHYL-AMINOAZO-BENZENE	$C_{14}H_{15}N_3$	N,N-dimethyl-4-aminoazo-benzene; N,N-Dimethyl-4-(phenylazo)-benzen-amine; p-Dimethyl-aminoazo-benzene; Methyl yellow; Butter yellow; DAB; N,N-Dimethyl-p-phenylazo-aniline	Not available	NA	NA	NA
DIMETHYLANILINE	$C_6H_5N(CH_3)_2$	N,N-Dimethylaniline	Strong oxidizers, strong acids	145	1	?
DIMETHYL-1,2-DIBROMO-2,2-DICHLOROETHYL PHOSPHATE	$C_4H_7O_4PBr_2Cl_2$	Naled; 1,2-Dibromo-2,2, dichloro-ethyl dimethyl phosphate; Dibrom	Strong oxidizers		Not combustible	
DIMETHYL FORMAMIDE	$HCON(CH_3)_2$	N,N-Dimethyl formamide; DMF	Carbon tetra-chloride; other halogenated com-pounds, when in contact with iron; strong oxidizers; alkyl aluminums	136	2.2	15.2
1,1-DIMETHYL-HYDRAZINE	$(CH_3)_2NNH_2$	Unsymmetrical Dimethyl-hydrazine, UDMH	Oxidizers, halo-gens, metallic mercury, fuming nitric acid, hydro-gen peroxide	5	2	95
DIMETHYL-PHTHALATE	$C_{10}H_{10}O_4$	DMP	Nitrates, strong oxidizers, alkalies, and acids	295	1.2 (at Fl.P)	?
DIMETHYLSULFATE	$(CH_3)_2SO_4$	Methyl sulfate	Strong oxidizers and ammonia solutions	182	?	?
DINITROBENZENE (ALL ISOMERS)	$C_6H_4(NO_2)_2$	o-Dinitrobenzene, 1,2-Dinitrobenzene; m-Dinitrobenzene, 1,3-Dinitrobenzene; p-Dinitrobenzene, 1,4-Dinitrobenzene	Strong oxidizers, caustics, metals, such as tin, zinc	Expl-odes	?	?
DINITRO-O-CRESOL	$CH_3C_6H_2OH(NO_2)_2$	3,5-Dinitro-2-hydroxy-toluene; 4,6-Dinitro-o-cresol; 4,6-Dinitro-2-methyl-phenol; DNOC; DN	Strong oxidizers	None		
DINITROTOLUENE	$C_6H_3CH_3(NO_2)_2$	DNT	Strong oxidizers, caustics, metals, such as tin, zinc	404	?	?
DI-SEC-OCTYL PHTHALATE	$C_{24}H_{38}O_4$	DOP, bis-(2-Ethyl-hexyl) phthalate, Di-2-Ethyl-hexyl phthalate, DEHP	Nitrates; strong oxidizers, acids, and alkalides	425(oc)	?	?
DIOXANE	$OCH_2CH_2OCH_2CH_2$	Diethylene dioxide; Diethylene ether; Dioxan; p-Dioxane; 1,4-Dioxane	Strong oxidizers	54	2	22
DIPHENYL	$C_6H_5C_6H_5$	Biphenyl, Phenyl benzene	Oxidizers	235	0.6 (212°F)	5.8 (311°F)
DIPROPYLENE GLYCOL METHYL ETHER	$C_7H_{16}O_3$	Dipropylene glycol monomethyl ether, Dowanol 50B	Strong oxidizers	185	?	?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
ENDRIN	$C_{12}H_8Cl_6O$	1,2,3,4,10,10-Hexa-chloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-dimethano-naphthalene	Strong oxidizers and acids	Not combustible, but may be dissolved in flammable solvent		
EPICHLOROHYDRIN	C_3H_5OCl	1-Chloro-2,3-epoxy-propane; 2-Chloro-propylene oxide; gamma-Chloropropyl-ene oxide	Strong oxidizers and acids, caustics, zinc, aluminum, chlorides of iron and aluminum	100	3.8	21
EPN	$C_{14}H_{14}NO_4PS$	o-Ethyl o-p-nitrophenyl thionobenzene phosphonate, o-Ethyl o-p-nitrophenyl benzene-phonothioate	Strong oxidizers	Not combustible		
ETHANOLAMINE	$HOCH_2CH_2NH_2$	Ethylolamine, Monoethanolamine, beta-Aminoethyl alcohol, 2-Amino-ethanol, 2-Hydrox-ethylamine	Strong oxidizers and acids	185	5.5	*17
2-ETHOXYETHYL-ACETATE	$C_2H_5OCH_2CH_2OOC$ CH_3	Ethylene glycol monoethyl ether, Cellosolve® solvent	Strong oxidizers	120(oc)	1.8	14
2-ETHOXYETHYL-ACETATE	$C_2H_5OCH_2CH_2OOC$ CH_3	Cellosolve® acetate, Glycol monoethyl ether acetate, Ethylene glycol monoethyl ether acetate	Nitrates; strong oxidizers, alkalies, and acids	117	1.7	?
ETHYL ACETATE	$CH_3COOC_2H_5$	Acetic ester, Acetic ether, Ethyl enthanoate	Nitrates; strong oxidizers, alkalies, and acids	24	2.2	11
ETHYLAMINE	$C_2H_5NH_2$	Ethylamine, anhydrous; Aminoethane; Mono-ethylamine	Strong acids and oxidizers	< 0	3.5	14
ETHYL ACRYLATE	$CH_2CHCOOC_2H_5$	Ethyl propenoate	Oxidizers, per-oxides, polymer-izers, strong alkalies, moisture	48	1.8	?
ETHYL BENZENE	$C_6H_5C_2H_5$	Phenylethane, Ethyl-benzol	Strong oxidizers	59	1.0	6.7
ETHYL BROMIDE	C_2H_5Br	Bromoethane	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	< -4	6.7	11.3
ETHYL BUTYL KETONE	$C_2H_5COC_4H_9$	Butyl ethyl ketone, 3-Heptanone	Oxidizers	115(oc)	1.4	8.8
ETHYL CHLORIDE	C_2H_5Cl	Chloroethane, Monochloroethane, Hydrochloric ether, Muriatic ether	Chemically active metals; sodium, potassium, calcium, powdered aluminum	-58	3.8	15.4
ETHYLENE CHLOROHYDRIN	CH_2ClCH_2OH	2-Chloroethanol, 2-Chloroethyl alcohol	Strong oxidizers and caustics	140	4.9	15.9
ETHYLENE-DIAMINE	$NH_2CH_2CH_2NH_2$	1,2-Diaminoethane; Ethylenediamine, anhydrous; 1,2-Ethanediamine	Strong acids and oxidizers, chlorinated organic compounds	93	5.8	11.1
ETHYLENE DIBROMIDE	CH_2BrCH_2Br	1,2-Dibromoethane; Ethylene bromide	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium; liquid ammonia; strong oxidizers	Not combustible		
ETHYLENE DICHLORIDE	$ClCH_2CH_2Cl$	Ethylene chloride; 1,2-Dichloroethane; Glycol dichloride	Strong oxidizers and caustics, chemically active metals, such as aluminum or magnesium powder, sodium, potassium	55	6.2	16
ETHYLENE GLYCOL DINITRATE AND/OR NITROGLYCERIN	$C_2H_4(NO_3)_2$ $C_3H_5(NO_3)_3$	Glycol dinitrate, Nitroglycol Blasting gelatin, Glycerin trinitrate, EGDN	Acids	Explodes		
ETHYLENEIMINE	C_2H_5N	Ethyleimine; Dimethyl-enimine; Dihydro-azirine; Azirane; Aziridine; Aminoethyl-ene; Azacyclo-propane; 1H-Azirine, dihydro-; Dihydro-1H-azirine; Dimethyl-eneimine; Ethylimine	Polymerizes explosively in presence of oxidizing materials	12	3.3	46

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
ETHYLENE OXIDE	C_2H_4O	Dimethylene oxide; 1,2-Epoxy ethane; Oxirane	Even small amounts of strong acids, alkalies, oxidizers; catalytic anhydrous chlorides of iron, aluminum, tin; oxides of iron; aluminum	< 0	3	100
ETHYL ETHER	$C_2H_5OC_2H_5$	Diethyl ether, Ethyl oxide, Ether, Diethyl oxide, Solvent ether	Strong oxidizers	-49	1.9	36
ETHYL FORMATE	$HCOOC_2H_5$	Ethyl methanoate, Formic acid ethyl ester	Nitrates; strong oxidizers, alkalies, and acids	-4	2.8	16
ETHYL MERCAPTAN	C_2H_5SH	Ethanethiol, Ethyl sulfhydrate	Strong oxidizers	-55	2.8	18
N-ETHYLMORPHO-LINE	$C_6H_{13}ON$	4-Ethylmorpholine	Strong acids and oxidizers	90	1.0	9.8
ETHYL SILICATE	$(C_2H_5)_4SiO_4$	Ethyl silicate, condensed; Tetraethyl silicate; Ethyl ortho-silicate; Tetraethoxy-silane	Strong oxidizers, water	99	1.3	23
FERBAM	$((CH_3)_2NCS_2)_3Fe$	Ferric dimethyl dithio-carbamate, tris (Dimethyl-dithio-carbamate) iron	Strong oxidizers			
FERROVANADIUM DUST		None	Strong oxidizers	NA		
FLUORIDES (AS F)	F	Synonyms vary depending upon specific compound	Strong acids	Properties vary depending upon specific compound		
FLUORINE	F_2	None	Water, nitric acid, most oxidizable materials	Not combustible but strong oxidizer	?	?
FLUOROTRICHLORO-METHANE	CCl_3F	Refrigerant 11, Mono-fluorotrichloro-methane, Trichlorofluorometh-ane, Trichloromono-fluoromethane, Freon 11	Chemically active metals: sodium, potassium, calcium, powdered aluminum, zinc, magnesium	Not combustible		
FORMALDEHYDE	HCHO	1) Methylene oxide; 2)Formalin, methanol free (30 to 50% formaldehyde); 3) Formalin, stabilized, N.F. (6 to 15% methanol)	Strong oxidizers, alkalies, and acids; phenols; urea	NA/ 185/ 122	7	73
FORMIC ACID	HCOOH	1) Formic acid 85%; 2)Formic acid 90%; 3)Formic acid 95%; Hydrogencarboxylic acid; Methanoic acid	Strong oxidizers, strong caustics, concentrated sulfuric acid	NA/ 185/ 122	18	57
FURFURAL	C_4H_3OCHO	2-Furaldehyde, Furfur-aldehyde, Fural, 2-Furan-carboxaldehyde	Strong acids, oxidizers	140	2.1	19.3
FURFURYL ALCOHOL	$C_4H_3OCH_2OH$	2-Hydroxy-methylfuran, 2-Furylmethanol	Strong oxidizers, strong acids, organic acids may lead to polymeriz-ation	149	1.8	16.3
GLYCIDOL	$C_3H_6O_2$	2-Hydroxymethyl-oxiran; Hydroxymethyl ethylene oxide; Epoxy-propyl alcohol; 3-Hydroxy-propylene oxide; 2,3-Epoxy-1-propanol	Strong oxidizers, nitrates	162	?	?
GRAPHITE (NATURAL)	C	Plumbago, Potelot, Corbo minerals, Black lead, Carburet of iron, Silver lead, Crayon noir	Very strong oxidizers, such as fluorine, chlorine trifluoride, potassium peroxide			
HAFNIUM AND COMPOUNDS (AS HF)	Hf	Synonyms vary depending upon specific compounds	Strong oxidizers and chlorine	Properties vary depending upon specific compound		
HEPTACHLOR	$C_{10}H_5Cl_7$	1,4,5,6,7,8,8-Hepta-chloro-3a,4,7,7a-tetra-hydro-4,7-methano-idene	Melted heptachlor with iron and rust	Not combustible		
HEPTANE	$CH_3(CH_2)_5CH_3$	Normal heptane, n-heptane	Strong oxidizers	25	1.1	6.7
HEXACHLORO-ETHANE	CCl_3CCl_3	Perchloroethane	Hot iron, zinc, aluminum, alkalies	Not combustible		

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
HEXACHLORO-NAPHTHALENE	$C_{10}H_2Cl_6$	Halowax 1014	Strong oxidizers		Not combustible	
HEXANE	$CH_3(CH_2)_4CH_3$	Hexyl hydride, Normal hexane, n-hexane	Strong oxidizers	-7	1.1	7.5
2-HEXANONE	$CH_3CO(CH_2)_3CH_3$	Methyl butyl ketone, MBK, Butyl methyl ketone, Methyl n-butyl ketone	Strong oxidizers	77	1.2	8
HEXONE	$CH_3COCH_2C_3H_7$	4-Methyl-2-pentanone, Methyl isobutyl ketone, Isobutyl methyl ketone, MIBK	Strong oxidizers	73	1.4	7.5
SEC-HEXYL ACETATE	$C_8H_{16}O_2$	1,3-Dimethylbutyl acetate; Methylamyl acetate; Methylisoamyl acetate; Methylisobutyl carbinol	Nitrates, strong oxidizers, alkalies, and acids	113	0.9 (at Fl.P)	?
HYDRAZINE	N_2H_4	Hydrazine, anhydrous	Oxidizers, hydro-gen peroxide, nitric acid; metal oxides, strong acids; porous materials	100	4.7	100
HYDROGEN BROMIDE	Hbr	Anhydrous hydrobromic acid	Strong oxidizers, strong caustics, metals, molsture		Not combustible	
HYDROGEN CHLORIDE	HCl	Anhydrous hydrogen chloride; Hydrochloric acid, anhydrous	Most metals, alkali or active metals		Not combustible	
HYDROGEN CYANIDE (AS CN)	HCN	Hydrocyanic acid, Prussic acid, Formonitrile	Bases, such as caustics, amines	0	5.6	40
HYDROGEN FLUORIDE	HF	Anhydrofluoric acid, HF-A	Metals, concrete, glass, ceramics		Not combustible	
HYDROGEN PEROXIDE	H_2O_2	High-strength hydroperoxide, Peroxide, Hydrogen dioxide	Oxidizable materials; iron, copper, brass, bronze, chromium, zinc, lead, manganese, silver, catalytic metals	Not combustible, but powerful oxidizer		
HYDROGEN SELENIDE	H_2Se	Selenium hydride	Oxidizers, acids, water, halogenated hydrocarbons	NA	?	?
HYDROGEN SULFIDE	H_2S	Sulfuretted hydrogen, Hydrosulfuric acid, Hepatic gas	Strong oxidizers, metals	NA	4.3	46
HYDROQUINONE	$C_6H_6O_2$	Quinol; 1,4-Dihydro-xybenzene; 1,4-Benzenediol	Strong oxidizers	329	?	?
IODINE	I_2	None	Gaseous or aqueous ammonia, acetylene, acet-aldehyde, powdered aluminum, active metals		Not combustible	
IRON OXIDE FUME	Fe_2O_3	Ferric oxide fume	Calcium hypochloride		Not combustible	
ISOAMYL ACETATE	$C_7H_{14}O_2$	3-Methyl-1-butanol acetate, Banana oil, 2-Methylbutyl ethanoate	Nitrates; strong oxidizers, alkalies, and acids	77	1 (212°F)	7.5
ISOAMYL ALCOHOL	$(CH_3)_2CHCH_2CH_2OH$	3-Methyl-1-butanol, Isobutylcarbinol, Isopentyl alcohol, Fermentation amyl alcohol, Fusel oil	Strong oxidizers	109	1.2 (212°F)	9 (212°F)
ISOBUTYL ACETATE	$CH_3COOCH_2CH(CH_3)_2$	2-Methylpropyl acetate, beta-Methyl-propyl ethanoate, Acetic acid isobutyl ester	Nitrates; strong oxidizers, alkalies, and acids	64	2.4	10.5
ISOBUTYL ALCOHOL	$(CH_3)_2CHCH_2OH$	Isobutanol, IBA, 2-Methyl-1-propanol, Isopropylcarbinol	Strong oxidizers	82	1.2 (212°F)	10.9 (212°F)
ISOPHORONE	$C_9H_{14}O$	3,5,5-Trimethyl-2-cyclohexene-1-one	Strong oxidizers	184	0.8	3.8
ISOPROPYL ACETATE	$CH_3COOCH(CH_3)_2$	Isopropyl ester of acetic acid, sec-Propyl acetate	Nitrates; strong oxidizers, alkalies, and acids	40	1.8	8
ISOPROPYL ALCOHOL	$CH_3CHOHCH_3$	Isopropanol, IPA, 2-Propanol, sec-Propyl alcohol	Strong oxidizers	53	2	12
ISOPROPYLAMINE	$(CH_3)_2CHNH_2$	Monoisopropylamine, 2-Aminopropane	Strong acids and oxidizers	-35	2.0	10.4
ISOPROPYL ETHER	$((CH_3)_2CH)_2O$	Diisopropyl ether, 2-Isopropoxy propane	Strong oxidizers	-18	1.4	7.9

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
ISOPROPYL GLYCIDYL ETHER	$C_6H_{12}O_2$	Isopropoxymethyl-oxiran; 1,2-Epoxy-3-isopropoxypropane; isopropyl epoxypropyl ether; IGE	Strong oxidizers and caustics	92	?	?
KETENE	CH_2CO	Carbomethene, Ethenone	Water, variety organic compounds	NA	?	?
LEAD, INORGANIC FUMES AND DUSTS (AS PB)	Pb	Synonyms vary depending upon specific compound	Strong oxidizers, hydrogen peroxide, active metals: sodium, potassium	Properties vary depending upon specific compound		
LEAD ARSENATE	$Pb_3(AsO_4)_2$	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		
LINDANE	$C_6H_6Cl_6$	1,2,3,4,5,6-Hexachlo-rocyclohexane; gamma-Hexachloro-cyclohexane; Benzene hexachloride	None hazardous	Not combustible		
LITHIUM HYDRIDE	LiH	None	Oxidizers, halo-genated hydro-carbons, acids, water	NA	NA	NA
LPG		Liquefied petroleum gas, Bottled gas	Strong oxidizers	NA	1.9	9.5
MAGNESIUM OXIDE FUME	MgO	Magnesia fume	Chlorine trifluoride	Not combustible		
MALATHION	$C_{10}H_{19}O_6PS_2$	o,o-Dimethyl dithio-phosphate of diethyl mercaptosuccinate; o,o-Dimethyl S-(1,2-dicarbethoxyethyl)phosphoro-dithiocite	Strong oxidizers	Not combustible		
MALEIC ANHYDRIDE	$(CHCO)_2O$	2,5-Furanedione; cis-Butenedioic anhydride; Toxilic anhydride	Strong oxidizers; alkali metals, caustics, amines at > 150°F	215	3.4	7.1
MANGANESE AND COMPOUNDS (AS MN)	Mn	Synonyms vary depending upon specific compound	Variable	?	?	?
MERCURY AND INORGANIC COMPOUNDS (AS HG)	Hg	Quicksilver	Acetylenes, ammonia gases	Not combustible		
MERCURY, (ORGANO) ALKYL COMPOUNDS (AS HG)		Synonyms vary depending upon specific compound	Strong oxidizers, such as chlorine	Properties vary depending upon specific compound		
MESITYL OXIDE	$CH_3COCH=C(CH_3)_2$	4-Methyl-3-penten-2-one, Isobutenyl methyl ketone, Methyl iso-butenyl ketone, Iso-propylidene acetone	Oxidizers	87	1.4	?
METHOXYCHLOR	$C_{16}H_{15}Cl_3O_2$	2,2-bis(p-Methoxy-phenyl)-1,1,1-Tri-chloroethane	Strong oxidizers	NA	NA	NA
METHYL ACETATE	CH_3COOCH_3	Acetic acid, methyl ester; Methyl acetic ester; Methyl ethanoate	Nitrates; strong oxidizers, alkalies, and acids	14	3.1	16
METHYL ACETYLENE	C_3H_4	Propyne, Allylene	Strong oxidizers, chlorine, copper, copper alloys	NA	1.7	11.7
METHYL ACETYLENE-PROPADIENE MIXTURE		MAPP gas, Methyl acetylene-allene mixture, Propyne-allene mixture	Strong oxidizers, copper alloys (> 67% Cu)	NA	3.4	11
METHYL ACRYLATE	$CH_2CHCOOCH_3$	Methyl propenoate	Nitrates, oxidizers, peroxides, polymerizers, strong alkalies, moisture	13	2.8	25
METHYLAL	$CH_3OCH_2OCH_3$	Dimethyoxymethane, Methyl formal, Formal, Dimethylacetal formaldehyde	Strong oxidizers, acids	0 (oc)	1.6	17.6
METHYL ALCOHOL	CH_3OH	Methanol, Wood alcohol, Columbian spirits, Carbinol	Strong oxidizers	52	6.7	36
METHYLAMINE	CH_3NH_2	Monomethylamine, Anhydrous methylamin	Mercury, strong oxidizers	NA	5	21
METHYL (N-AMYL) KETONE	$CH_3COC_5H_{11}$	n-Amyl methyl ketone, 2-Heptanone	Strong acids, alkalies, oxidizers	120	1.1	7.9
METHYL BROMIDE	CH_3Br	Bromomethane	Aluminum, strong oxidizers	?	13.5	14.5

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
METHYL CELLOSOLVE	$CH_3OCH_2CH_2OH$	2-Methoxyethanol, Glycol monomethyl ether, Ethylene glycol monomethyl ether, Methyl oxitol, Ekta-solve, Jeffersol EM	Strong oxidizers and caustics	107	2.5	19.8
METHYL CELLOSOLVE ACETATE	$C_5H_{10}O_3$	2-Methoxyethyl acetate, Glycol mono-methyl ether acetate, Ethylene glycol mono-methyl ether acetate	Nitrates; strong oxidizers, alkalies, and acids	111	1.1	8.2
METHYL CHLORIDE	CH_3Cl	Chloromethane	Chemically active metals: potassium, powdered aluminum, zinc, magnesium	NA	7.6	19
METHYL CHLOROFORM	CH_3CCl_3	1,1,1-Trichloro-ethane; 1,1,1-Trichloro-ethane, stabilized	Strong caustics, strong oxidizers, chemically active metals, such as aluminum, magnesium powders, sodium, potassium	None	7	16
METHYL CHLOROMETHYL ETHER–SEE CHLOROMETHYL METHYL ETHER						
METHYLCYCLO-HEXANE	$CH_3C_6H_{11}$	Cyclohexylmethane, Hexahydrotoluene	Strong oxidizers	25	1.2	6.7
METHYLCYCLO-HEXANOL	$CH_3C_6H_{10}OH$	Hexahydrocresols; mixture of 2-,3-, and 4-Methylcylohexanols	Strong oxidizers	149	?	?
O-METHYLCYCLO-HEXANONE	$C_7H_{12}O$	2-Methylcyclo-hexanone	Strong oxidizers	118	?	?
METHYLENE BISPHENYL ISOCYANATE	$C_{15}H_{10}O_2N_2$	MDI; 4,4-Diphenyl-methane diisocyanate; Methylene bis(4-phenyl isocyanate); 4,4-Diiso-cyano-diphenylmethane	Strong alkalies, acids, alcohol	396(oc)	NA	NA
METHYLENE CHLORIDE	CH_2Cl_2	Dichloromethane, Methylene dichloride	Strong oxidizers and caustics; chemically active metals, such as aluminum or magnesium powders; sodium, potassium	?	12	19
METHYL FORMATE	$HCOOCH_3$	Methyl methanoate, Formic acid, Methyl ester	Strong oxidizers	-2	5	23
5-METHYL-3-HEPTANONE	$C_8H_{16}O$	Ethyl sec-amyl ketone, Ethyl amyl ketone, Amyl ethyl ketone	Oxidizers	110	?	?
METHYL IODIDE	CH_3I	Iodomethane	Strong oxidizers	Not combustible		
METHYL ISOBUTYL CARBINOL	$C_6H_{14}O$	Methyl amyl alcohol, 4-Methyl-2-pentanol, MIBC	Strong oxidizers	106	1	5.5
METHYL ISOCYANATE	CH_3NCO	None	Water, rapid reaction in presence of acid, alkali, amine; iron, tin, copper, their salts, other catalysts	<0(oc)	5.3	26
METHYL MERCAPTAN	CH_3SH	Methanethiol	Strong oxidizers, bleaches	0 (oc)	3.9	21.8
METHYL METHACRYLATE	$CH_2C(CH_3)COOCH_3$	Methacrylic acid, methyl ester	Nitrates, oxidizers, peroxides, polymerizers, strong alkalies, moisture	50 (oc)	1.7	8.2
ALPHA-METHYL STYRENE	$C_6H_5C(CH_3)CH_2$	1-Methyl-1-phenyl-ethylene, AMS	Oxidizers, per-oxides, halogens, catalysts for vinyl or ionic polymers; aluminum, iron chloride	129	1.9	6.1
MICA (LESS THAN 1% QUARTZ)		Varies depending upon specific hydrous silicate	None	Not combustible		
MOLYBDENUM, SOLUBLE COM-POUNDS (AS MO)	Mo	Synonyms vary depending upon specific compound	Alkali metals; sodium, potassium, molten magnesium	Properties vary depending upon specific compound		
MOLYBDENUM, INSOLUBLE COM-POUNDS (AS MO)	Mo	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
MONOMETHYL ANILINE	$C_6H_5NHCH_3$	N-Methyl aniline, MA, Methyl aniline	Strong acids, strong oxidizers	175	?	?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
MONOMETHYL HYDRAZINE	CH_3NHNH_2	Methyl hydrazine	Oxides of iron, copper; manganese, lead, copper alloys; porous metals, earth, asbestos, wood, cloth; oxidants, hydrogen peroxide, nitric acid	17	2.5	98
MORPHOLINE	C_4H_9ON	Tetrahydro-1,4-oxa-zine; Diethylenimide oxide	Strong acids, strong oxidizers	95	1.8	11
NAPHTHA (COAL TAR)		Naphta, Crude Solvent coal tar naphtha, High solvent naphtha	Strong oxidizers	100 to 109	?	?
NAPHTHALENE	$C_{10}H_8$	White tar, Naphthalin	Strong oxidizers	174	0.9	5.9
ALPHA-NAPHTHYL-AMINE	$C_{10}H_9N$	1-Naphthylamine, 1-Amino-naphthalene	Not available	315	?	?
BETA-NAPHTHYL-AMINE	$C_{10}H_9N$	2-Naphthylamine; 2-Amino-naphthalene	Not available	Com-bustible solid	?	?
NICKEL, METAL AND SOLUBLE COMPOUNDS (AS Ni)	Ni	Synonyms vary depending upon specific compound	Strong acids, sulfur, $Ni(NO_3)_2$; wood, other combustibles	Properties vary depending upon specific compound		
NICKEL CARBONYL	$Ni(CO)_4$	None	Nitric acid, chlorine, other oxidizers, com-bustible vapors	< -4	2	?
NICOTINE	$C_{10}H_{14}N_2$	3-(1-Methyl-2-pyrro-lidyl) pyridine	Strong oxidizers, strong acids	203	0.7	4
NITRIC ACID	HNO_3	Aqua fortis, White fuming nitric acid (WFNA), Red fuming nitric acid (RFNA), Hydrogen nitrate	Combustible organics, oxidiz-able matter; wood, turpentine, metal powder, hydrogen sulfide, etc.; strong bases	Not combustible		
NITRIC OXIDE	NO	Nitrogen monoxide	Combustible matter, chlorinated hydrocarbons, ammonia, carbon disulfide, metals, fluorine, ozone	Not combustible		
P-NITROANILINE	$C_6H_6N_2O_2$	Azoic diazo component 37, para-Aminonitro-benzene, Fast red GG base, 4-Nitroaniline, PNA	Strong oxidizers and reducers	390	?	?
NITROBENZENE	$C_6H_5NO_2$	Nitrobenzol, Oil of mirbane	Concentrated nitric acid, nitrogen tetroxide, caustic, chemically active metals like tin or zinc	190	1.8	?
4-NITROBIPHENYL	$C_{12}H_9NO_2$	p-Nitrobiphenyl, p-Nitrodiphenyl, 4-Nitrodiphenyl, 4-Phenyl-nitro-benzene, p-Phenyl-nitro-benzene, PNB	Strong reducers	NA	NA	NA
P-NITROCHLORO-BENZENE	$ClC_6H_4NO_2$	PNCB, PCNB, 4-Chloronitro-benzene, p-Chloronitro-benzene, 1-Chloro-4-nitro-benzene	Strong oxidizers	261	?	?
NITROETHANE	$C_2H_5NO_2$	None	Amines, strong acids, alkalies, and oxidizers; hydro-carbons, other combustibles; metal oxides	82	3.4	?
NITROGEN DIOXIDE	NO_2 and N_2O_4	Nitrogen tetroxide, NTO, Dinitrogen tetroxide, Nitrogen peroxide	Combustible matter, chlorinated hydrocarbons, ammonia, carbon disulfide	Not combustible		
NITROGEN TRIFLUORIDE	NF_3	None	Water, oil, grease; oxidizable materials; ammonia, carbon monoxide, methane, hydro-gen, hydrogen sulfide, active metals; oxides	Not combustible		
NITROMETHANE	CH_3NO_2	None	Amines, strong acids, alkalies, and oxidizers; hydro-carbons, other combustibles; metallic oxides	95	7.3	?
1-NITROPROPANE	$CH_3CH_2CH_2NO_2$	None	Amines, strong acids, alkalies; strong oxidizers; hydrocarbons, other combust-ibles, metal oxides	96	2.2	?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
2-NITROPROPANE	$CH_3CH(NO_2)CH_3$	sec-Nitropropane	Amines, strong acids, alkalies, and oxidizers, metal oxides, combustible materials	82	2.6	?
N-NITROSODI-METHYLAMINE	$C_2H_6N_2O$	N-Nitrosodimethyl-amine; NDMA; Dimethylnitrosamine; DMNA; N,N-Dimethylnitros-amine; DMN; N-Methyl-N-Nitroso-methanamine	Strong oxidizing agents	?	?	?
NITROTOLUENE	$NO_2C_6H_4CH_3$	Orthonitrotoluene, o-Nitrotoluol, Metanitrotoluene, m-Nitrotoluol, Paranitrotoluene, p-Nitrotoluol	Strong oxidizers, sulfuric acid	223/ 214/ 223	2.2/ 1.6/ 1.6	?
OCTACHLORO-NAPHTHALENE	$C_{10}Cl_8$	Halowax 1051	Strong oxidizers	Not combustible		
OCTANE	C_8H_{18}	Normal octane	Strong oxidizers	56	1	6.5
OIL MIST (MINERAL)		Mist of white mineral oil, cutting oil, heat-treating oil, hydraulic oil, cable oil, lubricating oil	None hazardous	275	NA	NA
OSMIUM TETROXIDE	OsO_4	Osmic acid	Hydrochloric acid, easily oxidized organic materials	Not combustible		
OXALIC ACID	$HOOCCOOH\text{-}2H_2O$	Oxalic acid dihydrate, Ethane dioic acid	Strong oxidizers, silver	None	?	?
OXYGEN DIFLUORIDE	OF_2	Difluorine monoxide, Fluorine monoxide	All combustible materials, chlorine, bromine, iodine, platinum, metal oxides, moist air	Not combustible, but strong oxidizer		
OZONE	O_3	None	All oxidizable materials, both organic and inorganic	NA	NA	NA
PARAQUAT COMPOUNDS		Synonyms vary depending upon specific compound	Strong oxidizers	Not combustible		
PARATHION	$(C_2H_5O)_2PSOC_6H_4NO_2$	o,o-Diethyl-o,p-nitro-phenyl phosphoro-thioate; Ethyl parathion	Strong oxidizers	Not combustible		
PENTABORANE	B_5H_9	Stable pentaborane, Pentaboron nonahydride	Oxidizers, halo-gens, halogenated compounds; impure material ignites spontane-ously	86	0.42	?
PENTACHLORO-NAPHTHALENE	$C_{10}H_3Cl_5$	Halowax 1013	Strong oxidizers	Not combustible		
PENTACHLORO-PHENOL	C_6Cl_5OH	PCP, Penta	Strong oxidizers	Not combustible		
PENTANE	C_5H_{12}	Normal pentane	Strong oxidizers	-57	1.5	7.8
2-PENTANONE	$CH_3COC_3H_7$	Methyl propyl ketone, Ethyl acetone, MPK	Oxidizing agents	45	1.5	8.2
PERCHLOROMETHYL MERCAPTAN	CH_2SCl	PMM, Trichloromethyl sulfur chloride	Alkalies, amines, hot iron, hot water	Not combustible		
PERCHLORYL FLUORIDE	ClO_3F	Chlorine oxyfluoride	Combustibles, strong bases, amines, finely divided metals; oxidizable materials	Not combustible		
PETROLEUM DISTILLATES (NAPHTHA)		Petroleum naphtha; Aliphatic petroleum naphtha; Petroleum ether (95 to 115°C); Naphtha, petroleum	Strong oxidizers	-40 to -86	1	6
PHENOL	C_6H_5OH	Carbolic acid, Monohydroxy benzene	Strong oxidizers, calcium hypochlorite	174	1.7	8.6
P-PHENYLENE DIAMINE	$C_6H_8N_2$	p-Diamino benzene; 1,4-Diaminobenzene	Strong oxidizers	312		
PHENYL ETHER	$(C_6H_5)_2O$	Diphenyl ether, Diphenyl oxide	Strong oxidizers	239	0.8	1.5
PHENYL ETHER-BIPHENYL MIXTURE	$(C_6H_5)_2O$ and $C_6H_5C_6H_5$	Dowtherm A, Diphenyl oxide-diphenyl mixture	Strong oxidizers	255 (oc)	0.5	6.2 (500°F)

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
PHENYL GLYCIDYL ETHER	$C_6H_5OCH_2CHOCH_2$	Glycidyl phenyl ether; Phenyl epoxypropyl ether; 1,2-Epoxy-3-phenoxypropane; PGE	Strong oxidizers, amines, strong acids, strong bases	248	?	?
PHENYLHYDRAZINE	$C_6H_5NHNH_2$	Hydrazinobenzene	Strong oxidizers, lead dioxide	192	?	?
PHOSDRIN	$C_7H_{13}O_4PO_4$	Mevinphos ®, 2-Carbo-methoxy-1-methylvinyl dimethyl phosphate	Strong oxidizers	175 (oc)	?	?
PHOSGENE	$COCl_2$	Carbonyl chloride, Carbon oxychloride, Chloroformyl chloride	Moisture	Not combustible		
PHOSPHINE	PH_3	Hydrogen phosphide, Phosphorus hydride, Phosphorated hydrogen	Air, oxidizers, chlorine, acids, moisture, halogenated hydrocarbons	NA	?	?
PHOSPHORIC ACID	H_3PO_4	White phosphoric acid, Orthophosphoric acid, 85% Phosphoric acid, Metaphosphoric acid	Strong caustics, most metals	Not combustible		
PHOSPHORUS (YELLOW)	P_4	White phosphorus; WP; Phosphorus, elemental, white	Air, all oxidizing agents, including elemental sulfur, strong caustics	Spontaneous in air >86°F	NA	NA
PHOSPHORUS PENTACHLORIDE	PCl_5	None	Water; magnesium oxide; chemically active metals: sodium, potassium; alkalies	Not combustible		
PHOSPHORUS PENTASULFIDE	P_2S_5 or P_4S_{10}	Phosphorus persulfide, Regular phosphorus pentasulfide, Reactive phosphorus penta-sulfide, Distilled phosphorus penta-sulfide, Undistilled phosphorus penta-sulfide	Water, alcohols, strong oxidizers	?		
PHOSPHORUS TRICHLORIDE	PCl_3	Phosphorus chloride	Water, alcohol, when in contact with combustible organics; chemically active metals: sodium, potassium, aluminum, strong nitric acid	Not combustible		
PHTHALIC ANHYDRIDE	$C_6H_4(CO)_2O$	PAN	Strong oxidizers	304	1.7	10.4
PICRIC ACID	$HOC_6H_2(NO_2)_3$	2,4,6-Trinitrophenol; Lyddite; Pertite; Shimose; Melinite	Copper, lead, zinc, other metals, salts, plaster, concrete	302	?	?
PIVAL ®	$C_{14}H_{14}O_3$	2-Pivalyl-1,3-indandione; Pivalyl; Pindone; tert-Butyl-valone; 1,3-Dioxo-2-pivaloy-lindane	None hazardous	?	?	?
PLATINUM (SOLUBLE SALTS AS Pt)	Pt	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		
PORTLAND CEMENT (LESS THAN 1% QUARTZ)		Hydraulic cement, Cement, Portland cement silicate	None hazardous	Not combustible		
PROPANE	$CH_3CH_2CH_3$	Dimethyl methane	Strong oxidizers	NA	2.2	9.5
BETA-PROPIO-LACTONE	$C_3H_4O_2$	Hydroacrylic acid, beta-lactone; 3-Hydroxy-propionic acid; beta-Lactone; 2-Oxetanone; Betaprone; Propanolide; Propiolactone; Propionic acid; 3-Hydroxy-beta-lactone; beta-Propiolactone; beta-Proprolactone; BPL	Acetates, halogens, thiocyanates, and thiosulphates	158	2.9	?
N-PROPYL ACETATE	$CH_3COOCH_2CH_2CH_3$	Propylacetate; Acetic acid, n-propyl ester	Nitrates; strong oxidizers, alkalies, and acids	58	2	8
PROPYL ALCOHOL	$CH_3CH_2CH_2OH$	n-Propyl alcohol, 1-Propanol, Ethyl carbinol	Strong oxidizers	59	2	14
PROPYLENE DICHLORIDE	$CH_3CHClCH_2Cl$	1,2-Dichloropropane	Strong oxidizers and acids	60	3.4	14.5
PROPYLENEIMINE	C_3H_7N	2-Methylaziridine	Acids, strong oxidizers	25	?	?

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
PROPYLENE OXIDE	CH_3CHOCH_2	1,2-Epoxy propane, Propene oxide, Methyloxirane	Anhydrous metal chlorides, iron; strong acids, caustics, peroxides	-35	2.1	37
N-PROPYL NITRATE	$C_3H_7NO_3$	None	Strong oxidizers, combustibles	68	2	100
PYRETHRUM		Synonyms vary depending upon specific compound	Strong oxidizers	180 to 190(oc)	?	?
PYRIDINE	C_5H_5N	Azabenzene, Azine	Strong oxidizers, strong acids	68	1.8	12.4
QUINONE	OC_6H_4O	p-Benzoquinone	Strong oxidizers	?	?	?
RHODIUM, METAL FUME AND DUST (AS Rh)	Rh	Synonyms vary depending upon specific compound	None hazardous	Not combustible		
RHODIUM, SOLUBLE SALTS (AS Rh)	Rh	Synonyms vary depending upon specific compound	None hazardous	Properties vary depending upon specific compound		
RONNEL	$(CH_3O)_2PSOC_6H_2Cl_3$	Fenchlorophos; o,o- Dimethyl o-(2,4,5-trichlorophenyl) phosphoro-thioate	Strong oxidizers	Not combustible		
ROTENONE (COMMERCIAL)	$C_{23}H_{22}O_6$	Tubatoxin, "Cube", Derrin	Strong oxidizers	?	?	?
SELENIUM COMPOUNDS (AS SE)	Se	Synonyms vary depending upon specific compound	Acids, strong oxidizing agents	Properties vary depending upon specific compound		
SELENIUM HEXAFLUORIDE (AS SE)	SeF_6	None	None reported	Not combustible		
SILICA (AMORPHOUS)	SiO_2	Diatomite, Silicon dioxide (amorphous), Diatomaceous earth, Diatomaceous silica	Fluorine, oxygen difluoride, chlorine trifluoride	Not combustible		
SILICA (CRYSTALLINE)	SiO_2	Quartz, Cristobalite, Tridymite	Powerful oxidiz-ers: fluorine, chlorine trifluor-ide, manganese trioxide, oxygen difluoride, etc.	Not combustible		
SILVER, METAL, AND SOLUBLE COMPOUNDS (AS AG)	Ag	Synonyms vary depending upon specific compounds	Acetylene, ammo-nia, hydrogen per-oxide	Properties vary depending upon specific compound		
SOAPSTONE	$3MgO{\cdot}4SiO_2{\cdot}H_2O$	Massive talc, Steatite, Soapstone silicate	None hazardous	Not combustible		
SODIUM FLUOROACETATE	$CH_2FCOONa$	1080, Sodium mono-fluoroacetate, SFA	None hazardous	Not combustible		
SODIUM HYDROXIDE	NaOH	Caustic soda, Soda lye, Lye	Water, acids, flammable liquids, organic halogens, metals: aluminum, tin, zinc; nitro-methane and nitro compounds	Not combustible		
STIBINE	SbH_3	Hydrogen antimonide, Antimony trihydride	Acids, halogenated hydrocarbons, oxidizers, moisture	NA	?	?
STODDARD SOLVENT	C_9H_{20}	Dry cleaning safety solvent, Mineral spirits	Strong oxidizers	102 to 140	0.8	?
STRYCHNINE	$C_{21}H_{22}N_2O_2$	None	Strong oxidizers	Not combustible		
STYRENE	$C_6H_5CHCH_2$	Phenylethylene, Vinylbenzene, Cinnamene, Styrene monomer	Oxidizers, catalysts for vinyl polymers; peroxides, strong acids, aluminum chloride	90	1.1	6.1
SULFUR DIOXIDE	SO_2	None	Powdered and alkali metals such as sodium, potassium	Not combustible		
SULFURIC ACID	H_2SO_4	Oil of vitriol	Organics:chlora-tes, carbides, fulminates, picrates, metals	Not combustible, but highly reactive		
SULFUR MONOCHLORIDE	S_2Cl_2	Sulfur chloride, Sulfur subchloride	Peroxides, oxides of phosphorous, organics; water	245	?	?
SULFUR PENTAFLUORIDE	S_2F_{10}	Disulfur decafluoride	None reported	Not combustible		

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
SULFURYL FLUORIDE	SO_2F_2	None	None hazardous		Not combustible	
2,4,5-T	$Cl_3C_6H_2OCH_2COOH$	2,4,5-Trichlorophen-oxyacetic acid	None hazardous		Not combustible	
TALC (NON-ASBESTI-FORM)		Hydrous magnesium silicate, Steatite talc, Non-fibrous talc, Non-asbestiform talc	None hazardous		Not combustible	
TANTALUM METAL, OXIDE DUSTS (AS TA)	Ta	Synonyms vary depending upon specific compound	Strong oxidizers		Properties vary depending upon specific compound	
TEDP	$(C_2H_5)_4P_2S_3O_5$	Tetraethyl pyro-phosphorodithionate, Sulfotepp, Tetraethyl dithiono-pyrophosph-ate, Tetraethyl dithio-pyro-phosphate	Strong oxidizers		Not combustible	
TELLURIUM COMPOUNDS (AS TE)	Te	Synonyms vary depending upon specific compound	Hazards vary depending upon specific compound		Properties vary depending upon specific compound	
TELLURIUM HEXAFLUORIDE (AS TE)	TeF_6	None	None hazardous		Not combustible	
TEPP	$(C_2H_5)_4P_2O_7$	Tetraethyl pyro-phosphate, Commercial 40%, Ethyl pyro-phosphate, Bladan, Nifost, Vapotone, Tetron, Killax, Moropal	Strong oxidizers		Not combustible	
TERPHENYLS	$C_{18}H_{14}$	Triphenyls, ortho-Terphenyl, meta-Terphenyl, para-Ter-phenyl, Mixed ter-phenyls, Diphenyl benzenes	None hazardous	325 to 405(oc)	?	?
1,1,2,2-TETRA-CHLORO-1,2-DIFLUOROETHANE	CCl_2F-CCl_2F	Refrigerant 112, Halocarbon 112, Freon 112	Chemically active metals: sodium, potassium, beryllium, powdered aluminum, zinc, magnesium		Not combustible	
1,1,1,2-TETRA-CHLORO-2,2-DIFLUOROETHANE	CC_2F-$CClF_2$	Refrigerant 112a; Halocarbon 112a; 2,2-Difluoro-1,1,1,2-Tetrachloroetha ne; Freon 112a	Chemically active metals: sodium, potassium, beryllium, powdered aluminum, zinc, magnesium		Not combustible	
1,1,2,2-TETRA-CHLOROETHANE	$CHCl_2CHCl_2$	Symmetrical tetrachloroethane, Acetylene tetra-chloride, sym-tetra-chloroethane	Chemically active metals: strong caustics; hot iron, aluminum, zinc in presence of steam		Not combustible	
TETRACHLORO-ETHYLENE	CCl_2CCl_2	Perchloroethylene, Perchlorethylene, Tetrachlorethylene, Perk	Strong oxidizers, chemically active metals, such as barium, lithium, beryllium		Not combustible	
TETRACHLORO-NAPHTHALENE	$C_{10}H_4Cl_4$	Halowax, Seekay wax, Nibren wax	Strong oxidizers	410(oc)	?	?
TETRAETHYL LEAD (AS PB)	$Pb(C_2H_5)_4$	TEL, Lead tetraethyl, Motor fuel anti-knock compound	Strong oxidizers, sulfuryl chloride, potassium per-manganate	200	?	?
TETRAHYDRO-FURAN	C_4H_8O	Diethylene oxide, Tetramethylene oxide, THF	Strong oxidizers	6	2	11.8
TETRAMETHYL LEAD (AS PB)	$Pb(CH_3)_4$	TML, Lead tetra-methyl, Motor fuel anti-knock compound	Strong oxidizers, such as sulfuryl chloride or potassium per-manganate	100	?	?
TETRAMETHYL SUCCINONITRILE	$(CH_3)_2C(CN)C(CN)(CH_3)_2$	TMSN	Strong oxidizers	?	?	?
TETRANITRO-METHANE	$C(NO_2)_4$	Tetan	Hydrocarbons, alkalies, metals		Not combustible	
TETRYL	$(NO_2)_3C_6H_2N(NO_2)CH_3$	2,4,6-Trinitrophenyl-methylnitramin e; N-Methyl-N-2,4,6-tetra-nitro-aniline; Nitramine; Tetralite	Oxidizable materials		Explodes	
THALLIUM, SOLUBLE COMPOUNDS (AS TL)	Tl	Synonyms vary depending upon specific compound	None hazardous		Properties vary depending upon specific compound	
THIRAM	$C_6H_{12}N_2S_4$	Tetramethylthiuram disulfide	Strong oxidizers and acids, oxidiz-able materials	192		

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
TIN, INORGANIC COMPOUNDS EXCEPT OXIDES (AS SN)	Sn	Synonyms vary depending upon specific compound	Chlorine, turpentine; for stannic chloride: water, alcohols, amines	Properties vary depending upon specific compound		
TIN, ORGANIC COMPOUNDS (AS SN)	Sn	Synonyms vary depending upon specific compound	Strong oxidizers	Properties vary depending upon specific compound		
TITANIUM DIOXIDE	TiO_2	Rutile, Anatase, Brookite	None hazardous	Not combustible		
TOLUENE	$C_6H_5CH_3$	Toluol, Phenyl methane, Methyl benzene	Strong oxidizers	40	1.3	7.1
TOLUENE-2,4-DIISOCYANATE	$CH_3C_6H_3(NCO)_2$	TDI; 2,4-Toluene diisocyanate	Strong oxidizers, water, acids, bases, amines, etc., cause foam and spatter	270	0.9	9.5
O-TOLUIDINE	$CH_3C_6H_4NH_2$	ortho-Aminotoluene; o-Methylaniline; 1-Methyl-1,2-amino-benzene; 2-Methyl-aniline	Strong oxidizers	185	1.5	?
TRIBUTYL PHOSPHATE	$(C_4H_9O)_3PO$	Tri-n-butyl phosphate, TBP	None hazardous	330	?	?
1,1,2-TRICHLORO-ETHANE	$CHCl_2CH_2Cl$	Vinyl trichloride, beta-Trichloroethane	Strong oxidizers and caustics, chemically active metals, such as aluminum, magnesium powders, sodium, potassium	None	6	15.5
TRICHLORO-ETHYLENE	$CHClCCl_2$	Ethylene trichloride, Triclene	Strong caustics; when acidic reacts with aluminum; chemically active metals; barium, lithium, sodium, magnesium, titanium	None	11	41
TRICHLORO-NAPHTHALENE	$C_{10}H_4Cl_4$	Halowax, Seekay wax, Nibren wax	Strong oxidizers	392(oc)	?	?
1,2,3-TRICHLORO-PROPANE	$CH_2ClCHClCH_2Cl$	Allyl trichloride, Glyceroltrichloro-hydrin, Glycerin trichlorohydrin, Trichlorohydrin	Active metals, strong caustics and oxidizers	164	3.2	12.6
1,1,2-TRICHLORO-1,2,2-TRIFLUORO-ETHANE	Ccl_2FCClF_2	Halocarbon 113, Refrigerant 113, TTE, Freon 113	Chemically active metals: calcium, powdered aluminum, zinc, magnesium, beryllium; contact alloys >2% Mg decomposes	Not combustible		
TRIETHYLAMINE	$(C_2H_5)_3N$	None	Strong oxidizers and acids	20 (oc)	1.2	8
TRIFLUOROMONO-BROMOMETHANE	$CBrF_3$	Halon 1301, Halocarbon 13B1, Refrigerant 13B1, Bromotrifluoro-methane, Freon 13B1	Chemically active metals, calcium, powdered aluminum, zinc, magnesium	Not combustible		
TRINITROTOLUENE	$CH_3C_6H_2(NO_2)_3$	TNT; Trinitrotoluol; 2,4,6-Trinitrotoluene; sym-Trinitrotoluene	Strong oxidizers, ammonia, strong alkalies, oxidizable materials	Explodes		
TRIORTHOCRESYL PHOSPHATE	$(CH_3C_6H_4O)_3PO$	o-Tritolyl phosphate, TCP, TOCP	None hazardous	437	?	?
TRIPHENYL PHOSPHATE	$(C_6H_5O)_3PO$	Phenyl phosphate, TPP	None hazardous	428	?	?
TURPENTINE	$C_{10}H_{16}$	Gumspirits, Turps, Wood turpentine, Spirits of turpentine, Sulfate wood turpentine, Steam distilled turpentine, Gum turpentine	Strong oxidizers, chlorine	95	0.8	?
URANIUM, INSOLUBLE COM-POUNDS (AS U)	U	Synonyms vary depending upon specific compound	Uranium: CO_2, CCl_4, HNO_3, Uranium hydride: strong oxidizers; H_2O, halogenated hydrocarbons	Properties vary depending upon specific compound		
URANIUM, SOLUBLE COMPOUNDS (AS U)	U	Synonyms vary depending upon specific compound	Uranyl nitrates: combustibles, Uranium hexa-fluoride: water	Properties vary depending upon specific compound		
VANADIUM PENTOXIDE DUST (AS V)	V_2O_5	None	None hazardous	Not combustible		
VANADIUM PENTOXIDE FUME (AS V)	V_2O_5	None	None hazardous	Not combustible		

Table 15 Continued

Chemical Name	Formula	Synonyms	Incompatibilities	Flash Point, °F	LEL, %	UEL, %
VINYL CHLORIDE	C_2H_3Cl	Chloroethylene, Chloroethene, Mono-chloroethylene, Ethylene monochlor-ide, Monochloro-ethene, Vinyl C monomer, Trovidur, VC, Vinyl chloride monomer, VCM	Copper oxidizing materials	-108	3.6	33
VINYLTOLUENE	$CH_3C_6H_4CHCH_2$	Methylstryrene, Tolyethylene; meta- and para-vinyltoluene (mixed isomers)	Oxidizing agents, catalysts for vinyl polymerization, such as peroxides, strong acids, aluminum chloride	127	0.1	11
WARFARIN	$C_{19}H_{16}O_4$	3-(alpha-Acetonyl) benzyl-4-hydroxy-coumarin, WARF com-pound, compound 42, coumarin	Strong oxidizers	NA	?	?
XYLENE (O-, M-, AND P-ISOMERS)	$C_6H_4(CH_3)_2$	p-ortho-Xylene, 1,2-Dimethyl-benzene; meta-Xylene, 1,3-Dimethyl-benzene; para-Xylene, 1,4-Dimethyl-benzene	Strong oxidizers	90/84/ 81	1/1.1/ 1.1	6/7/7
XYLIDINE	$(CH_3)_2C_6H_3NH_2$	2,4-Dimethylaniline, etc. (6 isomers); Xylidine isomers; Xylidine mixed o-m-p	Strong oxidizers, hypochlorite bleaches	206	1.5	?
YTTRIUM COMPOUNDS (AS Y)	Y	Synonyms vary depending upon specific compound	Yttrium nitrate; combustible materials	Properties vary depending upon specific compound		
ZINC CHLORIDE FUME	$ZnCl_2$	None	None hazardous	Not combustible		
ZINC OXIDE FUME	ZnO	Calamine	Chlorinated rubber	Not combustible		
ZIRCONIUM COMPOUNDS (AS ZR)	Zr	Synonyms vary depending upon specific compound	ZrCl: water, moist air, alkali metals; ZrH_2: strong oxidizers	Properties vary depending upon specific compound		
*DIBROMOCHLORO-PROPANE	$C_3H_5Br_2Cl$	1-Chloro-2,3-dibromo-propane, DBCP, 1,2-Dibromo-3-chloro-propane	Chemically active metals: aluminum, magnesium, tin and alloys; attacks some rubber and coatings	170(oc)	?	?

B. Fire Hazard Classification Data

This subsection provides a listing of selected chemicals, their common synonyms and the listed NFPA (National Fire Protection Association) Hazard Classification for each chemical. Not all chemicals are identified in this table; primarily those that an NFPA Hazard Classification could be obtained for, usually from a material safety data sheet (MSDS). The NFPA's "Recommended System for the Identification of Hazards of Materials"(NFPA 704) provides basic warning information to fire fighters in industrial plants and storage facilities, as well as transporters of hazardous materials. The system is described in detail in Section 3 of Chapter 1, and also in Chapter 2. The system classifies hazards based on a color warning and number designation ranging from 0 to 4. Hazard warnings are denoted for flammability, health, and reactivity hazards. The higher the number designation, the more hazardous the chemical is for the designated hazard class. The exact meaning of each number is explained in Section 3 of Chapter 1, and the applicable numbers for each chemical are listed in Table 16. The column noted as Special Hazards refers to a unique hazard of the chemical; the most common of them is a warning against the use of water in a fire situation, indicated by the symbol ₩. The column designated as "Hazard Classification" is the primary hazard class defined for the chemical from CFR, Title 49.

Table 16. NFPA Hazard Classification Information

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
ACETALDEHYDE	Acetic Aldehyde, Ethanal, Ethyl Aldehyde	Flam mable Liquid, I	2	4	2	
ACETIC ACID	Glacial Acetic Acid, Ethanoic Acid, Vinegar Acid	Corrosive Material, II	2	2	1	
ACETIC ANHYDRIDE	Ethanoic Anhydride	Corrosive Material, II	2	2	1	W
ACETONE	Dimethyl Ketone, Propanone	Flammable Liquid, II	1	3	0	
ACETONE CYANOHYDRIN	2-Methyl Lactonitrile, Alpha-Hydroxy Isobutronitrile	Poisonous Liquid or Solid, Class B, I	4	1	2	
ACETONITRILE	Methyl Cianide, Cyanomethane, Ethanenitrile	Flammable Liquid	2	3	0	
ACETOPHENONE	Acetylbenzene, Methyl Plenyl Ketone	Combustible Liquid	1	2	0	
ACETYLACETONE	2,4-Pentanedione, Diacetylmethane	Not Listed	2	2	0	
ACETYL CHLORIDE	None	Corrosive Material, II	3	3	2	W
ACETYLENE	Ethyne, Ethine	Flammable Compressed Gas	1	4	2	
ACETYL PEROXIDE SOLUTION	Diacetyl Peroxide Solution	Organic Peroxide	1	2	4	
ACRIDINE	Dibenzo [b,e] Pyridine, 10-Azaanthracene, Benzo(b)-Quinoline	Poison, III	NL	NL	NL	
ACROLEIN	Acraldehyde, Acrylic Aldehyde, Allyl Aldehyde, Ethylene Aldehide, 2-Propenal, Acrylaldehyde	Flammable Liquid, III	3	3	2	
ACRYLIC ACID	Propenoic Acid	Corrosive Material, II	3	2	2	
ACRYLONITRILE	Cyanoethylene, Fumigrain, Ventox, Vinyl Cyanide	Flammable, I Liquid	4	3	2	
ADIPIC ACID	Adipinic Acid, 1,4 -Butane-dicarboxylic Acid, Hexanedioic Acid		1	1	0	
ADIPONITRILE	1,4-Dicyanobutane	Combustible Liquid, III	4	2	0	
ALDRIN	1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo-exo-5,8-dimethanonaph-thalene	Poisonous liquid or solid, Class B, II	2	0	0	
ALLYL ALCOHOL	Vinyl Carbinol, 2-Propen-1-ol	Flammable Liquid, I	3	3	0	
ALLYL BROMIDE	Bromallylene, 3-bromopropene, 3-bromopropylene	Flammable Liquid, I	3	3	1	
ALLYL CHLORIDE	3-Chloropropene, 3-Chloropropylene	Flammable Liquid, I	3	3	1	
ALLYL CHLOROFORMATE	Allyl Chlorocarbonate	Flammable Liquid, I	3	3	1	
ALLYLTRICHLORO-SILANE	Allylsilicone Trichloride	Corrosive Material, II	3	4	4	
ALUMINUM CHLORIDE	Anhydrous Aluminum Chloride	NL, II	3	0	2	W
ALUMINUM FLUORIDE	None	NL	1	0	0	
AMMONIA (ANHYDROUS)	Liquid Ammonia	Non-flammable Compressed Gas, III	3	1	0	
AMMONIUM BIFLUORIDE	Acid Ammonium Fluoride, Ammonium Acid Fluoride, Ammonium Hydrogen Fluoride	Corrosive Material	3	0	1	
AMMONIUM NITRATE	Nitram	Oxidizing Material, III	2	1	3	oxy
AMMONIUM NITRATE-UREA SOLUTION	Solar Nitrogen Solutions, Nitrex Nitrogen Solutions	NL	0	2	0	
AMMONIUM PERCHLORATE	None	Oxidizing Material, II	2	1	4	oxy
AMYL ACETATE	Amyl Acetate, Mixed Isomers, Pentyl Acetates	Flammable Liquid, III	1	3	0	
n-AMYL ALCOHOL	1-Amyl Alcohol, n-Butylcarbinol, 1-Pentanol, Pentyl Alcohol	Flammable Liquid, II	1	3	0	
n-AMYL CHLORIDE	Amyl Chloride, n-Butylcarbinyl Chloride, 1-Chloropentane, Chloride of Amyl	Flammable Liquid, II	1	3	0	
n-AMYL MERCAPTAN	1-Pentanethiol, Amyl Hydrosulfide, Amyl Sulfhydrate, Amyl Thioalcohol	Flammable Liquid, II	2	3	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
n-AMYL NITRATE	Mixed Primary Amyl Nitrates	Combustible Liquid, III	2	2	0	oxy
Iso-AMYL NITRITE	Amyl Nitrite, 3-Metylbutyl Nitrite, Isopentyl Nitrite	Flammable Liquid, II	1	NL	2	
n-AMYLTRI-CHLOROSILANE	Trichloropentyl-silane, Pentylsilicon Trichloride, Trichloroamyl-silane	Corrosive Material, II	4	2	4	W
ANILINE	Aminobenzene, Aniline Oil, Phenylamine	Poisonous Liquid or Solid, Class B, II	3	2	0	
ANTHRACENE	Paranaphthalene	NL	0	1	NL	
ANTIMONY PENTACHLORIDE	Antimony Perchloride	Corrosive Material, II	4	0	3	
ARSENIC ACID	Arsenic Pentoxide, Orthoarsenic Acid	Poisonous, Class B, I(L) II(S)	4	0	2	
ASPHALT	Asphaltic Bitumen, Petroleum Asphalt, Bitumen	Combustible Liquid, III	0	1	0	
ASPHALT BLENDING STOCK (ROOFERS FLUX)	Asphaltum Oil, Flux Oil, Petroleum Tailings, Road Oil, Residual Oil,	NL	0	1	0	
ASPHALT BLENDING STOCK (STRAIGHT RUN RESIDUE)	Petroleum Asphalt, Petroleum Pitch, Road Binder	NL	0	1	0	
ATRAZINE	2-Chloro-4-ethyl-amino-6-isopropylamino-s-triazine, Aatrex Herbicide	NL	2	0	1	
BARIUM CHLORATE	None	Oxidizing Material, II	1	0	2	oxy
BARIUM NITRATE	None	Oxidizing Material, II	1	0	0	oxy
BARIUM PEROXIDE	Barium Dioxide, Barium Binoxide	Oxidizing Material, II	1	0	0	oxy
BENZALDEHYDE	Benzoic Aldehyde, Oil of Bitter Almond	Combustible Liquid	2	2	0	
BENZENE	Benzol, Benzole	Flammable Liquid, II	2	3	0	
BENZENE HEXACHLORIDE	Gammexane, Lindane	Poisonous liquid or solid, Class B	2	1	0	
BENZOYL CHLORIDE	Benzoncarbonyl Chloride	Corrosive Material, II	3	2	1	W
BENZYL ALCOHOL	Benzencarbinol, Phenylmethanol, Phenylmethyl Alcohol	NL	2	1	0	
BENZYL BROMIDE	alpha-Bromotoluene, omega- Bromotoluene	Corrosive Material, II	2	2	0	
BENZYL n-BUTYL PHTHALATE	Butyl benzyl phthalate, Phthalic Acid, Benzyl Butyl Ester	NL	1	1	0	
BENZYL CHLORIDE	Chlorotoluene, alpha	Corrosive Material, II	2	2	1	
BENZYL CHLOROFORMATE	Chloroformic Acid, Benzylcarbonyl Chloride, Benzyl Chlorocarbonate	Corrosive Material, I	3	1	3	
BERYLLIUM METALLIC	None	NL	4	1	1	
BISPHENOL A DIGLYCIDYL ETHER	Diglycidyl Ether, Bisphenol A-epichlorohydrin Resin	NL	1	1	2	
BORON TRICHLORIDE	Boron Chloride	Corrosive Material	4	0	4	
BROMINE	None	Corrosive Material, I	4	0	0	oxy
BROMINE PENTAFLUORIDE	None	Oxidizer, I	4	0	3	W, oxy
BROMOBENZENE	Monobromo-benzene, Phenyl Bromide, Bromobenzol	Combustible Liquid, III	2	2	0	
BUTADIENE (INHIBITED)	Biethylene, 1,3-Butadiene, Bivinyl, Divinyl, Vinylethylene	Flammable Compressed Gas	2	4	2	
BUTANE	n-Butane	Flammable Compressed Gas	1	4	0	
n-BUTYL ACETATE	Acetic Acid, Butyl Acetate, Butyl Ethanoate	Flammable Liquid, II	1	3	0	
sec-BUTYL ACETATE	Acetic Acid, sec-Butyl Ester	Flammable Liquid	1	3	0	
Iso-BUTYL ACRYLATE	Acrylic Acid, Isobutyl Ester	Flammable Liquid, II	1	2	3	
n-BUTYL ACRYLATE	Acrylic Acid, Butyl Ester, Butyl Acrylate, Butyl 2-Propenoate	Combustible Liquid, II	2	2	2	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
n-BUTYL ALCOHOL	Butanol, Butyl Alcohol, 1-Butanol, 1-Hydroxybutane, n-Propylcarbinol	Flammable Liquid, II	1	3	0	
sec-BUTYL ALCOHOL	2-Butanol, Butylene Hydrate, 2-Hydroxybutane, Methylethyl-carbinol	Flammable Liquid, II	1	3	2	
tert-BUTYL ALCOHOL	2-Methyl-2 Propanol, Trimethylcarbinol	Flammable Liquid, II	1	3	0	
n-BUTYLAMINE	1-Aminobutane, Butylamine, Norvalamine	Flammable Liquid	2	3	0	
sec-BUTYLAMINE	None	Flammable Liquid	3	3	NL	
BUTYLENE OXIDE	1-Butene Oxide, alpha-Butylene Oxide, 1,2-Epoxybutane	Flammable Liquid	2	3	2	
tert-BUTYL HYDROPEROXIDE	Cadox TBH	Flammable Liquid	1	4	4	oxy
n-BUTYL MERCAPTAN	1-Butanethiol, Thiobutyl Alcohol	Flammable Liquid, II	2	3	0	
n-BUTYL METHACRYLATE	Methacrylic Acid, butyl ester, Butyl Methacrylate, n-Butyl alpha-methyl acrylate, Butyl 2-methyl-2-propenoate	NL, III	2	2	0	
BUTYLTRICHLORO-SILANE	n-Butyltrichloro-silane	Corrosive Material, II	2	2	0	
iso-BUTYRALDEHYDE	Isobutyric Aldehyde Isobutylaldehyde, 2-Methylpropanal	Flammable Liquid, II	2	3	0	
n-BUTYRALDEHYDE	Butanal, Butyraldehyde, Butyl Aldehyde, Butyric Aldehyde	Flammable Liquid, II	2	3	0	
n-BUTYRIC ACID	Butanic Acid, Butanoic Acid, Butyric Acid, Ethylacetic Acid	Corrosive Material, III	2	2	0	
CADMIUM FLUOROBORATE	Cadmium Fluoborate, Cadmium Fluoborate Solution	NL, I	1	0	0	
CADMIUM NITRATE	Cadmium Nitrate Tetrahydrate	NL, I	2	0	0	oxy
CADMIUM SULFATE	None	NL, I	1	0	0	
CALCIUM CARBIDE	Carbide Acetylenogen	Flammable Solid, II	1	4	2	W
CALCIUM CYANIDE	Cyanide of Calcium, Cyanogas G-Fumigant	Poisonous, Class B, I	3	0	0	
CALCIUM HYPOCHLORITE	HTH, HTH Dry Chlorine, Sentry	Oxidizing Material, II	2	0	2	oxy
CALCIUM, METALLIC	None	Flammable Solid	1	1	2	W
CALCIUM OXIDE	Unslaked Lime, Quick Lime	ORM - B, III	1	0	1	
CARBOLIC OIL	Middle Oil, Liquefied Phenol	Poisonous Liquid or Solid, Class B	3	2	0	
CARBON BISULFIDE	Carbon Disulfide	Flammable liquid, I	2	3	0	
CARBON MONOXIDE	Monoxide	Flammable Compressed Gas	2	4	0	
CARBON TETRACHLORIDE	Carbon Tet, Tetrachloro-methane, Benzinoform	ORM - A, II	3	0	0	
CAUSTIC POTASH SOLUTION	Potassium Hydroxide Solution, Lye	Corrosive Material, II	3	0	1	
CAUSTIC SODA SOLUTION	Sodium Hydroxide Solution, Lye	Corrosive Material, II	3	0	1	
CHLORINE	None	Non-flammable Compressed Gas	3	0	0	oxy
CHLOROACETO-PHENONE	Phenacyl Chloride, omega-Chloroaceto-phenone, Phenyl Chloromethyl Ketone, Tear Gas	Irritant	2	1	0	
CHLOROACETYL CHLORIDE	Chloracetyl Chloride	Corrosive Liquid, II	3	0	0	
CHLOROBENZENE	Benzene Chloride, MCB, Monochloro-benzene, Phenyl Chloride	Flammable Liquid, II	2	3	0	
CHLOROFORM	Trichloromethane	ORM - A, III	2	0	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
CHLOROHYDRINS (CRUDE)	Crude Epichlorohydrin	Poison, Class B, II	3	3	2	
p-CHLOROPHENOL	4-Chlorophenol	NL, III	3	1	0	
CHLOROPICRIN, LIQUID	Trichloronitro-methane, Nitrochloroform, Picfume, Nitrotrichloro-methane	Poisonous, Class B, I	4	0	3	
CHLOROSULFONIC ACID	Chlorsulfonic Acid	Corrosive, I	3	0	2	W, oxy
CHROMIC ANHYDRIDE	Chromic Oxide, Chromic Trioxide, Chromic Acid	Oxidizing Material, I (S)	3	0	1	
COBALT NITRATE	Cobalt (II) Nitrate, Cobaltous Nitrate Hexahydrate	NL	1	0	0	oxy
COLLODION	Cellulose Nitrate Solution, Nitrocellulose Solution, Pyroxylin Solution, Box Tee Gum	Flammable Liquid, II	2	3	3	
COPPER CHLORIDE	Cupric Chloride Dihydrate, Eriochelcite (anhydrous)	ORM - B, III	0	0	0	
COPPER FLUOROBORATE	Copper Borofluoride Solution, Copper (II) Fluoborate Solution, Cupric Fluoborate Solution	NL	1	0	0	
COPPER NITRATE	Cupric Nitrate Trihydrate, Gerhardite	NL	1	0	0	oxy
CREOSOTE, COAL TAR	Creosote Oil, Dead Oil	Combustible Liquid	2	2	0	
CRESOLS	Cresylic Acids, Hydroxytoluenes, Methylphenols, Tar Acids	Poisous Liquid or Solid, Class B, II	3	2	0	
CROTONALDEHYDE	beta-Methylacrolein, Crotenaldehyde, Crotonic Aldehyde, trans-2-Butenal	Flammable Liquid, II	3	3	2	
CUMENE	Cumol, Isopropylbenzene	Combustible Liquid	0	2	0	
CUMENE HYDROPEROXIDE	alpha, alpha-DimethylbenzeneHydroperoxide, Dimethylbenzyl Hydroperoxide, Isopropylbenzene Hydroperoxide	Organic Peroxide	1	2	4	oxy
CUPRIETHYLENE-DIAMINE SOLUTION	Cuprietheylene-diamine Hydroxide Solution	Corrosive	4	4	2	
CYANOACETIC ACID	Cyanacetic Acid,Malonic Mononitrile	NL, I	3	1	0	
CYANOGEN	Ethanedinitrile, Dicyan, Oxalonitrile, Dicyanogen	Poisonous, Class A, I	4	4	2	
CYANOGEN BROMIDE	None	Poisonous Liquid or Solid, I	3	0	2	
CYCLOHEXANE	Hexahydro-benzene, Hexamethylene, Hexanaphthene	Flammable Liquid, I	1	3	0	
CYCLOHEXANOL	Hexalin, Adronal, Anol, Cyclohexyl Alcohol	Combustible Liquid	1	2	0	
CYCLOHEXYL-AMINE	Aminocyclo-hexane, Hexahydroaniline	Flammable Liquid, II	2	3	0	
CYCLOPENTANE	Pentamethylene	Flammable Liquid, II	1	3	0	
CYCLOPROPANE	Trimethylene	Flammable Compressed gas	1	4	0	
p-CYMENE	Cymol, p-Isopropyltoluene, Isopropyltoluol, Methyl Propyl Benzene	NL	2	2	0	
DECABORANE	None	Flammable Solid, III	3	2	1	
DECAHYDRO-NAPHTHALENE	Bicycle [4,4,0] Decane, Naphthalane, Perhydro-naphthalene, Decalin	Combustible Liquid, II	2	2	0	
n-DECYLBENZENE	Decylbenzene, 1-Phenyldecane	NL	2	1	0	
DIACETONE ALCOHOL	Diacetone, 4-Hydroxy-4-Methyl-2-Pentanone, Tyranton	Flammable Liquid, III	1	2	0	
DI-n-AMYL PHTHALATE	Diamyl Phthalate, Dipentyl Phthalate, Phthalic Acid, diamyl ester, Phthalic Acid, dipentyl ester	NL	0	1	0	
DIBENZOYL PEROXIDE	Benzoyl Peroxide, Benzoyl Superoxide, BPO, Oxilite	Organic Peroxide	1	4	4	oxy
DI-n-BUTYLAMINE	1-Butalamine, N-Butyl, Dibutylamine	NL, II	3	2	0	
DI-n-BUTYL ETHER	n-Dibutyl Ether, n-Butyl Ether, Butyl Ether, Dibutyl Oxide	NL	2	3	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
o-DICHLORO-BENZENE	1,2-Dichlorobenzene, Dowtherm E, Orthodichloro-benzene	ORM-A, II	2	2	0	
DICHLORODI-FLUOROMETHANE	Arcton 6, Eskimon 12, F-12, Freon 12, Genetron 12	Non-flammable Compressed Gas	0	0	0	
1,2-DICHLORO-ETHYLENE	Acetylene Dichloride, Sym-Dichloroethylene, Dioform, cis- or trans- 1,2-Dichloroethylene	Flammable Liquid, II	2	3	2	
DICHLORO-METHANE	Methylene Chloride, Methylene Dichloride	ORM-A, III	2	1	0	
DICHLORO-PROPANE	1,2-Dichloropropane, Propylene Dichloride	Flammable Liquid, II	2	3	0	
DIETHYLENE GLYCOL	DEG, Diglycol, 2,2'-Oxybisethanol, 2,2'-Dihydroxydiethyl Ether	NL	1	1	0	
DIETHYLENE-GLYCOL MONOBUTYL ETHER	Butoxydiethylene Glycol, Butoxydiglycol, Diglycol Monobutyl Ether, Butyl "Carbinol", Dowanol DB	NL	1	2	0	
DIETHYLENE-GLYCOL MONOBUTYL ETHER ACETATE	Diglycol Monobutyl Ether Acetate, Butyl "Carbinol" Acetate, Ektasolve DB Acetate	NL		1	0	
DIETHYLENE-TRIAMINE	Bis(2-aminoethyl) Amine, 2,2'-Diamino-diethylamine	Corrosive Material, II	3	1	0	
DIETHYL PHTHALATE	Phalatic Acid, diethyl ester, Ethyl Phthalate, 1,2-Benzenedi-carboxylic Acid, diethyl ester	NL	0	1	0	
DIETHYLZINC	Zinc Diethyl, Ethyl Zinc, Zinc Ethyl	Flammable Liquid, I	0	3	3	W
DIISOBUTYL KETONE	DIBK, sym-Diiso-propylacetone, 2,6-Dimethyl-4-heptanone, Isovalerone	Combustible Liquid, III	1	2	0	
DIISO-PROPANOLAMINE	2-2'-Dihydroxydi-propylamine, 1,1'-Iminodi-2-propanol	NL	3	3	0	
DIISOPROPYL-AMINE	None	Flammable Liquid, II	3	3	0	
DIMETHYLAMINE	None	Flammable Compressed Gas	3	4	0	
DIMETHYLDI-CHLOROSILANE	None	Flammable Liquid	3	3	1	
DIMETHYL ETHER	Methyl Ether, Wood Ether	Flammable Compressed Gas	2	4	0	
1,1-DIMETHYL-HYDRAZINE	Dimazine, UDMH, unsym-Dimethyl-hydrazine	Flammable Liquid	3	3	1	
DIMETHYL SULFATE	Methyl Sulfate	Corrosive Material, I	4	2	0	
DIMETHYL SULFIDE	Methyl Sulfide, 2-Thiapropane, Methanethio-methane	Flammable Liquid, II	4	4	0	
2,4-DINITROANILINE	2,4-Dinitraniline	NL, II	3	1	3	
2,4-DINITROTOLUENE	2,4-Dinitrotoluol, 1-Metyul-2,4-Dinitrobenzene, DNT	NL, II	3	1	3	
1,4-DIOXANE	Dioxane, p-Dioxane, Di(Ethylene Oxide)	Flammable Liquid, II	2	3	1	
DIPENTENE	Limonene, p-Methal,8-diene, Terpinene, delta-1,8-Terpodiene	NL, III	0	2	0	
DIPHENYLAMINE	Anilinobenzene, N-Phenylaniline	NL, I	3	1	0	
DIPHENYL ETHER	Phenyl Ether, Diphenyl Oxide, Phenoxybenzene	NL, II	1	1	0	
Di-n-PROPYLAMINE	N-n-Propyl-1-Propanamine	Flammable Liquid	3	3	0	
DODECENE	Propylene Tetramer, Tetrapropylene	Combustible Liquid	0	2	0	
ENDRIN	Hexadrin, Mendrin, 1,2,3,4,10,10-hexachloro-,6,7-epoxy-1,4,4a,5,6,7,8,8a-Dimethano-naphthalene	Poisonous, Class B	3	1	0	
EPICHLOROHYDRIN	1-Chloro-2,3-Epoxypropane, 3-Chloro-1,2-Propylene Oxide	Poison, Class B	3	3	2	
ETHOXYDIHYDRO-PYRAN	2-Ethoxy-3,4-Dihydro-2H-Pyran	NL	2	2	1	
ETHYL ACETATE	Acetic Acid, ethyl ester, Acetic Ester, Acetic Ether, Vinegar Naphtha,	Flammable Liquid, II	1	3	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
ETHYL ACETOACETATE	Acetoacetic Acid,ethyl ester, Acetoacetic Ester, Diacetic Ether, EAA	NL	2	2	0	
ETHYL ACRYLATE	Acrylic Acid, ethyl ester, Ethyl 2-propenoate	Flammable Liquid, II	2	3	2	
ETHYL ALCOHOL	Ethanol, Alcohol, Grain Alcohol, Denatured Alcohol	Flammable Liquid	0	3	0	
ETHYLAMINUM DICHLORIDE	EADC, Aluminum Ethyl Dichloride	Flammable Liquid	3	3	3	W
ETHYLALUMINUM SESQUICHLORODE	EASC	Flammable Liquid	-	3	3	W
ETHYLAMINE	Aminoethane, Monoethylamine,	Flammable Liquid	3	4	0	
ETHYLBENZENE	EB, Phenylethane	Flammable Liquid	2	3	0	
ETHYL BUTANOL	Pseudohexyl Alcohol, sec-Pentylcarbinol, sec-Hexyl Alcohol, 2-Ethyl-1-butanol	Combustible Liquid	1	2	0	
ETHYL BUTYRATE	Ethyl Butanoate, Butyric Acid,ethyl ester, Butyric Ether	Flammable Liquid, III	0	3	0	
ETHYL CHLORIDE	Chloroethane, Monochloro-ethane	Flammable Liquid	2	4	0	
ETHYL CHLOROACETATE	Ethyl Chloroacetate, Ethyl Chloroethanoate, Monochloroacetic Acid,ethyl ester, Chloroacetic Acid,ethyl ester	Combustible Liquid, III	-	3	0	
ETHYL CHLOROFORMATE	Chloroformic Acid,ethyl ester, Ethyl Chlorocarbonate	Flammable Liquid, I	-	3	1	
ETHYLENE	Ethene, Oleflant Gas	Flammable Compressed Gas	1	4	2	
ETHYLENE CHLOROHYDRIN	2-Chloroethanol, 2-Chlorethanol, 2-Chloroethyl Alcohol, Glycol Chlorohydrin	Poison, Class B, II	3	2	0	
ETHYLENE CYANOHYDRIN	Hydracrylonitrile, 2-Cyanoethanol, Glycol Cyanohydril, 3-Hydroxy-propanenitrile	NL	2	1	1	
ETHYLENEDIAMINE	1,2-Diaminoethane, 1,2-Ethanediamine	NL	3	2	0	
ETHYLENE DIBROMIDE	1,2-Dibromoethane, Glycol Dibromide, Bromofume, Ethylene Bromide	ORM-A, II	3	0	0	
ETHYLENE DICHLORIDE	1,2-Dichloroethane, Ethylene Chloride, EDS	Flammable Liquid, II	2	3	0	
ETHYLENE GLYCOL	Glycol, Monoethylene Glycol, 1,2-Ethanediol	NL, II	1	1	0	
ETHYLENE GLYCOL DIACETATE	Ethylene Acetate, Glycol Diacetate, Ethylene Diacetate	NL	1	1	0	
ETHYLENE GLYCOL MONOBUTYL ETHER	2-Butoxyethanol, Butyl Cellosolve, Dowanol EB, Poly-Solv EB	Combustible Liquid	2	2	0	
ETHYLENEIMINE	Aziridine, Azirane	Flammable Liquid	3	3	2	
ETHYLENE OXIDE	Oxirane, 1,2-Epoxyethane	Flammable Liquid	2	4	3	
ETHYL ETHER	Anesthesia Ether, Diethyl Ether, Diethyl Oxide, Ethoxyethane, Sulfuric Ether	Flammable Liquid	2	4	1	
ETHYL FORMATE	Ethyl Formic Ester, Ethyl Methanoate, Formic Acid, ethyl ester	Flammable Liquid, II	2	3	0	
ETHYLHEXAL-DEHYDE	2-Ethylhexanal, Butylethyl-acetaldehyde, Octyl Aldehyde, 2-Ethyl Hexaldehyde	Combustible Liquid, III	2	2	1	
2-ETHYL HEXANOL	2-Ethyl-1-Hexanol, 2-Ethylhexyl Alcohol	Combustible Liquid	2	2	0	
2-ETHYLHEXYL ACRYLATE, INHIBITED	Acrylic Acid, 2-ethyl-hexyl ester, 2-Ethylhexyl, 2-propenoate	NL, II	2	2	1	
ETHYL LACTATE	Lactic Acid, ethyl ester, Ethyl 2-hydroxy-propioate, Ethyl 2-hydroxy-propanoate	Combustible Liquid, III	2	2	0	
ETHYL MERCAPTAN	Ethanethiol, Ethyl Sulfhydrate, Thioethyl Alcohol,	Flammable Liquid, I	2	4	0	
ETHYL METHACRYLATE	Ethyl 2-Methacrylate, Ethyl Methacrylate - Inhibited, Methacrylic Acid, ethyl ester	Flammable Liquid, II	2	3	0	
ETHYL NITRITE	Nitrous Ether, Sweet Spirit of Nitre, Spirit of Ether Nitrite	Flammable Liquid, I	2	4	4	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
ETHYL SILICATE	Tetraethyl Silicate, Silibond, Tetraethyl Orthosilicate, Ethyl Orthosilicate, Ethyl Silicate 40	Combustible Liquid, III	2	2	0	
ETHYLTRICHLORO-SILANE	Ethyl Silicone Trichloride, Ethyl Silicon Trichloride, Trichloroethyl-silane, Trichloroethyl-silicane	Flammable Liquid	3	3	0	
FLUORINE	None	Non-Flammable Gas	4	0	3	W, oxy
FLUOSILICIC ACID	Fluorosilicic Acid, Hexafluosilicic Acid, Hydrofluosilicic Acid, Sand Acid, Silicofluoric Acid	Corrosive Liquid, II	3	0	0	
FORMALDEHYDE SOLUTION	Formalith, Formalin, Formic Aldehyde, Methanal, Fide	Combustible Liquid, III	2	2	0	
FORMIC ACID	Methanoic Acid, Formylic Acid	Corrosive Material, II	3	2	0	
FURFURAL	Pyromucic Aldehyde, 2-Furaldehyde, Furfuraldehyde, Fural	Combustible Liquid, III	2	2	0	
FURFURAL ALCOHOL	2-Furancarbinol, Furfuralcohol, 2-Furylcarbinol, 2-Hydroxymethyl-furan	NL, III	1	2	1	
GALLIC ACID	Gallic Acid Monohydrate, 3,4,5-Trihydroxy-benzoic Acid	NL	0	1	0	
GAS OIL: CRACKED	None	Flammable Liquid, III	1	3	0	
GASOLINES: AUTOMOTIVE (<4,23g lead/gal)	Motor Spirit, Petrol	Flammable Liquid, II	1	3	0	
GASOLINES: AVIATION (<4,86g lead/gal)	None	Flammable Liquid, II	1	3	0	
GASOLINE BLENDING STOCKS: REFORMATES	None	Flammable Liquid	1	3	0	
GASOLINES: CASINGHEAD	Natural Gasoline	Flammable Liquid	1	3	0	
GASOLINES: POLYMER	None	Flammable Liquid	1	3	0	
GASOLINES: STRAIGHT RUN	None	Flammable Liquid	1	3	0	
GLYCERINE	Glycerol, 1,2,3-Propanetriol, 1,2,3-Trihydroxy-propane	NL	1	1	0	
n-HEXALDEHYDE	Caproaldehyde, Caproic Aldehyde, Capronaldehyde, n-Caproylaldehyde, Hexanal	Flammable Liquid, III	2	3	1	
HEXANE	n-Hexane	Flammable Liquid, II	1	3	0	
HEXYLENE GLYCOL	2-Methyl-2,4-pentanediol	Corrosive Material	3	3	2	
HYDRAZINE	None	Flammable Liquid, I	3	3	2	
HYDROCHLORIC ACID	Muriatic Acid	Corrosive Material	3	0	0	
HYDROFLUORIC ACID	None	Corrosive Material, I	4	0	0	
HYDRIGEN BROMIDE	Hydrobromic Acid	Non-flammable Compressed Gas	3	0	0	
HYDROGEN CHLORIDE	Hydrochloric Acid, anhydrous	Non-flammable Compressed gas	3	0	0	
HYDROGEN CYANIDE	Hydrocyanic Acid, Prussic Acid	Poisonous Gas or Liquid, Class A, I	4	4	2	
HYDROGEN FLUORIDE	Hydrofluoric Acid,anhydrous	Corrosive Material, I	4	0	0	
HYDROGEN, LIQUEFIED	Liquid Hydrogen, para Hydrogen	Flammable Compressed Gas	0	4	0	
HYDROGEN PEROXIDE	Peroxide, Albone, Superoxol	Oxidizer, II	2	0	3	oxy
HYDROGEN SULFIDE	Sulfuretted Hydrogen	Flammable Compressed Gas	3	4	0	
HYDROXYPROPYL ACRYLATE	1,2-Propanediol 1-acrylate, Propylene glycol mon- acrylate	NL	1	1	0	
ISOAMYL ALCOHOL	Fermentation amyl alcohol, Fusel oil, Isopentyl alcohol, 3-Methyl-1-butanol	Combustible Liquid	1	2	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
ISOBUTYL ACETATE	Acetic Acid, Isobutyl ester	Flammable Liquid, II	1	3	0	
ISOBUTYL ALCOHOL	Isobutanol, Isopropylcarbinol, 2-Methyl-1-propanol	Flammable Liquid, III	1	3	0	
ISOBUTYLAMINE	Monoisobutyl-amine, 1-Amino-2-methylpropane, Iso-Butylamine	Flammable Liquid	2	3	0	
ISOBUTYLENE	Isobutene, 2-Methylpropene	Flammable Compressed gas	1	4	0	
ISOPHORONE	3,5,5-Trimethyl-2-cyclohexane-1-one	NL, III	2	2	0	
ISOPRENE	2-Methyl-1,3-butadiene, beta-Methylbivinyl	Flammable Liquid, I	2	4	2	
ISOPROPYL ACETATE	Acetic Acid, isopropyl ester, 2-Propyl acetate	Flammable Liquid, II	1	3	0	
ISOPROPYL ALCOHOL	Dimethylcarbinol, Isopropanol, Petrohol, 2-Propanol, Rubbing alcohol	Flammable Liquid, II	1	3	0	
ISOPROPYLAMINE	2-Aminopropane, Monoisopropyl-amine, Iso-Propylamine	Flammable Liquid, I	3	4	0	
ISOPROPYL ETHER	Diisopropyl ether, Diisopropyl Oxide, 2-Isoproxypropane	Flammable Liquid, II	2	3	1	
JET FUELS: JP-1	Kerosene, Kerosine, Range Oil, Fuel Oil [1]	Combustible Liquid, I	0	2	0	
JET FUELS: JP-3	None	Combustible Liquid, I	0	2	0	
JET FUELS: JP-4	None	Flammable Liquid, I	0	2	0	
JET FUELS: JP-5	Kerosene, heavy	Combustible Liquid, I	0	2	0	
KEROSENE	Illuminating Oil, Kerosine, Range Oil, JP-1, Fuel Oil [1]	Combustible Liquid, III	0	2	0	
LAUROYL PEROXIDE	Dilauroyl peroxide, Dodecanoyl peroxide	Organic Peroxide	0	2	3	oxy
LAURYL MERCAPTAN	1-Dodecanethiol, Dodecyl mercaptan	NL	2	1	0	
LEAD ARSENATE	Lead arsenate, acid, Plumbous arsenate	Poisonous Liquid Or Solid, Class B, II	2	0	0	
LEAD FLUOROBORATE	Lead fluoborate, Lead Fluoborate solution	NL	1	0	0	
LEAD NITRATE	Nitric Acid, Lead II salt	Oxidizing Material, II	1	0	0	oxy
LEAD THIOCYANATE	Lead Sulfocyanate	Poison, Class B	1	1	1	
LIQUEFIED PETROLEUM GAS	Bottled Gas, LPG Propane-butane-(propylene) Pyrofax,	Flammable Compressed Gas	1	4	0	
LITHIUM ALUMINUM HYDRIDE	LAH	Flammable Solid, I	3	1	2	W
LITHIUM HYDRIDE	None	Flammable Solid, I	1	4	2	W
LITHIUM, METALLIC	None	Flammable Solid	1	1	2	W
MAGNESIUM	None	Flammable Solid, III	0	1	2	W
MAGNESIUM PERCHLORATE	Anhydrone, Dehydrite, Magnesium perchlorate, anhydrous, Magnesium perchlorate hexahydrate	Oxidizing Material, II	1	0	0	oxy
MALEIC ANHYDRIDE	Toxilic Anhydride, cis-Butenedioic anhydride	NL, III	3	1	1	
MESITYL OXIDE	Methyl isobutenyl ketone, Isopropylideneacetone, 4-Methyl-3-pentene-2-one	Flammable Liquid, III	3	3	0	
METHYL ACETATE	Acetic Acid, methyl ester	Flammable Liquid, II	1	3	0	
METHYL ACRYLATE	Acrylic Acid,methyl ester, Methyl 2-propenoate	Flammable Liquid, II	2	3	2	
METHYL ALCOHOL	Colonial Spirit, Columbian Spirit, Methanol, Wood Alcohol	Flammable Liquid, II	1	3	0	
METHYLAMINE	Aminomethane, Mercurialin, Monomethyl-amine, anhydrous	Flammable Compressed Gas, II	3	4	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
METHYL AMYL ACETATE	Hexyl Acetate, MAAc, 4-Methyl-2-pentyl acetate, 4-Methyl-2-pentanol acetate	Flammable Liquid, II	1	2	0	
METHYL AMYL ALCOHOL	Isobutylmethyl carbinol, Isobutyl methyl- methanol, 4-Methyl-2-pentanol	Combustible Liquid, II	2	2	0	
METHYL BROMIDE	Bromomethane, Embafume, M-B-C Fumigant, Monobromo-methane	Poisonous Liquid or Solid, Class B	3	1	0	
METHYL n-BUTYL KETONE	N-Butyl methyl ketone	NL, I	2	3	0	
METHYL CHLORIDE	Arctic, Chloromethane	Flammable Compressed gas	2	4	0	
METHYL CYCLOPENTANE	Cyclopentane, methyl	Flammable Liquid	2	3	0	
METHYL-DICHLOROSILANE	None	Flammable Liquid	3	3	2	W
METHYL ETHYL KETONE	MEK, 2-Butanone, Ethyl methyl ketone	Flammable Liquid, II	1	3	0	
METHYLETHYLPYRIDINE	MEP, 5-Ethyl-2-methyl pyridine, 5-Ethyl-2-picoline	Corrosive Material, III	2	2	0	
METHYL FORMAL	Methylal, Methylene dimethyl ether, Dimethoxy-methane, Dimethyl formal	Flammable Liquid, II	2	3	2	
METHYL FORMATE	FormicAcid, methyl ester	Flammable Liquid, I	2	4	0	
METHYL-HYDRAZINE	Monomethyl-hydrazine, MMH	Flammable Liquid	3	3	1	
METHYL ISOBUTYL CARBINOL	Isobutyl methyl carbinol, Methylamyl Alcohol, MAOH, MIBC, MIC	Flammable Liquid, III	2	2	0	
METHYL ISOBUTYL KETONE	MIBK, MIK, Hexone, Isobutyl methyl ketone, Isopropylacetone	Flammable Liquid, II	2	3	0	
METHYL ISOPROPENYL KETONE, INHIBITED	2-Methyl-1-butene-3-one	Flammable Liquid, II	2	-	0	
METHYL MERCAPTAN	Methanethiol, Methyl sulfhydrate, Thiomethyl alcohol, Mercaptomethane	Flammable Compressed Gas	2	4	0	
METHYL METHACRYLATE	Methacrylic Acid, methyl ester, Methacrylate monomer, Methyl 2-methyl-2-propenoate	Flammable Liquid, II	2	3	2	
METHYL PARATHION	Metron, MPT, Paridol, Alkron, Nitran, Wolfatox	Poisonous Liquid or Solid, Class B, II	4	3	2	
1-METHYL-PYRROLIDONE	1-Methyl-2-pyrrolidone, N-Methyl-pyrrolidone	NL	2	1	0	
alpha-METHYLSTYRENE	Isopropenyl-benzene, 1-Methyl-1-phenylethylene, Phenylpropylene	NL	1	2	1	
METHYL-TRICHLOROSILANE	Trichloromethyl-silane	Flammable Liquid	3	3	2	W
METHYL VINYL KETONE	3-Buten-2-one	Flammable Liquid, II	2	3	2	
MINERAL SPIRITS	Naphtha, Petroleum spirits	Combustible Liquid, II	0	2	0	
MONOCHLORO-ACETIC ACID	Chloroacetic Acid, Chloracetic Acid	Corrosive Liquid, II	3	1	0	
MONO-ETHANOLAMINE	2-Aminoethanol, beta-Aminoethyl alcohol, Ethanolamine, 2-Hydroxy-ethylamine	Corrosive Material, III	2	2	0	
MORPHOLINE	Tetrahydro-2H-2,4-oxazine, Tetrahydro-p-oxazine, Diethylene imidoxide	Flammable Liquid, III	2	3	0	
NAPHTHALENE, MOLTEN	Naphthalin, Tar Camphor	ORM-A, III	2	2	0	
NAPHTHA: STODDARD SOLVENT	Petroleum solvent, Dricleaner naphtha, Spotting Naphtha	Combustible Liquid, II	0	2	0	
1-NAPHTHYLAMINE	1-Amino-naphthalene, alpha-Naphthylamine	NL, III	2	1	0	
NEOHEXANE	2,2-Dimethylbutane	Flammable Liquid, II	1	3	0	
NICKEL ACETATE	Acetic Acid, nickel (2+) salt, Nickelous acetate, Nickel acetate tetrahydrate	NL, II	1	1	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
NICKEL CARBONYL	Nickel Tetracarbonyl	Flammable Liquid, I	-	3	1	W
NICKEL CHLORIDE	Nickel chloride hexahydrate	NL	1	0	0	
NICKEL FLUOROBORATE	Nickel (II) fluoborate, Nickel fluoborate solution	NL	1	0	0	
NICKEL NITRATE	Nickel nitrate hexahydrate	NL, III	1	0	0	oxy
NICOTINE	1-Methyl-2-(3-pyridyl) pyrrolidine, 3-(1-Methyl-2-pyrrolidyl) pyridine	Poisonous, Class B, II	4	1	0	
NITRIC ACID	None	Oxidizer, I	2	0	0	oxy
4-NITROANILINE	p-Nitroaniline, 1-Amino-4-nitrobenzene, Azoic Diazo Component 37, Fast Red IG base	Poisonous Solid, Class B, II	3	1	0	
NITROBENZENE	Nitrobenzol, Essence of Mirbane, Oil of Mirbane	Poisonous Liquid, Class B, II	3	2	0	
NITROETHANE	None	Flammable Liquid, III	1	3	3	
NITROGEN TETROXIDE	Nitrogen peroxide, Nitrogen dioxide, Red oxide of nitrogen, Oxides of nitrogen	Poisonous Gas or Liquid, Class A	3	0	0	oxy
NITROMETHANE	Nitrocarbol	Flammable Liquid, II	1	3	3	
4-NITROPHENOL	p-Nitrophenol, 4-Hydroxy-nitrobenzene, PNP	NL, III	3	1	0	
2-NITROPROPANE	Isonitropropane, 1- NP, sec-Nitropropane	Flammable Liquid, III	1	3	3	
NONANE	n-Nonane	NL, III	0	3	0	
NONYLPHENOL	None	NL	1	1	0	
OCTANE	n-Octane	Flammable Liquid, II	0	3	0	
OILS: CRUDE	Petroleum	Combustible Liquid, I	1	3	0	
OILS: DIESEL	Fuel Oil 1-D, Fuel Oil 2-D	Combustible Liquid	0	2	0	
OILS, EDIBLE: COCONUT	Coconut butter, Copra oil, Coconut oil	NL	0	1	0	
OILS, EDIBLE: COTTONSEED	None	NL	0	1	0	
OILS, EDIBLE: LARD	Kettle-rendered lard, Leaf lard, Prime steam lard	NL	0	1	0	
OILS, EDIBLE: PALM	Palm fruit oil, Palm butter, Palm oil	NL	0	1	0	
OILS, EDIBLE: PEANUT	None	NL	0	1	0	
OILS, EDIBLE: SOYA BEAN	Soybean oil	NL	0	1	0	
OILS, EDIBLE: TUCUM	American palm kernel oil, Acuara oil, Palm seed oil	NL	0	1	0	
OILS, EDIBLE: VEGETABLE	None	NL	0	1	0	
OILS, FUEL: 6	Bunker C oil, Residual fuel oil N°6	Combustible Liquid	0	2	0	
OILS, FUEL: 2	Home heating oil	Combustible Liquid	0	2	0	
OILS, FUEL: 4	Residual fuel oil N°4	Combustible Liquid	0	2	0	
OILS, FUEL: 5	Residual fuel oil N° 5	Combustible Liquid	0	2	0	
OILS, FUEL: 1-D	Diesel oil (light)	Combustible Liquid, III	0	2	0	
OILS, FUEL: 2-D	Diesel oil, medium	Combustible Liquid, III	0	2	0	
OILS, FUEL: N°1	JP-1, Kerosene, Kerosine, Range oil	Combustible Liquid, III	0	2	0	
OILS, MISCELLANEOUS: LINSEED	Flaxseed oil, Raw linseed oil	NL	0	1	0	
OILS, MISCELLANEOUS: LUBRICATING	Crankcase oil, Motor oil, Transmission oil	NL	0	1	0	
OILS, MISCELLANEOUS: MINERAL	Liquid petrolatum, White oil	NL	0	1	0	
OILS, MISCELLANEOUS: RANGE	Kerosine, Kerosene, JP-1	Combustible Liquid	0	2	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
OILS, MISCELLANEOUS: ROAD	Liquid asphalt, Petroleum asphalt, Slow curing asphalt	NL	0	1	0	
OILS, MISCELLANEOUS: SPRAY	Dormant oil, Foliage oil, Kerosene, heavy, Plant spray oil	Combustible Liquid	0	2	0	
OILS, MISCELLANEOUS: TRANSFORMER	Electrical insulating oil, Insulating oil, Petroleum insulating oil	NL	0	1	0	
OILS, MISCELLANEOUS: TURBINE	Steam turbine oil, Steam turbine lube oil	NL	0	1	0	
OLEIC ACID	cis-8-Heptadecylene-carboxylic acid, cis-9-Octane-cenoic acid, Red oil	NL	0	1	0	
OLEUM	Fuming Sulfuric Acid	Corrosive Material	3	0	2	W
OXALIC ACID	Ethanedioic Acid	Corrosive Material	2	1	0	
OXYGEN, LIQUEFIED	Liquid oxigen, LOX	Non-flammable Compressed Gas	3	0	0	oxy
PARATHION, LIQUID	O,O-Diethyl-(p-nitrophenyl) Phosphorothioate, Phosphorothioic Acid, Ethyl Parathion	Poisonous, Class B, I	4	1	2	
PENTABORANE	(9)-Pentaboron nonahydride	Flammable Liquid, I	3	3	2	
PENTACHLORO-PHENOL	Dowicide 7, Penta, Santophen 20	NL	3	0	0	
PENTANE	None	Flammable Liquid	1	4	0	
PERCHLORIC ACID	Dioxonium perchlorate solution, Perchloric acid solution	Oxidizer, I, II	3	0	3	oxy
PHENOL	Carbolic acid, Hydroxybenzene, Phenic acid, Phenyl hydroxide	Poisonous Liquid or Solid, Class B, II	3	2	0	
PHOSGENE	Carbonyl chloride, Chloroformyl chloride	Poisonous Gas or Liquid, Class A	4	0	0	
PHOSPHORIC ACID	Orthophosphoric acid	Corrosive Liquid, III	2	0	0	
PHOSPHORUS PENTASULFIDE	Phosphoric sulfide, Phosphorus persulfide, Thiophosphoric anhydride	Flammable Solid, II	3	1	2	W
PHOSPHORUS, RED	Amorphous phosphorus	Flammable Solid, III	0	1	1	
PHOSPHORUS TRICHLORIDE	None	Corrosive Material, II	3	0	2	W
PHOSPHORUS WHITE	Yellow phosphorus	Flammable Solid, I	3	3	1	
PHTHALIC ANHYDRIDE	1,2-Benzene-dicarboxylic acid anhydride, 1,3-Dioxophthalan, PAN, Phthalandione	NL, III	2	1	0	
PIPERAZINE	Piperazidine, Pyrazine hexahydride, Diethylene-diamine	NL, III	2	2	0	
POLYBUTENE	Butene resins, Polyisobutylene waxes	NL	0	1	0	
POTASSIUM CHLORATE	Chlorate of potash, Chlorate of potassium, Potcrate	Oxidizing Material, II	1	0	2	oxy
POTASSIUM CYANIDE	Cyanide	Poisonous Liquid or Solid, Class B, I	3	0	0	
POTASSIUM DICHLORO-s-TRIAZINETRIONE	Potassium dichloro-isocyanurate	Oxidizing Material, II	3	0	3	oxy
POTASSIUM DICHROMATE	Potassium bichromate, Bichrome	ORM-A	1	0	1	oxy
POTASSIUM HYDROXIDE	Caustic potash, Lye	Corrosive Material, II	3	0	1	
POTASSIUM PERMANGANATE	None	Oxidizing Material, II	1	0	0	oxy
POTASSIUM PEROXIDE	Potassium superoxide	Oxidizing Material, Solid, I	3	0	2	W
PROPANE	Dimethylmethane	Flammable Compressed Gas	1	4	0	
beta-PROPIOLACTONE	Betaprone, Hydracrylic acid, beta-lactone, 2-Oxetanone, Propanolide	Poisonous Liquid, Class B	0	2	0	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
PROPIONALDEHYDE	Propyl aldehyde, Propaldehyde, Propanal, Propionic aldehyde	Flammable Liquid, II	2	3	1	
PROPIONIC ACID	Ethanecarboxylic acid, Methylacetic acid, Propanoic acid	Corrosive Material, III	2	2	0	
PROPIONIC ANHYDRIDE	Methylacetic anhydride, Propanoic anhydride, Propionyl oxide	Corrosive Liquid, III	2	2	2	W
PROPYLENE	Methylethylene, Propene	Flammable Compressed Gas	1	4	1	
PROPYLENE OXIDE	Methyl oxirane, Propene oxide, 1,2-Epoxypropane	Flammable Liquid, I	2	4	2	
PROPYLENE TETRAMER	Dodecene (nonlinear), Tetrapropylene	Combustible Liquid, III	0	2	0	
PYRIDINE	None	Flammable Liquid, II	2	3	0	
PYROGALLIC ACID	1,2,3-Benzenetriol, Pyrogallol, 1,2,3-Trihydroxy-benzene	NL	1	1	0	
QUINOLINE	1-Benzazine, Chinoline, Leucol, Benzo(b)pyridine	NL, III	2	1	0	
RESORCINOL	1,3-Benzenediol, Dihydroxybenzol, m-Dihydroxy-benzene	NL, III	-	1	0	
SALICYLIC ACID	o-Hydroxybenzoic acid, Retarder W	NL	0	1	0	
SILVER NITRATE	Lunar caustic	Oxidizing Material, II	1	0	0	oxy
SODIUM	None	Flammable Solid, II	3	1	2	W
SODIUM CHLORATE	Chlorate of soda	Oxidizing Material, II	1	0	2	oxy
SODIUM CYANIDE	Hydrocyanic acid, sodium salt	Poisonous Liquid or Solid, Class B, I	3	0	0	
SODIUM DICHLORO-s-TRIAZINETRIONE	Sodium Dichloroiso-cyanurate	Oxidizing Material, II	3	0	2	oxy
SODIUM DICHROMATE	Sodium Bichromate	ORM-A	1	0	1	oxy
SODIUM FLUORIDE	None	ORM-B, III	2	0	0	
SODIUM HYDROXIDE	Caustic soda	Corrosive Material, II	3	0	1	
SODIUM SULFIDE	None	Flammable Solid, II	2	1	0	
STEARIC ACID	1-Hepta-decanecarboxylic acid, Octadecanoic acid, Stearophanic acid	NL	1	1	0	
STYRENE	Phenethylene, Phenylethylene, Styrol, Styrolene	Flammable Liquid, III	2	3	2	
SULFUR DIOXIDE	None	Non-flammable Compressed Gas	3	0	0	
SULFURIC ACID	Battery acid, Chamber acid, Fertilizer acid, Oil of vitriol	Corrosive Material, II	3	0	2	W
SULFURIC ACID, SPENT	None	Corrosive Material, II	3	0	2	
SULFUR (LIQUID)	Brimstone (liquid)	NL, III	2	0	1	
SULFUR MONOCHLORIDE	None	Corrosive Material	2	1	1	
TALLOW	Edible Tallow, Inedible Tallow, Tallow oil	NL	0	1	0	
TANNIC ACID	Tannin, Chinese Tannin, Gallotannic acid, Gallotannin, Glycerite	NL	0	1	0	
TETRAETHYLENE GLYCOL	Hi-Dry, Bis-[2-(2-hydroxy-ethoxy)ethyl] ether, 3,6,9-Trioxaundecan-1,11-diol	NL	1	1	0	
TETRAETHYLENE-PENTAMINE	1,1-Diamino-3,6,9-triazaundecane	NL	2	1	0	
TETRAETHYL LEAD	TEL, Lead tetraethyl	Poisonous Liquid or Solid Class B, I	3	2	3	
TETRAFLUORO-ETHYLENE, INHIBITED	Teflon monomer	Flammable Compressed Gas	3	4	3	

Table 16 Continued

Chemical Name	Synonyms	Hazard Classification	NFPA Hazard Classification			
			Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special (White)
TETRAHYDRO-FURAN	Tetramethylene oxide, THF	Flammable Liquid, II	2	3	1	
TETRAHYDRO-NAPHTHALENE	1,2,3,4-Tetra-hydronaphthalene, Tetralin, Tetranap	Combustible Liquid	1	2	0	
TETRAMETHYL LEAD	Lead tetramethyl	Poisonous Liquid or Solid, Class B	3	3	3	
THORIUM NITRATE	Thorium nitrate tetrahydrate	Radioactive Material	1	0	0	oxy
TITANIUM TETRACHLORIDE	None	Corrosive Material, II	3	0	1	
TOLUENE	Methylbenzene, Methylbenzol, Toluol	Flammable Liquid, II	2	3	0	
TOLUENE 2,4-DIISOCYANATE	TDI, Hylene T, Mondur TDS, Nacconate 100	Poison, Class B, II	3	1	1	
o-TOLUIDINE	2-Amino-1-methylbenzene, 2-Aminotoluene, 2-Methylaniline, o-Methylaniline	Poison, II	3	2	0	
TRICHLOROSILANE	Silicochloroform, Trichloromono-silane	Flammable Liquid, I	3	4	1	
TRICHLORO-s-TRIAZINETRIONE	Trichloroimino-isocyanuric acid, Trichloro-s-triazine-2,4,6-(1H,3H,5H)-trione	Oxidizing Material	3	0	2	oxy
TRIETHANOLAMINE	Triethylolamine, Trihydroxy-triethylamine, Tris(hydroxy-ethyl)amine	NL	2	1	1	
TRI-ETHYLALUMINUM	ATE, Aluminum Triethyl, TEA	Flammable Liquid	3	3	3	W
TRIFLUORO-CHLOROETHYLENE	Chlorotrifluoro-ethylene, Kel F monomer, Plaskon monomer, Trifluorovinyl chloride, CTFE	Flammable Compressed Gas	-	4	0	
TRIISOBUTYL-ALUMINUM	Aluminum triisobutyl, TIBA, TIBAL	Flammable Liquid	3	3	3	W
TRIMETHYLAMINE	None	Flammable Compressed Gas	3	4	0	
TURPENTINE	Spirits of turpentine, Turps, Gum turpentine, Wood turpentine	Flammable Liquid, III	1	3	0	
URANYL NITRATE	Uranium nitrate	Radioactive Material	1	0	0	oxy
VINYL ACETATE	VAM, Vinyl A Monomer, Vy Ac	Flammable Liquid, II	2	3	2	
VINYL CHLORIDE	Chloroethylene, Chloroethene, Vinyl C Monomer, VCL, VCM	Flammable Compressed Gas	2	4	1	
VINYL FLUORIDE, INHIBITED	Fluoroethylene, Monofluoro-ethylene	Flammable Compressed Gas	1	4	2	
VINYLIDENE CHLORIDE, INHIBITED	1,1-Dichloroethylene unsym-Dichloroethulene	Flammable Liquid, I	2	4	2	
VINYL METHYL ETHER, INHIBITED	Methyl vinyl ether, Methoxyethylene	Flammable Compressed Gas	2	4	2	
VINYLTOLUENE	p-Methylstyrene	Combustible Liquid, III	2	2	1	
m-XYLENE	Xylol, 1,3-Dimethylbenzene	Flammable Liquid, II	2	3	0	
o-XYLENE	Xylol, 1,2-Dimethylbenzene	Flammable Liquid, II	2	3	0	
p-XYLENE	Xylol, 1,4-Dimethylbenzene	Flammable Liquid, II	2	3	0	
XYLENOL	Cresylic acid, 2,6-Dimethylphenol, 2,6-Xylenol, 2-Hydroxy-m-xylene	NL, II	2	1	0	
ZINC ACETATE	Acetic acid, zinc salt, Dicarbomethoxy-zinc, Zinc diacetate	NL, II	1	1	0	
ZINC CHROMATE	Buttercup yellow, Zinc chromate (VI)hydroxide, Zinc yellow	NL	1	0	0	
ZINC NITRATE	Zinc nitrate hexahydrate	Solid Oxidizing Material, II	1	0	0	oxy
ZIRCONIUM ACETATE	Zirconium acetate solution	NL	0	0	0	

C. Fire Hazard and Chemical Reactivity Information

Following are summary descriptions of the fire hazard and chemical reactivity of various chemicals. The information is organized into the two information areas for each chemical. Chemicals are listed alphabetically, according to their most common chemical name. The reader can refer to the list of synonyms in Table 16 in order to identify a certain chemical compound, and should consult Chapter 5 for information on the physical, chemical and thermodynamic properties of many of these compounds. The following abbreviations are used in this subsection: CC - Closed Cup Method; OC - Open Cup Method. In a number of cases, the data entry for a certain property or characteristic is "No data", or "Not pertinent". The no data entry (or "no information found") means that no information could be found for that property in a review of the literature. "Not pertinent" refers to the fact that the particular property is not important in making a hazard or risk assessment of the chemical (as an example, a flash point would not be pertinent if the chemical is a combustible solid). Recommended fire extinguishing agents are generally listed in order of the most highly effective first. The reader should refer to section IV of Chapter 1 for an explanation of other terms and the sources of references used for the various data entries below.

A

Acetaldehyde — Fire Hazards: *Flash Point (deg. F)*: -36 CC; -59 OC; *Flammable Limits in Air* (%): 4 - 60; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Produces irritating vapors when heated; *Behavior in Fire*: Vapors are heavier than air and may travel to a considerable distance for a source of ignition and flash back; *Ignition Temperature (deg. F)*: 365; *Electrical Hazard*: Class 1, Group C; *Burning Rate*: 3.3 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not Pertinent; *Polymerization*: May occur. Avoid contact with heat, dust, strong oxidizing and reducing agents, strong acids and bases; *Inhibitor of Polymerization*: None.

Acetic Acid — Fire Hazards: *Flash Point (deg. F)*: 112 OC; 104 CC; *Flammable Limits in Air* (%): 5.4 - 16.0; *Fire Extinguishing* Agents: Water, alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: None; *Special Hazards of Combustion Products*: Irritating vapors produced when heated; *Behavior in Fire*: Not Pertinent; *Ignition Temperature (deg. F)*: 800; *Electrical Hazard*: Not Pertinent; *Burning Rate*: 1.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Corrosive, particularly when diluted. Attacks most common metals, including most stainless steels. Excellent solvent for many synthetic resins or rubber; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water, rinse with sodium bicarbonate solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetic Anhydride — Fire Hazards: *Flash Point (deg. F)*: 136 OC; 120 CC; *Flammable Limits in Air* (%): 2.7 - 10.0; *Fire Extinguishing Agents*: Water spray, dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water and foam react, but heat liberated is not enough to create a hazard. Dry chemical forced below the surface can cause foaming and boiling; *Special Hazards of Combustion Products*: Irritating vapors generated upon heating; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 600; *Electrical Hazard*: Not pertinent; *Burning Rate*: 3.3 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly with water, but considerable heat is liberated when contacted with spray water; *Reactivity with Common Materials*: Corrodes iron, steel and other metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water and use sodium bicarbonate solution to rinse; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetone — Fire Hazards: *Flash Point (deg. F)*: 4 OC, 0 CC; *Flammable Limits in Air* (%): 2.6 - 12.8; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water in straight hose streams will scatter fire and is not recommended; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 869; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 3.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetone Cyanohydrin — Fire Hazards: *Flash Point (deg. F)*: 165 CC; *Flammable Limits in Air* (%): 2.2 - 12;

Fire Extinguishing Agents: Water spray, dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic hydrogen cyanide is generated upon heating; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1270; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetonitrile — Fire Hazards: *Flash Point (deg. F)*: 42 OC; *Flammable Limits in Air (%)*: 4.4 - 16; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic vapors generated during heating; *Behavior in Fire*: Vapor is heavier than air and may travel considerable distance to ignition source and flash back; *Ignition Temperature (deg. F)*: 975; *Electrical Hazard*: Not pertinent; *Burning Rate*: 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetophenone — Fire Hazards: *Flash Point (deg. F)*: 180 OC; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: None; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1058; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetylacetone — Fire Hazards: *Flash Point (deg. F)*: 105 OC, 93 CC; *Flammable Limits in Air (%)*: 2.4 - 11.6; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: No information; *Behavior in Fire*: Vapor is heavier than air and may travel considerable distance to ignition source and flash back; *Ignition Temperature (deg. F)*: 644; *Electrical Hazard*: No information; *Burning Rate*: 3.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May dissolve some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetyl Bromide — Fire Hazards: *Flash Point (deg. F)*: Data not available; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: Toxic and irritating hydrogen bromide fumes may form in fires; *Behavior in Fire*: Do not apply water to adjacent fires. Reacts with water to produce toxic and irritating gases; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: Reacts violently, forming corrosive and toxic fumes of hydrogen bromide; *Reactivity with Common Materials*: Attacks and corrodes wood and most metals in the presence of moisture. Flammable hydrogen gas may collect in enclosed spaces; *Stability During Transport*: Stable if protected from moisture; *Neutralizing Agents for Acids and Caustics*: Flood with water, rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetyl Chloride — Fire Hazards: *Flash Point (deg. F)*: 40 CC; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Water, foam; *Special Hazards of Combustion* Products: When heated to decomposition, hydrogen chloride and phosgene, extremely poisonous gases, are involved; *Behavior in Fire*: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*:734; *Electrical Hazard*: Data not available; *Burning Rate: 2.6 mm/min.* **Chemical Reactivity:** *Reactivity with* Water: Reacts vigorously with water, involving hydrogen chloride fumes (hydrochloric acid); *Reactivity with Common Materials*: Is highly corrosive to most metals in the presence of moisture; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Following dilution with water, limestone or sodium bicarbonate can be used; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetylene — Fire Hazards: *Flash Point (deg. F)*:Gas; *Flammable Limits in Air* (%): 2.5 - 80; *Fire Extinguishing Agents*: Stop flow of gas; *Fire Extinguishing Agents Not To Be Used*: Carbon dioxide, dry chemical and water spray are not generally recommended because the discharged gas or volatile liquid may create a more serious explosion hazard; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May explode in fire; *Ignition Temperature (deg. F)*:581; *Electrical Hazard*: Class I Group A; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Under certain conditions forms spontaneously compounds with copper; *Stability During Transport*: Stable as shipped; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acetyl Peroxide Solution — Fire Hazards: *Flash Point (deg. F)*: 113 OC; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May explode. Burns with accelerating intensity; *Ignition Temperature (deg. F)*: Explodes; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May ignite combustible materials such as wood; *Stability During Transport*: Heat-and-shock-sensitive crystals may separate at very low temperature during transport; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acridine — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (combustible solid); *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water, foam, monoammonium phosphate, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Carbon dioxide and other dry chemicals may not be effective; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire; *Behavior in Fire*: Sublimes before melting; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Data not available; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Acrolein — Fire Hazards: *Flash Point (deg. F)*: <0 OC; -13 CC; *Flammable Limits in Air* (%): 2.8 - 31; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Poisonous vapor of acrolein is formed from hot liquid; *Behavior in Fire*: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back. Polymerization may take place, and containers may explode in fire; *Ignition Temperature (deg. F)*: 453; *Electrical Hazard*: Data not available; *Burning Rate*: 3.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable when inhibited; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Undergoes uncatalyzed polymerization reaction around 200°C. Light promotes polymerization; *Inhibitor of Polymerization*: Hydroquinone: 0.10 to 0.25 %.

Acrylamide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire; *Behavior in Fire*: Sealed containers may burst as a result of polymerization; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Data not available; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: May occur at temperature above 50°C (120° F); *Inhibitor of Polymerization*: Oxygen (air) plus 50 ppm of copper as copper sulfate.

Acrylic Acid — Fire Hazards: *Flash Point (deg. F)*: (Glacial) 118 OC; *Flammable Limits in Air* (%): (Tech.) 2.4 LEL; *Fire Extinguishing Agents*: Water spray, alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic vapor are generated when heated; *Behavior in Fire*: May polymerize and explode; *Ignition Temperature (deg. F)*: 374; *Electrical Hazard*: Not pertinent; *Burning Rate*: 1.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Normally unstable but will be detonate; *Neutralizing Agents for Acids and Caustics*: Wash with water, rinse with sodium bicarbonate solution; *Polymerization*: May occur in contact with acids, iron

salts, or at elevated temperatures and release high energy rapidly; may cause explosion under confinement; *Inhibitor of Polymerization*: Monomethyl ether of hydroquinone 180-200 ppm; phenothiazine (for tech. grades) 1000 ppm; hydroquinone (0.1%); methylene blue (0.5 %); N, N'-diphenyl-p-phenylenediamine (0.05%).

Acrylonitrile — Fire Hazards: *Flash Point (deg. F)*: 30 CC; 31 OC; *Flammable Limits in Air* (%): 3.05 - 17.0; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause frothing; *Special Hazards of Combustion Products*: When heated or burned, ACN may evolve toxic hydrogen cyanide gas and oxides of nitrogen; *Behavior in Fire*: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back. May polymerize and explode; *Ignition Temperature (deg. F)*: 898; *Electrical Hazard*: Class I, Group D; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Attacks copper and copper alloys; these metals should not be used. Penetrates leather, so contaminated leather shoes and gloves should be destroyed. Attacks aluminum in high concentrations; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: May occur spontaneously in absence of oxygen or on exposure to visible light or excessive heat, violently in the presence of alkali. Pure ACN is subject to polymerization with rapid pressure development. The commercial product is inhibited and not subject to this reaction; *Inhibitor of Polymerization*: Methylhydroquinone (35 -45 ppm).

Adipic Acid — Fire Hazards: *Flash Point (deg. F)*: Combustible solid 300 OC; 376 CC; *Flammable Limits in Air*): (dust) 10 -15 mg/l; *Fire Extinguishing Agents*: Foam, water fog, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Melts and may decompose to give volatile acetic vapors pf valeric acid and other substances. Dust may form explosive mixture with air; *Ignition Temperature (deg. F)*: 788; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Data not available; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Adiponitrile — Fire Hazards: *Flash Point (deg. F)*: 199 OC; *Flammable Limits in Air* (%): LFL= 1.0 at 200°C; *Fire Extinguishing Agents*: Water spray, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic gases are generated in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of* Polymerization: Not pertinent.

Aldrin — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water spray, dry chemical, foam or carbon dioxide for fire involving solutions of aldrin in hydrocarbon solvents; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating fumes of hydrochloric acid and chlorinated decomposition products are given off; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Alkylbenzenesulfonic Acids — Fire Hazards: *Flash Point (deg. F)*: 395 OC; *Flammable Limits in Air* (%): Data not available; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: irritating sulfuric acid mist may form in fire; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack metals, causing accumulation of flammable hydrogen gas in enclosed spaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Allyl Alcohol — Fire Hazards: *Flash Point (deg. F)*: 72 CC; 90 OC; *Flammable Limits in Air* (%): 2.5 - 18; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic vapor is generated when heated; *Behavior in Fire*: Vapor heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*:829; *Electrical Hazard*: Not pertinent; *Burning Rate*: 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable at ordinary temperatures and pressures; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of* Polymerization: Not pertinent.

Allyl Bromide — Fire Hazards: *Flash Point (deg. F)*: 30 CC; *Flammable Limits in Air* (%): 4.4 - 7.3; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic hydrogen bromide gas formed in fire; *Behavior in Fire*: Vapor heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 563; *Electrical Hazard*: Data not available; *Burning Rate*: 3.5 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Allyl Chloride — Fire Hazards: *Flash Point (deg. F)*: -20; *Flammable Limits in Air* (%): 3.3 -11.1; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water fog; *Special Hazards of Combustion Products*: Releases irritating hydrogen chloride gas on combustion; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 737; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Allyl Chloroformate — Fire Hazards: *Flash Point (deg. F)*: 92 OC; 88 CC; *Flammable Limits in Air* (%): Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: When heated to decomposition, emits highly toxic phosgene gas; *Behavior in Fire*: Vapor heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: 4.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly generating hydrogen chloride; *Reactivity with Common Materials*: Corrosive metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with sodium bicarbonate solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Allyltrichlorosilane — Fire Hazards: *Flash Point (deg. F)*: 100 OC; 95 CC; *Flammable Limits in Air* (%): Data not available; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: Irritating vapor of hydrogen chloride and phosgene may form; *Behavior in Fire*: Difficult to extinguish. Re-ignition may occur; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: 2.2 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously, generating hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Corrodes metals because of hydrochloric acid formed; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with sodium bicarbonate; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Aluminum Chloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing* Agents: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water on adjacent fires; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Reacts violently with water used in extinguishing adjacent fires; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Reacts violently with water, liberating hydrogen chloride gas and heat; *Reactivity with Common Materials*: None if dry. If wet it attacks metals because of hydrochloric acid formed; flammable hydrogen is formed; *Stability During Transport*: Stable if kept dry and protected from atmospheric moisture; *Neutralizing Agents for Acids and*

Caustics: Hydrochloric acid formed by reaction with water can be flushed away with water. Rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Aluminum Fluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: When heated to sublimation condition, emits toxic fumes of fluoride; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Aluminum Nitrate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire; *Behavior in Fire*: May increase the intensity if fire when used with combustible material; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Dissolves and forms a weak solution if nitric acid. The reaction is not hazardous; *Reactivity with Common Materials*: May corrode metals in presence of moisture; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Aluminum Sulfate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*:Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May corrode metals in presence of moisture; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Aminoethylethanolamine — Fire Hazards: *Flash Point (deg. F)*: 265 OC; *Flammable Limits in Air (%)*: 1 - 8 (calc.); *Fire Extinguishing Agents*: Alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 695; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonia, Anhydrous — Fire Hazards: *Flash Point (deg. F)*: Not flammable under condition likely to be encountered; *Flammable Limits in Air (%)*: 15.50 - 27.00; *Fire Extinguishing Agents*: Stop flow of gas or liquid. Let fire burn; *Fire Extinguishing Agents Not To Be Used*: None; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1204; *Electrical Hazard*: Class 1, Group D; *Burning Rate*: 1 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Dissolves with mild heat effect; *Reactivity with Common Materials*: Corrosive to copper and galvanized surfaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Acetate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating vapors of ammonia and acetic acid may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Benzoate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (combustible solid); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam. dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent;

Special Hazards of Combustion Products: Irritating and toxic ammonia gas may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Slowly releases ammonia gas, which may collect in closed container; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Bicarbonate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating and toxic ammonia gas may form in fires; *Behavior in Fire*: Decomposes, but reaction is not explosive. Ammonia gas is formed; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack copper, nickel and zinc; *Stability During Transport*: Decomposes above 34°C (91°F) with formation of ammonia gas, which may collect in closed containers; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Bifluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not apply water to adjacent fires; *Special Hazards of Combustion Products*: Toxic ammonia and hydrogen fluoride gases may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Dissolves and forms a weak solution of hydrofluoric acid; *Reactivity with Common Materials*: In presence of moisture will corrode glass, cement and most metals. Flammable hydrogen gas may collect in enclosed spaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with dilute solution of sodium of sodium bicarbonate or soda ash; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Carbonate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic ammonia gas will form in fires; *Behavior in Fire*: Decomposes, but reaction is not explosive. Ammonia gas is formed; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Chloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating ammonia and hydrogen chloride gases may form in fire; *Behavior in Fire*: May volatilize and condense on cool surfaces; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Citrate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (combustible solid); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic ammonia gas may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Dichromate — Fire Hazards: *Flash Point (deg. F)*: Flammable solid; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Greenish chromic oxide smoke may cause irritation of lungs and mucous membranes; *Behavior in Fire*: Decomposes at about 180°C with spectacular swelling and evolution of

heat and nitrogen, leaving chromic oxide residue. Pressure of confined gases can burst closed containers explosively; *Ignition Temperature (deg. F)*: 437; *Electrical Hazard*: Data not available; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Can ignite combustible material such as wood shavings; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Fluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic ammonia and hydrogen fluoride gases are formed in fires; *Behavior in Fire*: May sublime when hot and condense on cool surfaces; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Dissolves and formes dilute solution of hydrofluoric acid; *Reactivity with Common Materials*: May corrode glass, cement and most metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Formate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Toxic and irritating ammonia and formic acid gases may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Gluconate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During* Transport: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Hydroxide (< 20 % Aqueous Ammonia) — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*; Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Data not available; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Mild liberation of heat; *Reactivity with Common Materials*: Corrosive to copper, copper alloys, aluminum alloys, galvanized surfaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Iodide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating fumes of hydrogen iodide, iodine and oxides of nitrogen may form in fire; *Behavior in Fire*: Compound may sublime in fire and condense on cold surfaces; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Lactate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (combustible solid); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may be formed in a fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent;

Polymerization: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Lauryl Sulfate — Fire Hazards: *Flash Point (deg. F):* Not pertinent (non-combustible water solution); *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen and sulfur may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Molybdate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Use flooding amount of water in early stages of fire. When large quantities are involved in massive fires, control efforts should be confined to protecting from explosion; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Decomposes, giving off extremely toxic oxides of nitrogen; *Behavior in Fire*: May explode in fires. Supports combustion of common organic fuel; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: If heated strongly, decomposes, giving off toxic gases which support combustion. Undergoes detonation if heated under confinement; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Nitrate—Phosphate Mixture — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Steam, inert gases, foam, dry chemical; *Special Hazards of Combustion Products*: Toxic and irritating oxides of nitrogen may form in fires; *Behavior in Fire*: Will increase intensity of fire when in contact with combustible material. Containers may explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Corrodes metals to same degree as ordinary fertilizer; the reaction is not hazardous; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Nitrate-Sulfate Mixture — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Steam, inert gases, foam, dry chemical; *Special Hazards of Combustion Products*: Toxic and irritating oxides of nitrogen may form in fires; *Behavior in Fire*: Will increase intensity of fire when in contact with combustible material. Containers may explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Corrodes metals to same degree as ordinary fertilizer; the reaction is not hazardous; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Nitrate-Urea Solution — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Water of solution may evaporate, and remaining solids may then explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Oleate — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ammonium Oxalate — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ammonium Pentaborate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ammonium Perchlorate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Water (from protected location); *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic gases are produced in a fire; *Behavior in Fire:* May explode when involved in a fire or exposed to shock or friction; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* If contaminated with carbonaceous materials, can become an explosive which is sensitive to shock and friction. Ready detonates or explodes; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ammonium Persulfate — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen and sulfuric acid fumes are formed in fire; *Behavior in Fire:* Decomposes with loss of oxygen that increases intensity of fire; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Contact with grease, wood and other combustibles may result in fire; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ammonium Phosphate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating fumes of ammonia and oxides of nitrogen may form in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ammonium Silicofluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating hydrogen fluoride, silicon tetrafluoride, and oxides of nitrogen may form in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:*

No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Stearate — Fire Hazards: *Flash Point (deg. F):* >140 CC (pure material only; solution not flammable); *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Toxic ammonia and oxides of nitrogen may form in fires; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Sulfamate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Sulfide — Fire Hazards: *Flash Point (deg. F):* 72 CC; *Flammable Limits in Air* (%): 4 - 46 (hydrogen sulfide); *Fire Extinguishing Agents*: Water, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Toxic hydrogen sulfide gas is released when solution is heated. If ignited, this will form irritating sulfur dioxide gas; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Severely corrodes copper, zinc and their alloys; *Stability During Transport*: Stable, but toxic hydrogen sulfide and ammonia gases may form in enclosed spaces; *Neutralizing Agents for Acids and Caustics*: Dilute with water. Do not attempt to neutralize with acid; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Sulfite — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic sulfur dioxide and oxides of nitrogen may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water. Do not attempt to neutralize with acids; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Tartrate — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen or ammonia gas may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent

Ammonium Thiocyanate — Fire Hazards: *Flash Point (deg. F):* Solid may be combustible; solution is not flammable; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Decomposes to form ammonia, hydrogen sulfide and hydrogen cyanide. Oxides of nitrogen may also form. All of these products are toxic; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Ammonium Thiosulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic ammonia, hydrogen sulfide, and oxides of nitrogen and sulfur may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable, but toxic ammonia gas may collect in enclosed spaces; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Amyl Acetate — Fire Hazards: *Flash Point (deg. F):* (iso-): 69 CC (n-); 91 CC; *Flammable Limits in Air (%)*: 1.1 - 7.5; *Fire Extinguishing Agents*: alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water in straight hose stream will scatter and spread fire and should not be used; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 572 (n); *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.1 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Amyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 77 CC; *Flammable Limits in Air (%)*: 1.1 - 7.5; *Fire Extinguishing Agents*: Alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 680; *Electrical* Hazard: Not pertinent; *Burning Rate*: 3.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Amyl Chloride — Fire Hazards: *Flash Point (deg. F):* 55 OC; 34 CC; *Flammable Limits in Air (%)*: 1.4 - 8.6; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Irritating hydrogen chloride and toxic phosgene may be formed in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 500; *Electrical Hazard*: Data not available; *Burning Rate*: 4.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Amyl Mercaptan — Fire Hazards: *Flash Point (deg. F):* 65 OC; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Sulfur dioxide gas is formed; *Behavior in Fire*: Vapor is heavier than fire and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: 4.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Amyl Methyl Ketone — Fire Hazards: *Flash Point (deg. F):* 117 OC; 102 CC; *Flammable Limits in Air (%)*: 1.11 - 7.9; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*:

Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Will attack some forms of plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Amyl Nitrate — Fire Hazards: *Flash Point (deg. F)*: 120 OC; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in a fire; *Behavior in Fire*: Overheated material may detonate; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May form combustible mixture with wood or other combustibles. Liquid will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Iso-Amyl Nitrite — Fire Hazards: *Flash Point (deg. F)*: 0 OC; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen are formed; *Behavior in Fire*: Containers may explode; *Ignition Temperature (deg. F)*: 410; *Electrical Hazard*:; *Burning Rate*: 3.4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Decomposes on exposure to air, light or water, involving toxic oxides of nitrogen which are orange in color; *Reactivity with Common Materials*: May corrode metals if wet; *Stability During Transport*: Stable if kept sealed and not exposed to light; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Amyltrichlorosilane — Fire Hazards: *Flash Point (deg. F)*: 145 OC; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water, foam; *Special Hazards of Combustion Products*: Irritating hydrogen chloride and toxic phosgene may be formed; *Behavior in Fire*: Difficult to extinguish. Re-ignition may occur; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: 2.5 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously to generate toxic hydrogen chloride gas (hydrochloric acid); *Reactivity with Common Materials*: Corrodes metal; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: After flushing with water, rinse with sodium bicarbonate solution on lime water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Aniline — Fire Hazards: *Flash Point (deg. F)*: 168 OC; 158 CC; *Flammable Limits in Air (%)*: 1.3 (LEL); *Fire Extinguishing Agents*: Water, foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic vapors are generated when heated; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1418; *Electrical Hazard*: Not pertinent; *Burning Rate*: 3.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with dilute acetic acid; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Anisoyl Chloride — Fire Hazards: *Flash Point (deg. F)*: Data not available; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Water, foam; *Special Hazards of Combustion Products*: Irritating hydrogen chloride fumes may be formed; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical* Hazard: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly to generate hydrogen chloride (hydrochloric acid). The reaction is not hazardous; *Reactivity with Common Materials*: Corrodes metal slowly; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Anthracene — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (combustible solid); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: 1004; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with*

Water: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Antimony Pentachloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water or foam on adjacent fires; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Irritating fumes of hydrogen chloride given off when water or foam is used to extinguish adjacent fire; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts to form hydrogen chloride gas (hydrochloric acid); *Reactivity with Common Materials*: Causes corrosion on metal; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Soda ash or soda ash-lime mixture; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Antimony Pentafluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water or foam on adjacent fire; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Gives off toxic hydrogen fluoride fumes when water is used to extinguish adjacent fire; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts vigorously to form toxic hydrogen fluoride (hydrofluoric acid); *Reactivity with Common Materials*: When moisture is present, causes severe corrosion of metals (except steel) and glass. If confined and wet can cause explosion. May cause fire in contact with combustible material; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Antimony Potassium Tartrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Antimony Trichloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not apply water on adjacent fires; *Special Hazards of Combustion Products*: Toxic and irritating antimony oxide and hydrogen chloride may form in fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts vigorously to form a strong solution of hydrochloric acid; *Reactivity with Common Materials*: Corrodes may metals in the presence of moisture and flammable hydrogen gas may collect in confined spaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Large amounts of water followed by sodium bicarbonate or soda ash solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Antimony Trifluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not flammable; *Behavior in Fire*: Not flammable; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Antimony Trioxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and*

Caustics: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Arsenic Acid — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Will corrode metal and give off toxic arsine gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Arsenic Disulfide — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Poisonous fumes of the compound may be formed during fires. If ignited, will form sulfur dioxide gas; *Behavior in Fire*: May ignite at very high temperatures; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Arsenic Trichloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Avoid water on adjacent fires; *Special Hazards of Combustion Products*: Irritating and toxic hydrogen chloride formed when involved in fires; *Behavior in Fire*: Becomes gaseous and causes irritation. Forms hydrogen chloride (hydrochloric acid) by reaction with water used to fight adjacent fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts with water to form hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Corrodes metal; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Arsenic Trioxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic fumes of arsenic trioxide and arsine may form in fire situations; *Behavior in Fire*: Can volatilize forming toxic fumes of arsenic trioxide; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Arsenic Trisulfide — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Poisonous fumes of compound may be formed in fire situations; *Behavior in Fire*: May ignite at very high temperatures; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Asphalt — Fire Hazards: *Flash Point (deg. F)*: 300 - 350 OC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water spray, dry chemical, foam or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause foaming; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 400 - 700; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Asphalt Blending Stocks: Roofers Flux — Fire Hazards: *Flash Point (deg. F)*: 300 - 350 CC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause foaming; *Special Hazards of Combustion Products*:

Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 400 - 700; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Asphalt Blending Stocks: Straight Run Residue — Fire Hazards: *Flash Point (deg. F):* 400 - 600 OC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam, carbon dioxide or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 450 - 700; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Atrazine — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen chloride and toxic oxides of nitrogen may be formed; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Azinphosmethyl — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Oxides of sulfur and phosphorous may be formed when exposed to a fire situation; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

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Barium Carbonate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Barium Chlorate — Fire Hazards: *Flash Point (deg. F):* Not flammable but may cause explosions when involved in fires; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: No data; *Special Hazards of Combustion Products*: Produces toxic fumes when involved in a fire; *Behavior in Fire*: May cause an explosion when involved in a fire; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Can form explosive mixtures with combustible materials such as wood, oil - these mixtures can be ignited readily by friction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Barium Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable but can aggravate fires; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Produces toxic gaseous oxides of nitrogen when involved in fires; *Behavior in Fire*: Mixtures with combustible materials are readily ignited and may burn fiercely. Containers may explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Fire can result by contact of this material with combustibles; *Stability During Transport*: Stable;

Neutralizing Agents for Acids and Caustics: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Barium Perchlorate — Fire Hazards: *Flash Point (deg. F):* Not flammable but can aggravate fire intensity; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Increases the intensity of fires. Containers may burst or explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: When mixed with combustible materials or finely divided metals, can become an explosive mixture; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Barium Permanganate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not Pertinent; *Behavior in Fire*: Can increase the intensity of fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: When mixed with combustible materials, can ignite by friction or in an acidic state and may become spontaneously combustible; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Barium Peroxide — Fire Hazards: *Flash Point (deg. F):* Not flammable but may cause fires upon contact with combustible materials; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Flood with water, dry powder (e.g., graphite or powdered limestone); *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Can increase the intensity of fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Decomposes slowly but the reaction is not hazardous; *Reactivity with Common Materials*: Corrodes metals slowly. If mixed with combustible materials or finely divided metals, mixture can spontaneously ignite or become unstable by friction; *Stability During Transport*: Sable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzaldehyde — Fire Hazards: *Flash Point (deg. F):* 148 CC, 163 OC; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Water spray, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 378; *Electrical Hazard*: Not pertinent; *Burning Rate*: 3.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzene — Fire Hazards: *Flash Point (deg. F):* 12 CC; *Flammable Limits in Air (%)*: 1.3 - 7.9; *Fire Extinguishing Agents*: Dry chemical, foam and carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than air and can travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F)*: 1,097; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 6.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzene Hexachloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic gases are generated when solid is heated or when solution exposed to intense heat; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzene Phosphorous Dichloride — Fire Hazards: *Flash Point (deg. F):* 215 OC; This value may be lower because of the presence of phosphorus; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Large amounts of water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic fumes include oxides of phosphorous and hydrogen chloride; *Behavior in Fire*: Containers may rupture. The hot liquid is spontaneously flammable because of the presence of dissolved phosphorus; *Ignition Temperature (deg. F)*: 319; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity**: *Reactivity with Water*: Reacts vigorously to form hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Corrodes metal except 316 stainless steel, nickel, and Hastelloy; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzene Phosphorous Thiodichloride — Fire Hazards: *Flash Point (deg. F):* 252 OC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic fumes generated include oxides of phosphorous and sulfur and hydrogen chloride; *Behavior in Fire*: Containers may rupture; *Ignition Temperature (deg. F)*: 338; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity**: *Reactivity with Water*: Forms hydrogen chloride fumes (hydrochloric acid). Reaction is slow unless the water is hot; *Reactivity with Common Materials*: Corrodes metals slowly; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzoic Acid — Fire Hazards: *Flash Point (deg. F):* 250 CC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide, water fog, chemical foam; *Fire Extinguishing Agents Not To Be Used*: None; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor from molten benzoic acid may form explosive mixture with air. Concentrated dust may form explosive mixture in air; *Ignition Temperature (deg. F)*: 1,063; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzonitrile — Fire Hazards: *Flash Point (deg. F):* 167 CC, This material is combustible but burns with difficulty; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic hydrogen cyanide and oxides of nitrogen form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: Difficult to burn. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzophenone — Fire Hazards: *Flash Point (deg. F):* This is a combustible product; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzoyl Chloride — Fire Hazards: *Flash Point (deg. F):* 162 OC; *Flammable Limits in Air (%)*: 1.2 - 4.9; *Fire Extinguishing Agents*: Foam, carbon dioxide, dry chemical, water fog; *Fire Extinguishing Agents Not To Be Used*: Water spray. Do not allow water to enter containers; *Special Hazards of Combustion Products*: Highly poisonous phosgene gas forms during fires; *Behavior in Fire*: At fire temperature the compound may react violently with water or steam; *Ignition Temperature (deg. F)*: 185; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity**: *Reactivity with Water*: Slow reaction with water to produce hydrochloric acid fumes. The reaction is more rapid with steam; *Reactivity with Common Materials*: Slow corrosion of metals but no immediate danger; *Stability During Transport*: Not pertinent; *Neutralizing Agents for Acids and Caustics*: Soda ash and water, lime; *Polymerization*: Does not occur; *Inhibitor of Polymerization*: Not pertinent.

Benzyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 220 OC, 213 CC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Alcohol foam. dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause foaming; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: 817; *Electrical Hazard*: No data; *Burning Rate*: 3.74 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzylamine — Fire Hazards: *Flash Point (deg. F):* 168 OC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic nitrogen oxides form in fire situations; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: 4.13 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: In presence of moisture may severely corrode some metals. In liquid state this chemical will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzyl Bromide — Fire Hazards: *Flash Point (deg. F):* 174 CC; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating and toxic hydrogen bromide gas is formed; *Behavior in Fire*: Forms vapor that is powerful tear gas; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: 2.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly generating hydrogen bromide (hydrobromic acid); *Reactivity with Common Materials*: Decomposes rapidly in the presence of all common metals except nickel and lead, liberating heat and hydrogen bromide; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Rinse with sodium bicarbonate or lime solution; *Polymerization*: Polymerizes with evolution of heat and hydrogen bromide when in presence with all common metals except nickel and lead; *Inhibitor of Polymerization*: None.

Benzyl n-Butyl Phthalate — Fire Hazards: *Flash Point (deg. F):* 390 OC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause frothing; *Special Hazards of Combustion Products*: Irritating vapors of unburned chemical may form in fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzyl Chloride — Fire Hazards: *Flash Point (deg. F):* 165 OC, 140 CC; *Flammable Limits in Air* (%): 1.1 (LEL); *Fire Extinguishing Agents*: Water, dry chemical, foam, and carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen chloride gas forms; *Behavior in Fire*: Forms vapor that is a powerful tear gas; *Ignition Temperature (deg. F)*: 1,161; *Electrical Hazard*: No data; *Burning Rate*: 4.2 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Undergoes slow hydrolysis, liberating hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Decomposes rapidly in the presence of all common metals (with the exception of nickel and lead), liberating heat and hydrogen chloride; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Rinse with sodium bicarbonate or lime solution; *Polymerization*: Polymerizes with evolution of heat and hydrogen chloride when in contact with all common metals except nickel and lead; *Inhibitor of Polymerization*: Triethylamine, propylene oxide or sodium carbonate.

Benzyl Chloroformate — Fire Hazards: *Flash Point (deg. F):* 176 OC, 227 CC; Vigorous decomposition occurs at these temperatures. These values are anomalous due to the effect of the decomposition products of benzyl chloride and CO_2; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: No data; *Special Hazards of Combustion Products*: Toxic phosgene, hydrogen chloride, and benzyl chloride vapors may form; *Behavior in Fire*: Containers may explode; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: 4.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Forms hydrogen chloride (hydrochloric acid). Reaction not very

vigorous in cold water; *Reactivity with Common Materials*: Slow corrosion of metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzyldimethyloctadecylammonium Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen and hydrochloric acid fumes may form in fire situations; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Benzyltrimethylammonium Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen and hydrochloric acid fumes may form in fire situations; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Beryllium Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water on adjacent fires; *Special Hazards of Combustion Products*: Toxic and irritating beryllium oxide fumes and hydrogen chloride may form in fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously as an exothermic reaction. Forms beryllium oxide and hydrochloric acid solution; *Reactivity with Common Materials*: Corrodes most metals in the presence of moisture. Flammable and explosive hydrogen gas may collect in confined spaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Beryllium Fluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating vapors may form from unburned material in a fire situation; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Beryllium Metallic — Fire Hazards: *Flash Point (deg. F):* Not pertinent. This is a combustible solid; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Graphite, sand, or any other inert dry powder; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: Combustion results in beryllium oxide fumes which are toxic to inhalation; *Behavior in Fire*: Powder may form explosive mixture in air; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Beryllium Nitrate — Fire Hazards: *Flash Point (deg. F):* Not combustible; *Flammable Limits in Air (%)*: Not combustible; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating beryllium oxide and oxides of nitrogen may form in fires; *Behavior in Fire*: May increase the intensity of fire when in contact with combustible materials; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts to form weak solution of nitric acid, however the reaction is usually not

considered hazardous; *Reactivity with Common Materials*: In presence of moisture will attack and damage wood and corrode most metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Beryllium Oxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic beryllium oxide fume may form in fire situations; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Beryllium Sulfate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic beryllium oxide and sulfuric acid fumes may form in fire situations; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bismuth Oxychloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen chloride gas may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bisphenol A — Fire Hazards: *Flash Point (deg. F)*: 415 OC; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: No data; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Nor pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bisphenol A Diglycidyl Ether — Fire Hazards: *Flash Point (deg. F)*: 175 OC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: No data; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Boiler Compound, Liquid — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may burst; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Boric Acid — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with*

Common Materials: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Born Tribromide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water or foam on adjacent fires; *Special Hazards of Combustion Products*: Toxic fumes of the compound and hydrogen bromide form in fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Vigorously reacts forming hydrobromic acid solution and fumes; *Reactivity with Common Materials*: Strongly attacks metals and wood. Flammable hydrogen gas may collect in closed vessels or containers; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or soda ash solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Boron Trichloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Toxic fumes of hydrogen chloride are generated upon contact with water used to fight adjacent fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts vigorously, liberating heat and forming hydrogen chloride fumes (hydrochloric acid) and boric acid; *Reactivity with Common Materials*: Vigorously attacks elastomers and various packaging materials. Viton, Tygon, silastic elastomers, natural rubber, some synthetic rubbers are not recommended for service. Avoid lead and graphite impregnated asbestos. In the presence of moisture this chemical will aggressively attack most metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate and lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bromine — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Use water spray to cool exposed containers and to wash spill away from a safe distance; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating gases are formed when heated or in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Reacts violently with aluminum. May cause fire on contact with common materials such as wood, cotton, straw. Iron, steel, stainless steel, and copper are corroded by bromine and will undergo severe corrosion when in contact with wet bromine. Plastics are also degraded/ attacked by bromine except for highly fluorinated plastics which resist attack; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bromine Pentafluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable. This chemical is a strong oxidizer and may cause fire when in contact with organic materials including wood, cotton or straw; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water or foam on adjacent fires; *Special Hazards of Combustion Products*: Toxic fumes of hydrogen fluoride and bromine can form in fires; *Behavior in Fire*: Containers may burst when exposed to heat; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts violently with water generating hydrogen fluoride which is extremely irritating and corrosive; *Reactivity with Common Materials*: Reacts violently with many metals and materials of construction such as wood, glass and plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bromine Trifluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable but can cause fire on contact with combustibles; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water, foam; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: Forms highly toxic and irritating fumes; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts vigorously generating toxic hydrogen fluoride gas (hydrofluoric acid); *Reactivity with Common*

Materials: Causes severe corrosion of common metals and glass. May cause fire when in contact with organic materials such as wood, cotton or straw; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Bromobenzene — Fire Hazards: *Flash Point (deg. F)*: 124 CC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen bromide and other gases form in a fire situation; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1,049; *Electrical Hazard*: No data; *Burning Rate*: 3.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Brucine — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (combustible solid); *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire situations; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Butadiane, Inhibited — Fire Hazards: *Flash Point (deg. F)*: -105 (est.); *Flammable Limits in Air (%)*: 2.0 - 11.5; *Fire Extinguishing Agents*: Stop flow of gas; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than air and can travel distances to ignition source and flash back. Containers may explode in a fire due to polymerization; *Ignition Temperature (deg. F)*: 788; *Electrical Hazard*: Class I, Group B; *Burning Rate*: 8.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Explosive decomposition when contaminated with peroxides formed by reaction with air; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Polymerization inhibited when stabilizer is used; *Inhibitor of Polymerization*: tert-Butylcatehol (0.01 - 0.02%).

Butane — Fire Hazards: *Flash Point (deg. F)*: -100 (est.); *Flammable Limits in Air (%)*: 1.8 - 8.4; *Fire Extinguishing Agents*: Stop flow of gas; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 807; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 7.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

1,4-Butanediol — Fire Hazards: *Flash Point (deg. F)*: > 250 OC; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

1,4-Butenediol — Fire Hazards: *Flash Point (deg. F)*: 263 OC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Foam or water may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Butyl Acetate — Fire Hazards: *Flash Point (deg. F)*: 99 OC, 75 CC; *Flammable Limits in Air (%)*: 1.7 - 7.6; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water

in straight hose stream will scatter and spread fire and should be avoided; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 760; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

sec-Butyl Acetate — Fire Hazards: *Flash Point (deg. F)*: 62 CC, 88 OC; *Flammable Limits in Air (%)*: 1.7 - 9.8; *Fire Extinguishing Agents*: Foam, carbon dioxide or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

iso-Butyl Acrylate — Fire Hazards: *Flash Point (deg. F)*: 94 OC; *Flammable Limits in Air (%)*: 1.9 - 8.0; *Fire Extinguishing Agents*: Dry chemical, foam or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 644; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Polymerizes upon exposure to heat; uncontrolled bulk polymerization can be explosive; *Inhibitor of Polymerization*: Methyl ether of hydroquinone: 10 - 100 ppm; Hydroquinone : 5 ppm.

n-Butyl Acrylate — Fire Hazards: *Flash Point (deg. F)*: 118 OC; *Flammable Limits in Air (%)*: 1.4 - 9.4; *Fire Extinguishing Agents*: Dry chemical, foam or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 534; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Polymerizes upon exposure to heat; uncontrolled bulk polymerization can be explosive; *Inhibitor of Polymerization*: Methyl ether of hydroquinone: 15 - 100 ppm. Store in contact with air.

n-Butyl Alcohol — Fire Hazards: *Flash Point (deg. F)*: 84 CC, 97 OC; *Flammable Limits in Air (%)*: 1.4 - 11.2; *Fire Extinguishing Agents*: Carbon dioxide, dry chemicals; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 650; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 3.2 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

sec-Butyl Alcohol — Fire Hazards: *Flash Point (deg. F)*: 75 CC; *Flammable Limits in Air (%)*: 1.7 - 9.0; *Fire Extinguishing Agents*: Carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 763; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 3.1 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

tert-Butyl Alcohol — Fire Hazards: *Flash Point (deg. F)*: 52 CC, 61 OC; *Flammable Limits in Air (%)*: 2.35 - 8.00; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 896; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 3.4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Butylamine — Fire Hazards: *Flash Point (deg. F)*:30 OC, 10 CC; *Flammable Limits in Air (%)*: 1.7 - 9.8; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon

dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form during fires; *Behavior in Fire*: Vapor is heavier than air and can travel distances to ignition source and flash back. Containers may explode; *Ignition Temperature (deg. F)*: 594; *Electrical Hazard*: No data; *Burning Rate*: 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May corrode some metals in presence of water; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

sec-Butylamine — Fire Hazards: *Flash Point (deg. F)*: 16 CC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may be formed; *Behavior in Fire*: Vapor is heavier than air and can travel distances to ignition source and flash back. Containers may explode; *Ignition Temperature (deg. F)*: 712; *Electrical Hazard*: No data; *Burning Rate*: 6.2 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May corrode some metals in presence of water; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

tert-Butylamine — Fire Hazards: *Flash Point (deg. F)*: 16 CC; *Flammable Limits in Air* (%): 1.7 - 8.9 (at 212 of); *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: 716; *Electrical Hazard*: No data; *Burning Rate*: 7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Liquid will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Butylene — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air* (%): 1.6 - 10; *Fire Extinguishing Agents*: Stop flow of gas; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode in fires. Vapor is heavier than air and may travel considerable distance to ignition source and flash back; *Ignition Temperature (deg. F)*: 725; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Butylene Oxide — Fire Hazards: *Flash Point (deg. F)*:20 OC; *Flammable Limits in Air* (%): 1.5 - 18.3; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: Containers may explode in fires. Apply water to cool containers from a safe distance; *Ignition Temperature (deg. F)*: 959; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: May occur when the product is in contact with strong acids and bases; *Inhibitor of Polymerization*: No data.

tert-Butyl Hydroperoxide — Fire Hazards: *Flash Point (deg. F)*: 100 OC; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Reacts vigorously with easily oxidized materials including wood and some metals; *Stability During Transport*: This is a shock and heat sensitive product. Displays self-accelerating decomposition at 200 °F; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Butyl Mercaptan — Fire Hazards: *Flash Point (deg. F)*: 53 OC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: Irritating sulfur dioxide; *Behavior in Fire*: Vapors are heavier than air and may travel considerable distance to ignition source and flash back; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: 7.4 mm/min.

Chemical Reactivity: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Butyl Methacrylate — Fire Hazards: *Flash Point (deg. F):* 150 OC; *Flammable Limits in Air (%)*: 2 - 8; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode; *Ignition Temperature (deg. F)*: 562; *Electrical Hazard*: No data; *Burning Rate*: 4.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: May occur upon exposure to heat; *Inhibitor of Polymerization*: 9 - 15 ppm monomethyl ether of hydroquinone; 90 - 120 ppm hydroquinone.

p-tert-Butylphenol — Fire Hazards: *Flash Point (deg. F):* 235 CC (liquid); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Butyltrichlorosilane — Fire Hazards: *Flash Point (deg. F):* 130 OC, 126 CC; *Flammable Limits in Air (%)*: Data not available; *Fire Extinguishing Agents*: Dry chemical and carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water, foam; *Special Hazards of Combustion Products*: Hydrogen chloride, chlorine gas, or phosgene may be formed; *Behavior in Fire*: Difficult to extinguish because of reigniting; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: 2.2 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously forming hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Reacts with common metals evolving hydrogen chloride and may cause severe corrosion; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

1,4-Butynediol — Fire Hazards: *Flash Point (deg. F):* 263 OC (pure butynediol); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

iso-Butyraldehyde — Fire Hazards: *Flash Point (deg. F):* 13 OC, -40 CC; *Flammable Limits in Air (%)*: 2.0 - 10.0; *Fire Extinguishing Agents*: Foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapors are heavier than air and may travel considerable distances to a source of ignition and flash back. Fires are difficult to control because of reignition; *Ignition Temperature (deg. F)*: 385; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Butyraldehyde — Fire Hazards: *Flash Point (deg. F):* 15 OC, 20 CC; *Flammable Limits in Air (%)*: 2.5 - 10.6; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapors are heavier than air and may travel considerable distances to a source of ignition and flash back. Fires are difficult to control because of recognition; *Ignition Temperature (deg. F)*: 446; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: May occur in the presence of heat, acids or alkalis; *Inhibitor of Polymerization*: Not pertinent.

n-Butyric Acid — Fire Hazards: *Flash Point (deg. F):* 166 OC, 160 CC; *Flammable Limits in Air* (%): 2.19 - 13.4; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: 842; *Electrical Hazard*: No data; *Burning Rate*: 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack aluminum or other light metals with the formation of flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

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Cacodylic Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May form toxic oxides of arsenic when heated; *Ignition Temperature (deg. F)*:Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cadmium oxide fumes may form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Bromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cadmium oxide fumes can form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Fluoroborate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic hydrogen fluoride and cadmium oxide fumes can form; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen and cadmium oxide fumes can form; *Behavior in Fire*: Can increase the intensity of fires when in contact with combustible materials; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Mixtures with wood and other combustibles are readily ignited; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent;

Polymerization: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Oxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cadmium oxide fumes may form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cadmium Sulfate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cadmium oxide fumes may form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Arsenate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic arsenic fumes may form; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Carbide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Dry powder; preferably allow fire to burn out; *Fire Extinguishing Agents Not To Be Used*: Water, vaporizing liquid or foam, carbon dioxide; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: When contacted with water, generates highly flammable acetylene gas; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously with water to form highly flammable acetylene gas which can spontaneously ignite; *Reactivity with Common Materials*: Reacts with copper and brass to form an explosive formulation; *Stability During Transport*: Stable but in absence of water; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Chlorate — Fire Hazards: *Flash Point (deg. F)*: Not flammable but may cause fire with other materials; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Flood with water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May cause an explosion. Irritating gases may also form upon exposure to heat; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Can form an explosive mixture with finely divided combustible materials. The mixture can ignite with application of friction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Chloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Anhydrous grade dissolves with evolution of some heat; *Reactivity with Common Materials*: Metals slowly corrode in aqueous solutions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Chromate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic chromium

fumes are formed during fires; *Behavior in Fire*: The hydrated salt loses water when hot and changes color, however there is no increase in hazard; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Cyanide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Use dry chemical, sand or earth on adjacent fires; *Fire Extinguishing Agents Not To Be Used*: Do not use water or carbon dioxide on adjacent fires; *Special Hazards of Combustion Products*: Decomposes in fires resulting in hydrogen cyanide and other toxic gases; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Releases poisonous hydrogen cyanide slowly on contact with water. If the water is acidic, the release is rapid; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable if kept dry; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Fluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Hydroxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Hypochlorite — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Poisonous gases released upon exposure to heat; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Can cause fire on contact with wood or straw, and is corrosive to most metals; *Stability During Transport*: The 70 % grade decomposes violently when exposed to heat or direct sunlight. Gives off chlorine and chlorine monoxide gases above 350 of, which are poisonous gases; *Neutralizing Agents for Acids and Caustics*: Dilute with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium, Metallic — Fire Hazards: *Flash Point (deg. F)*: Not pertinent. This is a flammable solid; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Dry graphite, soda ash, powdered sodium chloride, or appropriate metal fire extinguishing dry powder; *Fire Extinguishing Agents Not To Be Used*: Water, halogenated hydrocarbons, dry chemical, carbon dioxide; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Burns violently, especially if finely divided or powder form; *Ignition Temperature (deg. F)*: 1454 +/- 18; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts to form flammable hydrogen gas which may ignite. The reaction is not violent; *Reactivity with Common Materials*: Reacts with moist air forming a skin of hydroxide. This reaction is not hazardous; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Nitrate — Fire Hazards: *Flash Point (deg. F)*: Not flammable however may cause fires when in contact with flammables; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Flood with water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent;

Special Hazards of Combustion Products: Produces toxic oxides of nitrogen when involved in fires; *Behavior in Fire*: Can greatly intensify the burning of all combustible materials; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Contact with combustible materials can result in fires; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Oxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not use water on adjacent fires; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Heat causes ignition of combustible materials. The material swells during the reaction; *Reactivity with Common Materials*: No reactions unless water is present; the principle effect is heat is liberated; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Peroxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable but may cause fires upon contact with combustible materials; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Flood with water or use dry powder such as graphite or powdered limestone; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Can increase the intensity and severity of fires; containers may explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly with water at room temperature to form limewater and oxygen gas; *Reactivity with Common Materials*: Heavy metals and dirt can accelerate decomposition to lime and oxygen. The reaction is not explosive; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Phosphate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Some calcium phosphates can form acid solutions in water. These may attack metals, forming flammable hydrogen gas which can collect in confined spaces; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Phosphide — Fire Hazards: *Flash Point (deg. F)*: Not flammable but can spontaneously ignite if in contact with water; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Extinguish adjacent fires with dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water, foam; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Can cause spontaneous ignition if wetted. Generates dense smoke of phosphoric acid; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously with water, generating phosphine, which is a poisonous and spontaneously flammable gas; *Reactivity with Common Materials*: Can react with surface moisture to generate phosphine, which is toxic and spontaneously flammable; *Stability During Transport*: Stable if kept dry; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Calcium Resinate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent. This is a combustible solid; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: 480 (this chemical may ignite spontaneously); *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Camphene — Fire Hazards: *Flash Point (deg. F):* 108 OC, 92 CC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Camphor Oil — Fire Hazards: *Flash Point (deg. F):* 117 CC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: The solid often evaporates without first melting; *Ignition Temperature (deg. F)*: 466; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Caprolactam, Liquid — Fire Hazards: *Flash Point (deg. F):* 257 OC, 230 CC; *Flammable Limits in Air* (%): 1.84 (LEL); *Fire Extinguishing Agents*: Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: 2.4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Captan — Fire Hazards: *Flash Point (deg. F):* Flammable solid; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water, carbon dioxide, foam; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating and toxic vapors are generated in a fire. These vapors may include sulfur dioxide, hydrogen chloride, phosgene, and oxides of nitrogen; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carbaryl — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: For solution fires apply water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carbolic Oil — Fire Hazards: *Flash Point (deg. F):* 185 OC, 175 CC; *Flammable Limits in Air* (%): 1.7 - 8.6; *Fire Extinguishing Agents*: Water, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: The unburned vapor is irritating and toxic; *Behavior in Fire*: Produces flammable vapors when heated, which will form explosive mixtures in air; *Ignition Temperature (deg. F)*:1,319; *Electrical Hazard*: Not pertinent; *Burning Rate*: 3.5 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carbon Dioxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode when exposed to heat; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent;

Polymerization: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carbon Bisulfide — Fire Hazards: *Flash Point (deg. F):* -22 CC; *Flammable Limits in Air* (%): 1.3 - 50; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic gases are generated. Self contained breathing apparatus (SCBA) are required in firefighting; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 212; *Electrical Hazard*: Contact of the liquid or vapor with the surface of a lighted electric light bulb can result in spontaneous ignition; *Burning Rate*: 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carbon Monoxide — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air* (%): 12 - 75; *Fire Extinguishing Agents*: Allow fire to burn out; shut off the flow of gas and cool adjacent exposures with water. Extinguish (only if wearing a SCBA) with dry chemicals or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Asphyxiation due to carbon dioxide production is a major concern; *Behavior in Fire*: Flame has very little color. Containers may explode in fires; *Ignition Temperature (deg. F)*: 1,128; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carbon Tetrachloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Forms poisonous phosgene gas when exposed to open flames; *Behavior in Fire*: Decomposes to chloride and phosgene; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Carene — Fire Hazards: *Flash Point (deg. F):* No data; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective on fire; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Will attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Catechol — Fire Hazards: *Flash Point (deg. F):* 278 OC, 261 CC; *Flammable Limits in Air* (%): Not pertinent. This is a combustible solid; *Fire Extinguishing Agents*: Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water and foam may be ineffective; *Special Hazards of Combustion Products*: May form toxic fumes at high temperatures; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Caustic Potash Solution — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Nor flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Attacks wool, leather and some metals such as aluminum, tin, lead and zinc to produce flammable hydrogen gas. This product should be separated from easily ignitible materials; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water and rinse with dilute acid such as acetic acid; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Caustic Soda Solution — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent;

Fire Extinguishing Agents Not To Be Used: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Corrosive to aluminum, zinc and tin. Contact with some metals can generate flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Dilute with water and rinse with dilute acetic acid; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Charcoal — Fire Hazards: *Flash Point (deg. F)*: This is a flammable solid. It may spontaneously ignite in air especially if finely divided; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Incomplete combustion produces toxic carbon monoxide; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 600 - 750; *Electrical Hazard*: Class I, Group F; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: In powder form may ignite spontaneously in air; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chlordane — Fire Hazards: *Flash Point (deg. F)*: 225 OC, 132 CC. In solid form the product is not flammable; *Flammable Limits in Air (%)*: 0.7 - 5 (kerosene solution); *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective on solution fires; *Special Hazards of Combustion Products*: Produces irritating and toxic hydrogen chloride and phosgene gases when the kerosene solution of the compound burns; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 419 (kerosene solution); *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Product is stable below 160 of; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chlorine — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic products are generated when combustibles burn in the presence of chlorine; *Behavior in Fire*: Most combustible materials will burn in the presence of chlorine even though chlorine itself is not flammable; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: No data; *Burning Rate*: Not flammable. **Chemical Reactivity**: *Reactivity with Water*: Forms a corrosive solution; *Reactivity with Common Materials*: Reacts vigorously with most metals especially at high temperatures. Copper may burn spontaneously; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chlorine Trifluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable, but can cause fire when mixed or in contact with some materials; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Dry chemical; *Fire Extinguishing Agents Not To Be Used*: Do not use water on adjacent fires unless well protected against hydrogen fluoride gas; *Special Hazards of Combustion Products*: Fumes are highly toxic and irritating; *Behavior in Fire*: Can greatly increase the intensity of fires. Containers or vessels may explode; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts explosively with water, producing hydrogen fluoride (hydrofluoric acid) and chlorine; *Reactivity with Common Materials*: Causes ignition of all combustible materials and some inerts such as sand and concrete. The chemical is very similar to fluorine gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flood with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chloroacetophenone — Fire Hazards: *Flash Point (deg. F)*: This is a combustible solid, but in solutions it has a flash point of 244 CC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen chloride may form; *Behavior in Fire*: Unburned material may become volatile and cause severe skin and eye irritation; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts slowly, producing hydrogen chloride. The reaction is not hazardous; *Reactivity with Common Materials*: Reacts slowly with metals, causing mild corrosion; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chloroacetyl Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Do not apply water to fighting adjacent fires; *Special Hazards of Combustion Products*: Exposure to fire or extreme heat can cause decomposition of this product with the evolution of highly toxic and irritating hydrogen chloride and phosgene gases; *Behavior in Fire*: Highly irritating (tear gas) vapors are generated upon exposure to heat. Hydrogen chloride gas is released when the chemical is in contact with water; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously with water forming hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Can react with surface moisture to generate hydrogen chloride which is corrosive to metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

p-Chloroaniline — Fire Hazards: *Flash Point (deg. F):* This os a combustible solid, > 220 OC; *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, foam or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating and toxic hydrogen chloride and oxides of nitrogen can form in fire situations; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chlorobenzene — Fire Hazards: *Flash Point (deg. F):* 84 CC, 97 OC; *Flammable Limits in Air (%)*: 1.3 - 7.1; *Fire Extinguishing Agents*: Carbon dioxide, dry chemical, foam or water spray; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Burning in open flame can result in the formation of toxic phosgene and hydrogen chloride gases; *Behavior in Fire*: Vapors are heavier than air and can travel considerable distances to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 1,184; *Electrical Hazard*: No data; *Burning Rate*: 4.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

4-Chlorobutyronitrile — Fire Hazards: *Flash Point (deg. F):* No data; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: No data; *Special Hazards of Combustion Products*: Toxic and irritating hydrogen cyanide, hydrogen bromide, and hydrogen chloride may form in fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack some plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chloroform — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Poisonous and irritating gases are generated upon heating; *Behavior in Fire*: Decomposes resulting in toxic vapors; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chlorohydrins (Crude) — Fire Hazards: *Flash Point (deg. F):* 92 OC, 100 CC; *Flammable Limits in Air (%)*: 3.8 - 21; *Fire Extinguishing Agents*: Alcohol foam, dry chemical, carbon dioxide, water spray; *Fire Extinguishing Agents Not To Be Used*: Avoid the use of dry chemical if the fire occurs in containers with confined vents; *Special Hazards of Combustion Products*: Toxic and irritating vapors are generated upon heating; *Behavior in Fire*: Containers may explode in fire because of polymerization; *Ignition Temperature (deg. F)*: 804; *Electrical Hazard*: No data; *Burning Rate*: 2.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts mildly with water, but generally the reaction is not considered to be hazardous; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids*

and Caustics: Not pertinent; *Polymerization*: Can polymerize in the presence of strong acids and bases, particularly at elevated temperatures; *Inhibitor of Polymerization*: None reported.

Chloromethyl Methyl Ether — Fire Hazards: *Flash Point (deg. F):* 0 OC; *Flammable Limits in Air* (%): No data; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Irritating and toxic hydrogen chloride and phosgene vapors can form; *Behavior in Fire*: Unburned material may form powerful tear gas. When wet, this chemical also forms irritating formaldehyde gas; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: 3.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts to form formaldehyde and hydrogen chloride. Reaction is slow and not violent; *Reactivity with Common Materials*: Can react with surface moisture to evolve hydrogen chloride which is corrosive to metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flood with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

p-Chlorophenol — Fire Hazards: *Flash Point (deg. F)*: 250 CC; *Flammable Limits in Air* (%): Not pertinent. This is a combustible solid; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: No data; *Special Hazards of Combustion Products*: Toxic and irritating hydrogen chloride and chlorine gases can form in fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions reported; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chloropicrin, Liquid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Recommended to cool containers that are exposed to fires with water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: This chemical forms a powerful tear gas when heated. Heated material may detonate under fire conditions; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chlorosulfonic Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Water; *Special Hazards of Combustion Products*: Decomposes into irritating and toxic vapors; *Behavior in Fire*: Although this chemical is nonflammable, it may ignite other combustibles. Contact with water and metal produces explosive hydrogen gas; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Reacts violently with water, generating hydrochloric acid vapor and sulfuric acid; *Reactivity with Common Materials*: Hydrogen, which is highly flammable and explosive, is formed by the action of this acid on most metals. May cause ignition by contact with combustible materials; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Even though this chemical reacts violently with water, flooding with water (from a safe distance) is recommended before neutralizing with lime water or sodium bicarbonate solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

4-Chloro-o-Toluidine — Fire Hazards: *Flash Point (deg. F):* This is a combustible solid; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen and hydrochloric acid fumes may form; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chromic Anhydride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode. Water should be applied to cool container surfaces exposed to adjacent

fires; *Ignition Temperature (deg. F)*: This product may ignite organic materials on contact; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Reacts with organic materials rapidly, generating sufficient heat to cause ignition. Prolonged contact on wood floors can result in a fire hazard; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flood with water and rinse with sodium bicarbonate solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Chromyl Chloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable, but may cause fire on contact with combustible materials; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Do not apply water on adjacent fires unless SCBA is used to protect against toxic vapors; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapors are extremely irritating to the eyes and mucous membranes. This product may increase the intensity of fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts violently with water forming hydrogen chloride (hydrochloric acid), chlorine gases, and chromic acid; *Reactivity with Common Materials*: Causes severe corrosion of common metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flood with water and rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Citric Acid — Fire Hazards: *Flash Point (deg. F)*: Not pertinent. This is a combustible solid; *Flammable Limits in Air*: 0.28 - 2.29 kg/m^3 as dust; *Fire Extinguishing Agents*: Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: This product melts and decomposes as a hazardous reaction; *Ignition Temperature (deg. F)*: 1,850 as powder; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Corrodes copper, zinc, aluminum, and alloys of these metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cobalt Acetate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cobalt oxide fumes form during fires; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions reported; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cobalt Chloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cobalt oxide fumes can form in fire situations; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cobalt Nitrate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen form in fires; *Behavior in Fire*: Can increase fire intensity; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Contact with wood or paper may result in fire; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cobalt Sulfate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic cobalt oxide fumes form in fire; *Behavior in Fire*: No data;

Ignition Temperature (deg. F): Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Collodion — Fire Hazards: *Flash Point (deg. F)*: -49 CC (ether); *Flammable Limits in Air (%)*: 1.9 - 36 (ether solution); *Fire Extinguishing Agents*: Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: This chemical forms extremely toxic vapors, most notably oxides of nitrogen, hydrogen cyanide, and carbon monoxide; *Behavior in Fire*: Highly flammable solvent vapors are formed during fires. These vapors can travel considerable distances to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 356 (ether); *Electrical Hazard*: Class I, Group C; *Burning Rate*: No data. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Acetate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating vapors of acetic acid form in fire situations; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Acetoarsenite — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Poisonous, volatile arsenic oxides may be formed in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Arsenite — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Poisonous, volatile arsenic oxides may be formed in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Bromide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen bromide gas may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Chloride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen chloride gas may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: In presence of moisture may corrode metals; the reaction is not hazardous; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with dilute solution of sodium bicarbonate or

soda ash; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Cyanide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic hydrogen cyanide gas may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable, in presence of moisture, toxic hydrogen cyanide gas may collect in enclosed spaces; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Fluoroborate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen fluoride gas may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May corrode some metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Iodide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Irritating hydrogen iodide or iodine vapors may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Naphthenate — Fire Hazards: *Flash Point (deg. F):* 100 CC (typical); *Flammable Limits in Air (%)*: 0.8 - 5.0 (mineral spirits); *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 540 (mineral spirits); *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating oxides of nitrogen may form in fire; *Behavior in Fire*: Can increase intensity of fire if in contact with combustible material; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Mixtures with wood, paper, and other combustibles may catch fire; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Oxalate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Toxic carbon monoxide gas may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Copper Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature*

(deg. F): Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Corn Syrup — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air* (%): Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Coumaphos — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water, foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Toxic and irritating oxides of sulfur and phosphorus may form in fires; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Creosote, Coal Tar — Fire Hazards: *Flash Point (deg. F):* > 160 CC; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide, or foam; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Heavy, irritating black smoke is formed; *Ignition Temperature (deg. F)*: 637; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cresols — Fire Hazards: *Flash Point (deg. F):* 175 - 185 OC; 178 CC; *Flammable Limits in Air* (%): LEL: 1.4 (ortho); 1.1 (meta or para); *Fire Extinguishing Agents*: Water, dry chemical, carbon dioxide, and foam; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Flammable toxic vapors given off in a fire; *Behavior in Fire*: Sealed closed containers can build up pressure if exposed to heat (fire); *Ignition Temperature (deg. F)*: 1110 (o-cresol); 1038 (m- or p-cresol); *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cresyl Glycidyl Ether — Fire Hazards: *Flash Point (deg. F):* 200 OC; *Flammable Limits in Air* (%): Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack some forms of plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Crotonaldehyde — Fire Hazards: *Flash Point (deg. F):* 59 OC; *Flammable Limits in Air* (%): 2.1 - 15.5; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Vapors are very irritating; *Behavior in Fire*: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 450; *Electrical Hazard*: data not available; *Burning Rate*: 3.3 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: May polymerize; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: May polymerize or condense with evolution of heat in presence of alkalies, amines, or acids; *Inhibitor of Polymerization*: None used.

Cumene — Fire Hazards: *Flash Point (deg. F):* 111 CC; *Flammable Limits in Air* (%): 0.9 - 6.5; *Fire Extinguishing*

Agents: Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 797; *Electrical Hazard*: Data not available; *Burning Rate*: 50 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cumene Hydroperoxide — Fire Hazards: *Flash Point (deg. F):* 147 OC; 120 CC; *Flammable Limits in Air (%)*: 0.9 - 6.5; *Fire Extinguishing Agents*: Foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water may be ineffective; *Special Hazards of Combustion Products*: Toxic phenol vapors may form hot material; *Behavior in Fire*: May decompose violently when heated. Burning rate becomes more rapid as fire burns; *Ignition Temperature (deg. F)*: Decomposes violently at temperatures above 300; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Decomposition is catalyzed by metals such as aluminum, copper, brass, zinc, and lead. The reaction is not hazardous; *Stability During Transport*: Stable if kept below 125° F and out of direct sunlight; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cupriethylenediamine Solution — Fire Hazards: *Flash Point (deg. F):* Non-flammable solution; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Irritating vapors of ethylenediamine may be produced when heated; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Dissolves cotton, wood, and other cellulosic materials. Corrosive to copper, aluminum, zinc, and tin; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyanoacetic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%)*: Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Data not available; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen and toxic and flammable acetonitrile vapors may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyanogen — Fire Hazards: *Flash Point (deg. F):* Flammable gas; *Flammable Limits in Air (%)*: 6.6 - 43; *Fire Extinguishing Agents*: Let fire burn, shut off flow of gas, cool exposed areas with water; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Unburned vapors are highly toxic; *Behavior in Fire*: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: data not available; *Burning Rate*:. **Chemical Reactivity:** *Reactivity with Water*: No reaction, but water, provides heat to vaporize liquid cyanogen; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyanogen Bromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Poison gases are produced in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Strong bleaching powder solution; let stand 24 hr; *Polymerization*: Does not occur; *Inhibitor of Polymerization*: Not pertinent.

Cyanogen Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent;

Behavior in Fire: Overheated containers can explode; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Very slow reaction; *Reactivity with Common Materials*: Slow, not immediately hazardous; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclohexane — Fire Hazards: *Flash Point (deg. F)*: -4 CC; *Flammable Limits in Air* (%): 1.33 - 8.35; *Fire Extinguishing Agents*: Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 518; *Electrical Hazard*: Data not available; *Burning Rate*: 6.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclohexanol — Fire Hazards: *Flash Point (deg. F)*: 160 OC; 154 CC; *Flammable Limits in Air* (%): Data not available; *Fire Extinguishing Agents*: Water, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 572; *Electrical Hazard*: Data not available; *Burning Rate*: 3.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclohexanone — Fire Hazards: *Flash Point (deg. F)*: 129 OC; 111 CC; *Flammable Limits in Air* (%): 1.1 LEL; *Fire Extinguishing Agents*: Water, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 788; *Electrical Hazard*: Data not available; *Burning Rate*: 4.2 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclohexanone Peroxide — Fire Hazards: *Flash Point (deg. F)*: Combustible solution 315 CC (dibutyl phthalate); *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Water foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May explode; *Ignition Temperature (deg. F)*: 757 (dibutyl phthalate); *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Not pertinent; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclohexenyltrichlorosilane — Fire Hazards: *Flash Point (deg. F)*: > 150 OC; *Flammable Limits in Air* (%): Not pertinent; *Fire Extinguishing Agents*: Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used*: Water or foam; *Special Hazards of Combustion Products*: Irritating, toxic hydrogen chloride and phosgene may be generated in a fire; *Behavior in Fire*: Difficult to extinguish. Re-ignition may occur. Water applied to adjacent fires will produce hydrogen chloride upon contact with this material; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: Reacts to generate hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Corrodes metals by reacting with surface moisture and generating hydrogen chloride; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclohexylamine — Fire Hazards: *Flash Point (deg. F)*: 90 OC; *Flammable Limits in Air* (%): Data not available; *Fire Extinguishing Agents*: Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used*: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 560; *Electrical Hazard*: Data not available; *Burning Rate*: 5.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics*: Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Cyclopentane — Fire Hazards: *Flash Point (deg. F):* <20 CC; *Flammable Limits in Air (%):* (approx.) 1.1 - 8.7; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 716; *Electrical Hazard:* Not pertinent; *Burning Rate:* 7.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Cyclopropane — Fire Hazards: *Flash Point (deg. F):* Flammable gas; *Flammable Limits in Air (%):* 2.4 - 10.3; *Fire Extinguishing Agents:* Shut off flow of gas; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 932; *Electrical Hazard:* Class I, Group D; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

p-Cumene — Fire Hazards: *Flash Point (deg. F):* 140 OC; 117 CC; *Flammable Limits in Air (%):* 0.7 - 5.6; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 817; *Electrical Hazard:* Data not available; *Burning Rate:* 6.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

D

Dalapon — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, alcohol foam; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating fumes of hydrochloric acid may form in fire; *Behavior in Fire:* Volatilizes with steam; *Ignition Temperature (deg. F):* data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly to form hydrochloric and pyruvic acids. The reaction is nor hazardous; *Reactivity with Common Materials:* Very corrosive to aluminum and copper alloys. Flammable and explosive hydrigen gas may form in enclosed spaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

DDD — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Irritating hydrogen chloride fumes may form in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

DDT — Fire Hazards: *Flash Point (deg. F):* 162 - 171 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases may be generated; *Behavior in Fire:* Melts and burns; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Decaborane — Fire Hazards: *Flash Point (deg. F):* (Flammable solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, and carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Halogenated extinguishing agents; *Special Hazards of Combustion Products:* May give toxic fumes of unburned material; *Behavior in Fire:* May explode when

hot. Burns with green-colored flame; *Ignition Temperature (deg. F):* 300; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly to form flammable hydrogen gas, which can accumulate in closed area; *Reactivity with Common Materials:* Corrosive to natural rubber, some synthetic rubbers, some greases and some lubricants; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with 3% aqueous ammonia solution, then with water. Methyl alcohol may also be used; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Decahydronaphthalene — Fire Hazards: *Flash Point (deg. F):* 134 OC; *Flammable Limits in Air (%):* 0.7 - 5.4; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 482; *Electrical Hazard:* Data not available; *Burning Rate:* 5.9 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Decaldehyde — Fire Hazards: *Flash Point (deg. F):* 185 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Decene — Fire Hazards: *Flash Point (deg. F):* 128 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 455; *Electrical Hazard:* Data not available; *Burning Rate:* 6.0 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

n-Decyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 180 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

n-Decylbenzene — Fire Hazards: *Flash Point (deg. F):* 225 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* water or foam may cause frothing; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* January 26, 1998ata not available; *Electrical Hazard:* Data not available; *Burning Rate:* 5.04 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Demeton — Fire Hazards: *Flash Point (deg. F):* 113 CC; *Flammable Limits in Air (%):* 1.0 - 5.3; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective on fire; *Special Hazards of Combustion Products:* Irritating fumes of sulfur dioxide and phosphoric acid may form in fire; *Behavior in Fire:* Compound may volatilize and form toxic fumes. Vapor of solvent is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 867 (xylene solvent); *Electrical Hazard:* (xylene) Class I, Group D; *Burning Rate:* 5.8 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent;

Polymerization: Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4-D Esters — Fire Hazards: *Flash Point (deg. F):* > 175 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical , carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating hydrogen chloride vapor may form in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dextrose Solution — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diacetone Alcohol — Fire Hazards: *Flash Point (deg. F):* 142 OC; 125 CC; *Flammable Limits in Air (%):* 1.8 - 6.9; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1118; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Di-n-Amyl Phthalate — Fire Hazards: *Flash Point (deg. F):* 245 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diazinon — Fire Hazards: *Flash Point (deg. F):* 82 - 105 CC (solutions only; pure liquid difficult to burn); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* (for solutions) Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Oxides of sulfur and phosphorus are generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Data not available; *Burning Rate:* (for solutions) 4 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dibenzoyl Peroxide — Fire Hazards: *Flash Point (deg. F):* Highly flammable solid; explosion-sensitive to shock, heat and friction; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Difficult to extinguish once ignited. Use water spray to cool surrounding area; *Fire Extinguishing Agents Not to be Used:* Do not use hand extinguishers; *Special Hazards of Combustion Products:* Suffocating smoke evolved; *Behavior in Fire:* May explode; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* Special care must be taken to avoid contamination with combustible materials (wood, paper, etc.), various inorganic and organic acids, alkalies, alcohols, amines, easily oxidizable materials such as ethers, or materials used as accelerators in polymerizations reactions; *Stability During Transport:* Extremely explosion-sensitive to shock (impact, blows), heat and friction. Has been reported to explode for apparently no specific reason. Self-reactive; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Di-n-Butylamine — Fire Hazards: *Flash Point (deg. F):* 125 OC; *Flammable Limits in Air (%):* 1.1 (LFL); *Fire Extinguishing Agents:* "Alcohol" foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fires; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 5.84 mm/min; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May corrode some metals and attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Di-n-Butyl Ether — Fire Hazards: *Flash Point (deg. F):* 92 OC; *Flammable Limits in Air (%):* 1.5 - 7.6; *Fire Extinguishing Agents:* Dry chemical, "alcohol" foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 382; *Electrical Hazard:* Data not available; *Burning Rate:* 5.7 mm/min; **Chemical Reactivity:** *Reactivity with Water No reaction:*; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Di-n-Butyl Ketone — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dibutylphenol — Fire Hazards: *Flash Point (deg. F):* > 200 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dibutyl Phthalate — Fire Hazards: *Flash Point (deg. F):* 355 OC; 315 CC; *Flammable Limits in Air (%):* 0.5 - 2.5 (calculated); *Fire Extinguishing Agents:* Dry powder, carbon dioxide, foam; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 757; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

o-Dichlorobenzene — Fire Hazards: *Flash Point (deg. F):* 165 OC; 155 CC; *Flammable Limits in Air (%):* 2.2 - 9.2; *Fire Extinguishing Agents:* Water, foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors including hydrogen chloride gas, chlorocarbones, chlorine; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1198; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.3 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

p-Dichlorobenzene — Fire Hazards: *Flash Point (deg. F):* 165 OC; 150 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors are irritating. Toxic chlorine, hydrogen chloride and phosgene gases may be generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.3 mm/min

(approx.); **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Di-(p-Chlorobenzoyl) Peroxide — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Flood with water, or use dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic chlorinated biphenyls are formed in fires; *Behavior in Fire:* Solid may explode. Burns very rapidly when ignited. Smoke is unusually heavy when paste form is involved; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May react vigorously with combustible materials; *Stability During Transport:* Stable (below 80° F); *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dichlorobutene — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* 1.5 - 4; *Fire Extinguishing Agents:* Water, foam, dry chemical ,or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Decomposition vapors contain phosgene and hydrogen chloride gases; both are toxic and irritating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* January 26, 1998ata not available; *Electrical Hazard:* Data not available; *Burning Rate:* 2.6 mm/min; **Chemical Reactivity:** *Reactivity with Water :* Reacts slowly to form hydrochloric acid; *Reactivity with Common Materials:* Corrodes metal when wet; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dichlorodifluoromethane — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Although non-flammable, dissociation products generated in a fire may be irritating or toxic; *Behavior in Fire:* Helps extinguish fire; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1,2-Dichloroethylene — Fire Hazards: *Flash Point (deg. F):* 37CC; *Flammable Limits in Air (%):* 9.7 - 12.8; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Phosgene and hydrogenchoride fumes may form in fires; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 2.6 mm/min; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Will not occur under ordinary conditions of shipment. The reaction is not vigorous; *Inhibitor of Polymerization:* None used.

Dichloroethyl Ether — Fire Hazards: *Flash Point (deg. F):* 180 OC; 131 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* May form phosgene or hydrogen chloride in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 696; *Electrical Hazard:* Data not available; *Burning Rate:* 2.4 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* V; *Inhibitor of Polymerization:* Not pertinent.

Dichloromethane — Fire Hazards: *Flash Point (deg. F):* Not flammable under conditions likely to be encountered; *Flammable Limits in Air (%):* 12 - 19; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Dissociation products generated in a fire may be irritating or toxic; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1184; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability*

During Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4-Dichlorophenol — Fire Hazards: *Flash Point (deg. F):* 200 OC, 237 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Toxic gases can be evolved; *Behavior in Fire:* Solid melts and burns; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May react vigorously with oxidizing material; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4-Dichlorophenoxyacetic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating hydrogen chloride or phosgene gases may form; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Data not available; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dichloropropane — Fire Hazards: *Flash Point (deg. F):* 70 OC; 60 CC; *Flammable Limits in Air (%):* 3.4 - 14.5; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases may be generated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1035; *Electrical Hazard:* Not pertinent; *Burning Rate:* (est.) 3.2 mm/min; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dichloropropene — Fire Hazards: *Flash Point (deg. F):* 95 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases may be generated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* (est.) 3.4 mm/min; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

4,4'-Dichloro-alpha-Trichloromethylbenzhydrol — Fire Hazards: *Flash Point (deg. F):* 75 OC (xylene); *Flammable Limits in Air (%):* 1.1 - 7.0 (For xylene solution); *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating hydrogen chloride fumes may form in fire; *Behavior in Fire:* Xylene solvent vapors may travel to source of ignition and flash back; *Ignition Temperature (deg. F):* 986; *Electrical Hazard:* (xylene) Class I, Group D; *Burning Rate:* (xylene) 5.8 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* Contact with steel at elevated temperature causes formation of toxic chlorine and hydrogen chloride gases. Liquid may attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dicyclopentadiene — Fire Hazards: *Flash Point (deg. F):* 90 OC; *Flammable Limits in Air (%):* 0.8 - 6.3; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical, or water spray; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 941; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* May occur in presence of acids, but not hazardous; *Inhibitor of Polymerization:* Not pertinent.

Dieldrin — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Toxic and irritating hydrogen chloride fumes may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethanolamine — Fire Hazards: *Flash Point (deg. F):* 305 OC; *Flammable Limits in Air (%):* 1.6 (calc.)- 9.8 (est); *Fire Extinguishing Agents:* Water, alcohol foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Addition of water may cause frothing; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1224; *Electrical Hazard:* Not pertinent; *Burning Rate:* 0.74 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylamine — Fire Hazards: *Flash Point (deg. F):* 5 OC; *Flammable Limits in Air (%):* 1.8 - 9.1; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, or alcohol foam; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Vapors are irritating; *Behavior in Fire:* Vapors are heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 594; *Electrical Hazard:* Data not available; *Burning Rate:* 6.7 mm/min; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No hazardous reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylbenzene — Fire Hazards: *Flash Point (deg. F):* 135 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, water, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 743 (ortho); *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethyl Carbonate — Fire Hazards: *Flash Point (deg. F):* 115 OC; 77 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* 3.4 mm/min; **Chemical Reactivity:** *Reactivity with Water :* Too slow to be hazardous; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylene Glycol — Fire Hazards: *Flash Point (deg. F):* 255 CC; *Flammable Limits in Air (%):* 1.6 - 10.8; *Fire Extinguishing Agents:* Alcohol foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 444; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.5 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylene Glycol Dimethyl Ether — Fire Hazards: *Flash Point (deg. F):* 158 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethyleneglycol Monobutyl Ether — Fire Hazards: *Flash Point (deg. F):* 230 OC; 172 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, "alcohol" foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 442; *Electrical Hazard:* Not pertinent; *Burning Rate:* 3.3 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethyleneglycol Monobutyl Ether Acetate — Fire Hazards: *Flash Point (deg. F):* 240 OC; *Flammable Limits in Air (%):* 0.8 - 5.0; *Fire Extinguishing Agents:* Water, alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 563; *Electrical Hazard:* Data not available; *Burning Rate:*; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylene Glycol Monoethyl Ether — Fire Hazards: *Flash Point (deg. F):* 201 CC; 205 OC; *Flammable Limits in Air (%):* 1.2 - 8.5 (est.); *Fire Extinguishing Agents:* alcohol foam, dry liquid, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 400; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.5 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylene Glycol Monomethyl Ether — Fire Hazards: *Flash Point (deg. F):* 200 OC; *Flammable Limits in Air (%):* LFL= 1.2; *Fire Extinguishing Agents:* Water, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylenetriamine — Fire Fire Hazards: *Flash Point (deg. F):* 200 OC; *Flammable Limits in Air (%):* (calc.) 1 - 10; *Fire Extinguishing Agents:* Water spray, alcohol foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 676; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No hazardous reaction; *Stability During Transport :*Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Di-(2-Ethylhexyl) Phosphoric Acid — Fire Hazards: *Flash Point (deg. F):* 385 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Irritating phosphorus oxides may be released; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Mildly corrosive to most metals; may form flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethyl Phthalate — Fire Hazards: *Flash Point (deg. F):* 305 OC; *Flammable Limits in Air (%):* LFL 0.75 (at 368° F); *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Irritating vapors of unburned chemical may form in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 855; *Electrical Hazard:* Data not available; *Burning Rate:* Data not

available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some form of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diethylzinc — Fire Hazards: *Flash Point (deg. F):* Not pertinent (ignites spontaneously); *Flammable Limits in Air (%):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, sand, or powdered limestone; *Fire Extinguishing Agents Not to be Used:* Water, foam, halogenated agents, carbon dioxide; *Special Hazards of Combustion Products:* Yields zinc fumes when burning; can cause " metal fume fever" (see 5.2); *Behavior in Fire:* Reacts spontaneously with air or oxygen, and violently with water, evolving flammable ethane gas. Contact with water applied to adjacent fires will intensify the fire; *Ignition Temperature (deg. F):* Below 0; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water* :Reacts violently to form flammable ethane gas; *Reactivity with Common Materials:* Will react with surface moisture, generating flammable ethane gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1,1-Difluoroethane — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* 3.7 - 18; *Fire Extinguishing Agents:* Shut off gas source; use water to cool adjacent combustibles; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Irritating hydrogen fluoride fumes may form in fire; *Behavior in Fire:* Containers may explode. Vapors are heavier than air And may travel a considerable distance; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Difluorophosphoric Acid, Anhydrous — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Do not use water on adjacent fires; *Special Hazards of Combustion Products:* Irritating and toxic fumes of hydrogen fluoride and phosphoric acid may be formed in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously to form corrosive and toxic hydrofluoric acid; *Reactivity with Common Materials:* In the presence of moisture, is corrosive to glass, other siliceous materials, and most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diheptyl Phthalate — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some form of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisobutylcarbinol — Fire Hazards: *Flash Point (deg. F):* 162 OC; 165 CC; *Flammable Limits in Air (%):* 0.8 - 6.1; *Fire Extinguishing Agents:* Carbon dioxide, dry chemical, alcohol foam; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 494 (calc.); *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisobutylene — Fire Hazards: *Flash Point (deg. F):* 35 (est.); *Flammable Limits in Air (%):* 0.9 LEL (est.); *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 788; *Electrical Hazard:* Not pertinent; *Burning Rate:* 7.9 mm/min; **Chemical**

Reactivity: *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisobutyl Ketone — Fire Hazards: *Flash Point (deg. F):* 131 OC; 120 CC; *Flammable Limits in Air (%):* 0.81 - 7.1 at 200 ° F; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 745; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisodecyl Phthalate — Fire Hazards: *Flash Point (deg. F):* 450 OC; *Flammable Limits in Air (%):* LFL 0.27 at 508° F; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 755; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisopropanolamine — Fire Hazards: *Flash Point (deg. F):* 200 OC; *Flammable Limits in Air (%):* 1.1 (calc.) - 5.4 (est.); *Fire Extinguishing Agents:* Water, alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 580 (calc.); *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisopropylamine — Fire Hazards: *Flash Point (deg. F):* 20 OC; 35 CC; *Flammable Limits in Air (%):* 0.8 - 7.1; *Fire Extinguishing Agents:* "Alcohol" foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fires; *Behavior in Fire:* Vapor is heavier than air and may travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 600; *Electrical Hazard:* Class I; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diisopropylbenzene Hydroperoxide — Fire Hazards: *Flash Point (deg. F):* 175; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Flammable alcohol and ketone gases are formed in fires; *Behavior in Fire:* Burns with a flare effect. Containers may explode; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* Aluminum, copper, brass, lead, zinc salts, mineral acids, oxidizing or reducing agents all can cause rapid decomposition; *Stability During Transport:* Unstable, slowly evolves oxygen; *Inhibitor of Polymerization:* Not pertinent..

Dimethylacetamide — Fire Hazards: *Flash Point (deg. F):* 158 OC; *Flammable Limits in Air (%):* 1.5 - 11.5; *Fire Extinguishing Agents:* Water, dry chemical, alcohol foam; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 914; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.8 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethylamine — Fire Hazards: *Flash Point (deg. F):* 20 CC; *Flammable Limits in Air (%):* 2.8 - 14.4; *Fire Extinguishing Agents:* Stop flow of gas. Use water spray, carbon dioxide, or dry chemical for fires in water

solutions; *Fire Extinguishing Agents Not to be Used:* Do not use foam; *Special Hazards of Combustion Products:* Vapors are eye, skin and respiratory irritants; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 756; *Electrical Hazard:* Data not available; *Burning Rate:* 4.5 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No hazardous reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethyldichlorosilane — Fire Hazards: *Flash Point (deg. F):* 15 OC; *Flammable Limits in Air (%):* 1.4 - 9.5; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam; *Special Hazards of Combustion Products:* Hydrogen chloride and phosgene gases may form; both are toxic and irritating; *Behavior in Fire:* Difficult to extinguish. Re-ignition may occur. Contact with water applied to adjacent fires produces toxic and irritating fumes; *Ignition Temperature (deg. F):* Above 750; *Electrical Hazard:* Data not available; *Burning Rate:* 3.3 mm/min; **Chemical Reactivity:** *Reactivity with Water :* reacts vigorously with water to generate hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Will react with surface moisture to generate hydrogen chloride, which is corrosive to most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Sodium bicarbonate or lime; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethyl Ether — Fire Hazards: *Flash Point (deg. F):* Not pertinent (flammable gas); *Flammable Limits in Air (%):* 2 - 50; *Fire Extinguishing Agents:* Let fire burn; shut off gas flow; cool exposed surroundings with water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode. Vapors are heavier than air and may travel long distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 662; *Electrical Hazard:* Data not available; *Burning Rate:* 6.6 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethylformamide — Fire Hazards: *Flash Point (deg. F):* 153 OC; 136 CC; *Flammable Limits in Air (%):* 2.2 - 15.2; *Fire Extinguishing Agents:* Water, foam carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors are irritating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 833; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.2 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethylhexane Dihydroperoxide, Wet — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective on fire; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Decomposes violently when heated in fire. Can increase intensity of fire when in contact with combustible material. Containers may explode; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* Decomposes with contact with many metals and acids; *Stability During Transport:* Stable below 100 °F; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1,1-Dimethylhydrazine — Fire Hazards: *Flash Point (deg. F):* 34 CC; *Flammable Limits in Air (%):* 2 - 95; *Fire Extinguishing Agents:* Flood with water; *Fire Extinguishing Agents Not to be Used:* In large fires, water fog, carbon dioxide, and bicarbonate types may allow flash back and explosive re-ignition; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Tends to re-ignite when dilutes with much water; *Ignition Temperature (deg. F):* 452 - 482; *Electrical Hazard:* Class 1, Group D; *Burning Rate:* 3.8 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* Dissolves, swells and disintegrates many plastics; *Stability During Transport:* Stable below 1112° F; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethylpolysiloxane — Fire Hazards: *Flash Point (deg. F):* 275 - 635 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, dry chemical,

carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 820 - 860; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethyl Sulfate — Fire Hazards: *Flash Point (deg. F):* 240 OC; 182 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Flammable, toxic vapors generated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 370; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water:* Slow, non-hazardous reaction; *Reactivity with Common Materials:* Corrodes metal when wet; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Sodium bicarbonate or lime; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethyl Sulfide — Fire Hazards: *Flash Point (deg. F):* - 36 CC; *Flammable Limits in Air (%):* 2.2 - 19.7; *Fire Extinguishing Agents:* January 27, 1998ry chemical, foam, carbon dioxide, or alcohol foam; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic and irritating sulfur dioxide is formed; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 403; *Electrical Hazard:* Data not available; *Burning Rate:* 4.8 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethyl Sulfoxide — Fire Hazards: *Flash Point (deg. F):* 203 OC; *Flammable Limits in Air (%):* 3 - 6.3; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Sulfur dioxide, formaldehyde, and methyl mercaptan may form; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 572; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.0 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethyl Terephthalate — Fire Hazards: *Flash Point (deg. F):* 298 OC (molten); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1.058 (dust); *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dimethylzinc — Fire Hazards: *Flash Point (deg. F):* Not pertinent (ignites spontaneous); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, sand, powdered limestone; *Fire Extinguishing Agents Not to be Used:* Water, foam, halogenated agents, or carbon dioxide; *Special Hazards of Combustion Products:* Smoke contains zinc oxide, which can irritate lungs and cause metal fume fever; *Behavior in Fire:* Reacts spontaneously with air or oxygen and violently with water, evolving methane. Contact with water applied to adjacent fires will intensify fire; *Ignition Temperature (deg. F):* Below 0; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* Reacts vigorously, generating flammable methane gas; *Reactivity with Common Materials:* Will react with surface moisture to generate flammable methane; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4-Dinitroaniline — Fire Hazards: *Flash Point (deg. F):* 435 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* For small fires, use water, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Vapors and combustion gases are irritating; *Behavior in Fire:* May explode; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:*

Reacts with oxidizing materials; *Stability During Transport:* May detonate when heated under confinement; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

m-Dinitrobenzene — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water from protected location; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May explode; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dinitrocresols — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4-Dinitrophenol — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors are toxic; *Behavior in Fire:* Can detonate or explode when heated under confinement; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* Reacts with oxidizing materials and combustibles; *Stability During Transport:* May detonate when heated under confinement; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4- Dinitrotoluene — Fire Hazards: *Flash Point (deg. F):* 404 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide from protected location; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Nitrogen oxides and dense black smoke are produced in a fire; *Behavior in Fire:* Decomposition in self-sustaining at 280° C. Containers may explode in a fire; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable below 482°F (250° C); *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dioctyl Adipate — Fire Hazards: *Flash Point (deg. F):* 390 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Data not available; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dioctyl Phthalate — Fire Hazards: *Flash Point (deg. F):* 425 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry powder, carbon dioxide, foam; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dioctyl Sodium Sulfosuccinate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Cause foaming and spreading

of water; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1,4-Dioxane — Fire Hazards: *Flash Point (deg. F):* 54 CC; 74 OC; *Flammable Limits in Air (%):* 1.9 - 22.5 by vol; *Fire Extinguishing Agents:* Alcohol foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors are generated when heated; *Behavior in Fire:* Vapor is heavier than air and may travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 356; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dipentene — Fire Hazards: *Flash Point (deg. F):* 115 CC; *Flammable Limits in Air (%):* 0.7 - 6.1; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 458; *Electrical Hazard:* Data not available; *Burning Rate:* 5.5 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diphenylamine — Fire Hazards: *Flash Point (deg. F):* (liquid) 307 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Dust may be explosive if mixed with air in critical proportions and in the presence of a source of ignition; *Ignition Temperature (deg. F):* 1.175; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diphenyldichlorosilane — Fire Hazards: *Flash Point (deg. F):* 288 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water and foam; *Special Hazards of Combustion Products:* Hydrochloric acid and phosgene fumes may be formed; *Behavior in Fire:* Difficult to extinguish; re-ignition may occur. Contact with water of foam applied to adjacent fires will produce irritating hydrogen chloride fumes; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 2,7 mm/min; **Chemical Reactivity:** *Reactivity with Water :* Reacts with water to generate hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Reacts with surface moisture to generate hydrogen chloride, which is corrosive to most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diphenyl Ether — Fire Hazards: *Flash Point (deg. F):* 239 CC; *Flammable Limits in Air (%):* 0.8 - 1.5; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1.148; *Electrical Hazard:* Data not available; *Burning Rate:* 3.2 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Diphenylmethane Diisocyanate— Fire Hazards: *Flash Point (deg. F):* 425 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors are generated when heated; *Behavior in Fire:* Solid melts and burns; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* Slow, non-hazardous. Form carbon dioxide gas; *Reactivity with Common Materials:* data not available;

Stability During Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* May occur slowly. Is not hazardous; *Inhibitor of Polymerization:* Not pertinent.

Di-n-Propylamine — Fire Hazards: *Flash Point (deg. F):* 45 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fires; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 6.1.mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dipropylene Glycol — Fire Hazards: *Flash Point (deg. F):* 280 OC; *Flammable Limits in Air (%):* LFL=2.2% (approx.); *Fire Extinguishing Agents:* Water fog, alcohol foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.0 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Distillates: Flashed Feed Stocks — Fire Hazards: *Flash Point (deg. F):* (a) <0 CC; (b) 0 - 73 CC; (3) 73 - 141 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Class I, Group D; *Burning Rate:* Approx. 4 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Distillates: Straight Run — Fire Hazards: *Flash Point (deg. F):* (a) <0 CC; (b) 0 - 73 CC; (3) 73 - 141 CC; *Flammable Limits in Air (%):* 1.1 - 8.7; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Class I, Group D; *Burning Rate:* Approx. 4 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecanol — Fire Hazards: *Flash Point (deg. F):* 260 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 527; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecene — Fire Hazards: *Flash Point (deg. F):* 120 CC; 134 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water fog, foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 400 (est.); *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Dodecene — Fire Hazards: *Flash Point (deg. F):* 174 (approx.); *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition*

Temperature (deg. F): 491; *Electrical Hazard:* Not pertinent; *Burning Rate:* 5.8 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecylbenzene — Fire Hazards: *Flash Point (deg. F):* 275OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 3.7 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecylbenzenesulfonic Acid, Calcium Salt — Fire Hazards: *Flash Point (deg. F):* > 100 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* ≈ 4 mm/min; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecylbenzenesulfonic Acid, Isopropylamine Salt — Fire Hazards: *Flash Point (deg. F):* (liquid) > 300 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecylbenzenesulfonic Acid, Triethanolamine Salt — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen and irritating oxides of sulfur may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecyl Sulfate, Diethanolamine Salt — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors of diethanolamine and nitrogen oxides may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecyl Sulfate, Magnesium Salt — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecyl Sulfate, Sodium Salt — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition*

Temperature (deg. F): Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor oF Polymerization:* Not pertinent.

Dodecylsulfate, Triethanolamine Salt — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors of triethanolamine and oxides of nitrogen may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dodecyltrichlorosilane — Fire Hazards: *Flash Point (deg. F):* > 150 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water, foam; *Special Hazards of Combustion Products:* Hydrochloric acid and phosgene fumes may form in fires; *Behavior in Fire:* Difficult to extinguish; re-ignition may occur. Contact with water applied to adjacent fires produces irritating hydrogen chloride fumes; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* Generates hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Reacts with surface moisture to generate hydrogen chloride, which is corrosive to most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Dowtherm — Fire Hazards: *Flash Point (deg. F):* 255 OC; *Flammable Limits in Air (%):* At 500° F: 0.5 - 6.2; At 300°F: 0.8 - 3.3; *Fire Extinguishing Agents:* Water fog, foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products:* Irritating gases generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1150; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available; **Chemical Reactivity:** *Reactivity with Water :* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

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Endrin — Fire Hazards: *Flash Point (deg. F):* Non flammable sold or combustible solution > 80 OC (xylene); *Flammable Limits in Air (%):* 1.1 - 7 (xylene); *Fire Extinguishing Agents:* (Solution) Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective on solution fire; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene may be generated when solution burns; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4 mm/min (xylene);**Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization* Not pertinent.

Epichlorohydrin — Fire Hazards: *Flash Point (deg. F):* 92 OC; 100 CC; *Flammable Limits in Air (%):* 3.8 - 21.0; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, carbon dioxide, water spray; *Fire Extinguishing Agents Not To Be Used:* Avoid use of dry chemical if fire occurs in container with confined vent; *Special Hazards of Combustion Products:* Toxic irritating vapors are generated when heated; *Behavior in Fire:* Containers may explode in fire because of polymerization; *Ignition Temperature (deg. F):* 804; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Mild reaction; not likely to be hazardous; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Can polymerize in presence of strong acids and bases, particularly when hot; *Inhibitor of Polymerization:* None used.

Epoxidized Vegetable Oils — Fire Hazards: *Flash Point (deg. F):* 585 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be*

Used: Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethane — Fire Hazards: *Flash Point (deg. F):* -211; *Flammable Limits in Air (%):* 2.9 - 13.0; *Fire Extinguishing Agents:* Stop flow of gas; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 940; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 7.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethoxydihydropyran — Fire Hazards: *Flash Point (deg. F):* 98 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 4.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of polymerization:* Not pertinent.

Ethoxylated Dodecanol — Fire Hazards: *Flash Point (deg. F):* 470 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reactio *Reactivity with Common Materials:* No reaction; *Sta ility During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of polymerization:* Not pertinent.

Ethoxylated Nonylphenol — Fire Hazards: *Flash Point (deg. F):* (burns with difficulty) 338 - 600 OC; > 140 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of polymerization:* Not pertinent.

Ethoxylated Pentadecanol — Fire Hazards: *Flash Point (deg. F):* 470 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical for small fires; alcohol foam and water for large fires; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethoxylated Tetradecanol — Fire Hazards: *Flash Point (deg. F):* 470 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical for small fires; alcohol foam and water for large fires; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethoxylated Tridecanol — Fire Hazards: *Flash Point (deg. F):* 385 OC; *Flammable Limits in Air (%):* Not

pertinent; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical for small fires; alcohol foam and water for large fires; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* NO reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethoxy Triglycol — Fire Hazards: *Flash Point (deg. F):* 275 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Acetate — Fire Hazards: *Flash Point (deg. F):* 24 CC; 55 OC; *Flammable Limits in Air (%):* 2.2 - 9.0; *Fire Extinguishing Agents:* Alcohol foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 800; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 3.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Acetoacetate — Fire Hazards: *Flash Point (deg. F):* 176 OC; 135 CC; *Flammable Limits in Air (%):* 1.4 - 9.5; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 563; *Electrical Hazard:* Data not available; *Burning Rate:* 2.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Acrylate — Fire Hazards: *Flash Point (deg. F):* 44 OC; *Flammable Limits in Air (%):* 1.8 - 9.5; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating vapors are generated when heated; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. May polymerize and cause container to explode; *Ignition Temperature (deg. F):* 721; *Electrical Hazard:* Data not available; *Burning Rate:* 4.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* May occur; exclude moisture, light; avoid exposure to high temperatures; store in presence of air; *Inhibitor of Polymerization:* 13 - 17 ppm monomethyl ether of hydroquinone.

Ethyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 55 CC; 64 OC; *Flammable Limits in Air (%):* 3.3 - 19; *Fire Extinguishing Agents:* Carbon dioxide, dry chemical, water spray, alcohol foam; *Fire Extinguishing Agents Not To Be Used:* None; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 689; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 3.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylaluminum Dichloride — Fire Hazards: *Flash Point (deg. F):* Not pertinent (ignites spontaneously); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, inert dry powders such as sand, limestone; *Fire Extinguishing Agents Not To Be Used:* Water, foam, halogenated agents, or carbon dioxide; *Special Hazards of Combustion Products:* Intense smoke may cause metal-fume fever. Irritating hydrogen chloride also formed; *Behavior in Fire:* Contact with water applied to adjacent fires will cause formation of irritating smoke containing aluminum oxide and hydrogen chloride;

Ignition Temperature (deg. F): Ignites spontaneously in air at ambient temperature; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form hydrogen chloride fumes and flammable ethane gas; *Reactivity with Common Materials:* Reacts with surface moisture to generate hydrogen chloride, which is corrosive to most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylaluminum Sesquichloride — Fire Hazards: *Flash Point (deg. F):* Not pertinent (ignites spontaneously); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, inert dry powders such as sand, limestone; *Fire Extinguishing Agents Not To Be Used:* Water, foam, halogenated agents, or carbon dioxide; *Special Hazards of Combustion Products:* Intense smoke may cause metal-fume fever. Irritating hydrogen chloride also formed; *Behavior in Fire:* Contact with water applied to adjacent fires will cause formation of irritating smoke containing aluminum oxide and hydrogen chloride; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form hydrogen chloride fumes and flammable ethane gas; *Reactivity with Common Materials:* Reacts with surface moisture to generate hydrogen chloride, which is corrosive to most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylamine — Fire Hazards: *Flash Point (deg. F):* 0 OC; *Flammable Limits in Air (%):* 3.5 - 14; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating and toxic oxides of nitrogen may be formed; *Behavior in Fire:* Vapor is heavier than fire and may travel a considerable distance to a source of ignition and flash back. Containers may explode when heated; *Ignition Temperature (deg. F):* 724; *Electrical Hazard:* Data not available; *Burning Rate:* 5.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Will strip and dissolve paint; dissolves most plastic materials; can cause swelling of rubber by absorption. The reactions are not hazardous; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylbenzene — Fire Hazards: *Flash Point (deg. F):* 80 OC; 59 CC; *Flammable Limits in Air (%):* 1.0 - 6.7; *Fire Extinguishing Agents:* Foam(most effective), water fog, carbon dioxide or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 860; *Electrical Hazard:* Not pertinent; *Burning Rate:* 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Butanol — Fire Hazards: *Flash Point (deg. F):* 128 OC; *Flammable Limits in Air (%):* 1.9 - 8.8; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical for small fires, alcohol foam for large fires; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 580 (calc.); *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Butyrate — Fire Hazards: *Flash Point (deg. F):* 85 OC; 75 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Vapor is heavier than fire and may travel considerable distance to a source of ignition and flash back. Containers may explode in fire; *Ignition Temperature (deg. F):* 865; *Electrical Hazard:* Data not available; *Burning Rate:* 4.72 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Chloride — Fire Hazards: *Flash Point (deg. F):* -58 CC; -45 OC; *Flammable Limits in Air (%):* 3.6 - 12; *Fire Extinguishing Agents:* Water fog, carbon dioxide, dry

chemical. For large fires it is best to allow material to burn while cooling surrounding equipment. Stop flow of ethyl chloride; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic ant irritating gases are generated in fires; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 966; *Electrical Hazard:* Not pertinent; *Burning Rate:* 3.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Chloroacetate — Fire Hazards: *Flash Point (deg. F):* 129 OC; 100 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water fog, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating, toxic hydrogen chloride gas may be generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 2.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Very slow, not hazardous; *Reactivity with Common Materials:* Slow hydrolysis to acidic products; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Chloroformate — Fire Hazards: *Flash Point (deg. F):* 82 OC; 61 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic chlorine and phosgene gas may be formed in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 932; *Electrical Hazard:* Data not available; *Burning Rate:* **Chemical Reactivity:** *Reactivity with Water:* Slow reaction with water, evolving hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Slow evolution of hydrogen chloride from surface moisture reaction can cause slow corrosion; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyldichlorosilane — Fire Hazards: *Flash Point (deg. F):* 30 OC; *Flammable Limits in Air (%):* 2.9; *Fire Extinguishing Agents:* Dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene gases may be formed; *Behavior in Fire:* Difficult to extinguish; re-ignition may occur. Contact with water applied to adjacent fire, produces irritating hydrogen chloride fumes and flammable hydrogen gas; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 3.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously, evolving hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Reaction with surface moisture will generate hydrogen chloride, which corrodes common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene — Fire Hazards: *Flash Point (deg. F):* -213 (approx.) CC; *Flammable Limits in Air (%):* 2.75 - 28.6; *Fire Extinguishing Agents:* Stop flow of gas if possible. Use carbon dioxide, dry chemical, water fog; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors are anesthetic; *Behavior in Fire:* Container may explode; *Ignition Temperature (deg. F):* 842; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 7.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Chlorohydrin — Fire Hazards: *Flash Point (deg. F):* 139 OC; *Flammable Limits in Air (%):* 4.9 - 15.9; *Fire Extinguishing Agents:* Water, alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene fumes may be formed; *Behavior in Fire:* Vapors are heavier than air and may flash back to a source of ignition; *Ignition Temperature (deg. F):* 797; *Electrical Hazard:* Data not available; *Burning Rate:* 1.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Cyanohydrin — Fire Hazards: *Flash Point (deg. F):* 265 OC; *Flammable Limits in Air (%):* 2.3 (calc.) - 12.1 (est.); *Fire Extinguishing Agents:* Carbon

dioxide or dry chemical for small fires; alcohol-type foam for large fires; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Toxic gases are generated when heated; *Behavior in Fire:* Decomposes, generating toxic fires; *Ignition Temperature (deg. F):* 922; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylenediamine — Fire Hazards: *Flash Point (deg. F):* 99 OC; 150 CC; *Flammable Limits in Air (%):* 5.8 - 11.1; *Fire Extinguishing Agents:* Carbon dioxide, dry chemical, water or foam; *Fire Extinguishing Agents Not To Be Used:* Do not use water in case of drum or tank fires; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 715; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Gives off heat, but reaction is not hazardous; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylenediamine Tetracetic Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Dibromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Decomposition gases are toxic and irritating; *Behavior in Fire:* Decomposes into toxic irritating gases. Reacts with hot metals such as aluminum and magnesium; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Dichloride — Fire Hazards: *Flash Point (deg. F):* 60 OC; 55 CC; *Flammable Limits in Air (%):* 6.2 - 15.6; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic and irritating gases (hydrogen chloride and phosgene) are generated; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 775; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 1.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol — Fire Hazards: *Flash Point (deg. F):* 240 OC; 232 CC; *Flammable Limits in Air (%):* LEL=3.2; UEL not listed; *Fire Extinguishing Agents:* Water fog, alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 775; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Diacetate — Fire Hazards: *Flash Point (deg. F):* 205 OC; 191 CC; *Flammable Limits in Air (%):* 1.6 - 8.4; *Fire Extinguishing Agents:* Water, dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 900; *Electrical Hazard:* Data not available; *Burning Rate:* 2.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During*

Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Diethyl Ether — Fire Hazards: *Flash Point (deg. F):* 90 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 406; *Electrical Hazard:* Data not available; *Burning Rate:* 4.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Dimethyl Ether — Fire Hazards: *Flash Point (deg. F):* 104 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode in fires; *Ignition Temperature (deg. F):* 1373; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Monobutyl Ether — Fire Hazards: *Flash Point (deg. F):* 165 OC; 155 CC; *Flammable Limits in Air (%):* 1.1 - 10.6; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical for small fires; alcohol-type foam for large fires; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 472; *Electrical Hazard:* Not pertinent; *Burning Rate:* 6.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Monobutyl Ether Acetate — Fire Hazards: *Flash Point (deg. F):* 190 OC; 160 CC; *Flammable Limits in Air (%):* 0.9 - 8.5; *Fire Extinguishing Agents:* Dry chemical, alcohol foam,or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 645; *Electrical Hazard:* Data not available; *Burning Rate:* 4.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Monoethyl Ether — Fire Hazards: *Flash Point (deg. F):* 120 OC; 202 CC; *Flammable Limits in Air (%):* 1.8 - 14,0; *Fire Extinguishing Agents:* Alcohol foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 455; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Monoethyl Ether Acetate — Fire Hazards: *Flash Point (deg. F):* 135 OC; *Flammable Limits in Air (%):* 1.7 - 6.7; *Fire Extinguishing Agents:* Alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 715; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data no available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylene Glycol Monomethyl Ether — Fire Hazards: *Flash Point (deg. F):* 120 OC; 107 CC; *Flammable Limits in Air (%):* 2.5 - 19 8; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 551; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.8 mm/min. **Chemical Reactivity:** *Reactivity with*

Water: No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent .

Ethyleneimine — Fire Hazards: *Flash Point (deg. F)*: 1 OC; 12 CC; *Flammable Limits in Air (%):* 3.3 - 54.8; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapor generated when heated; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 608; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* Mild reaction, non-hazardous; *Reactivity with Common Materials:* Contact with silver or aluminum may cause polymerization; *Stability During Transport:* Stable unless heated under pressure; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Explosive polymerization can occur when in contact with acids; *Inhibitor of Polymerization:* None used.

Ethylene Oxide — Fire Hazards: *Flash Point (deg. F)*: > 0 OC; *Flammable Limits in Air (%):* 3 - 100; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Stop flow of gas. Use water, carbon dioxide, dry chemical or alcohol foam; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. Containers may explode when heated; *Ignition Temperature (deg. F):* 804; *Electrical Hazard:* Class I, Group B; *Burning Rate:* 3.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Slow reaction, not hazardous; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* May polymerize violently if contaminated with alkaline or acidic materials and metal oxides or chlorides; *Inhibitor of Polymerization:* None used.

Ethyl Ether — Fire Hazards: *Flash Point (deg. F)*: -40 OC; -49 CC; *Flammable Limits in Air (%):* 1.85 - 36.5; *Fire Extinguishing Agents:* Carbon dioxide, dry chemical or foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. Decomposes violently when heated; *Ignition Temperature (deg. F):* 356; *Electrical Hazard:* Class I, Group C; *Burning Rate:* 6.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Formate — Fire Hazards: *Flash Point (deg. F)*: 10 OC; -4 CC; *Flammable Limits in Air (%):* 2.8 - 16.0; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 851; *Electrical Hazard:* Data not available; *Burning Rate:* 3.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylhexaldehyde — Fire Hazards: *Flash Point (deg. F)*: 127 OC; 112 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 387; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May ignite spontaneously when spilled on clothing, paper or other absorbent material; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2-Ethyl Hexanol — Fire Hazards: *Flash Point (deg. F)*: 85 OC; 175 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 581; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During*

Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2-Ethylhexyl Acrylate, Inhibited — Fire Hazards: *Flash Point (deg. F):* 195 OC; *Flammable Limits in Air (%):* 0.8 - 6.4; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Heat can result in a severe polymerization with rapid release of energy. Sealed containers may rapture explosively if hot; *Ignition Temperature (deg. F):* 496; *Electrical Hazard:* data not available; *Burning Rate:* 4.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Will polymerize in the absence of inhibitor and when heated; *Inhibitor of Polymerization:* Monomethyl ether of hydroquinone, 13 - 20 ppm. Hydroquinone, 90 - 120 ppm.

Ethyl Hexyl Tallate — Fire Hazards: *Flash Point (deg. F):* 395 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Data not available; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylidenenorbornene — Fire Hazards: *Flash Point (deg. F):* 98 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Lactate — Fire Hazards: *Flash Point (deg. F):* 1.58 OC; 115 CC; *Flammable Limits in Air (%):* 1.5 - 11.4; *Fire Extinguishing Agents:* Water, dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 752; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Mercaptan — Fire Hazards: *Flash Point (deg. F):* < 0 OC; *Flammable Limits in Air (%):* 2.8 - 18; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating fumes of sulfur dioxide are generated; *Behavior in Fire:* Vapor is heavier than air and may travel long distance to a source of ignition and flash back; containers may explode in a fire; offensive fumes are released when heated; *Ignition Temperature (deg. F):* 572; *Electrical Hazard:* Data not available; *Burning Rate:* 5.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stability; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Methacrylate — Fire Hazards: *Flash Point (deg. F):* 85 OC; 80 CC; *Flammable Limits in Air (%):* 1.8 (LFL); *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Sealed container may rupture explosively if hot. Heat can cause a violent polymerization reaction with rapid release of energy. Vapors are heavier than air and can travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 740; *Electrical Hazard:* Data not available; *Burning Rate:* 4.56 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* If proper concentration of inhibitor is not present or when material is hot, a violent polymerization reaction may occur;

Inhibitor of Polymerization: Oxygen in the air inhibits polymerization.

Ethyl Nitrite — Fire Hazards: *Flash Point (deg. F):* -31 CC; *Flammable Limits in Air (%):* 3 - >50; *Fire Extinguishing Agents:* Water dry chemical, carbon dioxide, water, foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen are generated; *Behavior in Fire:* Vapors are heavier than air and may travel a considerable distance to a source of ignition and flash back; can decompose violently above 194° F; containers may explode in a fire; *Ignition Temperature (deg. F):* 194; *Electrical Hazard:* Data not available; *Burning Rate:* 2.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable if stored in a cool place and not exposed to strong light; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethylphenyldichlorosilane — Fire Hazards: *Flash Point (deg. F):* > 150 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene fumes may be formed; *Behavior in Fire:* Difficult to extinguish; re-ignition may occur. Contact with water applied to adjacent fires will generate irritating hydrogen chloride gas; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 3.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts with water to generate hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Will react with surface moisture to evolve hydrogen chloride; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Phosphonothioic Dichloride, Anhydrous — Fire Hazards: *Flash Point (deg. F):* 203 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam; *Special Hazards of Combustion Products:* Oxides of sulfur, phosphorus; hydrogen chloride and phosgene; *Behavior in Fire:* Contact with water applied to adjacent fire will produce irritating fumes of hydrogen chloride; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* Reacts with water to evolve hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Will react with surface moisture to evolve hydrogen chloride, which is corrosive to common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Phosphorodichloridate — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam; *Special Hazards of Combustion Products:* Irritating fumes of hydrogen chloride and phosphoric acid may be formed; *Behavior in Fire:* Contact with water applied to adjacent fires produces irritating fumes of hydrogen chloride; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* Reacts with water to evolve hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Will react with surface moisture to evolve hydrogen chloride, which is corrosive to common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2- Ethyl-3-Propylacrolein — Fire Hazards: *Flash Point (deg. F):* 155 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 200; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyl Silicate — Fire Hazards: *Flash Point (deg. F):* 125 OC; 99 CC; *Flammable Limits in Air (%):* 1.3 - 23; *Fire Extinguishing Agents:* Water, foam, dry chemical,

carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly, forming non-toxic silica and ethyl alcohol; *Reactivity with Common Materials:* Causes swelling and hardening of some plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ethyltrichlorosilane — Fire Hazards: *Flash Point (deg. F):* 57 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene gases may form; *Behavior in Fire:* Vapors are heavier than fire and may travel a considerable distance to a source of ignition and flash back. Difficult to extinguish; re-ignition may occur. Contact with water applied to adjacent fires will produce irritating hydrogen chloride fumes; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 2.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously, evolving hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Reacts with surface moisture to form hydrogen chloride, which is corrosive to common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent.

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Ferric Ammonium Citrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen or ammonia gas may be formed in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferric Ammonium Oxalate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen, ammonia , and carbon monoxide may form in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferric Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating hydrogen chloride fumes may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Water solutions are acidic and corrosive to most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferric Glycerophosphate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferric Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen and nitric acid vapor may form in fires; *Behavior*

in Fire: In contact with combustible materials, will increase the intensity of a fire; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Solutions are corrosive to most metals. Contact of solid with wood or paper may cause fire; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferric Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrosive to copper, copper alloys, mild steel. and galvanized steel; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferrous Ammonium Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating and toxic ammonia and oxides of nitrogen may form in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferrous Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating hydrogen chloride fumes may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Solution may corrode metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferrous Fluoroborate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferrous Oxalate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Ferrous Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Fluorine — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Do not direct water onto fluorine leaks; *Special Hazards of Combustion Products:* Toxic gases generated in fires involving fluorine; *Behavior in Fire:* Dangerously reactive gas. Ignites most combustibles; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts with water to form hydrogen fluoride, oxygen and oxygen difluoride; *Reactivity with Common Materials:* Reacts violently with all combustible materials, except the metal cylinders in which it is shipped; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Fluosilicic Acid — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating fumes of hydrogen fluoride may form in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Will corrode most metals, producing flammable hydrogen gas which can collect in confined spaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with dilute solution of sodium carbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Fluosulfonic Acid — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Do not use water or foam on adjacent fires; *Special Hazards of Combustion Products:* Toxic and irritating fumes of hydrogen fluoride and sulfuric acid may form in fires; *Behavior in Fire:* Contact with water or chemical foam used to fight adjacent fires can result in the formation of toxic hydrogen fluoride gas; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently with water forming hydrogen fluoride and sulfuric acid mists; *Reactivity with Common Materials:* Reacts with metals forming flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water and rinse with sodium bicarbonate solution or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Formaldehyde Solution — Fire Hazards: *Flash Point (deg. F)*: 182 CC (based on solution of 37 % formaldehyde and Methanol free), 122 CC (based on solution with 15 % Methanol); *Flammable Limits in Air (%):* 7.0 - 73; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide, or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* No data or recommendations found; *Special Hazards of Combustion Products:* Toxic vapors form; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 806; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Formic Acid — Fire Hazards: *Flash Point (deg. F)*: 138 OC; *Flammable Limits in Air (%):* 18 - 57; *Fire Extinguishing Agents:* Water, carbon dioxide, dry chemical, or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors are generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1,114; *Electrical Hazard:* Not pertinent; *Burning Rate:* 0.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and neutralize with lime; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Fumaric Acid — Fire Hazards: *Flash Point (deg. F)*: Not pertinent. This is a combustible solid which can present a dust explosion problem; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water spray, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating fumes of maleic anhydride may form in fires; *Behavior in Fire:* Dust presents significant explosion hazard. Dust should be knocked down with water fog when fighting fires; *Ignition Temperature (deg. F):* 1,364 (powder); *Electrical Hazard* :Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During*

Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:*; *Inhibitor of Polymerization:* Not pertinent.

Furfural — Fire Hazards: *Flash Point (deg. F):* 153 OC, 140 CC; *Flammable Limits in Air (%):* 2.1 - 19.3; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, dry chemical, or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors are generated when exposed to heat; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 739; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common* Materials: No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Furfuryl Alcohol -Fire Hazards: *Flash Point (deg. F):* 167 OC, 149 CC; *Flammable Limits in Air (%):* 1.8 - 16.3; *Fire Extinguishing Agents:* Water, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 736; *Electrical Hazard:* No data; *Burning Rate:* 2.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* The product darkens and forms water insoluble material on exposure to air or acids. This reaction is accelerated at elevated temperatures; *Neutralizing Agents for Acids and* Caustics: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

G

Gallic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent. This is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent . **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Gas Oil: Cracked — Fire Hazards: *Flash Point (deg. F):* 150 CC; *Flammable Limits in Air (%):* 6.0 - 13.5; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 640; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Gasolines: Automotive — Fire Hazards: *Flash Point (deg. F):* -36 CC; *Flammable Limits in Air (%):* 1.4 - 7.4; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 853; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Gasolines: Aviation — Fire Hazards: *Flash Point (deg. F):* -50 CC; *Flammable Limits in Air (%):* 1.2 - 7.1; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 824; *Electrical Hazard:* Class 1, Group D; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Gasoline Blending Stocks: Alkylates — Fire Hazards: *Flash Point (deg. F):* < 0 CC; *Flammable Limits in Air (%):* 1.1 - 8.7; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of*

Combustion Products: None; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Class I, Group D; *Burning* Rate: 4 mm/min . **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Gasoline Blending Stocks: Reformates — Fire Hazards: *Flash Point (deg. F):* < 0 CC; *Flammable Limits in Air (%):* 1.1 - 8.7; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Class I, Group D; *Burning* Rate: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Glutaraldehyde Solution — Fire Hazards: *Flash Point (deg. F):* Non flammable solution; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Glycerine — Fire Hazards: *Flash Point (deg. F):* 350 OC, 320 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, carbon dioxide, water fog; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 698; *Electrical Hazard:* Not pertinent; *Burning Rate:* 0.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Glycidyl Methacrylate — Fire Hazards: *Flash Point (deg. F):* 183 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* No data; *Fire Extinguishing Agents Not To Be Used:* No data; *Special Hazards of Combustion Products:* Irritating vapors generated when exposed to heat; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Heat, peroxides, and caustics cause polymerization, however the reaction is slow and generally considered non hazardous; *Inhibitor of Polymerization:* 50 ppm of Hydroquinone Monomethyl Ether.

Glyoxal: 40 % Solution — Fire Hazards: *Flash Point (deg. F):* Non flammable solution; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Exposure to heat can cause polymerization to a combustible, viscous material; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrosive to most metals. Reactions are slow but accelerated at high temperatures; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

H

Heptachlor — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating and toxic hydrogen chloride fumes may form in fires; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable;

Neutralizing Agents for Acids and Caustics: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Heptane — Fire Hazards: *Flash Point (deg. F)*: 25 CC; *Flammable Limits in Air (%):* 1.0 - 7.0; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 433; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 6.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Heptanol — Fire Hazards: *Flash Point (deg. F)*: 170 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* 3.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Heptene — Fire Hazards: *Flash Point (deg. F)*: 25 CC; *Flammable Limits in Air (%):* 1.0 (LEL); *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 500; *Electrical Hazard:* Not pertinent; *Burning Rate:* 3.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexachlorocyclopentadiene — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* If water is used on adjacent fires, do not allow water to enter drums or storage tanks containing this product; *Special Hazards of Combustion Products:* Toxic hydrogen chloride, chlorine, and phosgene gases form in fires; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly forming hydrochloric acid. Since the reaction is slow, it is generally considered non hazardous; *Reactivity with Common Materials:* In the presence of moisture, this material will corrode iron and other metals. Flammable and explosive hydrogen gas may also form and collect in confined spaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexadecyl Sulfate, Sodium Salt — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexadecyltrimethylammonium Chloride — Fire Hazards: *Flash Point (deg. F)*: 69 CC (for isopropyl alcohol solutions); *Flammable Limits in Air (%):* 2 - 12 (isopropyl alcohol); *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating fumes of hydrogen chloride may form in fires; *Behavior in Fire:* Solvent vapors are heavier than air and may travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 750 (isopropyl alcohol solutions); *Electrical Hazard:* Class I, Group D; *Burning Rate:* 2.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

n-Hexaldehyde — Fire Hazards: *Flash Point (deg. F)*: 90 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distances to a source of ignition and flash back; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* 5.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexamethylenediamine — Fire Hazards: *Flash Point (deg. F)*: 160 OC; *Flammable Limits in Air (%):* 0.7 - 6.3; *Fire Extinguishing Agents:* Carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* No data; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexamethyleneimine — Fire Hazards: *Flash Point (deg. F)*: 99 OC; *Flammable Limits in Air (%):* 1.6 - 2.3; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fires; *Behavior in Fire:* Vapor is heavier than air and may travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexamethylenetetramine — Fire Hazards: *Flash Point (deg. F)*: 482 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Formaldehyde gas and ammonia may be given off when exposed to heat; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* > 700; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexane — Fire Hazards: *Flash Point (deg. F)*: -7 CC; *Flammable Limits in Air (%):* 1.2 - 7.7; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapors may explode; *Ignition Temperature (deg. F):* 437; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 7.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexanol — Fire Hazards: *Flash Point (deg. F)*: 149 OC, 145 CC; *Flammable Limits in Air (%):* 1.2 - 7.7; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 580; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Hexene — Fire Hazards: *Flash Point (deg. F)*: - 15 CC; *Flammable Limits in Air (%):* 1.2 (LEL); *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 521; *Electrical Hazard:* Not pertinent; *Burning Rate:* 8.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hexylene Glycol — Fire Hazards: *Flash Point (deg. F):* 126 OC; *Flammable Limits in Air (%):* 4.7 - 100; *Fire Extinguishing Agents:* Water, alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors are generated upon exposure to heat; *Behavior in Fire:* May explode if vapors are confined; *Ignition Temperature (deg. F):* May ignite spontaneously; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Can catch fire when in contact with porous materials such as wood, asbestos, cloth, soil, or rusty metals; *Stability During Transport:* Stable at ordinary temperatures, however when heated this material can decompose to nitrogen and ammonia gases. The decomposition is not generally hazardous unless it occurs in confined spaces; *Neutralizing Agents for Acids and Caustics:* Flush with water and neutralize the resulting solution with calcium hypochlorite; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrazine — Fire Hazards: *Flash Point (deg. F):* 100 OC; *Flammable Limits in Air (%):* 4.7 - 100; *Fire Extinguishing Agents:* Water, alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors are generated when heated; *Behavior in Fire:* May explode if confined; *Ignition Temperature (deg. F):* May ignite spontaneously, 518; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Can catch fire when in contact with porous materials such as wood, asbestos, cloth, soil, or rusty metals; *Stability During Transport:* Stable at ordinary temperatures, however when heated this material can decompose to nitrogen and ammonia gases. The decomposition is not generally hazardous unless it occurs in confined spaces; *Neutralizing Agents for Acids and Caustics:* Flush with water and neutralize the resulting solution with calcium hypochlorite; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrochloric Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating vapors are generated upon heating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrosive to most metals with the evolution of flammable and explosive hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and apply powdered limestone, slaked lime, soda ash, or sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrofluoric Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating vapors are generated upon heating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Will attack glass, concrete and certain metals containing silica, such as cast iron. Will attack natural rubber, leather, and many organic materials. Can generate flammable and explosive hydrogen when in contact with some metals; *Stability During Transport:* Stable but requires special packaging; *Neutralizing Agents for Acids and Caustics:* Flush with water and apply powdered limestone, slaked lime, soda ash, or sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen Bromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Pressurized containers may explode and release toxic and irritating vapors; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Moderate reaction with the evolution of heat; *Reactivity with Common Materials:* Rapidly absorbs moisture , forming hydrobromic acid . Highly corrosive to most metals, with the evolution of flammable and explosive hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and apply powdered limestone, slaked lime, soda ash, or sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not flammable; *Fire Extinguishing Agents Not To Be Used:* Not flammable; *Special Hazards of Combustion Products:* Not flammable; *Behavior in Fire:* Pressurized containers may explode releasing toxic and irritating vapors; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:*; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Moderate reaction with the evolution of heat; *Reactivity with Common Materials:* Rapidly absorbs moisture forming hydrochloric acid. Very corrosive to metals with the evolution of flammable and explosive hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and apply powdered limestone, slaked lime, soda ash, or sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen Cyanide — Fire Hazards: *Flash Point (deg. F):* 0 CC; *Flammable Limits in Air (%):* 5.6 - 40; *Fire Extinguishing Agents:* Stop flow of gas if practical; *Fire Extinguishing Agents Not To Be Used:* None; *Special Hazards of Combustion Products:* Extremely toxic vapors are generated even at ordinary temperatures; *Behavior in Fire:* Containers may explode and contents spontaneously ignite; *Ignition Temperature (deg. F):* 1,004; *Electrical Hazard:* No data; *Burning Rate:* 1.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Dissolves with a moderate reaction; *Reactivity with Common Materials:* None; *Stability During Transport:* May become unstable and subject to explosion if stored for extended periods of time or is exposed to high temperatures and pressures; *Neutralizing Agents for Acids and Caustics:* The weak acidity can be neutralized by slaked lime, however this does not destroy the hazardous properties of the material; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen Fluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating vapors are generated when exposed to hear; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Dissolves with liberation of heat; *Reactivity with Common Materials:* Will attack glass, concrete and certain metals containing silica, such as cast iron. Will attack natural rubber, leather, and many organic materials. Can generate flammable and explosive hydrogen when in contact with some metals; *Stability During Transport:* Stable but requires special packaging; *Neutralizing Agents for Acids and Caustics:* Flush with water and apply powdered limestone, slaked lime, soda ash, or sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen, Liquefied — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* 4.0 - 75.0; *Fire Extinguishing Agents:* Let fire burn; shut off gas supply; *Fire Extinguishing Agents Not To Be Used:* Carbon dioxide; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Burns with an almost invisible flame; *Ignition Temperature (deg. F):* 1,065; *Electrical Hazard:* Class I, Group B; *Burning Rate:* 9.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Ambient temperature of water will cause vigorous vaporization of hydrogen; *Reactivity with Common Materials:* No chemical reaction, but low temperature causes most materials to become very brittle; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen Peroxide — Fire Hazards: *Flash Point (deg. F):* Not flammable but may cause fire and violent reactions on contact with combustibles and metals; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Water for fires resulting from spillage; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May explode in fires; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Dirt and metals can cause rapid decomposition with the liberation of oxygen gas; *Stability During Transport:* Pure grades are stable, but contamination by dirt and metals can cause rapid or violent decomposition; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydrogen Sulfide - Fire Hazards: *Flash Point (deg. F):* This is a flammable gas; *Flammable Limits in Air (%):* 4.3 - 45; *Fire Extinguishing Agents:* Stop the flow of gas; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic gases are generated in fires; *Behavior in Fire:* Vapor is heavier than air and can travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 500; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.3 mm/min. **Chemical**

Reactivity: *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydroquinone — Fire Hazards: *Flash Point (deg. F):* 350 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* No data; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* Dust explosion is high probability; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2-Hydroxyethyl Acrylate, Inhibited — Fire Hazards: *Flash Point (deg. F):* 220 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water, dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* 2.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:*; *Polymerization:* In the absence of inhibitor, polymerization will occur especially at elevated temperature; *Inhibitor of Polymerization:* Monomethyl Ether of Hydroquinone (400 ppm).

Hydroxylamine Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Sulfuric acid fumes may form when exposed to heat or fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Can be corrosive to metals in the presence of moisture; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Hydroxypropyl Acrylate — Fire Hazards: *Flash Point (deg. F):* 212 OC; *Flammable Limits in Air (%):* 1.8 (LEL); *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization may occur. Avoid exposure to high temperatures, ultraviolet light, and free-radical catalysts; *Inhibitor of Polymerization:* 200 ppm Hydroquinone.

Hydroxypropyl Methacrylate — Fire Hazards: *Flash Point (deg. F):* 250 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* This product may polymerize when hot and burst containers; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Can polymerize when exposed to heat, ultraviolet light, or free-radical catalysts; *Inhibitor of Polymerization:* 200 ppm Hydroquinone.

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Isoamyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 114 OC; *Flammable Limits in Air (%):* 1.2 - 9.0 (212 of); *Fire Extinguishing Agents:* Water spray, dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 662; *Electrical Hazard:* Class I, Group C; *Burning Rate:* 3.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutane — Fire Hazards: *Flash Point (deg. F):* -117 CC; *Flammable Limits in Air (%):* 1.8 - 8.4; *Fire Extinguishing Agents:* Stop the flow of gas; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 890; *Electrical Hazard:* Not pertinent; *Burning Rate:* 9.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutyl Acetate — Fire Hazards: *Flash Point (deg. F):* 62 CC, 85 OC; *Flammable Limits in Air (%):* 2.4 - 10.5; *Fire Extinguishing Agents:* Foam, carbon dioxide, and dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 793; *Electrical Hazard:* Class I, Group D; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Softens and dissolves many types of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 82 CC, 90 OC; *Flammable Limits in Air (%):* 1.6 - 10.9; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 800; *Electrical Hazard:* Not pertinent; *Burning Rate:* 3.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutylamine — Fire Hazards: *Flash Point (deg. F):* 15 CC; *Flammable Limits in Air (%):* 3.4 - 9; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen form in fires; *Behavior in Fire:* Vapor is heavier than air and may travel to source of ignition and flash back. Containers may explode; *Ignition Temperature (deg. F):* 712; *Electrical Hazard:* No data; *Burning Rate:* 6.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutylene — Fire Hazards: *Flash Point (deg. F):* -105 CC; *Flammable Limits in Air (%):* 1.8 - 9.6; *Fire Extinguishing Agents:* Recommended to allow fire to burn. Stop the flow of gas if feasible. Water fog, dry chemical, or carbon dioxide may be used on small firs; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode in fires. Vapors are heavier than air and can travel to source of ignition and flash back; *Ignition Temperature (deg. F):* 869; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutyric Acid — Fire Hazards: *Flash Point (deg. F):* 170 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* 935; *Electrical Hazard:* No data; *Burning Rate:* 2.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrosive to aluminum and other metals. Flammable hydrogen gas may accumulate in enclosed spaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isobutyronitrile — Fire Hazards: *Flash Point (deg. F):* 47 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability*

During Transport:; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isooctaldehyde — Fire Hazards: *Flash Point (deg. F):* 104 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* No data; *Fire Extinguishing Agents Not To Be Used:* No data; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* 320; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isodecaldehyde — Fire Hazards: *Flash Point (deg. F):* 185 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isodecyl Acrylate, Inhibited — Fire Hazards: *Flash Point (deg. F):* 240 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May polymerize to form a gummy material, but the reaction is not violent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable if inhibited; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* In the absence of inhibitor, polymerization will occur, especially when heated; *Inhibitor of Polymerization:* Monomethyl Ether of Hydroquinone (25 ppm).

Isodecyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 220 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isohexane — Fire Hazards: *Flash Point (deg. F):* -20 CC; *Flammable Limits in Air (%):* 1.2 - 7.7; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 585; *Electrical Hazard:* Not pertinent; *Burning Rate:* 8.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isooctyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 180 OC; *Flammable Limits in Air (%):* 0.9 - 5.7; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 530; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isopentane — Fire Hazards: *Flash Point (deg. F):* -70 CC; *Flammable Limits in Air (%):* 1.4 - 8.3; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* This is a highly volatile liquid. The vapors are explosive when mixed with air; *Ignition Temperature (deg. F):* 800; *Electrical Hazard:* Not pertinent; *Burning Rate:* 7.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During*

Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isophorone — Fire Hazards: *Flash Point (deg. F)*: 205 OC, 184 CC; *Flammable Limits in Air (%):* 0.84 - 3.8; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 864; *Electrical Hazard:* No data; *Burning Rate:* 4.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isophthalic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent. This is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry powder, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* None; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Dust forms explosive mixture in air; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isoprene — Fire Hazards: *Flash Point (deg. F):* -65 CC; *Flammable Limits in Air (%):* 2 - 9; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic vapors are generated upon heating; *Behavior in Fire:* May polymerize in containers and explode; *Ignition Temperature (deg. F):* 428; *Electrical Hazard:* Class I, Group C; *Burning Rate:* 8.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization is accelerated by heat and exposure to oxygen, as well as the presence of contamination such as iron rust. Iron surfaces should be treated with an appropriate reducing agent such as sodium nitrate, before being placed into isoprene service; *Inhibitor of Polymerization:* Tertiary butyl catechol (0.06%). Di-n-butylamine, phenyl-beta-naphthylamine and phenyl-alpha-naphthylamine are also recommended.

Isopropyl Acetate — Fire Hazards: *Flash Point (deg. F):* 37 CC, 60 CC; *Flammable Limits in Air (%):* 1.8 - 8.0; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 860; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isopropyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 65 OC, 53 CC; *Flammable Limits in Air (%):* 2.3 - 12.7; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 750; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 2.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isopropylamine — Fire Hazards: *Flash Point (deg. F):* -15 OC; *Flammable Limits in Air (%):* 2.3 - 12; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen form in fires; *Behavior in Fire:* Burning product is difficult to control because of the ease of reigniting of vapors. Vapors are heavier than air and may travel to a source of ignition and flash back. There is danger of container explosion; *Ignition Temperature (deg. F):* 756; *Electrical Hazard:* No data; *Burning Rate:* 6.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isopropyl Ether — Fire Hazards: *Flash Point (deg. F)*: -15 OC, -18 CC; *Flammable Limits in Air (%):* 1.4 - 7.9; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel to a source of ignition and flash back. Containers may explode; *Ignition Temperature (deg. F):* 830; *Electrical Hazard:* No data; *Burning Rate:* 5.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Unstable peroxides may form if the product contacts air for long time periods. These may explode spontaneously or when heated; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isopropyl Mercaptan — Fire Hazards: *Flash Point (deg. F)*: -30 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating sulfur dioxide gas is formed in fires; *Behavior in Fire:* Vapor is heavier than air and may travel to a source of ignition and flash back. Containers may explode; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isopropyl Percarbonate — Fire Hazards: *Flash Point (deg. F)*: Not pertinent. This is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* All extinguishing agents may be ineffective; *Special Hazards of Combustion Products:* Flammable and toxic vapors are formed in fires, including acetone, isopropyl alcohol, acetaldehyde, and ethane; *Behavior in Fire:* This product undergoes auto-accelerated decomposition and can self-ignite. Fires are very difficult to extinguish because air is not needed for combustion; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May decompose with the formation of oxygen when in contact with metals; *Stability During Transport:* Unstable at temperatures above 0 of with the formation of oxygen gas; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Isovaleraldehyde — Fire Hazards: *Flash Point (deg. F)*: 55 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* 5.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

K

Kerosene — Fire Hazards: *Flash Point (deg. F)*: 100 CC; *Flammable Limits in Air (%): 0.7 - 5*; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 444; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport: Stable*; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

L

Lactic Acid — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (not flammable); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Slowly corrodes most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Dilute with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Latex, Liquid Synthetic — Fire Hazards: *Flash Point (deg. F)*: Not flammable unless coagulated; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* If the latex dries out and the burns, hydrochloric acid, hydrogen cyanide and styrene gases may be evolved. All are irritating and poisonous; *Behavior in Fire:* Heat may coagulate the latex and form sticky plastic lumps which may burn; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Data not available; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Coagulated by heat and acids to gummy, flammable material; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lauroyl Peroxide — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (oxidizing combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Can increase the severity of fire. Becomes sensitive to shock when hot. Containers may explode in a fire. May ignite or explode spontaneously if mixed with flammable materials; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May ignite or explode spontaneously when mixed with combustible materials; *Stability During Transport:* Stable if not overheated; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lauryl Mercaptan — Fire Hazards: *Flash Point (deg. F)*: 262 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Poisonous and irritating gases (e.g. sulfur dioxide) are generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Acetate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating acid fumes may be formed in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Arsenate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Fluoroborate — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating hydrogen fluoride gas may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Solution is acidic and will corrode most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; rinse with dilute solution of sodium bicarbonate of soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Fluoride — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire*

Extinguishing Agents Not To Be Used: Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Iodide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Increases the intensity of a fire when in contact with burning material. Use plenty of water to cool containers or spilled material; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Contact with wood or paper may cause fire; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Tetraacetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Can increase the intensity of a fire when in contact with combustible material. Cool containers with plenty of water; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Forms lead dioxide and acetic acid in a reaction that is not violent; *Reactivity with Common Materials:* May corrode metals when moist; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Dilute with water, rinse with dilute sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lead Thiocyanate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating sulfur dioxide gas may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Linear Alcohols — Fire Hazards: *Flash Point (deg. F):* 180 - 285 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Liquefied Natural Gas — Fire Hazards: *Flash Point (deg. F):* Flammable gas; *Flammable Limits in Air (%):* 5.3 - 14.0; *Fire Extinguishing Agents:* Do not extinguish large spill fires. Allow to burn while cooling adjacent equipment with water spray. Shut off leak if possible. Extinguish small fires with dry chemicals; *Fire Extinguishing Agents Not To Be Used:* Water; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 999; *Electrical Hazard:* Class 1, Group D; *Burning Rate:* 12.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No

reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Liquefied Petroleum Gas — Fire Hazards: *Flash Point (deg. F):* Propane: -156 CC; butane: -76 CC; *Flammable Limits in Air (%):* Propane: 2.2 - 9.5; butane: 1.8 - 8.4; *Fire Extinguishing Agents:* Allow to burn while cooling adjacent equipment with water spray. Extinguish small fires with dry chemical. Shut off leak if possible; *Fire Extinguishing Agents Not To Be Used:* Water (let fire burn); *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode. Vapor is heavier than air and may travel a long distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Litharge — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lithium Aluminum Hydride — Fire Hazards: *Flash Point (deg. F):* Solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Powdered graphite, powdered salt, or powdered limestone; *Fire Extinguishing Agents Not To Be Used:* Do not use water, soda acid, carbon dioxide or dry chemical; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Decomposes at 257 °F to form hydrogen gas. The heat generated may cause ignition and/or explosion; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Class I, Group B; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently with water as a dry solid or when dissolved in ether. The hydrogen produced by the reaction with water is a major hazard and necessitates adequate ventilation; *Reactivity with Common Materials:* Can burn in heated or moist air; *Stability During Transport:* Normally stable; unstable at high temperatures; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lithium Hydride — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry nitrogen, graphite, or lithium chloride; *Fire Extinguishing Agents Not To Be Used:* Never use water, foam, halogenated hydrocarbons, soda acid, dry chemical, or carbon dioxide; *Special Hazards of Combustion Products:* Irritating alkali fumes may form in fire; *Behavior in Fire:* May decompose when hot to form flammable hydrogen gas. Reacts violently with water to produce hydrogen, which may explode in air; *Ignition Temperature (deg. F):* 392; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently with water to produce flammable hydrogen gas and strong caustic solution; ignition may occur, especially with powder; *Reactivity with Common Materials:* May ignite combustible materials if they are damp; *Stability During Transport:* Stable, if air and moisture are excluded; *Neutralizing Agents for Acids and Caustics:* Residues should be washed well with water, then rinsed with dilute acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Lithium, Metallic — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Graphite, lithium chloride; *Fire Extinguishing Agents Not To Be Used:* Water, sand, halogenated hydrocarbons, carbon dioxide, soda-acid , or dry chemical; *Special Hazards of Combustion Products:* Strong alkali fumes are formed in fire; *Behavior in Fire:* Molten lithium is quite easily ignited and is then difficult to extinguish. Hot or burning lithium will react with all gases except those of the helium-argon group. It also reacts violently with concrete, wood, asphalt, sand, asbestos, and in fact, nearly everything except metal. Do not apply water to adjacent fires. Hydrogen explosion may result; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form flammable hydrogen gas and strong caustic solution. Ignition usually occurs; *Reactivity with Common Materials:* May ignite combustible

materials if they are damp; *Stability During Transport:* Stable, if air and moisture are excluded; *Neutralizing Agents for Acids and Caustics:* Residues should be flushed with water, then rinsed with dilute acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

M

Magnesium — Fire Hazards: *Flash Point (deg. F):* Not pertinent (solid). Flammable when in the form of turnings or powder; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Inert dry powders (e.g. graphite, limestone, salt); *Fire Extinguishing Agents Not To Be Used:* Water, foam, halogenated agents, carbon dioxide; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Forms dense white smoke. Flame is very bright; *Ignition Temperature (deg. F):* 883; *Electrical Hazard:* Class I, Group E; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* In finely divided form, reacts with water and acids to release flammable hydrogen gas; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Magnesium Perchlorate — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may cause or increase the intensity of a fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Can form explosive mixture with combustible material or finely powdered metals. Increases the intensity of fires; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Dissolves with liberation of heat. May cause spattering; *Reactivity with Common Materials:* Contact with wood, paper, oils, grease, or finely divided metals may cause fires and explosions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Malathion — Fire Hazards: *Flash Point (deg. F):* >325; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, foam, water spray; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors and fumes from fires are hazardous. They include sulfur dioxide and phosphoric acid; *Behavior in Fire:* Gives off hazardous fumes. Area surrounding fire should be diked to prevent water runoff; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* None; *Reactivity with Common Materials:* No hazardous reaction; *Stability During Transport:* Not pertinent; *Neutralizing Agents for Acids and Caustics:* Liquid bleach solution for decontamination; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Maleic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating smoke containing maleic anhydride may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May corrode metals when wet; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Maleic Anhydride-Fire Hazards: *Flash Point (deg. F):* (liquid) 215 CC; 230 OC; *Flammable Limits in Air (%):* 1.4-7.1; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* When heated above 300°F in the presence of various materials may generate heat and carbon dioxide. Will explode if confined; *Ignition Temperature (deg. F):* 878; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 1.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Hot water may cause frothing. Reaction with cold water is slow and non-hazardous; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Solid spills can usually be recovered before any significant reaction with water occurs. Flush area of spill with water; *Polymerization:* Very unlikely at ordinary temperatures, even in the molten state; *Inhibitor of Polymerization:* None.

Maleic Hydrazide— Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic nitrogen oxides are produced; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Acetate— Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Smoke may contain toxic mercury or mercury oxide fumes; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Ammonium Chloride— Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Smoke may contain toxic mercury compounds; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Chloride— Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Heat of fire may cause material to form fumes of mercuric chloride, which are toxic; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Cyanide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Fumes from fire may contain toxic mercury and hydrogen cyanide; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Contact with any acidic material will form poisonous hydrogen cyanide gas, which may collect in enclosed spaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Iodide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Fumes from fire may contain toxic mercury vapor; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may intensify fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors from fire may contain toxic mercury and oxides of nitrogen; *Behavior in Fire:* May increase intensity of fire if in contact with burning material; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:**

Reactivity with Water: Dissolves, then form cloudy acid solution. The reaction is not hazardous; *Reactivity with Common Materials:* Solution will corrode most metals. Solid in contact with wood or paper may cause fire; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush well with water, rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Oxide — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may intensify fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Fumes from fire may contain poisonous mercury vapor; *Behavior in Fire:* Decomposes at 500°C into mercury and oxygen which can increase intensity of fire. Solid changes color when hot; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercuric Sulfide — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, sand; *Fire Extinguishing Agents Not To Be Used:* Other agents may be ineffective; *Special Hazards of Combustion Products:* Smoke from fire contains poisonous mercury vapor and irritating sulfur dioxide gas; *Behavior in Fire:* Changes color when hot. Decomposes at burning temperature. The black form may soften, and molten sulfur may flow out and burn; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercurous Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Fumes from fire may contain toxic vapors of substance; *Behavior in Fire:* Vaporizes and escapes as a sublimate; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mercurous Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may intensify fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Smoke from fire may contain toxic mercury vapor and oxides of nitrogen; *Behavior in Fire:* May increase intensity of fire; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Dissolves, then forms cloudy acid solution. The reaction is not hazardous; *Reactivity with Common Materials:* Solution may corrode most metals. Solid in contact with wood or paper may cause fire; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mecuric Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Mesityl Oxide — Fire Hazards: *Flash Point (deg. F):* 84 OC; 73 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 652; *Electrical Hazard:* Data not available; *Burning Rate:* 4.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity*

with Common Materials: No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methallyl Chloride — Fire Hazards: *Flash Point (deg. F):* 14 OC; *Flammable Limits in Air (%):* 2.3 - 9.3; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating and toxic hydrogen chloride and phosgene vapors may be formed; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methane — Fire Hazards: *Flash Point (deg. F):* Flammable gas; *Flammable Limits in Air (%):* 5.0 - 15.0; *Fire Extinguishing Agents:* Stop flow of gas; *Fire Extinguishing Agents Not To Be Used:* Water; *Special Hazards of Combustion Products:* None; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1004; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 12.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Metanearsonic Acid, Sodium Salts — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic gases may be generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* None; *Reactivity with Common Materials:* None; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methoxychlor — Fire Hazards: *Flash Point (deg. F):* Burns only at high temperatures. For liquid forms, see Kerosene; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating and toxic hydrogen chloride gas may be formed in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Acetate — Fire Hazards: *Flash Point (deg. F):* 22 OC; 14 CC; *Flammable Limits in Air (%):* 3.1 - 16; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than fire and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 935; *Electrical Hazard:* Data not available; *Burning Rate:* 3.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly to form acetic acid and methyl alcohol; the reaction is not violent; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Acetylene-Propadiene Mixture — Fire Hazards: *Flash Point (deg. F):* Not pertinent (flammable liquefied compressed gas); *Flammable Limits in Air (%):* 3-11; *Fire Extinguishing Agents:* Let fire burn; shut off gas supply; cool adjacent exposures; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 850; *Electrical Hazard:* Data not available; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction, except forms explosive compounds in contact with alloys containing more than 67% copper at high pressures; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Acrylate — Fire Hazards: *Flash Point (deg. F):* 2.7 CC; 44 OC; *Flammable Limits in Air (%):* 2.8 - 25; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water

may be ineffective; *Special Hazards of Combustion Products:* Irritating vapors are generated in fires; *Behavior in Fire:* May polymerize. Vapor is heavier than fire and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Heat may cause an explosive polymerization. Strong ultraviolet light can also initiate polymerization; *Inhibitor of Polymerization:* Hydroquinone and its methyl ether, in presence of air .

Methyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 54 CC; 61 OC; *Flammable Limits in Air (%):* 6.0 - 36; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 867; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 1.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methylamine — Fire Hazards: *Flash Point (deg. F):* Not pertinent (flammable liquefied compressed gas); *Flammable Limits in Air (%):* 4.3 - 21; *Fire Extinguishing Agents:* Let gas fire burn; stop flow of gas. Extinguish solution fires with dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic nitrogen oxides may be formed; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 806; *Electrical Hazard:* Data not available; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Dissolves completely; *Reactivity with Common Materials:* Corrosive to copper, copper alloys, zinc alloys, aluminum, and galvanized surfaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Amyl Acetate — Fire Hazards: *Flash Point (deg. F):* 113 CC; 110 OC; *Flammable Limits in Air (%):* 0.9 - 5.7 (calc.); *Fire Extinguishing Agents:* Alcohol foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 510 (calc.); *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Amyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 120 - 130 OC; 106 CC; *Flammable Limits in Air (%):* 1.0 - 5.5; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 583 (calc.); *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

N-Methylaniline — Fire Hazards: *Flash Point (deg. F):* 175 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic vapors are generated when heated; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 3.65 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastic; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Bromide — Fire Hazards: *Flash Point (deg. F):* Practically not flammable; *Flammable Limits in Air (%):* 10 - 15; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases are generated when exposed to fire or heat; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 999; *Electrical Hazard:* Not

pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl n-Butyl Ketone — Fire Hazards: *Flash Point (deg. F):* 83 OC; 77 CC; *Flammable Limits in Air (%):* 1.3 - 8.0; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 795; *Electrical Hazard:* Data not available; *Burning Rate:* 4.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Chloride — Fire Hazards: *Flash Point (deg. F):* < 32 CC; *Flammable Limits in Air (%):* 8.1 - 17.2; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide. Stop flow of gas; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases are generated in fires; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 1170; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Reacts with zinc, aluminum, magnesium, and their alloys; reaction is not violent; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Chloroformate — Fire Hazards: *Flash Point (deg. F):* 76 OC; 73 CC; *Flammable Limits in Air (%):* LEL = 6.7; *Fire Extinguishing Agents:* Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating and toxic hydrogen chloride and phosgene may be formed; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 2.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly, evolving hydrogen chloride (hydrochloric acid). Reaction can be hazardous if water is hot; *Reactivity with Common Materials:* Corrodes rubber; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methylcyclopentadienylmanganese Tricarbonyl — Fire Hazards: *Flash Point (deg. F):* >200 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, foam, water spray, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors are formed in a fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Data not available; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Cyclopentane — Fire Hazards: *Flash Point (deg. F):* < 0 CC; *Flammable Limits in Air (%):* 1.1 - 8.7; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 624; *Electrical Hazard:* Data not available; *Burning Rate:* 7.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyldichlorosilane — Fire Hazards: *Flash Point (deg. F):* - 14 OC; *Flammable Limits in Air (%):* 6 - 55; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene gases may be formed; *Behavior in Fire:* Difficult to extinguish; re-ignition may occur. Contact with water, applied to adjacent fires will generate irritating hydrogen chloride gas; *Ignition Temperature (deg. F):* >600; *Electrical Hazard:* Data not available; *Burning Rate:* 3.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Reacts with surface moisture to

evolve hydrogen chloride, which is corrosive to common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Ethyl Ketone — Fire Hazards: *Flash Point (deg. F):* 20 CC; 22 OC; *Flammable Limits in Air (%):* 1.8 - 11.5; *Fire Extinguishing Agents:* Alcohol foam dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 961; *Electrical Hazard:* Class 1, Group D; *Burning Rate:* 4.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methylethylpyridine — Fire Hazards: *Flash Point (deg. F):* 155 OC; *Flammable Limits in Air (%):* 1.1 - 6.6; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 939; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, neutralize with dilute acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Formal — Fire Hazards: *Flash Point (deg. F):* 0 OC; *Flammable Limits in Air (%):* 1.6 - 17.6; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating formaldehyde smoke may be present in smoke; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 459; *Electrical Hazard:* Data not available; *Burning Rate:* 5.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Formate — Fire Hazards: *Flash Point (deg. F):* - 26 CC; *Flammable Limits in Air (%):* 5 - 22.7; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 853; *Electrical Hazard:* Data not available; *Burning Rate:* 2.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Slow reaction to form formic acid and methyl alcohol; reaction is not hazardous; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methylhydrazine — Fire Hazards: *Flash Point (deg. F):* 62 OC; *Flammable Limits in Air (%):* 2.5 - 98; *Fire Extinguishing Agents:* Water or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating nitrogen oxides are produced; *Behavior in Fire:* May explode; *Ignition Temperature (deg. F):* 382; *Electrical Hazard:* Data not available; *Burning Rate:* 2.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Reacts slowly with air, but heat may cause ignition of rags, rust or other combustibles; *Stability During Transport:* Stable if not in contact with iron, copper or their alloys; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Isobutyl Carbinol — Fire Hazards: *Flash Point (deg. F):* 120 -130 OC; 106 CC; *Flammable Limits in Air (%):* 1.0 - 5.5; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*

Methyl Isobutyl Ketone — Fire Hazards: *Flash Point (deg. F):* 73 CC; 75 OC; *Flammable Limits in Air (%):* 1.4 - 7.5; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special*

Hazards of Combustion Products: Irritating vapors are generated when heated; *Behavior in Fire:* Vapors may travel a considerable distance and ignite; *Ignition Temperature (deg. F):* 854; *Electrical Hazard:* Class I, Group D; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Isopropenyl Ketone, Inhibited — Fire Hazards: *Flash Point (deg. F):* < 73 CC; *Flammable Limits in Air (%):* 1.8 - 9.0; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May polymerize and explode; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 4.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Will polymerize in the absence of inhibitor, especially when heated; *Inhibitor of Polymerization:* Up to 1% hydroquinone.

Methyl Mercaptan — Fire Hazards: *Flash Point (deg. F):* Not pertinent (flammable, liquefied compressed gas); *Flammable Limits in Air (%):* 3.9 - 21.8; *Fire Extinguishing Agents:* Preferably let fire burn, stop gas flow. Fires may be extinguished with dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating sulfur dioxide is produced; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* 3.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Methacrylate — Fire Hazards: *Flash Point (deg. F):* 50 OC; *Flammable Limits in Air (%):* 2.1 - 12.5; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back. Containers may explode in fire or when heated because of polymerization; *Ignition Temperature (deg. F):* 790; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Heat, oxidizing agents, and ultraviolet light may cause polymerization; *Inhibitor of Polymerization:* Hydroquinone, 22 - 65 ppm; hydroquinone methyl ether, 22 - 120 ppm; dimethyl tert-butylphenol, 45 - 65 ppm.

Methyl Parathion — Fire Hazards: *Flash Point (deg. F):* 115 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic gases are produced in fires; *Behavior in Fire:* Drums may rupture violently; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* Half decomposed in 8 days at 40° C; *Reactivity with Common Materials:* Is absorbed in wood. etc., which must be replaced to eliminate poison hazard; *Stability During Transport:* Decomposes above 50 °C with possible explosive force; *Neutralizing Agents for Acids and Caustics:* Apply caustic or soda ash slurry until yellow stains disappear; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Phosphonothioic Dichloride (Anhydrous) — Fire Hazards: *Flash Point (deg. F):* >122 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam; *Special Hazards of Combustion Products:* Irritating hydrogen chloride, sulfur dioxide and other fumes may be formed in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* Reacts with water to form hydrochloric acid and/or hydrogen chloride vapor. The reaction may be violent; *Reactivity with Common Materials:* Corrosive to metals because of its high acidity; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Methylpyrrolidone — Fire Hazards: *Flash Point (deg. F)*: 204 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Dry chemical, "alcohol foam", or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may be formed in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

alpha-Methylstyrene — Fire Hazards: *Flash Point (deg. F)*: 137 CC; *Flammable Limits in Air (%):* 1.9 - 6.1; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 1,066; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and* Caustics: Not pertinent; *Polymerization:* Hazardous polymerization unlikely to occur except when in contact with alkali metals or metallo-organic compounds; *Inhibitor of Polymerization:* 10 -20 ppm tert-butylcatechol.

Methyltrichlorosilane — Fire Hazards: *Flash Point (deg. F)*: 45 OC; 15 CC; *Flammable Limits in Air (%):* 5.1 - >20; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene gases may form in fires; *Behavior in Fire:* Difficult to extinguish; re-ignition may occur. Contact with water applied to adjacent fires produces irritating hydrogen chloride; *Ignition Temperature (deg. F):* >760; *Electrical Hazard:* Data not available; *Burning Rate:* 1.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form hydrogen chloride, which is corrosive to metals; *Reactivity with Common Materials:* Reacts with surface moisture to evolve hydrogen chloride, which is corrosive to metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Methyl Vinyl Ketone — Fire Hazards: *Flash Point (deg. F)*: 30 OC; 20 CC; *Flammable Limits in Air (%):* 2.1 - 15.6; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back. At elevated temperatures (fire conditions) polymerization may take place in containers, causing violent rupture. Unburned vapors are very irritating; *Ignition Temperature (deg. F):* 915; *Electrical Hazard:* Data not available; *Burning Rate:* 4.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerize spontaneously upon exposure to heat or sunlight; *Inhibitor of Polymerization:* Up to 1% hydroquinone.

Mineral Spirits — Fire Hazards: *Flash Point (deg. F)*: 105 - 140 CC, depending on grade; *Flammable Limits in Air (%):* 0.8 - 5.0; *Fire Extinguishing Agents:* Foam, carbon dioxide, dry chemical; *Fire Extinguishing Agents Not To Be Used:* Do not use straight hose water stream; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 540; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Molybdic Trioxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Monochloroacetic Acid — Fire Hazards: *Flash Point (deg. F):* (almost nonflammable); *Flammable Limits in Air (%):* 8 (LEL); *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* hydrogen chloride and phosgene may be generated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Cause mild corrosion to common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Monochlorodifluoromethane — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Decomposition gases are toxic and irritating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Monoethanolamine - Fire Hazards: *Flash Point (deg. F):* 185 CC; 200 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Water spray, alcohol foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Monoisopropanolamine — Fire Hazards: *Flash Point (deg. F):* 165 OC; 171 CC; *Flammable Limits in Air (%):* 2.2 (calc.) - 12 (est.); *Fire Extinguishing Agents:* Dry chemical, water spray, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 706 (est.); *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Morpholine — Fire Hazards: *Flash Point (deg. F):* 100 OC; *Flammable Limits in Air (%):* 1.8 - 10.8; *Fire Extinguishing Agents:* Water fog, alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors are generated when heated; *Behavior in Fire:* Vapor is heavier than air and may travel some distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 590; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Motor Fuel Anti-knock Compounds Containing Lead Alkyls — Fire Hazards: *Flash Point (deg. F):* 89 -265 OC; *Flammable Limits in Air (%):* None established; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic lead-containing gases are generated in fires; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* Begins to decompose above 212° F; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Reacts with oxidizing materials, active metals and rust, but not considered hazardous; *Stability During Transport:* A self-sustaining decomposition occurs if the temperature of the bulk liquid is above 212 °F and a flame or hot metal surface serves to ignite the mass. The presence of ethylene dibromide makes the compound stable at 300°F for 15 hrs; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

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Nabam — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* If water solution boils, poisonous hydrogen sulfide and highly flammable carbon disulfide vapors form; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction unless water is boiling hot, when poisonous hydrogen sulfide and flammable carbon disulfide vapors form; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Naphtha: Coal Tar — Fire Hazards: *Flash Point (deg. F):* 107 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 900 - 950; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Naphthalene, Molten — Fire Hazards: *Flash Point (deg. F):* 174 CC; 190 OC; *Flammable Limits in Air (%):* 0.9 - 5.9; *Fire Extinguishing Agents:* Water fog, carbon dioxide, dry chemical, or foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic vapors given off in a fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 979; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Molten naphthalene spatters and foams in contact with water. No chemical reaction. No chemical reaction is involved; *Reactivity with Common Materials:* None; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Naphtha: Solvent — Fire Hazards: *Flash Point (deg. F):* >100 CC; *Flammable Limits in Air (%):* 0.8 - 5.0; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 444; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Naphtha: Stoddard Solvent — Fire Hazards: *Flash Point (deg. F):* 110 CC; *Flammable Limits in Air (%):* 0.8 - 5.0; *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 540 (est.); *Electrical Hazard:* Class I, Group D; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Naphtha: VM & P (75 % Naphtha) — Fire Hazards: *Flash Point (deg. F):* 20 - 55 CC; *Flammable Limits in Air (%):* 0.9 - 6.7; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and travel a long distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 450; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Naphthenic Acids — Fire Hazards: *Flash Point (deg. F):* 300 OC; *Flammable Limits in Air (%):* 1.0 (LEL); *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Data not available; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common*

Materials: No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Naphthylamine — Fire Hazards: *Flash Point (deg. F):* (combustible solid) 315 CC (molten solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Toxic nitrogen oxides are produced in a fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Neohexane — Fire Hazards: *Flash Point (deg. F):* -54 CC; *Flammable Limits in Air (%):* 1.2 - 7.7; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 787; *Electrical Hazard:* Data not available; *Burning Rate:* 9.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Ammonium Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may be formed in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Bromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating hydrogen bromide vapors may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Carbonyl — Fire Hazards: *Flash Point (deg. F):* < -4 CC; *Flammable Limits in Air (%):* 2 (LEL); *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Unusually toxic gases formed by incomplete combustion; *Behavior in Fire:* Containers may explode when heated; *Ignition Temperature (deg. F):* <200° F (vapor); *Electrical Hazard:* Data not available; *Burning Rate:* 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable below 100° C; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with*

Common Materials: No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Cyanide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Fluoroborate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Formate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may intensify fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire. May increase intensity of fire if in contact with combustible material; *Behavior in Fire:* May increase intensity of fire if in contact with combustible material; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Contact of solid with wood or paper may cause fires; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nickel Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nicotine — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* 0.7 - 4.0; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Smoke may contain toxic vapors of unburned compound; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 471; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nicotine Sulfate — Fire Hazards: *Flash Point (deg. F):* Nonflammable as solid or water solution; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic decomposition products are released in a fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with*

Common Materials: No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitralin — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Irritating oxides of sulfur and nitrogen are formed in fire; *Behavior in Fire:* Decomposes vigorously in a self-sustaining reaction at or above 225° C; *Ignition Temperature (deg. F):* 435; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitric Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Use water on adjacent fires; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* May give off poisonous oxides of nitrogen and acid fumes when heated in fires; *Behavior in Fire:* Decomposes and gives off poisonous oxides of nitrogen and acid fumes when heated in fires; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* May heat up on mixing,, but explosion or formation of steam unlikely; *Reactivity with Common Materials:* Very corrosive to wood, paper, cloth and most metals. Toxic red oxides of nitrogen are formed; *Stability During Transport:* When heated may give off toxic red oxides of nitrogen; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitric Oxide — Fire Hazards: *Flash Point (deg. F):* Not pertinent (nonflammable compressed gas); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Supports combustion, so all fires burn more vigorously; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts with water to form nitric acid. The reaction is not violent; *Reactivity with Common Materials:* Reacts rapidly with air to form nitrogen tetroxide; see this compound; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flood with water, rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitrilotriacetic Acid and Salts — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2-Nitroaniline — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 970; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

4-Nitroaniline — Fire Hazards: *Flash Point (deg. F):* 329 OC (molten solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* No data; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Melts and burns; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitrobenzene — Fire Hazards: *Flash Point (deg. F):* 171 OC; 190 CC; *Flammable Limits in Air (%):* 1.8 LEL; *Fire Extinguishing Agents:* Water, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 924; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitroethane — Fire Hazards: *Flash Point (deg. F):* 105 OC; 87 CC; *Flammable Limits in Air (%):* 3.4 (LEL); *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; "alcohol" foam is not effective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* 778; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitrogen, Liquefied — Fire Hazards: *Flash Point (deg. F):* Not pertinent (nonflammable compressed gas); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode when heated; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Heat of water will vigorously vaporize liquid nitrogen; *Reactivity with Common Materials:* No chemical reaction. Low temperature may cause brittleness in rubber and plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitrogen Tetroxide— Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Stop flow of gas; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Produces toxic gas when heated; *Behavior in Fire:* Does not burn but supports combustion of combustible materials such as wood. May cause fire or explode on contact with other materials; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Data not available; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Dissolves to form nitric acid and nitric oxide. Nitric oxide reacts with air to form more nitrogen tetroxide; *Reactivity with Common Materials:* Very corrosive to metals when wet. Reacts vigorously with combustible materials such as wood; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, then use soda ash or lime; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitromethane — Fire Hazards: *Flash Point (deg. F):* 110 OC, 95 CC; *Flammable Limits in Air (%):* 7.3 LEL; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* 785; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Wet material corrodes steel and copper, but the reaction is slow; *Stability During Transport:* Considered stable, but may become sensitized by organic bases (amines) and some metal oxides, such as led pigments; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2-Nitrophenol — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Data not available; *Special Hazards of Combustion Products:* Toxic and irritating fumes of unburned materials and oxides of nitrogen can form in fire; *Behavior in Fire:* Data not available; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

4-Nitrophenol — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air*

(%): Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* No data; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen and fumes of unburned material may form in fire; *Behavior in Fire:* Decomposes violently at 279° C and will burn even in absence of air; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* NO reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2-Nitropropane — Fire Hazards: *Flash Point (deg. F):* 100 OC; 82 CC; *Flammable Limits in Air (%):* 2.6 (LEL); *Fire Extinguishing Agents:* Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* "Alcohol" foam; water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fire; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* 802; *Electrical Hazard:* Data not available; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitrosyl Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Very toxic gases are generated when heated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Dissolves and reacts to form acid solution and toxic red oxides of nitrogen; *Reactivity with Common Materials:* Corrosive to most metals, but reaction is not hazardous; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water. Residual acid may be neutralized with soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nitrous Oxide — Fire Hazards: *Flash Point (deg. F):* Not pertinent (nonflammable compressed gas); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Will support combustion, and may increase intensity of fire. Containers may explode when heated; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Supports combustion but does not cause spontaneous combustion; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nonane — Fire Hazards: *Flash Point (deg. F):* 88 CC; *Flammable Limits in Air (%):* 0.87 - 2.9; *Fire Extinguishing Agents:* Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 401; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nonanol — Fire Hazards: *Flash Point (deg. F):* 210 OC; 165 CC; *Flammable Limits in Air (%):* 0,8 - 6.1; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nonene — Fire Hazards: *Flash Point (deg. F):* 78 OC; *Flammable Limits in Air (%):* 0.7 - 3.9; *Fire Extinguishing Agents:* Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* 6.0 mm/min.

Chemical Reactivity: *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Nonene — Fire Hazards: *Flash Point (deg. F)*: Data not available; *Flammable Limits in Air (%):* 0.8 (LEL); *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* 6.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Nonylphenol — Fire Hazards: *Flash Point (deg. F)*: 300 OC; 285 CC; *Flammable Limits in Air (%):* Approx 1% (calc. LEL); *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Data not available; *Electrical Hazard:* Not pertinent; *Burning Rate:* Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

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Octane — Fire Hazards: *Flash Point (deg. F):* 56 CC; *Flammable Limits in Air (%):* 1.0 - 6.5; *Fire Extinguishing Agents*: Dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than fire and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 428; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 6.3 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Octanol — Fire Hazards: *Flash Point (deg. F):* 178 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 3.7 mm/min (approx.). **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; Neutralizing Agents for Acids and Caustics: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

1-Octene — Fire Hazards: *Flash Point (deg. F):* 70 OC; *Flammable Limits in Air (%):* 0.9 (LEL); *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 493; *Electrical Hazard*: Not pertinent; *Burning Rate*: 6.5 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Octyl Epoxy Tallate — Fire Hazards: *Flash Point (deg. F):* 450 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack some forms of plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils: Clarified — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not

available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils: Crude — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils: Diesel — Fire Hazards: *Flash Point (deg. F):* (1 - D) 100 CC; (2 - D) 125 CC; *Flammable Limits in Air (%):* 1.3 - 6.0 vol; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: (1 - D) 350 -625; (2 - D) 490 - 545; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Castor — Fire Hazards: *Flash Point (deg. F):* 445 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 840; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Coconut — Fire Hazards: *Flash Point (deg. F):* 420 CC (crude); 580 CC (refined); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Cottonseed — Fire Hazards: *Flash Point (deg. F):* 486 CC (refined oil); 610 CC (cooking oil); *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 650 (refined oil); *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Fish — Fire Hazards: *Flash Point (deg. F):* 420 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent;

Polymerization: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Lard — Fire Hazards: *Flash Point (deg. F):* 395 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 833; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Olive — Fire Hazards: *Flash Point (deg. F):* 437 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 650; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible — Fire Hazards: *Flash Point (deg. F):* 373 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 600; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Peanut Fire Hazards: *Flash Point (deg. F):* 640 OC; 540 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 833; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Safflower — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Soya bean — Fire Hazards: *Flash Point (deg. F):* 540 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 833; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Tucum — Fire Hazards: *Flash Point (deg. F):* 398 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical**

Reactivity: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Edible: Vegetable — Fire Hazards: *Flash Point (deg. F):* 610 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: 6 — Fire Hazards: *Flash Point (deg. F):* > 150 CC; *Flammable Limits in Air (%):* 1 -5; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 765; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: 2 — Fire Hazards: *Flash Point (deg. F):* 136 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 494; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: 4 — Fire Hazards: *Flash Point (deg. F):* > 130 CC; *Flammable Limits in Air (%):* 1 -5; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 505; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: 5 - Fire Hazards: *Flash Point (deg. F):* > 130 CC; *Flammable Limits in Air (%):* 1 -5; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: 1-D - Fire Hazards: *Flash Point (deg. F):* 100 CC; *Flammable Limits in Air (%):* 1.3 - 6; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 350 - 625; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: 2-D — Fire Hazards: *Flash Point (deg. F):* 125 CC; *Flammable Limits in Air (%):* 1.3 - 6; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 490 - 545; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability*

During Transport: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Fuel: No. 1 — Fire Hazards: *Flash Point (deg. F):* 100 CC; *Flammable Limits in Air (%):* 0.7 - 5; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 444; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Absorption — Fire Hazards: *Flash Point (deg. F):* 255; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 300; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Coal Tar — Fire Hazards: *Flash Point (deg. F):* 60 - 77 CC; *Flammable Limits in Air (%):* 1.3 - 8; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Croton — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Linseed — Fire Hazards: *Flash Point (deg. F):* 535 OC; 403 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 650; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Lubricating — Fire Hazards: *Flash Point (deg. F):* 300 - 450 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 500 - 700; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Mineral — Fire Hazards: *Flash Point (deg. F):* 380 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 500 - 700; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:**

Reactivity with Water: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Mineral Seal — Fire Hazards: *Flash Point (deg. F):* 170 - 275 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Motor — Fire Hazards: *Flash Point (deg. F):* 275 - 600 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 325 - 625; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Neatsfoot — Fire Hazards: *Flash Point (deg. F):* 430 OC; 470 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 828; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Penetrating — Fire Hazards: *Flash Point (deg. F):* 295; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Range — Fire Hazards: *Flash Point (deg. F):* 100 CC; *Flammable Limits in Air (%):* 0.7 - 5; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 400; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Resin — Fire Hazards: *Flash Point (deg. F):* 255 - 390 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 648; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Road — Fire Hazards: *Flash Point (deg. F):* 300 -550; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 400 - 700;

Electrical Hazard: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Rosin — Fire Hazards: *Flash Point (deg. F):* 255 - 390 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 648; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Sperm — Fire Hazards: *Flash Point (deg. F):* 428 CC(No.1); 460 CC (No.2); 500 - 510 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 586 (No.1); *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Spindle — Fire Hazards: *Flash Point (deg. F):* 169 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 478; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Spray — Fire Hazards: *Flash Point (deg. F):* 140 (min.)CC; *Flammable Limits in Air (%):* 0.6 - 4.6; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 475; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Tall — Fire Hazards: *Flash Point (deg. F):* 255; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Tanner's — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Transformer — Fire Hazards: *Flash Point (deg. F):* 295 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing*

Agents Not to be Used: Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oils, Miscellaneous: Turbine — Fire Hazards: *Flash Point (deg. F):* 390 - 485 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide, water fog; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 700; *Electrical Hazard*: Not pertinent; *Burning Rate*: (approx.) 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oleic Acid — Fire Hazards: *Flash Point (deg. F):* 390 - 425 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: 685; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oleic Acid, Potassium Salt — Fire Hazards: *Flash Point (deg. F):* 140 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oleic Acid, Sodium Salt — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid;) *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical, foam, water, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oleum — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Avoid use of water on adjacent air; *Special Hazards of Combustion Products*: Toxic and irritating vapors are generated; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Vigorous reaction with water; spatters; *Reactivity with Common Materials*: May react with cast iron with explosive violence. Attack many metals, releasing flammable hydrogen gas. Capable of igniting finely divided combustible material on contact. Extremely hazardous in contact with many materials; *Stability During Transport*: Normally stable; *Neutralizing Agents for Acids and Caustics:* Cautious dilution with water, with protection against violent spattering. Diluted acid may be neutralized with lime or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oxalic Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Generates poisonous gases; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity*

with Common Materials: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Lime or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Oxygen, Liquefied — Fire Hazards: *Flash Point (deg. F):* Not flammable, but supports combustion; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Increases intensity of any fire. Mixtures of liquid oxygen and any fuel are highly explosive; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Heat of water will vigorously vaporize liquid oxygen; *Reactivity with Common Materials*: Avoid organic and combustible materials, such as oil, grease, coal dust, etc. If ignited, such mixtures can explode. Low temperature may cause brittleness in some materials; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

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Paraformaldehyde — Fire Hazards: *Flash Point (deg. F):* 199 OC; 160 CC; *Flammable Limits in Air (%):* (formaldehyde gas) 7.0 - 73.0; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Changes to formaldehyde gas which is highly flammable; *Ignition Temperature (deg. F)*: 572 (approx.); *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Forms water solution of formaldehyde gas; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Slowly decomposes to formaldehyde gas; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Parathion, Liquid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Water o adjacent fires; *Fire Extinguishing Agents Not to be Used:* High pressure water hoses may scatter parathion from broken containers, increasing contamination hazard; *Special Hazards of Combustion Products*: Fumes from decomposing material may contain oxides of sulfur and nitrogen; *Behavior in Fire*: Containers may explode when heated; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Slow reaction, not considered hazardous; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Pentaborane — Fire Hazards: *Flash Point (deg. F):* Not pertinent (ignites spontaneously in air); *Flammable Limits in Air (%):* 0.42 - 98; *Fire Extinguishing Agents*: Preferable let fire burn and shut off leak; extinguish with dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Halogenated hydrocarbons, water; *Special Hazards of Combustion Products*: Toxic fumes may be formed; *Behavior in Fire*: Tends to re-ignite. Contact with water applied to adjacent fires produces flammable hydrogen gas; *Ignition Temperature (deg. F)*: Spontaneously flammable if impure. Approx. 35° C when pure; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly to form flammable hydrogen gas. The reaction is not hazardous unless water is hot or unless confined; *Reactivity with Common Materials*: Corrosive to natural rubber, some synthetic rubbers, some greases and some lubricants; *Stability During Transport*: Stable below 302° F; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Pentacholrophenol Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Generates toxic and irritating vapors; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Pentadecanol — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards*

of Combustion Products: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Pentaerythritol — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 842 (dust cloud); *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Pentane — Fire Hazards: *Flash Point (deg. F):* -57 CC; *Flammable Limits in Air (%):* 1.4 - 8.3 (by vol.); *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode; *Ignition Temperature (deg. F)*: 544; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 8.6 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

1-Pentene — Fire Hazards: *Flash Point (deg. F):* - 60 CC; 0 OC; *Flammable Limits in Air (%):* 1.4 - 8.7; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide. Stop flow of vapor; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode; *Ignition Temperature (deg. F)*: 527; *Electrical Hazard*: Data not available; *Burning Rate*: 9.1 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Peracetic Acid — Fire Hazards: *Flash Point (deg. F):* 104 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapors are very flammable and explosive. Liquid will detonate if concentration rises above 56% because of evaporation of acetic acid; *Ignition Temperature (deg. F)*: 392; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May cause fire in contact with organic materials such as wood, cotton or straw. Corrosive to most metals including aluminum; *Stability During Transport*: Stable if kept cool and out of contact with most metals. At 30°C concentration decreases about 0.4% each month; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Perchloric Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable , but may explode in fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Water from protected area; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Above 160°C (320° F) will react with combustible material and increase intensity of fire. Containers may explode; *Ignition Temperature (°F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Contact with most combustible materials may cause fires and explosions. Corrosive to most metals with formation of flammable hydrogen gas, which may collect in enclosed spaces; *Stability During Transport*: Unstable if heated; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute sodium bicarbonate or soda ash solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Perchloromethyl — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Very irritating vapors formed from hot material. May form toxic phosgene gas, hydrogen chloride and sulfur dioxide; *Behavior in Fire*: At elevated temperatures will decompose to carbon tetrachloride, sulfur chloride, and heavy oily polymers; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not

pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts only when hot to give carbon dioxide, hydrochloric acid, and sulfur; *Reactivity with Common Materials*: Reacts with iron or steel, evolving carbon tetrachloride. Corrosive to most metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Petrolatum — Fire Hazards: *Flash Point (deg. F):* 360 - 430 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Petroleum Naphtha — Fire Hazards: *Flash Point (deg. F):* 20 (approx.); *Flammable Limits in Air (%):* 0.9 - 6.0; *Fire Extinguishing Agents*: Foam carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 450 (approx.); *Electrical Hazard*: Not pertinent; *Burning Rate*: 4 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phenol — Fire Hazards: *Flash Point (deg. F):* 185 OC; 175 CC; *Flammable Limits in Air (%):* 1.7 - 8.6; *Fire Extinguishing Agents*: Water fog, dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating vapors are generated when heated; *Behavior in Fire*: Yields flammable vapors when heated which form explosive mixtures with air; *Ignition Temperature (deg. F)*: 1319; *Electrical Hazard*: Not pertinent; *Burning Rate*: 3.5 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phenyldichloroarsine, Liquid — Fire Hazards: *Flash Point (deg. F):* Data not available; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Highly toxic arsenic fumes are formed when hot; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Data not available; *Burning Rate*: 1.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Very slow reaction, considered non-hazardous. Hydrochloric acid is formed; *Reactivity with Common Materials*: Corrodes metals because of acid formed; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phenylhydrazine Hydrochloride — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products*: Toxic and irritating oxides of nitrogen and hydrogen chloride may form in fire; *Behavior in Fire*: The solid may sublime without melting and deposit on cool surfaces; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May be corrosive to metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosgene — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Water to cool containers; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic gas is generated when heated; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Decomposes, but not vigorously; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Can be absorbed in caustic soda solution. One ton of phosgene

requires 2,480 lbs. of caustic soda dissolved in 1000 gal. of water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphoric Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Mild evolution of heat; *Reactivity with Common Materials*: Reacts with metals to liberate flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, neutralize with lime; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphorus Oxychloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Sand and carbon dioxide on adjacent fires; *Fire Extinguishing Agents Not to be Used:* Water; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Poisonous, corrosive, irritating gases are generated when heated or when in contact with water; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Vigorous reaction with evolution of hydrogen chloride fumes; *Reactivity with Common Materials*: Corrosive to most metals except nickel and lead. Products of its reaction with water rapidly corrode steel and most metals with formation of flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, neutralize acids formed with lime or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphorus Pentasulfide — Fire Hazards: *Flash Point (deg. F):* Flammable solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Sand and carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water; *Special Hazards of Combustion Products*: Products of combustion include sulfur dioxide and phosphorus pentoxide, which are irritating, toxic and corrosive; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 527 (liquid); *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts with liquid water or atmospheric moisture to liberate toxic hydrogen sulfide gas; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Can be ignited by friction; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphorus, Red — Fire Hazards: *Flash Point (deg. F):* Flammable solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Heat may cause reversion to yellow phosphorus which is toxic and spontaneously flammable upon contact with air. Burning yields toxic oxides of phosphorus; *Behavior in Fire*: Refer to 6.5; *Ignition Temperature (deg. F)*: 395; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Avoid uncontrolled contact with oxidizing agents (chlorates, nitrates, halogens, etc.) or with strong alkaline hydroxides. Can react violently with oxidizing agent in presence of air and moisture, liberating phosphorus acids and toxic, spontaneously flammable phosphine gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphorus Tribromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Do not use water on adjacent fire; *Special Hazards of Combustion Products*: Irritating hydrogen bromide and phosphoric acid vapors may form in fire; *Behavior in Fire*: Acids formed by reaction with water will attack metals and generate flammable hydrogen gas, which may form explosive mixtures in enclosed spaces; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts violently with water, evolving hydrogen bromide, an irritating and corrosive gas apparent as white fumes; *Reactivity with Common Materials*: In the presence of moisture, highly corrosive to most metals except lead and nickel; *Stability During Transport*: Unstable if heated; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute aqueous sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphorus Trichloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):*

Not flammable; *Fire Extinguishing Agents*: Sand, carbon dioxide and dry chemicals on adjacent fires; *Fire Extinguishing Agents Not to be Used:* Water; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Generates toxic, irritating gases; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Reacts violently and may cause flashes of fire. Hydrochloric acid fumes are formed in the reaction; *Reactivity with Common Materials*: Corrodes most common construction materials. Reacts with water to form hydrochloric acid, which reacts with most metals to form flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; neutralize acids formed with lime or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phosphorus White — Fire Hazards: *Flash Point (deg. F):* Ignites spontaneously in air; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Fumes from burning phosphorus are highly irritating; *Behavior in Fire*: Intense white smoke is formed; *Ignition Temperature (deg. F)*: 86; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Ignites when exposed to air; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Phthalic Anhydride — Fire Hazards: *Flash Point (deg. F):* 329 OC; 305 CC; *Flammable Limits in Air (%):* 1.7 - 10.5; *Fire Extinguishing Agents*: Water fog, dry chemical, carbon dioxide, or foam; *Fire Extinguishing Agents Not to be Used:* Water may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1058; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: Solid has very slow reaction; no hazard. Liquid spatters when in contact with water; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Water and sodium bicarbonate; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Piperazine — Fire Hazards: *Flash Point (deg. F):* 225 OC (molten solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, "alcohol" foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may cause frothing; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fires; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: 851; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May be corrosive to aluminum, magnesium and zinc; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Polybutene — Fire Hazards: *Flash Point (deg. F):* 215 - 470 OC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Carbon dioxide, dry chemical, or foam; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Polychlorinated Biphenyl — Fire Hazards: *Flash Point (deg. F):* >286; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Irritating gases are generating in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Polymethylene Polyphenyl Isocyanate — Fire Hazards: *Flash Point (deg. F):* 425 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode; *Ignition Temperature (deg. F)*: Data not available; *Electrical*

Hazard: Not pertinent; *Burning Rate*: Data not available. **Chemical Reactivity**: *Reactivity with Water*: Reacts slowly, forming heavy scum and liberating carbon dioxide gas. Dangerous pressure can build up if container is sealed; *Reactivity with Common Materials*: No hazardous reaction unless confined and wet; *Stability During Transport*: Stable if kept sealed and dry; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Polyphosphoric Acid — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity**: *Reactivity with Water*: Reacts with water to generate heat and form phosphoric acid. The reaction is not violent; *Reactivity with Common Materials*: Reacts with metals to liberate flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, neutralize acid with lime or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Polypropylene — Fire Hazards: *Flash Point (deg. F):* Not pertinent (combustible solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Foam, dry chemical, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Data not available; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Polypropylene Glycol — Fire Hazards: *Flash Point (deg. F):* 390 - 495 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium, Metallic — Fire Hazards: *Flash Point (deg. F):* Not pertinent. This is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Graphite, sand, sodium chloride; *Fire Extinguishing Agents Not to be Used:* Water, foam, carbon dioxide, or halogenated hydrocarbons; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: Reacts violently with water, forming flammable and explosive hydrogen gas. This product may spontaneously ignite in air; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts violently forming flammable hydrogen gas and a strong caustic solution; *Reactivity with Common Materials*: May ignite combustible materials if they are damp or moist; *Stability During Transport*: Stable if protected from air and moisture; *Neutralizing Agents for Acids and Caustics:* Caustic that is formed by the reaction with water should be flushed with water and then can be rinsed with dilute acetic acid solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Arsenate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Binoxalate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Below 50°C product dissolves in

water and reacts to form the precipitate potassium tetraoxalate; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Cyanide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not flammable; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: When potassium cyanide dissolves in water, a mild reaction occurs and poisonous hydrogen cyanide gas is released. The gas readily dissipates, however if it collects in a confined space, then workers may be exposed to toxic levels. If the water is acidic, toxic amounts of the gas will form instantly; *Reactivity with Common Materials*: Contact with even weak acids will result in the formation of deadly hydrogen cyanide gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Dichloro-s-Triazinetrione — Fire Hazards: *Flash Point (deg. F):* Not flammable but may cause fires upon contact with ordinary combustibles; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: May form toxic chlorine and other gases in fires; *Behavior in Fire*: Decomposition can be initiated with a heat source and can propagate throughout the mass with the evolution of dense fumes. Containers may also explode when exposed to the heat from adjacent fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: A non violent reaction occurs resulting in the formation of a bleach solution; *Reactivity with Common Materials*: Contact with most foreign materials, organic matter, or easily chlorinated or oxidized materials may result in fire. Avoid contact with oils, greases, sawdust, floor sweepings, and other easily oxidized organic compounds; *Stability During Transport*: Stable if kept dry; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Dichromate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Flood the spill area with water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May decompose, generating oxygen and hence supports the combustion of other materials; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Ignition may occur when the product is in contact with finely divided combustibles, such as sawdust; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Hydroxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: Dissolves with the liberation of much heat. Steam and violent agitation can be observed in the reaction; *Reactivity with Common Materials*: When wet, this material attacks metals such as aluminum, tin, lead, and zinc, producing flammable hydrogen gas; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with a dilute solution of acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Iodide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Corrosive in all concentrations to most metals, except stainless steels, titanium, and tantalum; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Oxalate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Loses water at about 160°C and decomposes to carbonate with no charring. The reaction is considered non hazardous; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Permanganate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Flood spill area with water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May cause fire on contact with combustibles. Also containers may e; *Ignition Temperature (deg. F)*: Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Attacks rubber and most fibrous materials. May cause ignition of organic materials such as wood. Some acids, suchas sulfufic acid, may result in explosion; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Potassium Peroxide — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Flood with water from a protected area; *Fire Extinguishing Agents Not To Be Used:* A small amount of water may cause an explosion; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* Increases intensity of fire and can start fires when in contact with organic materials; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently with liberation of heat and oxygen and the formation of caustic solution; *Reactivity with Common Materials:* Forms explosive and self-igniting mixtures with wood and other combustible materials; *Stability During Transport:* Stable if kept dry; *Neutralizing Agents for Acids and Caustics:* Following the reaction with water, the caustic solution formed can be flushed away with water and area rinsed with dilute acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Propane — Fire Hazards: *Flash Point (deg. F)*: -156 CC; *Flammable Limits in Air (%):* 2.1 - 9.5; *Fire Extinguishing Agents:* Stop the flow of gas. For small fires, use dry chemicals. Cool adjacent areas with water spray; *Fire Extinguishing Agents Not To Be Used:* Water; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode. Vapor is heavier than air and can travel considerable distances to a source of ignition and flash back; *Ignition Temperature (deg. F):* 842; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 8.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common* Materials: No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

beta-Propiolactone — Fire Hazards: *Flash Point (deg. F)*: 165 CC; *Flammable Limits in Air (%):* 2.9 (LEL); *Fire Extinguishing Agents:* Water, dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Vapors of unburned material are highly toxic; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* A slow, non-hazardous reaction occurs forming beta-hydroxypropionic acid; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Can polymerize and rupture containers especially at elevated temperatures. At 22°C, approximately 0.04 % polymerizes per day; *Inhibitor of Polymerization:* None reported in the literature.

Propionaldehyde — Fire Hazards: *Flash Point (deg. F)*: -22 OC; *Flammable Limits in Air (%):* 2.6 - 16.1; *Fire Extinguishing Agents:* On small fires use carbon dioxide or dry chemical. For large fires use alcohol type foam; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to source of ignition and flash back; *Ignition Temperature (deg. F):* 405; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction;

Reactivity with Common Materials: No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerizes in the presence of acids and caustics; *Inhibitor of Polymerization:* Not pertinent.

Propionic Acid — Fire Hazards: *Flash Point (deg. F):* 134 OC, 130 CC; *Flammable Limits in Air (%):* 2.9 - 14.8; *Fire Extinguishing Agents:* Water, carbon dioxide, dry chemical, or alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 1105; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrodes ordinary steel and many other metals. Reaction is non-violent and generally not hazardous; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Dilute with water then neutralize with lime solution or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Propionic Anhydride — Fire Hazards: *Flash Point (deg. F):* 136 OC, 145 CC; *Flammable Limits in Air (%):* 1.48 - 11.9; *Fire Extinguishing Agents:* Water, dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 545; *Electrical Hazard:* No data; *Burning Rate:* 3.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly forming weak propionic acid. The reaction is non-violent and non-hazardous; *Reactivity with Common Materials:* Slowly forms a corrosive material if wet; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

n-Propyl Acetate — Fire Hazards: *Flash Point (deg. F):* 58 CC, 65 OC; *Flammable Limits in Air (%):* 2.0 - 8.0; *Fire Extinguishing Agents:* For small fires use carbon dioxide or dry chemical. For large fires, use alcohol foam; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 842; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

n-Propyl Alcohol — Fire Hazards: *Flash Point (deg. F):* 81 OC, 77 CC; *Flammable Limits in Air (%):* 2.1 - 13.5; *Fire Extinguishing Agents:* Carbon dioxide for small fires, and alcohol foam for large fires; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 700; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 2.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Propylene — Fire Hazards: *Flash Point (deg. F):* -162 CC; *Flammable Limits in Air (%):* 2.0 - 11; *Fire Extinguishing Agents:* Stop the flow of gas; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode. Vapors are heavier than air and can travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 927; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 8 mm/min as liquid. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Propylene Glycol — Fire Hazards: *Flash Point (deg. F):* 210 CC, 225 OC; *Flammable Limits in Air (%):* 2.6 - 12.5; *Fire Extinguishing Agents:* Water fog, alcohol foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 790; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.5 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Propylene Oxide — Fire Hazards: *Flash Point (deg. F):* -35 CC, -20 OC; *Flammable Limits in Air (%):* 2.1 - 38.5; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical

for small fires. Alcohol or polymer foam for large fires.; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may explode. Vapors are heavier than air and can travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 869; *Electrical Hazard:* Class I, Group B; *Burning Rate:* 3.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization can occur when this product is exposed to high temperatures or is contaminated with alkalies, aqueous acids, amines, and acidic alcohols; *Inhibitor of Polymerization:* Not pertinent.

Propylene Tetramer — Fire Hazards: *Flash Point (deg. F):* 120 CC, 134 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water fog, foam, carbon dioxide or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 400; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Propyleneimine, Inhibited — Fire Hazards: *Flash Point (deg. F):* 25 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may be ineffective; *Special Hazards of Combustion Products:* Irritating nitrogen oxides are generated in fires; *Behavior in Fire:* Containers may explode when exposed to heat; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* 4.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* A slow, non-hazardous reaction occurs, forming propanolamine; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* The product is stable if it is kept in contact with solid caustic soda (sodium hydroxide); *Neutralizing Agents for Acids and Caustics:* Dilute with water and rinse with vinegar solution; *Polymerization:* This material will polymerize explosively when in contact with any acid; *Inhibitor of Polymerization:* Solid sodium hydroxide (caustic soda).

n-Propyl Mercaptan — Fire Hazards: *Flash Point (deg. F):* 5 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic vapors of sulfur dioxide are generated; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* 5.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Pyridine — Fire Hazards: *Flash Point (deg. F):* 68 CC; *Flammable Limits in Air (%):* 1.8 - 12.4; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 900; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 4.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Pyrogallic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reactions; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Q

Quinoline — Fire Hazards: *Flash Point (deg. F):* 225 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water, dry chemical, foam, or

carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen form in fires; *Behavior in Fire:* Exposure to heat can result in pressure build-up in closed containers, resulting in bulging or even explosion; *Ignition Temperature (deg. F):* 896; *Electrical Hazard:* No data; *Burning Rate:* 4.1 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Attacks some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

S

Salicylic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Application of water or foam may cause frothing; *Special Hazards of Combustion Products:* Irritating vapors of unburned product and phenol form during fires; *Behavior in Fire:* This product sublimes and forms vapor or dust that can explode; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Selenium Dioxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* This product sublimes and forms toxic vapors when heated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* In presence of water will corrode most metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Selenium Trioxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously with water forming selenic acid solution; *Reactivity with Common Materials:* Corrodes all metals in the presence of water; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silicon Tetrachloride - Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Do not apply water or foam on adjacent fires; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Contact with water or foam applied to adjacent fires results in the formation of toxic and irritating fumes of hydrogen chloride; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously with water forming hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* In the presence of moisture, will corrode metals. The reaction is generally non-hazardous; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Carbonate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not

flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Decomposes to silver oxide, silver, and carbon dioxide. The reaction is non violent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Fluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Iodate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Increases the flammability of combustible materials; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Oxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Decomposes into metallic silver and oxygen. If large amounts of the product are involved in a fire, the oxygen liberated may increase the intensity of the fire; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Silver Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium — Fire Hazards: *Flash Point (deg. F):* Not pertinent; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry soda ash, graphite, salt, or other approved dry powder such as dry limestone; *Fire Extinguishing Agents Not To Be Used:* Water, carbon dioxide, or halogenated extinguishing agents; *Special Hazards of Combustion Products:* The fumes of burning sodium are highly irritating to the eyes, skin, and mucous membranes.; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 250; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Sodium reacts violently with water, forming flammable hydrogen gas, and caustic soda solution. Fire often accompanies the reaction; *Reactivity with Common Materials:* No reactions; *Stability*

During Transport: Stable; *Neutralizing Agents for Acids and Caustics:* After the reaction with water, the caustic soda formed as a by-product can be diluted with water and then neutralized with acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Alkylbenzenesulfonates — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Irritating vapors form in fires; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Alkyl Sulfates — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating vapors are generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Amide — Fire Hazards: *Flash Point (deg. F):* Flammable solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry soda ash, graphite, salt, or other recommended dry powder such as dry limestone; *Fire Extinguishing Agents Not To Be Used:* Water; *Special Hazards of Combustion Products:* Toxic and irritating ammonia gas may be formed in fires; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* No data; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently and often bursts into flames. Also forms caustic soda solution; *Reactivity with Common Materials:* No data; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* The caustic solution formed by the reaction with water can be diluted with water and then neutralized by acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Arsenate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* No information; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Arsenite — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic arsenic fumes may form. The use of self-contained breathing apparatus (SCBA) is recommended; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Azide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* May form toxic hydrazoic acid fumes in fires; *Behavior in Fire:* Containers may explode; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Dissolves to form an alkaline solution. The reaction is non-violent; *Reactivity with Common Materials:* Forms explosion-sensitive materials with some metals such as lead, silver, mercury, and copper; *Stability During Transport:* Stable but must not be in contact with acids; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Bisulfite — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Borate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* The compound melts into a glassy material that may flow in large quantities and ignite combustible materials it comes in contact with; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Borohydride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Graphite, limestone, soda ash, sodium chloride powders; *Fire Extinguishing Agents Not To Be Used:* Water, carbon dioxide, or halogenated extinguishing agents; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Decomposes and produces highly flammable hydrogen gas; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts to form flammable hydrogen gas; *Reactivity with Common Materials:* Reacts with acids to form toxic, flammable diborane gas. Slowly attacks and destroys glass; *Stability During Transport:* Stable unless contaminated with acids or is overheated, thereby forming flammable hydrogen gas; *Neutralizing Agents for Acids and Caustics:* Caustic formed by the reaction with water can be diluted with water and then neutralized with acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Cacodylate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Arsenic containing fumes are formed in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrodes many common metals but the reaction is non-hazardous; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Chlorate — Fire Hazards: *Flash Point (deg. F):* Not flammable but the product will support combustion; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Fire blankets; *Special Hazards of Combustion Products:* In fire situations, oxygen is liberated which can increase the intensity of fires; *Behavior in Fire:* The product melts and then decomposes giving off oxygen gas that increases the intensity of fires. This product reacts explosively, either as a solid or liquid with all organic matter and some metals; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Chlorates are powerful oxidizing agents and can cause explosions when heated or rubbed with wood, organic matter, sulfur, and many metals. Even water solutions react in this manner if the solution is more than 30% concentrated, especially when warm; *Stability During Transport:* This product begins decomposing at 572 of with the evolution of oxygen gas. The decomposition may become self-sustaining. Oxygen liberation will increase the intensity of fires; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Chromate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic chromium oxide fumes may form in fires; *Behavior in Fire:* Can increase the intensity of fires when in contact with

combustible materials; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Causes fire when in contact with combustible materials; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Cyanide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* When sodium cyanide dissolves in water, a mild reaction occurs and some poisonous hydrogen cyanide gas is liberated. The gas is not generally a concern unless it is generated in an enclosed space. If the water is acidic, then large amounts of the toxic gas forms rapidly; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Dichromate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Flood with large amounts of water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Decomposes to produce oxygen upon heating. May ignite other combustibles upon contact; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* When in contact with finely divided combustibles, such as sawdust, ignition may occur; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Ferrocyanide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Flood with large amounts of water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Decomposes to produce oxygen upon heating. May ignite other combustibles upon contact; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* When in contact with finely divided combustibles, such as sawdust, ignition may occur; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Hydride — Fire Hazards: *Flash Point (deg. F):* Oil is flammable; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Powdered limestone and nitrogen-propelled dry powder; *Fire Extinguishing Agents Not To Be Used:* Water, soda ash, chemical foam, or carbon dioxide; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Accidental contact with water used to extinguish surrounding fires will result in the release of hydrogen gas and possible explosion; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously with water with the release of flammable hydrogen gas; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable at temperatures below 225 °C; *Neutralizing Agents for Acids and Caustics:* Neutralize only when accidental reaction with water is complete. Do not neutralize the flammable solid with aqueous solutions. Spent reaction solution may be neutralized with dilute solutions of acetic acid.; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Hydrosulfide Solution — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Corrodes most metals, but the reactions are generally non-hazardous; *Stability During Transport:* No reaction; *Neutralizing Agents for Acids and Caustics:* Flood with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Hydroxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Dissolves with the liberation of considerable heat. The reaction violently produces steam and agitation; *Reactivity with Common Materials:* When wet, attacks metals such as aluminum , tin, lead, and zinc to produce flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water, rinse with dilute acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Hypochlorite — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May decompose, generating irritating chlorine gas; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Destroy with sodium bisulfite or hypo and water, then neutralize with soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Methylate — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a flammable solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, inert powders such as sand or limestone, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Contact with water or foam adjacent to fires will produce flammable mathanol; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Produces a caustic soda solution and a solution of methyl alcohol. The reaction is not violent; *Reactivity with Common Materials:* Attacks some polymers such as nylon and polyesters; *Stability During Transport:* Stable if kept dry; *Neutralizing Agents for Acids and Caustics:* Water followed by dilute acetic acid or vinegar; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Nitrite — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may intensify fires; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Apply large amounts of water to adjacent fires. Cool exposed containers with water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen may form in fires; *Behavior in Fire:* May increase the intensity of fires if the chemical is in contact with combustible materials. This product may melt and flow at elevated temperatures; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Oxalate -Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Phosphate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May melt with the loss of steam; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* All variations or grades of this chemical readily dissolve in water. ASPP and MSP form weakly acidic solutions. TSP forms a strong caustic solution, similar to soda lye: TSPP forms weekly alkali solution; *Reactivity with Common Materials:* When wet, MSP, ASPP, and TSP corrodes mild steel or brass. Others are not considered corrosive; *Stability During Transport:* All forms of sodium phosphate are stable. TSP tends to be hygroscopic and will form a hard cake; *Neutralizing Agents for Acids and Caustics:* For those grades of sodium hydroxide that form acidic or alkali solutions, dilution by

water is recommended; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Silicate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Silicofluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Decomposes at red heat; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Sulfide — Fire Hazards: *Flash Point (deg. F):* Moderately flammable solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating fumes of sulfur dioxide are generated in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Sulfite — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sodium Thiocyanate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating oxides of sulfur and nitrogen form in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sorbitol — Fire Hazards: *Flash Point (deg. F):* 542; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not data; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Stearic Acid — Fire Hazards: *Flash Point (deg. F):* 410 – 435 OC, 365 CC (as molten solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* 743; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Styrene — Fire Hazards: *Flash Point (deg. F)*: 93 OC, 88 CC; *Flammable Limits in Air (%):* 1.1 - 6.1; *Fire Extinguishing Agents:* Water fog, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. At elevated temperatures as under fire conditions, polymerization may occur, resulting in containers exploding; *Ignition Temperature (deg. F):* 914; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 5.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization can occur if the product's temperature is raised above 150 of. This can cause the rupture of containers. Avoid contact with metal salts, peroxides, and strong acids, which can cause polymerization to occur; *Inhibitor of Polymerization:* Tertiarybutylcatechol (10 ~ 15 ppm).

Sucrose — Fire Hazards: *Flash Point (deg. F)*: Not pertinent; this is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating fumes may form in fire situations; *Behavior in Fire:* The product melts and chars; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sulfolane — Fire Hazards: *Flash Point (deg. F)*: 330 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water, foam, dry chemicals, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases may form in fire situations; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sulfur Dioxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Containers may rupture, releasing toxic and irritating sulfur dioxide; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts non-violently with water to form corrosive acid; *Reactivity with Common Materials:* Corrodes aluminum; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* The mild acidity of water solution may be neutralized by dilute caustic soda; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sulfuric Acid — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Water used on adjacent fires should be carefully handled; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not flammable; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* None; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently with the evolution of heat (exothermic reaction). Significant agitation and spattering occurs when water is added to the chemical; *Reactivity with Common Materials:* Sulfuric acid is extremely hazardous in contact with many materials, particularly metals and combustibles. Dilute acid reacts with most metals, releasing hydrogen which can form explosive mixtures with air in confined spaces; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Dilute with large amounts of water, then neutralize with lime, limestone, or soda ash; *Polymerization:* Not flammable; *Inhibitor of Polymerization:* Not flammable.

Sulfuric Acid, Spent — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction, unless strength is above 80 ~ 90 %, in which case an exothermic reaction will occur. See sulfuric acid; *Reactivity with Common Materials:* Attacks many metals, releasing flammable

hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Neutralize with limestone, lime, or soda ash after further dilution with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sulfur (Liquid) — Fire Hazards: *Flash Point (deg. F):* 405 CC; for recovered sulfur, see hydrogen sulfide; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Produces toxic sulfur dioxide gas; *Behavior in Fire:* Burns with a pale blue flame that is often difficult to see in daylight; *Ignition Temperature (deg. F):* 450 (for recovered sulfur, refer to hydrogen sulfide); *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No hazardous reactions noted; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sulfur Monochloride — Fire Hazards: *Flash Point (deg. F):* 245 CC, 266 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide, or water spray; *Fire Extinguishing Agents Not To Be Used:* Water reacts violently with this chemical; *Special Hazards of Combustion Products:* Toxic and corrosive fumes evolve upon heating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 453; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently with water generating considerable heat and hydrogen chloride fumes. The resulting solution is a strong acid; *Reactivity with Common Materials:* As a liquid, it dissolves rubbers and plastics. After the reaction with water, the strong acid will attack metals, generating flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* After reaction with water, the acid formed can be neutralized with lime or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Sulfuryl Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Water applied to adjacent fires should be handled carefully; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Toxic and irritating gases will form in fire situations; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously with water, releasing hydrogen chloride fumes and forming corrosive sulfuric acid; *Reactivity with Common Materials:* Acids formed by the reaction with moisture corrode metals and liberate flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Acid formed by the reaction with water can be neutralized by limestone, lime, or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

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Tallow — Fire Hazards: *Flash Point (deg. F):* 509; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, water, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water or foam can cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tallow Fatty Alcohol — Fire Hazards: *Flash Point (deg. F):* > 270 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tannic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a combustible solid; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* This product decomposes at about 210 of to carbon dioxide and

pyrogallol, which can form highly irritating vapors; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* 980; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4,5-T (Esters) — Fire Hazards: *Flash Point (deg. F):* 265 ~ 420 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Hydrogen chloride gas as well as other irritating fumes may form in fire situations; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Incompatible with some plastics and elastomers; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Terabutyl Titanate — Fire Hazards: *Flash Point (deg. F):* 170 CC; *Flammable Limits in Air (%):* 2 - 12; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* May give off a dense white smoke. Containers may explode; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* 3.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts to form butanol and titanium dioxide. The reaction is non-violent; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetrachloroethane — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating hydrogen chloride vapor can form in fire situations; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Attacks some forms of plastics and elastomers; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetrachloroethylene — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating vapors may form in fire situations; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetradecanol — Fire Hazards: *Flash Point (deg. F):* 285 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Tetradecene — Fire Hazards: *Flash Point (deg. F):* 230 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 455; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetradecylbenzene — Fire Hazards: *Flash Point (deg. F):* No data; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon

dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.4 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetraethyl Dithiopyrophosphate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic phosphorous and sulfur oxides are formed in fire situations; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* A slow reaction occurs forming non-hazardous by-products; *Reactivity with Common Materials:* Corrosive to most metals in the presence of moisture; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetraethylene Glycol — Fire Hazards: *Flash Point (deg. F):* 360 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* No data; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics and elastomers; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetraethylenepentamine — Fire Hazards: *Flash Point (deg. F):* 340 OC; *Flammable Limits in Air (%):* 0.8 - 4.6; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Ammonia and toxic oxides of nitrogen may form in fires; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* 572; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics and elastomers; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetraethyl Lead — Fire Hazards: *Flash Point (deg. F):* 200 CC, 185 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic gases are generated in fire situations; *Behavior in Fire:* Product may explode in fires; *Ignition Temperature (deg. F):* Decomposes at temperatures above 230 of; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Contact with rust and some metals can cause decomposition of the product; *Stability During Transport:* The product is stable at temperatures below 230 of. At higher temperatures, the product may detonate or explode when confined; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetraethyl Pyrophosphate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Highly toxic gases and vapors of unburned material and phosphoric acid are formed in fire situations; *Behavior in Fire:* Water streams applied to adjacent fires will spread the contamination of this pesticide over a wide area; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly to form phosphoric acid; *Reactivity with Common Materials:* Corrosive to aluminum; slowly corrosive to copper, brass, zinc, and tin; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and then rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetrafluoroethylene, Inhibited — Fire Hazards: *Flash Point (deg. F):* Not pertinent (gas); *Flammable Limits in*

Air (%): 10 - 50; *Fire Extinguishing Agents:* Allow fire to burn itself out; stop the flow of gas if practicable; cool containers with water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* When burned in air, the gas forms toxic carbonyl fluoride and hydrogen fluoride; *Behavior in Fire:* Vapor is heavier than air and can travel distances to a source of ignition and flash back. Containers may explode; *Ignition Temperature (deg. F):* 370; *Electrical Hazard:* C_2F_4-air mixtures produce explosions which propagate through the smallest clearances. Product does not meet any group classification; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Can polymerize in the absence of inhibitor, especially when heated or in the presence of air; *Inhibitor of Polymerization:* d-limonene; pinene; tetrahydronaphthalene; 1-octene; methyl methacrylate.

Tetrahydrofuran — Fire Hazards: *Flash Point (deg. F):* 6 CC, -4 OC; *Flammable Limits in Air (%):* 1.8 - 11.8; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Irritating vapors are generated upon heating; *Behavior in Fire:* Product may explode. Vapor is heavier than air and can travel distances to a source of ignition and flash back; *Ignition Temperature (deg. F):* 610; *Electrical Hazard:* Not pertinent; *Burning Rate:* 4.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable unless about 0.1% of peroxides has accumulated because of prolonged storage in the presence of air. When concentrated by evaporation of solution, the product can explode; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* 0.025 % butylated hydroxytoluene (BHT) present to prevent peroxide formation.

Tetrahydronaphthalene — Fire Hazards: *Flash Point (deg. F):* 176 CC, 190 OC; *Flammable Limits in Air (%):* 0.8 - 5.0; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Avoid contact with water; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 725; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tetramethyl Lead — Fire Hazards: *Flash Point (deg. F):* 100 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic gases are generated in fires; *Behavior in Fire:* May explode; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* The product starts to decompose at around 212 of. If the decomposition occurs in a confined space, an explosion hazard can exist; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Thiophosgene — Fire Hazards: *Flash Point (deg. F):* No data; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic phosgene, hydrogen chloride, and sulfur dioxide may form in fire situations; *Behavior in Fire:* Product decomposes at temperatures above 200 °C to carbon bisulfide, which is extremely flammable, and carbon tetrachloride; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* In cold water, a slow reaction occurs forming hydrogen chloride, carbon disulfide, and carbon dioxide. In hot water, the reaction is accelerated; *Reactivity with Common Materials:* Corrodes metals in the presence of moisture; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization* Not pertinent.

Thiram — Fire Hazards: *Flash Point (deg. F):* Not pertinent (solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating oxides of sulfur are formed. Carbon disulfide may be formed from unburned material; *Behavior in Fire:* Not pertinent; *Ignition Temperature*

(deg. F): No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Thorium Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable, but may cause fire on contact with ordinary combustibles; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Releases toxic gaseous oxides of nitrogen in fire situations; *Behavior in Fire:* When large amounts of this product are involved in a fire situation, nitrate may fuse or melt, in which condition the application of water may result in extensive scattering of the molten material. The result is also an increase in the intensity of the fire; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* A non-violent reaction occurs, forming a weak solution of nitric acid; *Reactivity with Common Materials:* In the presence of easily oxidizable materials, may react rapidly causing possible ignition, violent combustion, or an explosion. Solutions in water are acidic and can corrode metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Titanium Tetrachloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Dry powder or carbon dioxide on adjacent fires; *Fire Extinguishing Agents Not To Be Used:* Do not use water if it can directly contact this chemical; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* If containers leak, a very dense white fume can form and obscure operations; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not flammable. **Chemical Reactivity:** *Reactivity with Water:* Reacts with moisture in air forming a dense white fume. Reaction with liquid water gives off heat and forms hydrochloric acid; *Reactivity with Common Materials:* The acid formed by reaction with moisture attacks metals, forming flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Acid formed by the reaction with water can be neutralized by limestone, lime, or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Toluene — Fire Hazards: *Flash Point (deg. F):* 40 CC, 55 OC; *Flammable Limits in Air (%):* 1.27 - 7.0; *Fire Extinguishing Agents:* Carbon dioxide or dry chemical for small fire; ordinary foam for large fires; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapors are heavier than air and may travel considerable distances to a source of ignition and flash back; *Ignition Temperature (deg. F):* 997; *Electrical Hazard:* Class I, Group D; *Burning Rate:* 5.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Toluene 2,4-Diisocyanate — Fire Hazards: *Flash Point (deg. F):* 270 OC; *Flammable Limits in Air (%):* 0.9 - 9.5; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Irritating vapors are generated upon heating; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* > 300; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* A non violent reaction occurs forming carbon dioxide gas and an organic base; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Slow polymerization occurs at temperatures above 113 of. The reaction is not hazardous; *Inhibitor of Polymerization:* Not pertinent.

p-Toluenesulfonic Acid — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a solid with low flammability; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Irritating oxides of sulfur may be formed; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* This is a strong acid that can react with common materials; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

o-Toluidine — Fire Hazards: *Flash Point (deg. F)*: 167 OC, 85 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic oxides of nitrogen and flammable vapors may form; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* 900; *Electrical Hazard:* No data; *Burning Rate:* 3.6 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Toxaphene — Fire Hazards: *Flash Point (deg. F)*: 84 CC (solution); *Flammable Limits in Air (%):* 1.1 - 6.4; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Toxic vapors are generated when heated; *Behavior in Fire:* Solution in xylene may produce corrosive products when heated; *Ignition Temperature (deg. F):* 986 (solution); *Electrical Hazard:* Not pertinent; *Burning Rate:* 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trichloroethane — Fire Hazards: *Flash Point (deg. F)*: No data; *Flammable Limits in Air (%):* 7 - 16; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating gases are formed in fire situations; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 932; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.9 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts slowly to form corrosive hydrochloric acid; *Reactivity with Common Materials:* Corrodes aluminum. The reaction is non-hazardous; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trichloroethylene — Fire Hazards: *Flash Point (deg. F)*: 90 CC; practically nonflammable; *Flammable Limits in Air (%):* 8.0 - 10.5; *Fire Extinguishing Agents:* Water fog; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and irritating vapors are produced in fire situations; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 770; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reaction; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trichlorofluoromethane — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Produces toxic and irritating vapors when heated to its decomposition temperature; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trichlorophenol — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:*; *Special Hazards of Combustion Products:*; *Behavior in Fire:*; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

2,4,5-Trichlorophenoxy Acetic Acid — Fire Hazards: *Flash Point (deg. F)*: Not pertinent (solid); *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene gases; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* Can be corrosive to common metals; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trichlorosilane — Fire Hazards: *Flash Point (deg. F):* -18 OC, > -58 CC; *Flammable Limits in Air (%):* 1.2 - 90.5; *Fire Extinguishing Agents:* Dry chemical, carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and phosgene gases may form; *Behavior in Fire:* Difficult to extinguish; reignition may occur. Also, vapor is heavier than air and can travel to a source of ignition and flash back; *Ignition Temperature (deg. F):* 220; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form hydrogen chloride fumes (hydrochloric acid); *Reactivity with Common Materials:* Reacts with surface moisture to form hydrochloric acid which corrodes metals and generates flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trichloro-s-Triazinetrione — Fire Hazards: *Flash Point (deg. F):* Not flammable but may cause fire on contact with ordinary combustible materials; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water in large amounts; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic chlorine or nitrogen trichloride may be formed in fires; *Behavior in Fire:* Containers may explode when heated; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* A non-hazardous reaction occurs forming a bleach solution; *Reactivity with Common Materials:* Contact with most foreign material, organic matter, or easily chlorinated or oxidized materials may result in fires. Avoid contacting this product with oil, sawdust, floor sweepings, other easily oxidized organic compounds; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tricresyl Phosphate — Fire Hazards: *Flash Point (deg. F):* 410 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tridecanol — Fire Hazards: *Flash Point (deg. F):*250 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Alcohol, dry chemical, water fog; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

1-Tridecene — Fire Hazards: *Flash Point (deg. F):* 175 (est.); *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triethanolamine — Fire Hazards: *Flash Point (deg. F):* 355 CC, 375 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Dilute with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triethylaluminum — Fire Hazards: *Flash Point (deg. F):* Spontaneously ignites in air at all temperatures; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Inert powders such as limestone or sand, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water, foam, halogenated extinguishing agents; *Special Hazards of Combustion Products:* Intense smoke

may cause metal-fume fever; *Behavior in Fire:* Dense smoke of aluminum oxide is formed. Contact with water on adjacent fires causes violent reaction producing toxic and flammable gases; *Ignition Temperature (deg. F):* Not pertinent - product spontaneously ignites at ambient temperature; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form flammable ethane gas; *Reactivity with Common Materials:* No significant reactions reported; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triethylamine — Fire Hazards: *Flash Point (deg. F):* 20 OC; *Flammable Limits in Air (%):* 1.2 - 8.0; *Fire Extinguishing Agents:* Carbon dioxide or dry chemicals for small fires; alcohol foam for large fires; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 842; *Electrical Hazard:* Not pertinent; *Burning Rate:* 6.2 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Dilute with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triethylbenzene — Fire Hazards: *Flash Point (deg. F):* 181 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triethylene Glycol — Fire Hazards: *Flash Point (deg. F):* 350 CC, 330 OC; *Flammable Limits in Air (%):* 0.9 - 9.2; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 700; *Electrical Hazard:* Not pertinent; *Burning Rate:* 1.7 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triethylenetetramine — Fire Hazards: *Flash Point (deg. F):* 275 CC, 290 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents:* Dry chemical, alcohol foam, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Application of water or foam may cause frothing; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* 640; *Electrical Hazard:* Not pertinent; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* After dilution with water, can be stabilized with acetic acid; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trifluorochloroethylene — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a gas; *Flammable Limits in Air (%):* 16 - 34; *Fire Extinguishing Agents:* Let fire burn; stop the flow of gas; cool containers with water; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic hydrogen chloride and hydrogen fluoride gases are formed; *Behavior in Fire:* Vapor is heavier than air and can travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization can occur; *Inhibitor of Polymerization:* Terpenes or Tributylamine (1%).

Trifluralin — Fire Hazards: *Flash Point (deg. F):* > 185 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Toxic and hazardous hydrogen fluoride gas may be formed in fires; *Behavior in Fire:* Not pertinent; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction;

Reactivity with Common Materials: No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Triisobutylaluminum — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this product ignites spontaneously; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents:* Inert powder such as sand or limestone, or dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water, foam, halogenated extinguishing agents; *Special Hazards of Combustion Products:* Dense smoke may cause metal-fume fever; *Behavior in Fire:* Dense smoke of aluminum oxide forms in fires; *Ignition Temperature (deg. F):* Ignites spontaneously under ambient conditions; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* Reacts violently to form flammable hydrocarbon gases; *Reactivity with Common Materials:* Not compatible with silicone rubber or urethane rubbers; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trimethylamine — Fire Hazards: *Flash Point (deg. F):* Not pertinent; this is a gas; *Flammable Limits in Air (%):* 2.0 - 11.6; *Fire Extinguishing Agents:* Stop flow of gas. Use water, alcohol foam, dry chemical, or carbon dioxide on water solution fires; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F):* 374; *Electrical Hazard:* Not pertinent; *Burning Rate:* 8.0 mm/min. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Although water solutions may be neutralized with acetic acid, simple evaporation will remove all the compound; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Trimethylchlorosilane — Fire Hazards: *Flash Point (deg. F):* 0 OC; *Flammable Limits in Air (%):* 1.8 (LEL); *Fire Extinguishing Agents:* Dry chemical; *Fire Extinguishing Agents Not To Be Used:* Water, foam; *Special Hazards of Combustion Products:* Toxic and irritating hydrogen chloride and phosgene may form in fires; *Behavior in Fire:* Difficult to extinguish; material easily re-ignites. Contact with water on adjacent fires should be avoided as irritating and toxic hydrogen chloride gas will form; *Ignition Temperature (deg. F):* 743; *Electrical Hazard:* No data; *Burning Rate:* 5.3 mm/min. **Chemical Reactivity:** *Reactivity with Water:* Reacts vigorously forming hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials:* Reacts with surface moisture evolving hydrogen chloride, which will corrode common metals and form flammable hydrogen gas; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tripropylene Glycol — Fire Hazards: *Flash Point (deg. F):* 285 OC; *Flammable Limits in Air (%):* 0.8 - 5.0; *Fire Extinguishing Agents:* Alcohol foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not To Be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Acrid fumes of acids and aldehydes may form in fires; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* No data; *Electrical Hazard:* No data; *Burning Rate:* No data. **Chemical Reactivity:** *Reactivity with Water:* No reaction; *Reactivity with Common Materials:* May attack some forms of plastics and elastomers; *Stability During Transport:* Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

Tris(Aziridinyl)Phosphine Oxide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents:* Not pertinent; *Fire Extinguishing Agents Not To Be Used:* Not pertinent; *Special Hazards of Combustion Products:* Phosphoric acid mist may form in fires. Toxic oxide of nitrogen may form; *Behavior in Fire:* No data; *Ignition Temperature (deg. F):* Not pertinent; *Electrical Hazard:* Not pertinent; *Burning Rate:* Not pertinent. **Chemical Reactivity:** *Reactivity with Water:* No reaction unless in the presence of acids and caustics; *Reactivity with Common Materials:* Slow decomposition occurs, but generally the reactions are not hazardous; *Stability During Transport:* Stable if cool; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Violent, exothermic polymerization occurs at about 225 of. Acid fumes will also cause polymerization at ordinary temperatures; *Inhibitor of Polymerization:* None reported.

Turpentine— Fire Hazards: *Flash Point (deg. F):* 95 CC; *Flammable Limits in Air (%):* 0.8 (LEL); *Fire Extinguishing Agents:* Foam, dry chemical, or carbon

dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products:* Not pertinent; *Behavior in Fire:* Forms heavy black smoke and soot; *Ignition Temperature (deg. F):* 488; *Electrical Hazard:* Not pertinent; *Burning Rate:* 2.4 mm/min. **Chemical Reactivity:** *Reactivity with Water* No reaction; *Reactivity with Common Materials:* No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization:* Not pertinent.

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Undecanol — Fire Hazards: *Flash Point (deg. F):* 200 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents*: Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

1-Undecene — Fire Hazards: *Flash Point (deg. F):* 160 OC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*:;Not pertinent *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: 4.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

n-Undecylbenzene — Fire Hazards: *Flash Point (deg. F)*: 285 CC; *Flammable Limits in Air (%):* No data; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: No data. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: May attack some forms of plastics; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Stable; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Uranyl Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Dissolves and reacts producing a milky like solution. The reaction is non hazardous; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Uranyl Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable but may cause fire on contact with combustible materials; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Apply flooding amounts of water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen are formed in fires; *Behavior in Fire*: Intensifies fires. When large quantities are involved, nitrate may fuse or melt. The application of water may then cause extensive scattering of the molten material; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Dissolves in water forming a weak solution of nitric acid. The reaction is nonhazardous; *Reactivity with Common Materials*: When in contact with easily oxidizable materials, this chemical may react rapidly enough to cause ignition, violent combustion, or explosion. Water solutions are acidic and can corrode metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization*: Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Uranyl Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: No data; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*:

No data; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Urea — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Melts and decomposes, generating ammonia; *Ignition Temperature (deg. F):* Not flammable; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not flammable. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Occurs only above melting point (132 °C), yielding ammonia and other products. The decomposition is not explosive; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Urea Peroxide — Fire Hazards: *Flash Point (deg. F)*: Not pertinent. This is a combustible solid that may cause fire upon contact with ordinary combustible materials; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Inert powders such as sand and limestone, or water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Irritating ammonia gas may be formed in fires; *Behavior in Fire*: Melts and decomposes, giving off oxygen and ammonia. Increases the severity of fires. Containers may explode; *Ignition Temperature (deg. F)*: > 680; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Forms solution of hydrogen peroxide. The reaction is nonhazardous; *Reactivity with Common Materials*: There are no significant reactions under ordinary conditions and temperatures. At 50 °C (122 of) the chemical reacts with dust and rubbish; *Stability During Transport*: Stable below 60 °C (140 of); *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

V

Valeraldehyde — Fire Hazards: *Flash Point (deg. F)*: 54 OC; *Flammable Limits in Air (%)*: No data; *Fire Extinguishing Agents*: Foam, dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: Not pertinent; *Burning Rate*: 1.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Vanadium Oxytrichloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Water, unless in flooding amounts should not be used on adjacent fires; *Special Hazards of Combustion Products*: Irritating fumes of hydrogen chloride form during fires;*Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: Reacts forming a solution of hydrochloric acid; *Reactivity with Common Materials*: In presence of moisture will corrode most metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water and sprinkle with powdered limestone or rinse with dilute solution of sodium bicarbonate or soda ash; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Vanadium Pentoxide — Fire Hazards: *Flash Point (deg. F)*: Not flammable; *Flammable Limits in Air (%)*: Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: May increase the intensity of fires; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Vanadyl Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: No data; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable;

Neutralizing Agents for Acids and Caustics: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Vinyl Acetate — Fire Hazards: *Flash Point (deg. F):* 18 CC, 23 OC; *Flammable Limits in Air (%):* 2.6 - 13.4; *Fire Extinguishing Agents*: Carbon dioxide or dry chemical for small fires, and ordinary foam for large fires; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than air and may travel to a source of ignition and flash back, causing product to polymerize and burst or explode containers; *Ignition Temperature (deg. F)*: 800; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 3.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: *Stable*; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization can occur when the product is in contact with peroxides and strong acids, but only under extreme conditions; *Inhibitor of Polymerization*: Hydroquinone and or Diphenylamine.

Vinyl Chloride — Fire Hazards: *Flash Point (deg. F):* -110 OC; *Flammable Limits in Air (%):* 4 - 26; *Fire Extinguishing Agents*: For small fires use dry chemical or carbon dioxide. For large fires stop the flow of gas if feasible. Cool exposed containers with water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Forms highly toxic combustion products such as hydrogen chloride, phosgene, and carbon monoxide;*Behavior in Fire*: Container may explode in fire. Gas is heavier than air and may travel to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 882; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 4.3 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerizes when exposed to sunlight, air, or heat unless stabilized by inhibitors; *Inhibitor of Polymerization*: Not normally used except when high temperatures are expected. Normally phenol can be used (typically 40 to 100 ppm).

Vinyl Fluoride, Inhibited — Fire Hazards: *Flash Point (deg. F):* Not pertinent. This is a flammable, compressed liquified gas; *Flammable Limits in Air (%)*: 2.6 - 21.7; *Fire Extinguishing Agents*: Allow fire to burn out; stop the flow of gas if feasible. Cool adjacent containers with water; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic hydrogen fluoride gas is generated in fires; *Behavior in Fire*: Vapor is heavier than air and can travel to a source of ignition and flash back. Containers may explode; *Ignition Temperature (deg. F)*: 725; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Polymerization can occur in the absence of inhibitor; *Inhibitor of Polymerization*: Terpene B (0.2%).

Vinylidene Chloride, Inhibited — Fire Hazards: *Flash Point (deg. F)*: 0 OC; *Flammable Limits in Air (%):* 7.3 - 16.0; *Fire Extinguishing Agents*: Foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Toxic hydrogen chloride and phosgene form in fires;*Behavior in Fire*: May explode in fires due to polymerization. Vapor is heavier than air and can travel to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 955 - 1,031; *Electrical Hazard*: Not pertinent; *Burning Rate*: 2.7 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: Contact with copper or aluminum can cause polymerization; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization*: Can occur if the product is exposed to sunlight, air, copper, aluminum, or heat; *Inhibitor of Polymerization*: Methyl Ether of Hydroquinone (200 ppm) and or phenol (0.6 to 0.8 %).

Vinyl Methyl Ether, Inhibited — Fire Hazards: *Flash Point (deg. F):* -69 OC; *Flammable Limits in Air (%)*: 2.6 - 39; *Fire Extinguishing Agents*: Allow fire to burn and shut off the flow of gas if feasible. Extinguish small fires with dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode. Vapor is heavier than air and can travel to a source of ignition and flash back; *Ignition Temperature (deg. F)*: No data; *Electrical Hazard*: No data; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly to form acetaldehyde. The reaction is generally not hazardous unless occurring in hot water or acids are present; *Reactivity with Common Materials*: Acids cause polymerization; *Stability During Transport*: Stable but must be segregated from acids;*Neutralizing Agents for*

Acids and Caustics: Not pertinent; *Polymerization:* Can polymerize in the presence of acids; *Inhibitor of Polymerization*: Dioctylamine; Triethanolamine; Solid Potassium Hydroxide.

Vinyltoluene — Fire Hazards: *Flash Point (deg. F)*: 137 OC, 125 CC; *Flammable Limits in Air (%):* 0.8 - 11; *Fire Extinguishing Agents*: Water fog, foam, carbon dioxide, or dry chemical; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Containers may explode or rupture in fires due to polymerization; *Ignition Temperature (deg. F)*: 914; *Electrical Hazard*: Not pertinent; *Burning Rate*: 6.0 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reactions; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Slow at ordinary temperatures but when hot may rupture container. Also polymerized by metal salts such as those of iron or aluminum; *Inhibitor of Polymerization*: Tertiary Butylcatechol (typically 10 to 50 ppm).

Vinyltrichlorosilane — Fire Hazards: *Flash Point (deg. F)*: 60 OC, 52 CC; *Flammable Limits in Air (%)*: 3 (LEL); *Fire Extinguishing Agents*: Dry chemical or carbon dioxide; *Fire Extinguishing Agents Not to be Used*: Water, foam; *Special Hazards of Combustion Products*: Toxic chlorine and phosgene gases are formed; *Behavior in Fire*: Fire is difficult to extinguish because of ease in re-ignition. Contact with water applied to fight adjacent fires will result in the formation of irritating hydrogen chloride gas; *Ignition Temperature (deg. F)*: 505; *Electrical Hazard*: No data; *Burning Rate*: 2.9 mm/min. **Chemical Reactivity:** *Reactivity with Water*: Reacts vigorously, producing hydrogen chloride (hydrochloric acid); *Reactivity with Common Materials*: Reacts with surface moisture to evolve hydrogen chloride, which will corrode common metals and form flammable hydrogen gas; *Stability During Transport*: Stable if protected from moisture;*Neutralizing Agents for Acids and Caustics:* Flush with water and rinse with sodium bicarbonate or lime solution; *Polymerization:* May occur in absence of inhibitor; *Inhibitor of Polymerization*: Diphenylamine, Hydroquinone.

W

Waxes: Carnauba — Fire Hazards: *Flash Point (deg. F):* 540 CC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Waxes: Paraffin — Fire Hazards: *Flash Point (deg. F):* 390 CC; 380 - 465 OC; *Flammable Limits in Air (%):* Not pertinent; *Fire Extinguishing Agents*: Water, foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water or foam may cause frothing; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 473; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

X

m-Xylene — Fire Hazards: *Flash Point (deg. F):* 84 CC; *Flammable Limits in Air (%):* 1.1 - 6.4; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 986; *Electrical Hazard*: Class 1, Group D; *Burning Rate*: 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

o-Xylene — Fire Hazards: *Flash Point (deg. F):* 63 CC; 75 OC; *Flammable Limits in Air (%):* 1.1 - 7.0; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than air and may travel considerable distance to a

source of ignition and flash back; *Ignition Temperature (deg. F)*: 869; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

p-Xylene — Fire Hazards: *Flash Point (deg. F):* 81 CC; *Flammable Limits in Air (%):* 1.1 - 6.6; *Fire Extinguishing Agents*: Foam, dry chemical, or carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Water may be ineffective; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back; *Ignition Temperature (deg. F)*: 870; *Electrical Hazard*: Class I, Group D; *Burning Rate*: 5.8 mm/min. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Xylenol — Fire Hazards: *Flash Point (deg. F):* 186; *Flammable Limits in Air (%):* 1.4 (LEL); *Fire Extinguishing Agents*: Water, dry chemical, carbon dioxide, foam; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic vapor of unburned material may form in fire; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: 1110; *Electrical Hazard*: Data not available; *Burning Rate*: Data not available. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; Neutralizing Agents for Acids and Caustics: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Z

Zinc Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Ammonium Chloride - Zinc Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Arsenate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Borate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire*

Extinguishing Agents Not to be Used: Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Bromide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Chloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Chromate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Dialkyldithiophosphate — Fire Hazards: *Flash Point (deg. F):* 360 CC; *Flammable Limits in Air (%):* Data not available; *Fire Extinguishing Agents*: Water, dry chemical, foam, carbon dioxide; *Fire Extinguishing Agents Not to be Used:* Data not available; *Special Hazards of Combustion Products*: Irritating oxides of sulfur and phosphorus may form in fires; *Behavior in Fire*: Data not available; *Ignition Temperature (deg. F)*: Data not available; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction at ordinary temperatures; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; Neutralizing Agents for Acids and Caustics: Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Fluoroborate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire; *Behavior in Fire*: May increase intensity of fire when in contact with combustible material; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Phenolsulfonate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Irritating oxides of sulfur may form in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent;

Electrical Hazard: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Phosphide — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Use water, foam, or dry chemical on adjacent fires; *Fire Extinguishing Agents Not to be Used:* Any agent with an acid reaction (e.g. carbon dioxide or halogenated agents) will liberate phosphine, a toxic and spontaneously flammable gas; *Special Hazards of Combustion Products*: Irritating oxides of phosphorus may be formed in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: No data . **Chemical Reactivity:** *Reactivity with Water*: Reacts slowly with water, more rapidly with dilute acid, to form phosphine gas, which is toxic and spontaneously flammable; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable unless exposed to moisture; toxic phosphine gas may then be released and collect in closed spaces; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Silicofluoride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic and irritating hydrogen fluoride and silicon tetrafluoride are formed in fires; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zinc Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zirconium Acetate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zirconium Nitrate — Fire Hazards: *Flash Point (deg. F):* Not flammable but may intensify fire; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Toxic oxides of nitrogen may form in fire; *Behavior in Fire*: May increase intensity of fire when in contact with combustible materials; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: Dissolves to give an acid solution; *Reactivity with Common Materials*: Will corrode most metals; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Flush with water; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zirconium Oxychloride — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity:** *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

Zirconium Sulfate — Fire Hazards: *Flash Point (deg. F):* Not flammable; *Flammable Limits in Air (%):* Not flammable; *Fire Extinguishing Agents*: Not pertinent; *Fire Extinguishing Agents Not to be Used:* Not pertinent; *Special Hazards of Combustion Products*: Not pertinent; *Behavior in Fire*: Not pertinent; *Ignition Temperature (deg. F)*: Not pertinent; *Electrical Hazard*: Not pertinent; *Burning Rate*: Not pertinent. **Chemical Reactivity**: *Reactivity with Water*: No reaction; *Reactivity with Common Materials*: No reaction; *Stability During Transport*: Stable; *Neutralizing Agents for Acids and Caustics:* Not pertinent; *Polymerization:* Not pertinent; *Inhibitor of Polymerization*: Not pertinent.

D. Hazard Information on Oxidizers, Organic Peroxides and Self Reacting Materials

Oxidizers and organic peroxides are Class 5 Hazards, and because of their inherent reactivity, and in some cases unstable nature, warrant special discussion. An oxidizer (Division 5.1) is a material that may, generally by yielding oxygen, cause or enhance the combustion of other materials. A number of these chemicals are described in the previous subsection. A solid material is classed under USDOT regulations as a Division 5.1 material, if when tested, the mean burning time of the test mixture, is equal to or less than that of the average of the three tests with ammonium persulfate mixture. A liquid is classed as a Division 5.1 material by analogy to existing entries in the Hazard Materials Table of 49 CFR Parts 100 to 177, Section 172.101.

An organic peroxide (Division 5.2) is any organic compound containing oxygen (O) in the bivalent -O-O- structure which may be considered a derivative of hydrogen peroxide, where one or more hydrogen atoms have been replaced by organic radicals. Division 5.2 organic peroxides are assigned to a generic system which is comprised of seven types according to US DOT regulations (refer to 49 CFR, Parts 100 to 177, Section 173.128). The US DOT definitions used are as follows:

- Type A - Organic peroxide type A is an organic peroxide which can detonate or deflagrate rapidly.
- Type B - This is an organic peroxide which neither detonates nor deflagrates rapidly, but can undergo a thermal explosion.
- Type C - This is an organic peroxide which neither detonates nor deflagrates rapidly and cannot undergo thermal explosion.
- Type D - This is an organic peroxide which (i) detonates only partially, but does not deflagrate rapidly and is not affected by heat when confined; (ii) does not detonate, deflagrates slowly, and shows no violent effect if heated when confined; or (iii) does not detonate or deflagrate, and shows a medium effect when heated under confinement.
- Type E - This is an organic peroxide which neither detonates nor deflagrates and shows low, or no effect when heated under confinement.
- Type F - Organic peroxide type F is an organic peroxide which will not detonate in a cavitated state, does not deflagrate, shows only a low, or no, effect if heated when confined, and has low, or no, explosive power.
- Type G - This is an organic peroxide which will not detonate in a cavitated state, will not deflagrate, shows no effect when heated under confinement, has no explosive power, is thermally stable (self-accelerating decomposition temperature >60°C (140°F)), and, for desensitized liquid formulations, is desensitized with a compatible organic liquid which boils above 150°C (300°F).

An organic peroxide is assigned to a generic type based on (i) its physical state (i.e., liquid or solid), (ii) a determination as to its control temperature and emergency temperature, and (iii) by its performance under test procedures specified in the *United Nations Recommendations on the Transport of Dangerous Goods, Tests and Criteria, Part III.* Table 17 provides a list of organic peroxides that are regulated and cited under 49 CFR. The table contains the following entries of information: *column 1: Technical Name* - This column provides the technical name of the chemical; *column 2: ID Number* - The second column specifies the identification (ID) number (i.e., 4-digit shipping number) used to identify the proper shipping name; *column 3: Concentration* - This column specifies concentration (mass percent) limitations, if any, in mixtures or solutions for the organic peroxide in shipping. Limitations are given as minimums, maximums, or a range, as appropriate. A range includes the lower and upper limits (i.e., "53-95" means from, and including, 53 percent to, and including 95 percent); *column 4: Diluent* - This column specifies the type and concentration (in mass percent) of diluent or inert solid, when required. The required mass percent of "Diluent type A" is specified in the first subcolumn . A diluent type A is an organic liquid that does not detrimentally affect the thermal stability or increase the hazard of the organic peroxide and with a boiling point of less than 150°C at atmospheric pressure. Type A diluents

may be used for desensitizing all organic peroxides. The required mass percent of "Diluent type B" is specified in the second subcolumn. A diluent type B is an organic liquid that does not detrimentally affect the thermal stability or increase the hazard of the organic peroxide, and which has a normal boiling point of less than 150°C but at least 60°C, and a flash point greater than 5°C. A Type B diluent may only be used for the desensitizing of an organic peroxide for which it is specified in Table 17. The boiling point of a type B diluent must be at least 50°C above the control temperature of the organic peroxide. A Type A diluent may be used to substitute for a Type B diluent in equal concentration. The third subcolumn (indicated by "I") is the required mass percent of "Inert solid". An inert solid is a solid that does not detrimentally affect the thermal stability or increase the hazard of the organic peroxide; *column 5: Water* - This column provides the concentration of water, in mass percent, which is the minimum amount of water (if any) which must be in the formulation for safe handling; *column 6: Temperatures* - The two subcolumns provide the control temperature and the emergency temperature for the chemical. Temperatures are specified only for those cases where temperature controls are necessary.

Table 17. Organic Peroxides Table

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
Acetyl acetone peroxide	UN3105	≤42	≥48	≥8				
Acetyl acetone peroxide as a paste	UN3106	≤32						
Acetyl benzoyl peroxide	UN3105	≤45	≥55					
Acetyl cyclohexanesulfonyl peroxide	UN3112	≤82				≥12	-10	0
Acetyl cyclohexanesulfonyl peroxide	UN3115	≤32		≥68			-10	0
tert-Amyl hydroperoxide	UN3107	≤88	≥6		≥6			
tert-Amyl peroxybenzoate	UN3105	≤96	≥4					
tert-Amyl peroxy-2-ethylhexanoate	UN3115	≤100					20	25
tert- Amyl peroxyneodecanoate	UN3115	≤77		≥23			0	10
tert-Amyl peroxypivalate	UN3113	≤77		≥23			10	15
tert-Amylperoxy-3,5,5-trimethylhexanoate	UN3101	≤100						
tert-Butyl cumyl peroxide	UN3105	≤100						
n-Butyl-4,4-di-(tertbutylperoxy) valerate	UN3103	>52, ≤100						
n-Butyl-4,4-di-(tertbutylperoxy) valerate	UN3106	≤52			≥48			
tert-Butyl hydroperoxide	UN3103	>72, ≤90				≥10		
tert-Butyl hydroperoxide	UN3105	≤ 80	≥20					
tert-Butyl hydroperoxide	UN3109	≤ 72				≥28		

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
tert-Butyl hydroperoxide and di-tert-butyl peroxide	UN3103	≤82				≥7		
tert-Bytyl monoperoxymaleate	UN3102	>52, ≤100						
tert-Bytyl monoperoxymaleate	UN3103	≤52	≥48					
tert-Bytyl monoperoxymaleate as a paste	UN3108	≤42						
tert-Butyl peroxyacetate	UN3101	>52, ≤77	≥23					
tert-Butyl peroxyacetate	UN3103	≤52	≥48					
tert-Butyl peroxybenzoate	UN3103	>77, ≤100	≤22					
tert-Butyl peroxybenzoate	UN3105	>52, ≤77	≥23					
tert-Butyl peroxybenzoate	UN3106	≤52		≥48				
tert-Butyl peroxycrotonate	UN3105	≤77	≥23					
tert-Butyl peroxydiethylacetate	UN3113	≤100					20	25
tert-Butyl peroxydiethylacetate and tert-Butyl peroxybenzoate	UN1305	≤33 ≤33	≥33					
tert-Butyl peroxy-2-ethylhexanoate	UN3113	>52, ≤100					20	25
tert-Butyl peroxy-2-ethylhexanoate	UN3117	≤52		≥48			20	25
tert-Butyl peroxy-2-ethylhexanoate and 2,2-Di-(tert-butylperoxy)butane	UN3115	≤31 ≤36		≥33			35	40
tert-Butyl peroxy-2-ethylhexanoate and 2,2-Di-(tert-butylperoxy)butane	UN3106	≤12	≥14		≥60			
tert-Butyl peroxyisobutyrate	UN3111	>52, ≤77		≥23			15	20
tert-Butyl peroxyisobutyrate	UN3115	≤52	≥48				15	20
tert-Butylperoxy isopropylcarbonate	UN3103	≤77	≥23					
tert-Butyl peroxyneodecanoate	UN3115	>77,≤100					-5	5
tert-Butyl peroxyneodecanoate	UN3115	≤77		≥23			0	10
3-tert Butylperoxy-3-phenylphthalate	UN3106	≤100						
3-tert Butylperoxypivalate	UN3113	>67, ≤77	≥23				0	10

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
3-tert Butylperoxypivalate	UN3115	≤67		≥33			0	10
tert-Butylperoxy stearylcarbonate	UN3106	≤100						
tert-Butyl peroxy-3,5,5-trimethylhexanoate	UN3105	≤100						
3-Chloroperoxybenzoic acid	UN3102	>57,≤86				≥14		
3-Chloroperoxybenzoic acid	UN3106	≤57			≥3	≥40		
Cumul hydroperoxide	UN3109	≤90	≥10					
Cumyl peroxyneodecanoate	UN3115	≤77	≥23				-10	0
Cumul peroxypivalate	UN3115	≤77		≥23			-5	5
Cyclohexanone peroxide(s)	UN3104	≤91				≥9		
Cyclohexanone peroxide(s) as a paste	UN3106	≤72						
Cyclohexanone peroxide(s)	UN3105	≤72	≥28					
Cyclohexanone peroxide(s)	Exempt	≤32			≥68			
Diacetone alcohol peroxides	UN3115	≤57		≥26		≥8	30	35
Diacetyl peroxide	UN3115	≤27		≥73			20	25
Di-tert-amyl peroxide	UN3107	≤100						
Dibenzoyl peroxide	UN3102	>52,≤100			≤48			
Dibenzoyl peroxide	UN3102	>78,≤94				≥6		
Dibenzoyl peroxide	UN3104	≤77				≥23		
Dibenzoyl peroxide	UN3106	≤62			≥28	≥10		
Dibenzoyl peroxide as a paste	UN3106	>52,≤62						
Dibenzoyl peroxide as a paste	UN3108	≤52						
Dibenzoyl peroxide	UN3106	>35,≤52			≥48			
Dibenzoyl peroxide	Exempt	≤35			≥65			
Dibenzyl peroxydicarbonate	UN3112	≤87				≥13	25	30

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
Di-(tert-butylcyclohexyl)peroxydicarbonate	UN3114	≤100					30	35
Di-(tert-butylcyclohexyl)peroxydicarbonateas a stable dispersion in water	UN3119	≤42					30	35
Di-tert-butylperoxide	UN3107	≤100						
2,2-Di-(tert-butylperoxy)butane	UN3103	≤52	≥48					
1,1-Di-(tert-butylperoxy)cyclohexane	UN3101	>80,≤100						
1,1-Di-(tert-butylperoxy)cyclohexane	UN3103	>52,≤80	≥20					
1,1-Di-(tert-butylperoxy)cyclohexane	UN3105	≤52	≥48					
1,1-Di-(tert-butylperoxy)cyclohexane	UN3106	≤42	≥13		≥45			
1,1-Di-(tert-butylperoxy)cyclohexane	UN3107	≤27	≥36					
2,2-Di-(4,4-tert-butylperoxycyclohexyl)propane	UN3106	≤42			≥58			
Di-n-butyl peroxydicarbonate	UN3115	>27, ≤52	≥48				-15	-5
Di-n-butyl peroxydicarbonate	UN3117	≤27		≥73			-10	0
Di-sec-butyl peroxydicarbonate	UN3113	>52,≤100					-20	-10
Di-sec-butyl peroxydicarbonate	UN3115	≤52		≥48			-15	-5
Di-(2-tert-butylperoxyisopropyl)benzene(s)	UN3106	>42,≤100			≤57			
Di-(2-tert-butylperoxyisopropyl)benzene(s)	Exempt	≤42			≥58			
Di-(tert-butylperoxy)phthalate	UN3105	>42,≤52	≥48					
Di-(tert-butylperoxy)phthalate as a paste	UN3106	≤52						
Di-(tert-butylperoxy)phthalate	UN3107	≤42	≥58					
2,2-Di-(tert-butylperoxy)propane	UN3105	≤52	≥48					
2,2-Di-(tert-butylperoxy)propane	UN3106	≤42	≥13		≥45			

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
1,1-Di-(tert-butylperoxy)-3,3,5-trimethylcyclohexane	UN3101	>57,≤100						
1,1-Di-(tert-butylperoxy)-3,3,5-trimethylcyclohexane	UN3106	≤57			≥43			
1,1-Di-(tert-butylperoxy)-3,3,5-trimethyl cyclohexane	UN3107	≤57	≥43					
Dicetyl peroxydicarbonate	UN3116	≤100					20	25
Dicetyl peroxydicarbonate as a atable dispersion in water	UN3119	≤42						
Di-4-chlorobenzoyl peroxide	UN3102	≤77				≥23		
Di-4-chlorobenzoyl peroxide as a paste	UN3106	≤52						
Di-4-chlorobenzoyl peroxide	Exempt	≤32			≥68			
Dicumyl peroxide	UN3110	>42,≤100			≥57			
Dicumyl peroxide	Exempt	≤42			≥58			
Dicyclohexyl peroxydicarbonate	UN3112	>91,≤100					5	10
Dicyclohexyl peroxydicarbonate	UN3114	≤91				≥9	5	10
Didecanoyl peroxide	UN3114	≤100					15	20
Di-2,4-dichlorobenzoyl peroxide	UN3102	≤77				≥23		
Di-2,4-dichlorobenzoyl peroxide as a paste with silicon oil	UN3106	≤52						
Di-(2-ethylhexyl) peroxydicarbonate	UN3113	>77,≤100					-20	-10
Di-(2-ethylhexyl) peroxydicarbonate	UN3151	≤77					-15	-5
Di-(2-ethylhexyl) peroxydicarbonate as a stable dispersion in water	UN3117	≤42					-15	-5
Di-(2-ethylhexyl) peroxydicarbonate as a stable dispersion in water (frozen)	UN3117	≤42					-15	-5
Diethyl peroxydicarbonate	UN3115	≤27		≥73			-10	0
2,2-Dihydroperoxypropane	UN3102	≤27			≥73			

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
Di-(1-hydroxycyclohexyl)peroxide	UN3106	≤100						
Diisobutyl peroxide	UN3111	>32, ≤52		≥48			-20	-10
Diisobutyl peroxide	UN3115	≤32		≥68			-20	-10
Diisopropyl peroxydicarbonate	UN3112	>52, ≤100					-15	-5
Diisopropyl peroxydicarbonate	UN3115	≤52		≥48			-10	0
Diisotridecyl peroxydicarbonate	UN3115	≤100					-10	0
Dilauroyl peroxide	UN3106	<100						
Dilauroyl peroxide as a stable dispersion in water	UN3109	42≤						
Di-(2-methylbenzoyl) peroxide	UN3112	≤87				≥13	30	35
2,5-Dimethyl-2,5-di-(benzoyl peroxy) hexane	UN3102	>82, ≤100						
2,5-Dimethyl-2,5-di-(benzoyl peroxy) hexane	UN3106	≤82			≥18			
2,5-Dimethyl-2,5-di-(benzoyl peroxy) hexane	UN3104	≤82				≥18		
2,5-Dimethyl-2,5-di-(tert-butyl peroxy) hexane	UN3105	>52, ≤100						
2,5-Dimethyl-2,5-di-(tert-butyl peroxy) hexane	UN3106	<52			≥48			
2,5-Dimethyl-2,5-di-(tert-butyl peroxy) hexyne-3	UN3103	>52, ≤100						
2,5-Dimethyl-2,5-di-(tert-butyl peroxy) hexyne-3	UN3106	≤52			≥48			
2,5-Dimethyl-2,5-di-(2-ethylhexanoylperoxy)hexane	UN3115	≤100					20	25
2,5-Dimethyl-2,5-dihydroperoxyhexane	UN3104	≤82				≥18		
2,5-Dimethyl-2,5-trimethylhexanoylperoxy)hexane	UN3105	≤77	≥23					
Dimyristyl peroxydicarbonate	UN3116	≤100					20	25

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
Dimyristyl peroxydicarbonate as a stable dispersion in water	UN3119	≤42						
Di-n-nonanoyl peroxide	UN3116	≤100					0	10
Di-n-octanoyl peroxide	UN3114	≤100					10	15
Diperoxy azelaic acid	UN3116	≤27			≥73		35	40
Diperoxy dodecane diacid	UN3116	>13,≤42			≥58		40	45
Diperoxy dodecane diacid	Exempt	≤13						
Di-(Phenoxyethyl) peroxydicarbonate	UN3102	>85,≤100	≥					
Di-(Phenoxyethyl) peroxydicarbonate	UN3106	≤85				≥15		
Dipropionyl peroxide	UN3117	≤27		≥73			15	20
Di-n-propyl peroxydicarbonate	UN3113	≤100	≥				-25	-15
Distearyl peroxydicarbonate	UN3106	≤87			≥13			
Disuccinic acid peroxide	UN3102	>72,≤100	≥					
Disuccinic acid peroxide	UN3116	≤72				≥28	10	15
Di-(3,5,5-trimethyl-1,2-dioxo-lanyl-3) peroxide	UN3116	≤52						
Di-(3,5,5-trimethylhexanoyl)peroxide	UN3115	≤82	≥18					
Ethyl-3,3-di-(tert-amylperoxy) butyrate	UN3105	≤67	≥33					
Ethyl-3,3-di-(tert-amylperoxy) butyrate	UN3105	≤77	≥23					
Ethyl-3,3-di-(tert-amylperoxy) butyrate	UN3106	≤52			≥48			
3,3,6,9,9-Hexamethyl-1,2,4,5-tetraoxacyclononane	UN3102	>52,≤100						
3,3,6,9,9-Hexamethyl-1,2,4,5-tetraoxacyclononane	UN3105	≤52	≥48					
3,3,6,9,9-Hexamethyl-1,2,4,5-tetraoxacyclononane	UN3106	≤52			≥48			
Isopropylcumyl hydroperoxide	UN3109	≤72	≥28					
p-Methyl hydroperoxide	UN3105	>55,≤100						

Table 17 Continued

Technical Name	ID Number	Concentration (Mass %)	Diluent (Mass %)			Water (Mass %)	Temperatures (°C)	
			A	B	I		Control	Emergency
p-Methyl hydroperoxide	UN3109	≤55	≥45					
Methylcyclohexanone peroxide(s)	UN3115	≤67		≥33			35	40
Methyl ethyl ketone peroxide(s)	UN3101	≤52	≥48					
Methyl ethyl ketone peroxide(s)	UN3105	≤45	≥55					
Methyl ethyl ketone peroxide(s)	UN3107	≤40	≥60					
Methyl isobutyl ketone peroxide(s)	UN3105	≤62	≥19					
Organoc peroxide, solid, temperature controlled	UN3114							
Organic peroxide, liquid, sample	UN3103							
Organoc peroxide, liquid, temperature controlled	UN3113							
Organic peroxide, solid, sample	UN3104							
Peroxyacetic acid, type D, stabilized	UN3105	≤43						
Peroxyacetic acid, type E, stabilized	UN3107	≤43						
Peroxyacetic acid, type F, stabilized	UN3109	≤43						
Pinanyl hydroperoxide	UN3105	>55, ≤100						
Pinanyl hydroperoxide	UN3109	≤55	≥45					
Tetrahydronaphthyl hydroperoxide	UN31	≤3106	≥100					
1,1,3,3-Tetramethybutyl hydroperoxide	UN3105	≤100						
1,1,3,3-Tetramethylbutylperoxy-2-ethylhexanoate	UN3115	≤100					20	25
2,4,4-Trimethylpentyl-2 phenoxyacetate	UN3115	≤37		≥63			-10	0

Self reacting materials are Hazard Class 4. They include Division 4.1 (*flammable solids*), Division 4.2 (*spontaneously combustible materials*), and Division 4.3 (*dangerous when wet materials*). In general, self reactive materials are materials that are liable to undergo, at normal or elevated temperatures, a strongly exothermic decomposition caused by excessivley high temperatures or by contamination. Division 4.1 includes materials that are readily combustible solids (typically solids that may cause a fire through friction); also included are metal powders. Division 4.2 materials are pyrophoric; such as a liquid or solid that, even without an external ignition source, can ignite without within a few minutes after coming in contact with air. This division also includes so-called self-heating materials. A self-heating material is a material that, when in contact with air and without any energy supply, is liable to self heat. These materials exhibit spontaneous ignition. Division 4.3 refers to a material that, by contact with water, is liable to become spontaneously flammable or to give off flammable or toxic gas. Table 18 provides a list of USDOT regulated self-reactive materials. There are three columns of information provided in this table: column (1) - provides the identification number (ID) as based upon section 172.101 of the Hazard Materials Table of 49 CFR; column (2) - provides the proper shipping name of the material; column (3) - Column 3a specifies the control temperature for safe shipping and handling off the material, and column 3b specifies the emergency temperature. The letters "NR" means that temperature controls are not required.

Table 18. Self-Reactive Materials Table

ID Nº (1)	Proper shipping name (2)	Temperature, °C (F)	
		Control (3a)	Emergency (3b)
UN2951	Diphenyloxide-4-4' disulfohydrazide	NR	NR
UN2952	Azodiisobutyronitrile	40 (104)	45 (113)
UN2953	2,2'-Azodi-(2,4 dimethylvaleronitrile)	10(50)	15 (59)
UN2954	1,1'-Azodi-(hexahydrobenzonitrile)	NR	NR
UN2955	2,2'-Azodi-(2,4-dimethyl-4-methoxy valeronitrile)	-5 (23)	5 (41)
UN2970	Benzene sulfohydrazide	NR	NR
UN2971	Benzene-1,3-disulfohydrazide, [not more than 52% as a paste]	NR	NR
UN2972	N,N'-Dinitrosopentamethylenetetramine [not more than 82 with phlegmatizer]	NR	NR
UN2973	N,N'-Dinitroso-N,N'-dimethyl terephthalamide [not more than 72 as a paste]	NR	NR
UN3030	2,2'-Azodi (2-methyl-butylonitrile)	40 (104)	45 (113)
UN3033	3-Chloro-diethylaminobenzene diazonium zinc chloride	NR	NR
UN3034	4-Dipropylaminobenzenediazonium zinc chloride	NR	NR
UN3035	3-(2-Hydroxyethoxy)-4-pyrrolidin-1-yl-benzene-diazonium zinc chloride	40 (104)	45 (113)
UN3036	2,5-Diethoxy-4-morphol inobenzene-diazonium zinc chloride	35 (95)	40 (104)
UN3037	4-(Benzyl (ethyl) amino)-3-ethoxy-benzenediazonium zinc chloride	40 (104)	45 (113)

Table 18 Continued

ID Nº (1)	Proper shipping name (2)	Temperature, °C (F)	
		Control (3a)	Emergency (3b)
UN3038	4-(Benzyl (methyl) amino)-3-ethoxy-benzenediazonium zinc chloride	40 (104)	45 (113)
UN3039	4-Dimethylamino-6-(2-dimethyl) aminoethoxy) toluene-2-diazonium zinc chloride	40 (104)	45 (113)
UN3040	Sodium 2-diazo-1-naphthol-4-sulphonate	NR	NR
UN3041	Sodium 2-diazo-1-naphthol-5-sulphonate	NR	NR
UN3042	2-Diazo-1-naphthol-4-sulphochloride	NR	NR
UN3043	2-Diazo-1-naphthol-5-sulphochloride	NR	NR

5

HEALTH RISK INFORMATION

I. INTRODUCTION

This chapter contains a compilation of health risk exposure information to chemicals. The information compiled for the reader is a summary of the health risks and safe handling precautions for common chemicals. There are four fields of information provided for each chemical. The first field provides information on the chemical designation; namely common synonyms and the chemical formula. The second field includes information on observable characteristics such as the chemical's physical state as it is normally handled, its color, and characteristic odor. The third field of information covers the major physical and chemical properties of the chemical (including pertinent thermodynamic properties). The fourth field includes information on health hazards or risks. The reader will find basic information on chemical over-exposure and medical emergency response actions for stabilizing victims. Much of the information gathered in this chapter is derived from the CHRIS data base, and is supplemented by data obtained from the material safety data sheets of chemical manufacturers and suppliers. The reader should also cross reference fire safety and chemical reactivity information compiled in section IV-C of Chapter 4. Additional information can be found among the references cited in Chapter 1, and in the emergency response fact sheets provided in Chapter 6. The general intent of this chapter is to provide health information along with appropriate first aid treatment for overexposure by the primary routes of entry (inhalation, ingestion, skin absorption). The health risk may not necessarily be the primary risk in handling the chemical, hence the information in Chapter 4 is also critical to the reader.

The reader should make note of the use of the following units of measure for the data entries given for the chemicals compiled in this chapter - *Boiling Point, Freezing Point and Critical Temperature data* are given in three sets of units as follows °F, °C, °K (hence, for the chemical acetaldehyde, the boiling point at 1 atm. is 68.7 °F, 20.4 °C, and 293.6 °K); *Critical Pressure data* are given in the units of psia, atm., MN/m^2 (hence, the critical pressure for acetaldehyde is 820 psia, 56 atm., 5.7 MN/m^2); Data concerning *Latent Heat of Vaporization, Heat of Combustion, and Heat of Decomposition* are given in units of Btu/lb, cal/g, $\times 10^5$ J/kg (hence for the chemical acetaldehyde, the latent heat of vaporization is 245 Btu/lb, 136 cal/g, 5.69×10^5 J/kg).

II. CHEMICAL SPECIFIC HEALTH RISK INFORMATION

A

Acetaldehyde — (i) Chemical Designations — *Synonyms*: Acetic Aldehyde; Ethanal, Ethyl Aldehyde; *Chemical Formula*: CH_3CHO; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Penetrating, fruity; sharp pungent; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 44.05; *Boiling Point at 1 atm.*: 68.7, 20.4, 293.6; *Freezing Point*: -189, -123, 150; *Critical Temperature*: 370, 188, 461; *Critical Pressure*: 820, 56, 5.7; *Specific Gravity*: 0.780 at 20 °C (liquid); *Vapor (Gas) Density*: 1.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.182; *Latent Heat of Vaporization*: 245, 136, 5.69; *Heat of Combustion*: -10600, -5890, -246.4; *Heat of Decomposition*: Not pertinent; **(iv) Health**

Hazards Information — *Recommended Personal Protective Equipment*: Rubber gloves, eye goggles, and other equipment to prevent contact with the body. Organic canister or air pack as required; *Symptoms Following Exposure*: Breathing vapors will be irritating and may cause nausea, vomiting, headache, and unconsciousness. Contact with eyes may cause burns. Skin contact from clothing wet with the chemical causes burns or severe irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if breathing has stopped, give artificial respiration; if breathing is difficult, give oxygen; call a physician at once. SKIN: wash with soap and water. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 50 ppm for 60 min.; *Toxicity by Ingestion*: LD_{50} 0.5 to 5 g/kg (cat); *Late Toxicity*: No data found; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that workers will not usually tolerate moderate to high concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.21 ppm.

Acetic Acid — (i) Chemical Designations — *Synonyms*: Ethanoic Acid, Glacial Acetic Acid, Vinegar acid; *Chemical Formula*: CH_3COOH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic vinegar, pungent; vinegar-like; sharp; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 60.05; *Boiling Point at 1 atm.*: 244, 117.9, 391.1; *Freezing Point*: 62.1, 16.7, 290; *Critical Temperature*: 611, 321.6, 594.8; *Critical Pressure*: 839, 57.1, 5.78; *Specific Gravity*: 1.051 at 20 °C(liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.145; *Latent Heat of Vaporization*: 17.1, 96.7, 4.05; *Heat of Combustion*: -5645, -3136, -131.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing should be worn when skin contact can occur. Respiratory protection is necessary when exposed to vapor. Complete eye protection is recommended; *Symptoms Following Exposure*: Breathing of vapors causes coughing, chest pains, and irritation of the nose and throat; may cause nausea and vomiting. Contact with skin and eyes causes burns; *General Treatment for Exposure*: INHALATION: Move the victim immediately to fresh air. If breathing becomes difficult, give oxygen and get medical attention immediately. INGESTION: If the victim is conscious, have him drink water or milk. Do not induce vomiting. SKIN OR EYE CONTACT: Flush immediately with lots of clean running water; wash eyes for at least 15 min. and get medical attention as quickly as possible; remove contaminated clothing; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: 40 ppm for 5 min.; *Toxicity by Ingestion*: LD_{50} 0.5 to 5.0 g/kg (rat); *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that workers will find high concentrations very unpleasant. Effects are temporary; *Liquid or Solid Irritant Characteristics*: This is a fairly severe skin irritant; may cause pain and secondary burns after a few minutes of contact; *Odor Threshold*: 1.0 ppm.

Acetic Anhydride — (i) Chemical Designations — *Synonyms*: Ethanoic Anhydride; *Chemical Formula*: $CH_3CO\text{-}O\text{-}COCH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Very strong; pungent; vinegar-like characteristic odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.09; *Boiling Point at 1 atm.*: 282, 139, 412; *Freezing Point*: -101, -74.1, 199.1; *Critical Temperature*: 565, 296, 569; *Critical Pressure*: 679, 46.2, 4.68; *Specific Gravity*: 1.08 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.093; *Latent Heat of Vaporization*: 119, 66.2, 2.77; *Heat of Combustion*: -7058, -3921, -164.2; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing when skin contact might occur; respiratory protection is necessary for all exposures; complete eye protection is recommended; *Symptoms Following Exposure*: Liquid is volatile and causes little irritation on unprotected skin. However, causes severe burns when cloning is wet with the chemical, or if it enters gloves or shoes; causes skin and eye burns and irritation of the respiratory tract. Nausea and vomiting may develop after exposure; *General Treatment for Exposure*: INHALATION: Move the victim immediately to fresh air; if breathing becomes difficult, give oxygen, and seek medical attention immediately. INGESTION: Do not induce vomiting. SKIN OR EYE CONTACT WITH LIQUID OR VAPOR: Flush immediately with clean, running water; wash eyes for at least 15 minutes; seek medical attention immediately; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: No data found; *Toxicity by Ingestion*: 0.5 to 5.0 g/kg (rat); *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high

concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second degree burns; burns skin after a few minutes of contact; *Odor Threshold*: 0.14 ppm.

Acetone — (i) Chemical Designations — *Synonyms*: Dimethyl Ketone, 2-Propanone; *Chemical Formula*: CH_3COCH_3; **(ii) Observable Characteristics** - *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweetish; pleasant, resembling that of mint or fruit; pungent, sharp, penetrating, ketonic pleasant, non-residual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 58.08; *Boiling Point at 1 atm.*: 133, 56.1, 329.3; *Freezing Point*: -138, -94.7, 178.5; *Critical Temperature*: 455, 235, 508; *Critical Pressure*: 682, 46.4, 4.70; *Specific Gravity*: 0.971 at 20 °C (liquid); *Vapor (Gas) Density*: 2.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.127; *Latent Heat of Vaporization*: 220, 122, 5.11; *Heat of Combustion*: -12,250, -6,808, -285.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister or air-supplied respirator; synthetic rubber gloves; chemical safety goggles or face splash shield; *Symptoms Following Exposure*: INHALATION: vapor irritating to eyes and mucous membranes; acts as an anesthetic in very high concentrations. INGESTION: low order of toxicity but very irritating to the mucous membranes. SKIN: prolonged excessive contact causes defatting of the skin, possibly leading to dermatitis; *General Treatment for Exposure*: INHALATION: if victim is overcome, remove to fresh air and call a physician; administer artificial respiration if breathing is irregular or stopped. INGESTION: if victim has swallowed large amounts and is conscious and not having convulsions, induce vomiting and seek medical help immediately. SKIN: wash with clean running water. EYES: flush with water immediately for at least 15 min. and consult a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm; *Short-Term Exposure Limits*: 1000 ppm for 30 minutes; *Toxicity by Ingestion*: LD_{50} 5 to 15 g/kg (dog); *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: If present in high concentrations, vapors cause moderate irritation of the eyes or respiratory system. Effects are temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly from the skin; *Odor Threshold*: 100 ppm.

Acetone Cyanohydrin — (i) Chemical Designations — *Synonyms*: alpha-Hydroxyisobutyronitrile, 2-Methyllactonitrile; *Chemical Formula*: $(CH_3)_2C(OH)CN$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; distinct, strong cyanide; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 85.11; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: -5.8, -21, 252; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.925 at 25 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.074; *Latent Heat of Vaporization*: No data; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied respirator or chemical cartridge respirator approved for use with acrylonitrile in less than 2% concentrations; rubber or plastic gloves; cover goggles or face mask; rubber boots; chemical protective suit; safety helmet; *Symptoms Following Exposure*: At low dosages the earliest symptoms may be weakness, headaches, confusion, sporadic nausea and vomiting. Respiratory rate and depth will usually be increased at the beginning and at later stages become slow and gasping; *General Treatment for Exposure*: Call a physician for all cases of over-exposure. INHALATION: Remove victim to fresh air. First responders/rescuers should wear suitable respiratory protection. If breathing has stopped, give artificial respiration until physician arrives. CHRIS advises that if victim is unconscious, administer amyl nitrate by crushing an ampule in a cloth and holding it under the nose for 15 seconds in every minute. Do not interrupt artificial respiration during the process. Replace the ampule when its strength is spent; continue treatment until victim's condition improves or physician arrives. INGESTION: If the victim is conscious, induce vomiting by having him drink strong salt water. SKIN: Remove contaminated clothing and wash affected skin thoroughly with soap and water. Use copious amount of water. EYES: Hold eyelids apart and wash with continuous, gentle stream of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: < 50 mg/kg (rats); *Late Toxicity*: Causes liver damage in rats; *Vapor (Gas) Irritant Characteristics*: Vapors irritate eyes and respiratory tract when present in high concentrations; however effects are temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree chemical burns on short exposure, and second-degree chemical burns on long exposure; *Odor Threshold*: No data found.

Acetonitrile — (i) Chemical Designations — *Synonyms*: Ethanenitrile, Ethyl Nitrate, Cyanomethane,

Methyl cyanide; *Chemical Formula*: CH_3CN; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquis; *Color*: Colorless; *Odor*: Sweet; ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 41.05; *Boiling Point at 1 atm.*: 179, 81.6, 354.8; *Freezing Point*: -50.3, -45.7, 227.5; *Critical Temperature*: 526.5, 274.7, 547.9; *Critical Pressure*: 701, 47.7, 4.83; *Specific Gravity*: 0.787 at 20 °C (liquid); *Vapor (Gas) Density*: 1.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.192; *Latent Heat of Vaporization*: 313, 174, 7.29; *Heat of Combustion*: -13360, -7420, -310.7; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Must wear self contained breathing apparatus (SCBA); *Symptoms Following Exposure*: Exposure to 160 ppm for 4 hours causes flushing of the face and feeling of constriction in the chest. Exposure to 500 ppm for brief periods is irritating to the nose and throat. Severe exposure results in irritability, skin eruptions, confusion, delirium, convulsions, paralysis, and death due to central nervous system depression; *General Treatment for Exposure*: Remove victim from contaminated atmosphere. Apply artificial respiration and oxygen if respiration is impaired; *Toxicity by Inhalation (Threshold Limit Value)*: 40 ppm; *Short-Term Exposure Limits*: 40 ppm for 60 minutes; *Toxicity by Ingestion*: 500 mg/kg (guinea pig); *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Vapors cause slight smarting of the eyes or respiratory system if present in high concentrations. Effects are temporary; *Liquid or Solid Irritant Characteristics*: Represents a minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 40 ppm.

Acetophenone — (i) Chemical Designations — *Synonyms*: Acetylbenzene, Methyl Phenyl Ketone; *Chemical Formula*: $C_6H_5COCH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Persistent; like orange blossoms and jasmine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 120.15; *Boiling Point at 1 atm.*: 395.1, 201.7, 474.9; *Freezing Point*: 67.5, 19.7, 292.9; *Critical Temperature*: 802, 428, 701; *Critical Pressure*: 560, 38, 3.8; *Specific Gravity*: 1.028 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.071; *Latent Heat of Vaporization*: 150, 83.6, 3.5; *Heat of Combustion*: -14850, -8250, -345.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protect eyes and skin from direct contact; *Symptoms Following Exposure*: No toxicity expected from inhalation or ingestion except slight narcotic effect. Liquid can cause eye and skin irritation on contact; *General Treatment for Exposure*: SKIN OR EYE CONTACT: Irrigate affected areas with fresh running water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: No data found; *Short-Term Exposure Limits*: No data found; *Toxicity by Ingestion*: LD_{50} 0.5 to 5.0 g/kg; *Late Toxicity*: No data found; *Vapor (Gas) Irritant Characteristics*: Nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard; if spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 0.01 - 0.025 mg/m^3.

Acetylacetone — (i) Chemical Designations — *Synonyms*: Diacetylmethane, 2,4-Pentanedione; *Chemical Formula*: $CH_3COCH_2COCH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Water-white; *Odor*: Unpleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.12; *Boiling Point at 1 atm.*: 284.7, 140.4, 413.6; *Freezing Point*: -10.3, -23.5, 249.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.975 at 20 °C; *Vapor (Gas) Density*: 3.45; *Ratio of Specific Heats of Vapor (Gas)*: 1.072; *Latent Heat of Vaporization*: 194, 108, 4.52; *Heat of Combustion*: -11,070, -6150, -257; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses, eye bath and safety shower, air supplied mask for concentrations of about 2%; *Symptoms Following Exposure*: Inhalation causes dizziness and headache, nausea, vomiting, and loss of consciousness. Contact with liquid irritates eyes; *General Treatment for Exposure*: INHALATION: Remove victim to fresh air; if victim is not breathing, give artificial respiration and then oxygen; contact physician immediately. EYES or SKIN: flush with clean running water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: Oral LD_{50} 1,000 mg/kg (rat); *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Acetyl Bromide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: CH_3COBr; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless;

Odor: Acrid and sharp; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 122.95; *Boiling Point at 1 atm*: 169, 76, 349; *Freezing Point*: -141.7, -96.5, 176.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.66 at 16 °C (liquid); *Vapor (Gas) Density*: 4.24; *Ratio of Specific Heats of Vapor (Gas)*: 1.44; *Latent Heat of Vaporization*: 106, 59, 2.5; *Heat of Combustion*: No data; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles; gloves; adequate ventilation; provisions for flushing eyes or skin with water; *Symptoms Following Exposure*: Inhalation results in primary irritation of the respiratory tract; symptoms of lung damage may be delayed. Contact with liquid produces primary irritation of eyes and severe skin damage; delayed blistering of the skin often occurs; *General Treatment for Exposure*: INHALATION: Remove the victim from the contaminated area. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. Watch victim carefully for any signs of delayed lung damage. EYES: Flush with water for at least 15 min. and seek medical attention. SKIN: Flush with water and treat chemical burns as needed; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: Oral rat LD50 3,310 mg/kg (acetic acid). Note that this chemical decomposes violently in water, forming bromic acid and acetic acid; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: 5.0×10^{-4} ppm.

Acetyl Chloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: CH_3COCl; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 78.5; *Boiling Point at 1 atm.*: 124, 51, 324; *Freezing Point*: -170, -112, 161; *Critical Temperature*: 475, 246, 519; *Critical Pressure*: 845, 57.5, 5.83; *Specific Gravity*: 1.1039 at 21 °C (liquid); *Vapor (Gas) Density*: 3; *Ratio of Specific Heats of Vapor (Gas)*: 1.1467; *Latent Heat of Vaporization*: 160, 88, 3.7; *Heat of Combustion*: -6000, -3300, -140; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles, rubber or plastic gloves, self contained breathing apparatus (SCBA); *Symptoms Following Exposure*: Vapor irritates mucous membranes. Ingestion of liquid or contact with eyes or skin causes severe irritation; *General Treatment for Exposure*: INHALATION; Remove victim from exposure and seek immediate medical attention. EYES: Flush with copious amounts of fresh running water. INGESTION: Administer plenty of water; do not induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: Readily hydrolyzes to form hydrochloric and acetic acids. Oral human LD_{LO} 1470 mg/kg (acetic acid). oral rat LD_{50} 3310 mg/kg (acetic acid); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. Cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree chemical burns on short contact and is very injurous to eyes; *Odor Threshold*: Acetic acid - 1 ppm; hydrochloric acid - 1 ppm.

Acetylene — (i) Chemical Designations — *Synonyms*: Ethine, Ethyne; *Chemical Formula*: C_2H_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Distinct, garlic-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Compressed gas; *Molecular Weight*: 26.04; *Boiling Point at 1 atm.*: -119, -84.0, 189.2; *Freezing Point*: Not pertinent; *Critical Temperature*: 95.3, 35.2, 308.4; *Critical Pressure*: 890.7, 60.59, 6.138; *Specific Gravity*: 0.613 at -80 °C; *Vapor (Gas) Density*: 0.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.235; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -20,747, -11526, -482.57; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Use air supplied respirator in areas of high concentration. Avoid all sources of ignition; *Symptoms Following Exposure*: Headache, dizziness, and loss of consciousness may occur. Death from asphyxiation may occur if the oxygen level in air is severely diluted with acetylene; *General Treatment for Exposure*: INHALATION: No specific antidote known; remove victim to fresh air; keep warm and quiet and call a physician- recovery is usually rapid. If patient is unconscious, administer oxygen. If breathing has stopped, give artificial respiration; *Toxicity by Inhalation (Threshold Limit Value)*: 5000 ppm; *Short-Term Exposure Limits*: 100,000 ppm for 30 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Not pertinent; *Odor Threshold*: No data.

Acetyl Peroxide Solution — (i) Chemical Designations — *Synonyms*: Diacetyl Peroxide Solution; *Chemical Formula*: $CH_3CO(O_2)OCCH_3$ in dimethyl phthalate; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 17, -8, 265; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -15,700, -8750, -366; *Heat of Decomposition*: -50, -28, -1.2; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, rubber apron, and gloves; *Symptoms Following Exposure*: Contact with liquid causes irritation of eyes and skin. If ingested, irritates mouth and stomach; *General Treatment for Exposure*: EYES: Wash with plenty of water and seek medical attention. SKIN: Flush with water and wash thoroughly with soap and water; seek medical attention. INGESTION: Induce vomiting and seek immediate medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: No data; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Acridine — (i) Chemical Designations — *Synonyms*: 10-Azaanthracene, Benzo (b) Quinoline, Dibenzo [b,e] Pyridine; *Chemical Formula*: $C_{13}H_9N$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Weak, somewhat irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 179.08; *Boiling Point at 1 atm.*: 655, 346, 619; *Freezing Point*: 230, 110, 383; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -15800, -8790, -368; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator, chemical goggles, rubber gloves; *Symptoms Following Exposure*: Inhalation irritates respiratory system and causes sneezing. Contact with liquid causes eye irritation, irritation of skin, and mucous membranes. At high temperatures and during sun exposure, damage to the cornea, skin and mucous membranes may occur following the liberation of acridine vapor; *General Treatment for Exposure*: INHALATION: Remove victim to fresh air; if breathing has stopped, give artificial respiration; if breathing is difficult, give oxygen. EYES: wash with copious amounts of water for 20 minutes and seek immediate medical attention. SKIN: wash with large amounts of water for 20 min.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: oral rat LD_{50} 2,000 mg/kg; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Acrolein — (i) Chemical Designations — *Synonyms*: Acraldehyde, Acrylic Aldehyde, 2-Propenal, Acrylaldehyde; *Chemical Formula*: $CH_2{=}CH{\bullet}CHO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to slight yellow; *Odor*: Extremely sharp - lachrymator; piercing and disagreeable; extremely irritating, acrid, pungent.; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 56.1; *Boiling Point at 1 atm.*: 127, 53, 326; *Freezing Point*: -125, -87, 186; *Critical Temperature*: 489, 254, 527; *Critical Pressure*: 737, 50.0, 5.08; *Specific Gravity*: 0.843 at 20 °C (liquid); *Vapor (Gas) Density*: 1.94; *Ratio of Specific Heats of Vapor (Gas)*: 1.1487; *Latent Heat of Vaporization*: 216, 120, 5.02; *Heat of Combustion*: -12500, -6950, -290; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles and full face shield, self-contained breathing apparatus (SCBA), positive pressure hose mask, airline mask; rubber safety shoes, chemical protective clothing; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat, a feeling of pressure in the chest, and shortness of breath. Nausea and vomiting occur. Loss of consciousness can occur if exposure has been sufficiently great. Congestion in the chest may be present in varying amounts, and fluid may collect in the lungs (pulmonary edema) of severely exposed victims. Vapor also causes severe eye irritation (redness, weeping, and swelling of lids; liquid burns eyes, contact with skin causes reddening or blistering. Ingestion causes severe irritation of mouth and stomach; *General Treatment for Exposure*: Keep patient warm and quiet; if conscious, give coffee and call a physician immediately after all types of exposures to this chemical. INHALATION: Remove patient to fresh air; if breathing becomes difficult, give oxygen. If breathing has stopped, give artificial respiration. EYES: Immediately flush with plenty of water

for at least 15 min. If medical attention is not immediately available, continue eye irrigation for another 15 min. period. Upon completion of first 15 min. eye irrigation period, it is permissible to instill 2 or 3 drops of an effective aqueous local eye anesthetic for relief of pain. No oils or ointments should be used unless so instructed by a physician. SKIN: Flush at once with large amounts of water. Wash thoroughly with soap and large amounts of water. INGESTION: Have victim drink large amounts of water. Induce vomiting and keep patient warm and quiet until physician arrives; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm; *Short-Term Exposure Limits*: 0.5 ppm - 5 min.; 0.2 ppm - 60 min.; *Toxicity by Ingestion*: LD_{50} < 50 mg/kg; *Late Toxicity*: oral rat LD_{50} 46 mg/kg; oral rabbit LD_{50} 7 mg/kg; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat, and can cause eye and lung injury. There is no tolerance even at very low concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree chemical burns on short exposure; may cause second degree chemical burns on short exposure; *Odor Threshold*: 0.21 ppm.

Acrylamide — (i) Chemical Designations — *Synonyms*: Acrylic Amide 50%, Propenamide 50%; *Chemical Formula*: $CH_2=CHCONH_2—H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Clear; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 71 (solute only); *Boiling Point at 1 atm.*: Data not available (Vapor Pressure 0.033 atm at 125 °C; *Freezing Point*: 183, 84, 357; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.05 at 25 °C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses with side shields; clean body-covering clothing; rubber gloves, boots, apron as dictated by circumstances; in absence of proper environmental control, use approved dust respirator; *Symptoms Following Exposure*: Has produced central nervous system damage, which is partly reversible. Effects can be produced by oral or skin contact as well as by injection. Chronic acrylamide poisoning can cause midbrain disturbance and peripheral neuropathy. Contact with liquid can cause moderate irritation of eyes and skin and may cause moderate transient corneal injury; *General Treatment for Exposure*: INHALATION: if ill effects occur, immediately get patient to fresh air, keep him quiet and warm, and get medical help. INGESTION: if ingested, immediately give large amounts of water (or milk if immediately available), then induce vomiting and get medical help. EYES: immediately flush with plenty of water for at least 15 min. and get medical promptly. SKIN: immediate, continuous, and thorough washing in flowing water is imperative, preferably deluge shower with abundant soap; if burns are present, get medical help; discard all contaminated clothing and wearing accessories; *Toxicity by Inhalation (Threshold Limit Value)*: 0.3 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 170 mg/kg; *Late Toxicity*: Repeated exposure to small amounts may cause essentially reversible neurological effects; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Acrylic Acid — (i) Chemical Designations — *Synonyms*: Propenoic Acid; *Chemical Formula*: $CH_2=CHCOOH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72.06; *Boiling Point at 1 atm.*: 286.3, 141.3, 414.5; *Freezing Point*: 54.1, 12.3, 285.5; *Critical Temperature*: 648, 342, 615; *Critical Pressure*: 840, 57, 5.8; *Specific Density*: 1.0497 at 20 °C (liquid); *Vapor (Gas) Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.121; *Latent Heat of Vaporization*: 272.7, 151.5, 6.343; *Heat of Combustion*: -8100, -4500, -188.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical respirator at ambient temperatures to avoid inhalation of noxious fumes; rubber gloves if exposed to wet material; acid goggles or face shield for splash exposure; safety shower and/or eye fountain may be required; *Symptoms Following Exposure*: May burn skin or eyes upon short contact. INHALATION: eye and nasal irritation and lacrimation. INGESTION: may cause severe damage to the gastrointestinal tract; *General Treatment for Exposure*: Get medical attention promptly for all exposures. INHALATION: remove victim to fresh air. INGESTION: do NOT induce vomiting. SKIN OR EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will

not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain second-degree burns after a few minutes of contact; *Odor Threshold*: Data not available.

Acetylene — (i) Chemical Designations — *Synonyms*: Ethine, Ethyne; *Chemical Formula*: C_2H_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Distinctive; garlic-like; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Compressed gas; *Molecular Weight*: 26.04; *Boiling Point at 1 atm.*: -119, -84.0, -189.2; *Freezing Point*: Not pertinent; *Critical Temperature*: 95.3, 35.2, 308.4; *Critical Pressure*: 890.7, 60.59, 6.138; *Specific Gravity*: 0.613 at -80°C (liquid); *Vapor (Gas) Density*: 0.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.235; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: 120.747, -11.526, -482.57; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air supply respirator in areas of high concentration. Avoid all sources of ignition; *Symptoms Following Exposure*: Headache, dizziness and loss of consciousness may occur. Death from "smothering" may occur if oxygen content of the air is severely reduced by dilution with acetylene; *General Treatment for Exposure*: INHALATION: no specific antidote known; remove victim to fresh air, keep him warm and quiet, and call a doctor; recovery as usually rapid. If patient is unconscious, administer oxygen; if breathing has stopped, give artificial respiration; *Toxicity by Inhalation (Threshold Limit Value)*: 5000 ppm (suggested); *Short-Term Inhalation Limits*: 100,000 ppm for 30-60 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Not pertinent; *Odor Threshold*: Data not available.

Acetyl Peroxide Solution — (i) Chemical Designations — *Synonyms*: Diacetyl Peroxide Solution; *Chemical Formula*: $CH_3CO(O_2)OCCH_3$ in dimethyl phthalate; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 17, -8, 265; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -15,700, -8,750, -366; *Heat of Decomposition*: -50, -28, -1.2; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Protective goggles; rubber apron and gloves; *Symptoms Following Exposure*: Contact with liquid causes irritation of eyes and skin. If ingested, irritates mouth and stomach; *General Treatment for Exposure*: EYES: wash with plenty of soap and water and get medical attention. SKIN: wash with plenty of soap and water. INGESTION: induce vomiting and call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Acrylonitrile — (i) Chemical Designations — *Synonyms*: Cyanoethylene, Fumigrain, Ventox, Vinyl Cyanide; *Chemical Formula*: $CH_2{=}CHCN$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild; pungent, resembling that of peach seed kernels; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 53.06; *Boiling Point at 1 atm.*: 171, 77.4, 350.6; *Freezing Point*: -118, -83.6, 189.6; *Critical Temperature (°F,, °K)*: 505, 263, 536; *Critical Pressure*: 660, 45, 4.6; *Specific Gravity*: 0.8075 at 20°C (liquid); *Vapor (Gas) Density*: 1.8; *Ratio of Specific Heats of Vapor (Gas)*: 1.151; *Latent Heat of Vaporization*: 265, 147, 6.16; *Heat of Combustion*: -14,300, -7930, -332; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air-supplied mask, industrial chemical type, with approved canister for acrilonitrile in low (less than 2%) concentrations; rubber or plastic gloves; cover goggles or face mask; rubber boots; slicker suit; safety helmet; *Symptoms Following Exposure*: Similar to those of hydrogen cyanide. Vapor inhalation may cause weakness, headache, sneezing, abdominal pain, and vomiting. Similar symptoms shown if large amounts of liquid are absorbed through the skin; lesser amounts cause stinging and sometime blisters; contact with eyes causes severe irritation. Ingestion produced nausea, vomiting and abdominal pain; *General Treatment for Exposure*: Skilled medical treatment is necessary; call physician for all cases of exposure. INHALATION: remove victim to fresh air. (Wear an oxygen or fresh-air-supplied mask when entering contaminated area). INGESTION: induce vomiting by administering strong solution of salt water, but only if

victim is conscious. SKIN: remove contaminated clothing and wash affected area thoroughly with soap and water. EYES: hold eyelids apart and wash with continuous gentle stream of water for at least 15 min.. If victim is not breathing, give artificial respiration until physician arrives. If he is unconscious, crush an amyl nitrite ampule in a cloth and hold it under his nose for 15 seconds in every minute. Do not interrupt artificial respiration while doing this. Replace ampule when its strength is spent and continue treatment until condition improves or physician arrives; *Toxicity by Inhalation (Threshold Limit Value)*: 20 ppm; *Short-Term Exposure Limits*: 40 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (rat, guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. Large amounts may be absorbed through the skin and cause poisoning; *Odor Threshold*: 21.4 ppm (Sense of smell fatigues rapidly).

Adipic Acid — (i) Chemical Designations — *Synonyms*: Adipinic Acid, 1,4-Butanedicarboxylic Acid, Hexanedioic Acid; *Chemical Formula*: $HOOC(CH_2)_4.COOH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Crystalline; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 146.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 304, 151, 424; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.36 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,242, -4,579, -191.6; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Normal protection against exposure to finely divided organic solids (rubber gloves, plastic goggles); *Symptoms Following Exposure*: Inhalation of vapor irritates mucous membranes of the nose and lungs, causing coughing and sneezing. Contact with liquid irritates eyes and has a pronounced drying effect on the skin; may produce dermatitis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention if irritation persists. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral mouse LD_{50} 1,900 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Adiponitrile — (i) Chemical Designations — *Synonyms*: 1,4-Dicyanobutane; *Chemical Formula*: $CN(CH_2)_4CN$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Water-white to light yellow; *Odor*: Practically odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 108; *Boiling Point at 1 atm.*: 554, 290, 563; *Freezing Point*: 36, 2.4, 275.5; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.9611 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 240, 134, 5.59; *Heat of Combustion*: -14,230, -7910, -331; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves and clothing giving full body and face protection to avoid contact with skin. Air or oxygen mask; *Symptoms Following Exposure*: Ingestion of a few ml. may cause weakness, mental confusion, vomiting, rapid respiration, and tachycardia and convulsions. Headache and convulsions can result fro exposure to vapor; *General Treatment for Exposure*: Symptomatic treatment. Call physician. Thiosulfate should be considered. Administer vapor of amyl nitrite if patient is unconscious; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: If present in high concentrations, vapor cause a slight smarting of the eyes or respiratory system and may also cause more severe symptoms such as headache and convulsions; *Liquid or Solid Irritant Characteristics*: If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. If absorbed by skin may cause more severe symptoms such as headache and convulsions; *Odor Threshold*: Data not available.

Aldrin — (i) Chemical Designations — *Synonyms*: endo-, exo-,1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-Hexahydro-1,4:5,8-Dimethanonaphtalene, HHDN; *Chemical Formula*: $C_{12}H_8Cl_6$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Tan to dark brown; *Odor*: Mild chemical; **(iii) Physical and**

Chemical Properties — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 364.93; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 219, 104, 377; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.6 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: During prolonged exposure to mixing and loading operations, wear clean synthetic rubber gloves and mask or respirator of the type passed by the U.S. Bureau of Mines for aldrin protection; *Symptoms Following Exposure*: Ingestion, inhalation, or skin absorption of a toxic dose will induce nausea, vomiting, hyperexcitability, tremors, epileptiform convulsions, and ventricular fibrillation. Aldrin may cause temporary reversible kidney and liver injury. Symptoms may be seen after ingestion of less than 1 gram in an adult; ingestion of 25 mg has caused death in children; *General Treatment for Exposure*: SKIN CONTACT: wash with soap and running water. If material gets into eyes, wash immediately with running water for at least 15 min.; get medical attention. INGESTION: call physician immediately; induce vomiting. Repeat until vomit fluid is clear. Never give anything by mouth to an unconscious person. Keep patient prone and quiet. PHYSICIAN: administer barbiturates as anti-convulsant therapy. Observe patient carefully because repeated treatment may be necessary; *Toxicity by Inhalation (Threshold Limit Value)*: 0.25 mg/m^3; *Short-Term Exposure Limits*: 1 mg/m^3 for 30 min.; *Toxicity by Ingestion*: Grade 3; LD 50 to 500 mg/kg (rat); *Late Toxicity*: Chronic exposure produces benign tumors in mice; *Vapor (Gas) Irritant Characteristics*: Vapors cause slight smarting of the eyes or respiratory system if present in high concentration. Effects is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening if the skin; *Odor Threshold*: Data not available.

Alkylbenzenesulfonic Acids — (i) Chemical Designations — *Synonyms*: Un-, Do-, Tri-, Tetra-, Penta-, Hexa-Desylbenzenesulfonic Acid; *Chemical Formula*: $C_nH_{2n}+C_6H_4SO_3H$(n=10-16); **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 310 - 394; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0 to 1.4 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Ingestion causes irritation of mouth and stomach. Contact with liquid irritates eyes and skin; *General Treatment for Exposure*: INGESTION: give large amount of water. EYES: flush with water for at least 15 min. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5-5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Allyl Alcohol — (i) Chemical Designations — *Synonyms*: 2-Propen-1-ol-Vinylcarbinol; *Chemical Formula*: $CH_2=CHCH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic, pungent; sharp; causes tears; **(iii) Physical and Chemical Properties** — *Physical State at 15 and 1 atm.*: Liquid; *Molecular Weight*: 58.08; *Boiling Point at 1 atm.*: 206, 96.9, 370.1; *Freezing Point*: -200, -129, 144; *Critical Temperature*: 521.4, 271.9, 545.1; *Critical Pressure*: 840, 57, 5.8; *Specific Gravity*: 0.852 at 20 °C (liquid); *Vapor (Gas) Density*: 2.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.12; *Latent Heat of Vaporization*: 295, 164, 6.87; *Heat of Combustion*: -13,720, -7620, -319.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister or air pack; rubber gloves, goggles; other protective equipment as required to prevent all body contact; *Symptoms Following Exposure*: Vapors are quite irritating to eyes, nose and throat. Eye irritation may be accompanied by complaints of photophobia and pain in the eyeball; pain may not begin until 6 hours after exposure. Liquid may cause first- and second-degree burns of the skin, with blister formation; underlying part will become swollen and painful, and local muscle spasms may occur; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area and administer oxygen; get medical attention immediately. SKIN: remove liquid with soap and water. EYES: flush with continuous stream of water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 2 ppm; *Short-Term Exposure*

Limits: 5 ppm for 30 min; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (mouse, rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentration; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on a long exposure; *Odor Threshold*: 0.78 ppm.

Allyl Bromide — (i) Chemical Designations — *Synonyms*: Bromallylene, 3-Bromopropene, 3-Bromopropylene; *Chemical Formula*: $CH_2=CH•CH_2Br$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Irritating, unpleasant; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 121; *Boiling Point at 1 atm.*: 158, 70, 343; *Freezing Point*: -182, -119, 154; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.4161 at 20°C (liquid); *Vapor (Gas) Density*: 4.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.1210; *Latent Heat of Vaporization*: 110, 59, 2.5; *Heat of Combustion*: 6,700, 3,700, 150; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and face shield; protective clothing; self-contained breathing apparatus for high vapor concentrations; *Symptoms Following Exposure*: Inhalation of vapor irritates mucous membranes and causes dizziness, headache, and lung irritation. Contact with liquid irritates eyes and skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure; if breathing is difficult, give oxygen; call physician. EYES: flush with water for at least 15 min. and call physician. SKIN: flush with water; get medical attention for skin irritation. INGESTION: do NOT induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} 30 mg/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high vapor concentration; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

Allyl Chloride — (i) Chemical Designations — *Synonyms*: 3-Chloropropene, 3-Chloropropylene; *Chemical Formula*: $CH_2=CHCH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp; penetrating; irritating; characteristic pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 76.53; *Boiling Point at 1 atm.*: 113, 45, 318; *Freezing Point*: -210, -134, 138.7; *Critical Temperature*: 466, 241, 514; *Critical Pressure*: 690, 47, 4.8; *Specific Gravity:* 0.938 at 20°C (liquid); *Vapor (Gas) Density*: 2.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.124; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -9749, -5416, -226.8; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory protection: (1 ppm to 2% for ½ hr or less) full face mask and canister; (greater concentration) self-contained breathing apparatus or its equivalent. Rubber or neoprene gloves, apron, boots; clean body-covering clothes; chemical goggles, gas-tight goggles, or equivalent; full face shield; *Symptoms Following Exposure*: Causes marked irritation of skin and may burn. Burns the eyes; effect may be delayed; *General Treatment for Exposure*: INHALATION: if ill effects develop, move person to fresh air, keep him warm and quiet. Get medical attention immediately. Start artificial respiration if breathing stops. INGESTION: promptly induce vomiting. Get medical attention immediately; no known antidote; treat symptomatically. EYES: immediately flush with plenty of water for at least 15 min.; get medical attention promptly. SKIN: remove clothing and flush affected area thoroughly; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD50 0.5 to 5 g/kg (rat); *Late Toxicity*: Lung liver and kidney damage in experimental animals; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentration; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: 0.47.

Allyl Chloroformate — (i) Chemical Designations — *Synonyms*: Allyl Chlorocarbonate; *Chemical Formula*: $CH_2=CH•CH_2•O•COCl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Extremely irritating, causes tears; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 120.5; *Boiling Point at 1 atm.*: 113, 45, 318; *Freezing Point*: -112, -80, 193; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific*

Gravity: 1.139 at 20°C (liquid); *Vapor (Gas) Density*: 4.15; *Ratio of Specific Heats of Vapor (Gas)*: 1.0804; *Latent Heat of Vaporization*: 100, 56, 2.3; *Heat of Combustion*: -7,800, -4,300, -180; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Vapor-proof protective goggles and face shield; plastic or rubber gloves, shoes and clothing; gas mask or self-contained breathing apparatus; *Symptoms Following Exposure*: Vapor irritates eyes and respiratory tract. Contact with liquid causes eye and skin irritation, and ingestion irritates mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration if necessary; call physician. EYES: if irritated by either vapor or liquid, flush with water for at least 15 min. SKIN: wash with large amounts of water for at least 15 min. INGESTION: do NOT induce vomiting; give water; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 1.4 ppm.

Allyltrichlorosilane — (i) Chemical Designations — *Synonyms*: Allylsilicone Trichloride; *Chemical Formula*: $CH_2{=}CH{\bullet}CH_2{\bullet}SiCl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp; pungent, irritating, like hydrochloric acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 175.5; *Boiling Point at 1 atm.*: 241, 116, 389; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.215 at 20°C (liquid); *Vapor (Gas) Density*: 6; *Ratio of Specific Heats of Vapor (Gas)*: 1.0863; *Latent Heat of Vaporization*: 97, 54, 2.3; *Heat of Combustion*: -5,200, -2,900, -120; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection; rubber gloves; chemical goggles; other equipment necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation of vapor irritates mucous membranes. Liquid causes severe burns of eyes and skin and severe internal burns if ingested; *General Treatment for Exposure*: Get medical attention after all exposures of this compound. INHALATION: remove from exposure; support respiration. EYES: flush with water 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; give water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye or lung injury. They can not be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Aluminum Chloride — (i) Chemical Designations — *Synonyms*: Anhydrous Aluminum Chloride; *Chemical Formula*: $Al\ Cl_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Orange to yellow through gray to white; *Odor*: Like hydrogen chloride; like hydrochloric acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 133.34; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.44 to 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: All personnel in the area should wear safety clothing, including fully closed goggles, rubber or plastic-coated gloves, rubber shoes and coverall of acid-resistant material. An acid-vapor canister mask should be carried in case of emergency. In certain applications, it may be advisable to wear this equipment on a routine basis; *Symptoms Following Exposure*: Contact with the skin or eyes in the presence of moisture causes thermal and acid burns; *General Treatment for Exposure*: INGESTION: if victim is conscious have him drink water or milk. Do NOT induce vomiting. SKIN: flush immediately with plenty of water. For eye contact, flush with water for at least 15 min. and get medical attention immediately; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm (hydrogen chloride); *Short-Term Exposure Limits*: 5 ppm for 5 min.; 30 ppm for 10 min.; 20 ppm for 20 min.; 10 ppm for 60 min.; *Toxicity by Ingestion*: No systemic effects, but severe burns of mouth; *Late Toxicity*: None recognized; *Vapor (Gas) Irritant Characteristics*: Vapor (or hydrogen chloride) is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin

irritant; may cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 1-5 ppm (hydrogen chloride).

Aluminum Fluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $AlF_3 \cdot 3H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 83.98; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.88 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles to protect against airborne particles and possibly respirator for intermittent heavy dust exposures; *Symptoms Following Exposure*: ACUTE: respiratory irritation; possible nose bleeding or vomiting; CHRONIC: aggravates bronchitis/asthma; increased bone density; *General Treatment for Exposure*: For acute poisoning, oral administration of lime water, intravenous infusion of glucose, and intravenous injections of calcium gluconates; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: LDL_0 600 mg/kg (guinea pig); *Late Toxicity*: Skeletal fluorosis (bone abnormalities) in humans, working in aluminum plant for 12 years; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Aluminum Nitrate — (i) Chemical Designations — *Synonyms*: Aluminum Nitrate Nonahydrate; Nitric Acid, Aluminum Salt; *Chemical Formula*: $Al(NO_3)_3 \cdot 9H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 375.13; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 163, 73, 346; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* > 1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; dust respirator; rubber gloves; *Symptoms Following Exposure*: Ingestion of large doses causes gastric irritation, nausea, vomiting, and purging. Contact with dust irritates eyes and skin; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD50 264 mg/kg (nonahydrate); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Aluminum Sulfate — (i) Chemical Designations — *Synonyms*: Cake Alum, Patent Alum; *Chemical Formula*: $Al_2(SO_4)_3 \cdot 18H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Gray-white; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 666.4; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.7 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust respirator; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and mouth. Ingestion of large doses causes gastric irritation, nausea, vomiting, and purging. Dust irritates eyes and skin; *General Treatment for Exposure*: INHALATION: rinse nose and mouth with water. INGESTION: give large amounts of water. EYES: flush with water form at least 15 min. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral mouse LD_{50} 770 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Aminoethylethanolamine — (i) Chemical Designations — *Synonyms*: 2-[(2-Aminoethyl)amino]ethanol, N-(2-Aminoethyl)ethanolamine, N-beta-Hydroxyethylene-diamine, N-Hydroxyethyl-1,2-ethanediamine; *Chemical Formula*: $HOCH_2CH_2NHCH_2CH_2NH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*:

Liquid; *Color*: Colorless; *Odor*: Mild ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 104.15; *Boiling Point at 1 atm.*: 469, 243, 516; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.028 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.053; *Latent Heat of Vaporization*: 209, 116, 4.85; *Heat of Combustion*: -12,300, -6,860, -287; Heat of Decomposition: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; protective clothing; *Symptoms Following Exposure*: Skin contact will cause mild irritation; eye contact will cause more severe irritation; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting; call physician immediately. SKIN: wash area with plenty of water. EYES: flush thoroughly with running water, preferably for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: High concentration of vapor cause a slight smarting of the eyes or respiratory system. The effevt is temporary; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

Ammonia, Anhydrous — (i) Chemical Designations — *Synonyms*: Liquid Ammonia; *Chemical Formula*: NH_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed liquified gas; *Color*: Colorless; *Odor*: Pungent; extremely pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 17.03; *Boiling Point at 1 atm.*: -28.1, -33.4, 239.8; *Freezing Point*: -108, -77.7, 265.5; *Critical Temperature*: 271, 133, 406; *Critical Pressure*: 1,636, 11.3, 11.27; *Specific Gravity:* 0.682 at -33.4°C (liquid); *Vapor (Gas) Density*: 0.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.3 at 20°C; *Latent Heat of Vaporization*: 589, 327, 13.7; *Heat of Combustion*: -7992, -4440, -185.9; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gas-tight chemical goggles, self-contained breathing apparatus, rubber boots, rubber gloves, emergency shower and eye bath; *Symptoms Following Exposure*: 700 ppm causes eye irritation, and permanent injurymay result if prompt remedial measures are not taken; 5000 ppm can cause immediate death from spasm, inflammation, or edema of the larynx. Contact of the liquid with skin freezes the tissue and than produces a caustic burn; *General Treatment for Exposure*: INHALATION: move victim to fresh air and give artificial respiration if necessary. Oxygen may be useful. Observe for laryngeal spasm and perform tracheostomy if indicated. SKIN OR EYES: flood immediately with running water for 15 min. Treat subsequently as thermal burn; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Exposure Limits*: 50 ppm for 5 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe eye or throat irritation and may cause eye or lung injury; vapors cannot be tolerated even at low concentartions; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 46.8 ppm.

Ammonium Acetate — (i) Chemical Designations — *Synonyms*: Acetic Acid, Ammonium Salt; *Chemical Formula*: $NH_4C_2H_2O_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Weak ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 77.08; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.17 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and mouth. Ingestion irritates mouth and stomach. Contact with dust causes irritation of eyes and mild irritation of skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; rinse nose and mouth with water. INGESTION: give large amounts of water. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Benzoate — (i) Chemical Designations — *Synonyms*: Benzoic Acid, Ammonium Salt; *Chemical*

Formula: $C_6H_5COONH_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 139.15; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 388, 198, 471; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.26 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses, gloves; *Symptoms Following Exposure*: Inhalation of dust may irritate nose; *General Treatment for Exposure*: INHALATION: move to uncontaminated atmosphere. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion:* Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Bicarbonate — (i) Chemical Designations — *Synonyms*: Acid Ammonium Carbonate, Ammonium Hydrogen Carbonate, Carbonic Acid, Monoammonium Salt; *Chemical Formula*: NH_4HCO_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Slight ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 79.06; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent (decomposes at 35°C); *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.57 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Work gloves; dust respirator; safety glasses or chemical safety goggles if dusty; *Symptoms Following Exposure*: Inhalation may cause respiratory irritation. Ingestion could be harmful. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: Consult physician in case of ingestion or severe irritation. INHALATION: move to uncontaminated atmosphere. EYES OR SKIN: wash with large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Bifluoride — (i) Chemical Designations — *Synonyms*: Acid Ammonium Fluoride, Ammonium Acid Fluoride, Ammonium Hydrogen Fluoride; *Chemical Formula*: NH_4NF_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 57.04; *Boiling Point at 1 atm.*: 463.1, 239.5, 512.7; *Freezing Point*: 258, 125.6, 398.8; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.5 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator; rubber gloves; safety goggles; *Symptoms Following Exposure*: Inhalation of dust may cause irritation of respiratory system. Ingestion causes irritation of mouth and stomach, vomiting, abdominal pain, convulsions, collapse, acute toxic nephritis. Contact with dust irritates eyes and may cause burns or rash on skin. High concentrations of fluorine in the urine have been reported following skin contact; *General Treatment for Exposure:* Begin first aid as quickly as possible. INHALATION: remove victim to fresh air. INGESTION: perform gastric lavage with lime water or 1% calcium chloride solution; support respiration; call a physician. EYES: flush with water for at least 15 min.; consult physician. SKIN: flush with water; treat burns. OTHER: remove all contaminated clothing in the shower at once; *Toxicity by Inhalation (Threshold Limit Value)*: 2.5 mg/m^3 (as fluorine); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 mg/kg (guinea pig), 60 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Carbonate — (i) Chemical Designations — *Synonyms*: Hartshorn; Salt Volatile; *Chemical Formula*: $(NH_4)_2CO_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Strong ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular*

Weight: 157.1; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.5 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; protection against ammonia vapors; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion may cause gastric irritation. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: leave contaminated area. INGESTION: give large amount of water. EYES: flush with copious amounts of water. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: <1.5 ppm (as ammonia gas).

Ammonium Chloride — (i) Chemical Designations — *Synonyms*: Amchlor; Ammoneric; Ammonium Muriate; Salammoniac; Salmiac; *Chemical Formula*: NH_4Cl; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 53.5; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.53 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves of any material; safety glasses or chemical safety goggles; dust mask or respirator as necessary; *Symptoms Following Exposure*: Inhalation of fumes irritates respiratory passages. Ingestion irritates mouth and stomach. Fumes are irritating to eyes. Contact with skin may cause irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. INGESTION: give large amount of water; get medical attention if irritation persists. EYES OR SKIN: flush with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 1,650 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ammonium Citrate — (i) Chemical Designations — *Synonyms*: Ammonium Citarte, Dibasic; Citric Acid, Diammonium Salt; Diammonium Citrate; *Chemical Formula*: $(NH_4)_2HC_6H_5O_7$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Slight ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 226; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.48 at 20° C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved air dust respirator; eye goggles; *Symptoms Following Exposure*: Inhalation causes respiratory irritation. Ingestion causes diarrhea. Contact with eyes causes mild irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water or physiological saline; get medical care if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Dichromate — (i) Chemical Designations — *Synonyms*: Ammonium Bichromate; *Chemical Formula*: $(NH_4)_2Cr_2O_7$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Orange-yellow; bright red-orange; orange to red; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 252.06; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.15 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust

respirator; protective goggles, gloves, clothing; *Symptoms Following Exposure*: Inhalation causes irritation or ulceration of the mucous membranes of the nose, throat or respiratory tract. Respiratory irritation can produce symptoms resembling those of asthma. Continuing irritation of the nose may lead to perforation of the nasal septum. External contact can cause eye irritation and conjunctivitis, irritation and ulceration of skin wounds, and rash or external ulcers. If ingested, irritates mucous membrane and causes vomiting; *General Treatment for Exposure*: INHALATION: remove to clean air and summon medical attention. EYES: immediately flush with water for at least 15 min. and consult a physician. SKIN: flush with water; if skin irritation develops, get medical attention. INGESTION: vomiting should occur; follow with an emetic of soapy water; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Ammonium Fluoride — (i) Chemical Designations — *Synonyms*: Neutral Ammonium Fluoride; *Chemical Formula*: NH_4F; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 37.04; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.32 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of dust may cause irritation of respiratory system. Ingestion is harmful; readily soluble fluorides may be fatal if relatively small quantities are swallowed. Contact with eyes may causes local irritation of the mucous membrane. Contact with skin may cause burns. High concs. of fluorine in the urine have been reported following skin contact; *General Treatment for Exposure*: Begin first aid as quickly as possible. INHALATION: remove to fresh air. INGESTION: perform gastric lavage with limewater or 1% calcium chloride solution; support respiration; call a physician. EYES: flush with water for 15 min.; consult physician. SKIN: shower immediately with large quantities of water; remove all contaminated clothing in the shower at once; consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: 2.5 mg/m^3 (as fluorine); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Formate — (i) Chemical Designations — *Synonyms*: Formic Acid, Ammonium Salt; *Chemical Formula*: $HCOONH_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Weak ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 63.06; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 241, 116, 389; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.28 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion irritates mouth and stomach. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. INGESTION: give large amounts of water; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 2,250 mg/kg (mouse); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Gluconate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $NH_4C_6H_{11}O_7$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Weak ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 213; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* > 1 at 20°C (solid); *Vapor*

(Gas) Density: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator for nuisance dust; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Contact with eyes causes mild irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES OR SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Hydroxide (< 20 % Aqueous Ammonia) — (i) Chemical Designations — *Synonyms*: Ammonia Water, Aqueous Ammonia, Household Ammonia; *Chemical Formula*: $NH_4OH—H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 0.89 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber boots, gloves. apron, and coat; broad-brimmed rubber or felt hat; safety goggles. Use of protective oil will reduce skin irritation from ammonia; *Symptoms Following Exposure*: Contact of liquid or vapor with skin, mucous membranes, lungs, or gastroenteric tract causes marked local irritation. Ingestion causes burning pain in mouth, throat, stomach, and thorax, constriction of throat, and coughing. This is soon followed by vomiting of blood or by passage of loose stools containing blood. Breathing difficulty, convulsions, and shock may result. Brief exposure to 5000 ppm of ingestion of 3-4 ml may be fatal; *General Treatment for Exposure*: INHALATION: give artificial respiration and oxygen if needed; enforce rest. INGESTION: do NOT induce vomiting; lavage stomach with water or lemon juice, milk, or demulcents; delay may cause perforation of esophagus or stomach; swelling of glottis may necessitate tracheostomy. EYES OR SKIN: wash with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: (ammonia gas) 100 ppm for 30 min.; 500 ppm for 10 min.; *Toxicity by Ingestion*: Grade 3; oral rat, LD_{50} 350 mg/kg; *Late Toxicity*: Data nat available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations intolerable. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: 50 ppm.

Ammonium Iodide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NH_4I; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 144.94; *Boiling Point at 1 atm.*: Not pertinent (sublimes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.56 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. INGESTION: if significant amount has been ingested, get medical attention. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ammonium Lactate — (i) Chemical Designations — *Synonyms*: Ammonium Lactate Syrup; *dl*-Lactic Acid, Ammonium Salt; *Chemical Formula*: $CH_3CH(OH)COONH_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or liquid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Solid; *Molecular Weight*: 107.11; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.2 at 15°C (solid); *Vapor (Gas) Density*:

Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles of face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Lauryl Sulfate — (i) Chemical Designations — *Synonyms*: Dodecyl Sulfate, Ammonium Salt; Lauryl Ammonium Sulfate; *Chemical Formula*: $C_{12}H_{25}OSO_2ONH_4—H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Light yellow; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 283 (solute only); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.03 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Contact with liquid irritates eyes and may have drying effect on the skin. Prolonged contact will cause skin irritation; *General Treatment for Exposure*: EYES OR SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Molybdate — (i) Chemical Designations — *Synonyms*: Molybdic Acid, 85%; *Chemical Formula*: $(NH_4)_6Mo_7O_{24}•4H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White or greenish-yellow; colorless to yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 123.6; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.4 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3 (as molybdenum); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 333 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Nitrate — (i) Chemical Designations — *Synonyms*: Nitram; *Chemical Formula*: NH_4NO_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Colorless (pure) to gray or brown (fertilizer grades); *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 80.05; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 337.8, 169.9, 443.1; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.72 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Wear self-contained breathing apparatus; *Symptoms Following Exposure*: Irritation of eyes and mucous membranes. Absorption via ingestion or inhalation causes urination and acid urine. Large amount causes systemic acidosis and metheglobinemia (abnormal hemoglobin); *General Treatment for Exposure*: Remove from exposure - symptoms reversible; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Ammonium Nitrate-Phosphate Mixture — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NH_4NO_3—$(NH_4)_2HPO_4$—$NH_4H_2PO_4$—$CaHPO_4$—KCl—K_2SO_4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Grayish-white; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent (mixture); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.8 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus must be used when fighting fires. At other time dust mask is adequate; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ammonium Nitrate-Sulfate Mixture — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NH_4NO_3—$(NH_4)_2SO_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Grayish-white; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.8 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus must be used when fighting fires. At other times a dust mask is adequate; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD50 58 mg/kg (ammonium sulfate); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Nitrate-Urea Solution — (i) Chemical Designations — *Synonyms*: Solar Nitrogen Solutions; Nitrex Nitrogen Solutions (non-pressure); *Chemical Formula*: NH_4NO_3—NH_2CONH_2—H_2O; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >212, >100, >373; *Freezing Point*: 32, 0, 273; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.327 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Liquid irritates eyes, particularly those grades that contain a little free ammonia; *General Treatment for Exposure*: EYES: wash with plenty of water for 10-15 min. and rinse with a 5% boric acid solution; call a doctor. SKIN: rinse well with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Ammonium Oleate — (i) Chemical Designations — *Synonyms*: Ammonia Soap; Oleic Acid, ammonium Salt; *Chemical Formula*: $C_{17}H_{33}COONH_4$—H_2O; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Pasty solid; *Color*: Yellow-brown; *Odor*: Weak ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 299.5 (solute); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* >1 at 20°C (liquid or solid); *Vapor*

(Gas) Density: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with eyes causes irritation. Prolonged contact may cause skin irritation; *General Treatment for Exposure*: EYES OR SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Oxalate — (i) Chemical Designations — *Synonyms*: Ammonium Oxalate Hydrate; Diammonium Oxalate; Oxalic Acid, Diammonium Salt; *Chemical Formula*: $(NH_4)_2C_2O_4 \cdot H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 142.11; *Boiling Point at 1 atm.*: Not pertinent (decomposes at 70°C); *Freezing Point*: Not pertinent (decomposes at 70°C); *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.50 at 18.5°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust respirator; rubber or plastic-coated gloves; chemical goggles; *Symptoms Following Exposure*: Ingestion or excessive inhalation of dust causes systemic poisoning; possible symptoms include pain in throat, esophagus, and stomach; mucous membranes turn white; vomiting, severe purging, weak pulse, cardiovascular collapse, neuromuscular symptoms. Contact with eyes causes irritation. Contact with skin causes irritation of severe burns; *General Treatment for Exposure*: Speed is essential. INHALATION: remove to fresh air. INGESTION: call physician immediately; induce vomiting. EYES: flush with water and seek medical attention. SKIN: flush with water. OTHER: watch for swelling of the glottis and delayed constriction of the esophagus; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Kidney damage; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ammonium Pentaborate — (i) Chemical Designations — *Synonyms*: Ammonium Decaborate Octahydrate; Ammonium Pentaborate Tetrahydrate; *Chemical Formula*: $NH_4B_5O_8 \cdot 4H_2O$ or $(NH_4)_2B_{10}O_{16} \cdot 8H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 272.20; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.58 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Disposable-type respirator; side-shield safety spectacles; full-brimmed hard hat; goggles; ammonia gas mask; *Symptoms Following Exposure*: Inhalation of dust may result in non-specific irritation of upper respiratory tract. Ingestion of large quantities may produce symptoms of non-specific irritation of the gastrointestinal tract, nausea, vomiting, cramps, diarrhea. Contact with dust causes moderate eye irritation and minor skin irritation; *General Treatment for Exposure*: INHALATION: move from contaminated atmosphere; if respiratory discomfort persists, see a physician. INGESTION: give large amounts of water or warm salty water to induce vomiting and continue until vomitus is clear; obtain medical attention if abdominal discomfort persists. EYES: flush with large quantities of running water for a minimum of 15 min.; obtain medical help if irritation persists. SKIN: immediately flush affected areas with water; obtain medical help if irritation persists; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3 (as boric acid); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Perchlorate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NH_4ClO_4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular*

Weight: 117.49; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.95 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Irritating to skin and mucous membranes; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 3500 mg/kg; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Ammonium Persulfate — (i) Chemical Designations — *Synonyms*: Ammonium Peroxydisulfate; Peroxydisulfuric Acid, Diammonium Salt; *Chemical Formula*: $(NH_4)_2S_2O_8$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Light straw to colorless; *Odor*: Slight acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 228.20; *Boiling Point at 1 atm.*: Not pertinent (decomposes at 120°C); *Freezing Point*: Not pertinent(decomposes at 120°C); *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.98 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: U.S. Bu. Mines approved toxic dust mask; chemical goggles; rubber gloves; neoprene-coated shoes; *Symptoms Following Exposure*: Inhalation produces slight toxic effects. Contact with eyes irritates eyes and causes skin rash; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: wash with water for 20 min.; call a physician. SKIN: wash with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 820 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Phosphate — (i) Chemical Designations — *Synonyms*: Ammonium Phosphate, Dibasic; Diammonium Hydrogen Phosphate; Diammonim Orthophosphate; Monoammonium Orthophosphate; Secondary Ammonium Phosphate; *Chemical Formula*: $NH_4H_2PO_4$ and $(NH_4)_2HPO_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Diammonium - faint ammonia; Monoammonium - faint acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Monoammonium: 115, Diammonium: 132; *Boiling Point at 1 atm.*: Not pertinent (begins to decompose at 100°C); *Freezing Point*: (begins to decompose at 100°C); *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: Diammonium: 1.8 at 20°C, Monoammonium: 1.6 at 20 C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, protective gloves, and goggles. When diammonium phosphate is stored in closed area, self-contained breathing apparatus is required to protect against ammonia fumes; *Symptoms Following Exposure*: Inhalation of monoammonium form causes irritation of mucous membranes; with diammonium form, ammonia vapors in closed area can cause pulmonary edema and asphyxia. Contact with solid or with ammonia gas causes irritation of eyes and skin; *General Treatment for Exposure*: INHALATION: if exposed to ammonia fumes from diammonium phosphate, give artificial respiration and oxygen if needed; enforce rest. EYES: flush with water for at least 15 min.; if irritation persists, get medical attention. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ammonium Silicofluoride — (i) Chemical Designations — *Synonyms*: Ammonium Fluosilicate; *Chemical Formula*: $(NH_4)_2SiF_6$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 178.14; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.0 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of*

Vapor (Gas): Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; acid resistant clothing and hat; rubber gloves; goggles and safety shoes; *Symptoms Following Exposure*: Inhalation of dust can cause pulmonary irritation and can be fatal in some cases. Ingestion may be fatal. Contact with dust causes irritation of eyes and irritation or ulceration of skin; *General Treatment for Exposure*: INHALATION: remove patient to fresh air. INGESTION: cause vomiting by giving soapy water or mustard water; have patient drink large quantities of lime water; if necessary, give stimulant such as strong coffee; keep patient warm. EYES: flush with water for 20 min., holding eyelids open. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 2.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 100 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Stearate — (i) Chemical Designations — *Synonyms*: Ammonium Stearate Dispersion; Stearic Acid, Ammonium Salt; *Chemical Formula*: $C_{18}H_{35}COONH_4$-—H_2O; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Pasty solid or liquid; *Color*: White to yellow; *Odor*: Slightly ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 301.5; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.01 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves and goggles; *Symptoms Following Exposure*: None experienced under normal conditions of use. Ingestion causes irritation of mouth and stomach. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION or INGESTION: no treatment required. EYES: flush with copious quantities of tap water. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Sulfamate — (i) Chemical Designations — *Synonyms*: Ammate; Ammonium Amidosulfonate; Ammonium Amidosulfonate; Ammonium Amidosulphate; AMS; Sulfamic Acid, Monoammonium Salt; *Chemical Formula*: $NH_2SO_3NH_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White or brownish-gray; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 114.13; *Boiling Point at 1 atm.*: Decomposes above 200°C; *Freezing Point*: 268, 131, 404; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* > 1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion causes gastrointestinal disturbances. Dust irritates eyes; *General Treatment for Exposure*: INHALATION: remove to fresh air. INGESTION: give large amount of water; get medical attention. EYES: flush with water for 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 1,600 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Sulfate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(NH_4)_2SO_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 132.14; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.78 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not

available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50} 58 mg/kg (rat); *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Not pertinent; *Odor Threshold*: Not pertinent.

Ammonium Sulfide — (i) Chemical Designations — *Synonyms*: Ammonium Hydrogen Sulfide Solution; Ammonium Sulfhydrate Solution; Ammonium Sulfide Solution; *Chemical Formula*: $(NH_4)_2S—NH_4SH—H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Yellow to orange (fuming solution); colorless to yellow; *Odor*: Strong odor of sulfide and ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 68.14 (solute); *Boiling Point at 1 atm.*: 104, 40, 313; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 0.99 - 1.01 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; rubber or plastic gloves; splash goggles; rubber shoes; *Symptoms Following Exposure*: Inhalation of 500 ppm for 30 min. produces headaches, dizziness, bronchial pneumonia; 600 ppm for 30 min. ca cause death. Ingestion causes severe irritation of mucous membranes and stomach. Contact with liquid causes severe burns of eyes and severe skin irritation. May be absorbed through skin and cause hydrogen sulfide poisoning; *General Treatment for Exposure*: Get medical attention following all overexposures to this compound. INHALATION: move victim to fresh air; give artificial respiration, oxygen; consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Sulfite — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(NH_4)_2SO_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 134.2; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* > 1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Dust irritates eyes; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; get medical attention. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Tartrate — (i) Chemical Designations — *Synonyms*: *l*-Tartaric Acid, Ammonium Salt; *Chemical Formula*: $C_4H_{12}N_2O_6$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 184; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.60 at 25 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with solid may irritates eyes; *General Treatment for Exposure*: EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Thiocyanate — (i) Chemical Designations — *Synonyms*: Ammonium Rhodanate; Ammonium

Rhodanide; Ammonium Sulfocyanate; Ammonium Sulfocyanide; Thiocyanic Acid, Ammonium Salt; *Chemical Formula*: NH_4SCN; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or solution in water; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 76.12; *Boiling Point at 1 atm.*: 239, 115, 388; *Freezing Point*: 320, 160, 433; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* > 1.1 at 20°C (solid), 1.1 - 1.15 at 20°C (solution); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber or plastic gloves; rubber or plastic apron; standard goggles; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion causes dizziness, cramps, nervous disturbances. Dust irritates eyes. Can be adsorbed through skin; prolonged contact may produce various skin eruptions, dizziness, gramps, nausea, and mild to severe disturbance of the nervous system; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; get medical attention. EYES OR SKIN: wash with water, consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 854 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ammonium Thiosulfate — (i) Chemical Designations — *Synonyms*: Ammonium Hypo; Ammonium Hyposulfite; *Chemical Formula*: $(NH_4)_2S_2O_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or solution in water; *Color*: Clear, colorless; *Odor*: Ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 148.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator; rubber gloves; safety glasses; face shield; rubber apron, shield, or suit if necessary; *Symptoms Following Exposure*: Inhalation of dust may irritates respiratory system. Ingestion could be harmful. Contact with eyes or skin may cause irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: get medical attention at once. EYES: flush with plenty of water for at least 15 min. and get immediate medical attention. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Amyl Acetate — (i) Chemical Designations — *Synonyms*: Amyl Acetate, Mixed Isomers; Pentyl Acetates; *Chemical Formula*: $CH_3COOC_5H_{11}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Pleasant banana-like; mild; characteristic banana- or pear- like odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 130.19; *Boiling Point at 1 atm.*: 295, 146, 419; *Freezing Point*: <-148, <-100, <173; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; Specific Gravity: 0.876 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140, 75, 3.1; *Heat of Combustion*: -13,360, -7423, -310.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask or chemical cartridge respirator, protective gloves, goggles, safety shower, and eye bath; *Symptoms Following Exposure*: Irritation of eyes, nose and throat. Dizziness, nausea, headache; *General Treatment for Exposure*: INHALATION: move victim to fresh air; call physician; administer oxygen. SKIN OR EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 200 ppm for 30 min.; *Toxicity by Ingestion*: Grade 1; LD_{50} 6.5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: o appreciable hazard. Practically harmless to the skin. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.067 ppm.

n-Amyl Alcohol — (i) Chemical Designations — *Synonyms*: 1-Amyl Alcohol; n-Butylcarbinol; 1-Pentanol; Pentyl

Alcohol; *Chemical Formula*: $CH_3(CH_2)_3CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like alcohol; causes coughing; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 88.15; *Boiling Point at 1 atm.*: 280.2, 137.9, 411.1; *Freezing Point*: -110, -79, 194; *Critical Temperature*: 595, 313, 586; *Critical Pressure*: Not pertinent; *Specific Gravity:* 0.818 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.06; *Latent Heat of Vaporization*: 217.1, 120.6, 5.049; *Heat of Combustion*: -16,200, -9000, -376.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Face splash shield, goggles, protective clothing, and cartridge respirator; *Symptoms Following Exposure*: Irritation of skin, eyes and respiratory tract; headache and vertigo; dyspnea and cough; nausea, vomiting, and diarrhea. Double vision, deafness, delirium, and occasionally fatal poisoning, preceded by severe nervous symptoms, have been reported. Coma, glycosuria, and methemoglobinemia can occur; *General Treatment for Exposure*: SKIN: remove chemical by thorough washing with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data nat available; *Short-Term Exposure Limits*: 150 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: 0.12 ppm.

n-Amyl Chloride — (i) Chemical Designations — *Synonyms*: Amyl Chloride; 1-Chloropentane; n-Butylcarbinyl Chloride; 1-Pentyl Chloride; Chloride of Amyl; *Chemical Formula*: $CH_3CH_2CH_2CH_2CH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless, straw; deep purple; *Odor*: Aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 106.6; *Boiling Point at 1 atm.*: 226, 108, 381; *Freezing Point*: -146, -99, 174; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.8834 at 20°C (liquid); *Vapor (Gas) Density*: 3.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.0650; *Latent Heat of Vaporization*: 132.1, 73.40, 3.073; *Heat of Combustion*: -13,500, -7,500, -314; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes mild irritation of mucous membranes. Ingestion of liquid or contact with skin or eyes causes mild irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air; apply artificial respiration if required. EYES: flush with water. SKIN: wash well with soap and water. INGESTION: induce vomiting; give water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

n-Amyl Mercaptan — (i) Chemical Designations — *Synonyms*: 1-Pentanethiol; Amyl Hydrosulfide; Amyl Sulfhydrate; Amyl Thioalcohol; *Chemical Formula*: $CH_3CH_2CH_2CH_2CH_2SH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; water-white to yellow; *Odor*: Strong, offensive; garlic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 104.2; *Boiling Point at 1 atm.*: 248, 120, 393; *Freezing Point*: -105, -76, 197; *Critical Temperature*: 610, 321, 594; *Critical Pressure*: 508, 34.5, 3.50; *Specific Gravity:* 0.8392 at 25°C (liquid); *Vapor (Gas) Density*: 3.59; *Ratio of Specific Heats of Vapor (Gas)*: 1.0622; *Latent Heat of Vaporization*: 171, 94.9, 3.97; *Heat of Combustion*: -17,070, -9.480, -397; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves; goggles; *Symptoms Following Exposure*: Inhalation may cause nausea because of offensive odor. Contact with eyes or skin causes slight irritation. Ingestion may cause vomiting; *General Treatment for Exposure*: INHALATION: remove to fresh air; apply artificial respiration if required. EYES: wash with water; see a physician. SKIN: wash with soap and water. INGESTION: induce vomiting if it does not occur spontaneously; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.3 mg/m^3.

n-Amyl Methyl Ketone — (i) Chemical Designations — *Synonyms*: 2-Heptanone; 2-Ketoheptane; Methyl Amyl Ketone; Methyl Pentyl Ketone; Penthyl Methyl Ketone; *Chemical Formula*: $CH_3CH_2CH_2CH_2CH_2COCH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 114.19; *Boiling Point at 1 atm.*: 304.7, 151.5, 424.7; *Freezing Point*: -31, -35, 238; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity:* 0.8204 at 15°C (liquid); *Vapor (Gas) Density*: 3.94; *Ratio of Specific Heats of Vapor (Gas)*: 1.051; *Latent Heat of Vaporization*: 148.9, 82.7, 3.46; *Heat of Combustion*: Data not available; *Heat of Decomposition*: No pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves and goggles; *Symptoms Following Exposure*: Inhalation of concentrated vapor may have narcotic effect. Ingestion causes gastrointestinal disturbances. Contact with eyes cause irritation. Prolonged and repeated contact with skin may cause defatting with resultant irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: get medical attention. EYES: flush with water for 15 to 20 min. SKIN: flush affected areas with water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm (suggested); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 1,670 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.897 ppm.

n-Amyl Nitrate — (i) Chemical Designations — *Synonyms*: Diesel Ignition improver; Mixed Primary Amyl Nitrates; *Chemical Formula*: $C_5H_{11}ONO_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Light straw; water white; *Odor*: Ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 133; *Boiling Point at 1 atm.*: 292 - 314, 144 - 156, 417 - 429; *Freezing Point*: -190, -123, 150; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0 at 20°C; *Vapor (Gas) Density*: 4.59; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator with canister for vapor at high concentrations; *Symptoms Following Exposure*: Inhalation or ingestion may cause headache, methemoglobin, and nausea. Liquid or vapor irritates eyes. Contact with skin may cause slight irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; support respiration; get medical attention. EYES: irritate thoroughly with water. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Iso-Amyl Nitrite — (i) Chemical Designations — *Synonyms*: Isopentyl Nitrite; Amyl Nitrite; 3-Methylbutyl Nitrite; *Chemical Formula*: $(CH_3)_2CHCH_2CH_2ONO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Light yellow, transparent; *Odor*: Pleasant, fragrant, fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 117.1; *Boiling Point at 1 atm.*: 210, 99, 372; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 0.8758 at 20°C (liquid); *Vapor (Gas) Density*: 4; *Ratio of Specific Heats of Vapor (Gas)*: 1.0709; *Latent Heat of Vaporization*: 212, 118, 4.94; *Heat of Combustion*: -12,500, -6,930, -290; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles or face shield; self-contained breathing apparatus; protective gloves and clothing; *Symptoms Following Exposure*: Inhalation or ingestion causes flushing of the face, pulsatile headache, disturbing tachycardia, cyanosis (methemoglobinemia), weakness, confusion, restlessness, faintness, and collapse. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION or INGESTION: place patient in recumbent position; if necessary, administer oxygen. For treatment for severe methemoglobinemia, transfuse with hole blood or give I.V. or I.M. a dose of 1-2 mg/kg methylene blue or an oral dose of 3-5 mg/kg. EYES: after contact with liquid, irrigate with large quantities of water for 15 min.; call physician. SKIN: after contact with liquid, wash with large amounts of water. Call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: methemoglobinemia may occur; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and

throat; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

n-Amyltrichlorosilane — (i) Chemical Designations — *Synonyms*: Trichloropentylsilane; Pentylsilicon Trichloride; Trichloroamylsilane; *Chemical Formula*: CH_3CH_2. $CH_2CH_2CH_2SiCl_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, like hydrochloric acid; pungent; acrid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 205.6; *Boiling Point at 1 atm.*: 320, 160, 433; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.137 at 25°C (liquid); *Vapor (Gas) Density*: 7.1; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 86.8, 48.2, 2.02; *Heat of Combustion*: -6,630, -3,680, -154; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection; rubber gloves; chemical workers goggles; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membrane. Contact of liquid with eyes or skin cause severe burns, and ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: Get medical attention immediately after exposure to this compound. INHALATION: remove from exposure; support respiration. INGESTION: give large amounts of water. EYES: flush with water for 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD50 2,340 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Aniline — (i) Chemical Designations — *Synonyms*: Aminobenzene; Aniline Oil; Blue Oil; Phenylamine; *Chemical Formula*: $C_6H_5NH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale brown; *Odor*: Aromatic amine like; characteristic, peculiar; strongly amine-like; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 93.13; *Boiling Point at 1 atm.*: 363.6, 184.2, 457.4; *Freezing Point*: 21, -6.1, 267.1; *Critical Temperature*: 798.1, 425.6, 698.8; *Critical Pressure*: 770, 52.4, 5.31; *Specific Gravity:* 1.022 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.1; *Latent Heat of Vaporization*: 198, 110, 4.61; *Heat of Combustion*: -14,980, -8320, -348,3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Respirator for organic vapors, splashproof goggles, rubber gloves, boots; *Symptoms Following Exposure*: ACUTE EXPOSURE: blue discoloration of finger-tips, cheeks, lips and nose; nausea, vomiting, headache and drowsiness followed by delirium, coma and shock. CHRONIC EXPOSURE: loss of appetite, loss of weight, headaches,, visual disturbances; skin lesions; *General Treatment for Exposure*: Remove victim to fresh air and call a physician at once. SKIN OR EYES: immediately flush skin or eyes with plenty of water for at least 15 min. If cyanosis is present, shower with soap and warm water, with special attention to scalp and fingernails; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: 50 ppm for 30 min.; 5 ppm for 8 hr.; *Toxicity by Ingestion*: Grade 3; LD_{50} 5 to 500 mg/kg; *Late Toxicity*: None recognized; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.; *Odor Threshold*: 0.5 ppm.

Anisoyl Chloride — (i) Chemical Designations — *Synonyms*: p-Anisoyl Chloride; *Chemical Formula*: p-$CH_3OC_6H_5COCl$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Yellow; brown; *Odor*: Sharp, penetrating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 171.6; *Boiling Point at 1 atm.*: 504, 262, 535; *Freezing Point*: 72, 22, 295; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.26 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -10,500, -5,830, -244; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; plastic gloves; protective clothing; *Symptoms Following Exposure*: Vapor irritates mucous membranes. Contact of liquid with eyes or skin causes severe irritation. Ingestion causes

severe irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: flush with water for at least 15 min.; get medical attention. SKIN: flush with water; wash well with soap and water. INGESTION: do NOT induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Anthracene — (i) Chemical Designations — *Synonyms*: Anthracin; Green Oil; Paranaphtalene; *Chemical Formula*: $C_{14}H_{10}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to yellow; *Odor*: Weak aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 178.23; *Boiling Point at 1 atm.*: 646.2, 341.2, 614.4; *Freezing Point*: 421.7, 216.5, 489.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.24 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -17,100, -9,510, -398; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Antimony Pentachloride — (i) Chemical Designations — *Synonyms*: Antimony (V) Chloride; Antimony Perchloride; *Chemical Formula*: $SbCl_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to medium brown; yellow; red-brown; *Odor*: Pungent; offensive; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 299.05; *Boiling Point at 1 atm.*: 347, 175, 448; *Freezing Point*: 37, 3, 276; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.354 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 68.9, 38.3, 1.60; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor-acid gas type canister mask; rubber, neoprene, vinyl, etc. gloves; chemical safety goggles, plus face shield where appropriate; acid resistant clothing, plus apron for splash protection; rubber safety shoes or boots; hard hat; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact of liquid with eyes or skin causes severe burns. Ingestion causes vomiting and severe burns of mouth and stomach. Overexposure by any route can cause bloody stools, slow pulse, low blood pressure, coma, convulsions, cardiac arrest; *General Treatment for Exposure*: INHALATION: remove to clean air; rinse mouth and gargle with water; if overexposure is serious, get prompt medical attention. EYES: flush eyes and eye-lids thoroughly with large amounts of water; get prompt medical attention. SKIN: flush thoroughly with water; remove contaminated clothing; wash affected area with soap and water; if overexposure is serious, get prompt medical attention. INGESTION: dilute by drinking water; if vomiting occurs, adminster more water. If overexposure is serious, get prompt medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 as antimony; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD50 1,115 mg/kg (rat), 900 mg/kg (guinea pig); *Late Toxicity*: Antimony poisoning may result; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high vapor concentartions; *Liquid or Solid Irritant Characteristics*: Severe skin irritant; causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Antimony Pentafluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: SbF_5; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 216.7; *Boiling Point at 1 atm.*: 289, 143, 416; *Freezing Point*: 45, 7, 280; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.340 at 30°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 79, 44, 1.8; *Heat*

of Combustion: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-gas-type canister mask; rubber gloves, protective clothing; safety goggles and face shield; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact of liquid with eyes or skin causes severe burns. Ingestion causes vomiting and severe burns of mouth and throat. Overexposure by any route can cause bloody stools, slow pulse, low blood pressure, coma, convulsions, cardiac arrest; *General Treatment for Exposure*: INHALATION: remove to fresh air; rinse mouth with water; give oxygen if necessary to assist breathing; get medical attention. EYES: irrigate with copious amounts of water for at least 15 min.; get medical attention. SKIN: flush with copious amounts of water; wash well with soap and water. INGESTION: dilute by drinking water; if vomiting occurs, drink more water; get medical attention promptly; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 as antimony; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Antimony poisoning may result; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Antimony Potassium Tartrate — (i) Chemical Designations — *Synonyms*: Potassium Antimonyl Tartrate; Tartar Emetic; Tartarized Antimony; Tartrated Antimony; *Chemical Formula*: KOOC•CHOH•CHOH•COO(SbO)•-½H_2O; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 334; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.60 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; rubber or plastic-coated gloves; chemical goggles; tightly woven, close fitting clothes; Bu. Mines approved respirator; *Symptoms Following Exposure*: Inhalation causes inflammation of membranesof nose and throat, upper respiratory irritation, headache, dizziness. Ingestion causes gastrointestinal upset, strong irritation, vomiting. Contact with eyes or skin causes irritation. Further symptoms of exposure include nervous complaints (i.e., irritability, dizziness, muscular and neurological pain); *General Treatment for Exposure*: INGALATION: move to fresh air. INGESTION: call physician immediately; use water (plain, soapy, or salty) or milk (3-4 glasses) to provoke vomiting. EYES: flush with water for 15 min.; consult a physician. SKIN: flush with water; wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as antimony); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 115 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Antimony Trichloride — (i) Chemical Designations — *Synonyms*: Antimony Butter; Antimony (iii) Chloride; Butter of Antimony; *Chemical Formula*: $SbCl_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to pale yellow; *Odor*: Sharp, acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 228; *Boiling Point at 1 atm.*: 433, 223, 496; *Freezing Point*: 163, 73, 346; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 3.14 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator; chemical safety goggles; face shield; leather or rubber safety shoes; rubber apron; rubber gloves; *Symptoms Following Exposure*: Inhalation of small amounts may cause only irritation of the nose, throat, and air passages; large exposures result in severe air-passage irritation. Ingestion causes vomiting, purging with bloody stools, slow pulse and low blood pressure; slow, shallow breathing; coma and convulsions sometimes followed by death. Contact with eyes causes severe eye burns or at least severe eye irritation. Contact of dry chemical with skin may result in deep chemical burns; *General Treatment for Exposure*: INHALATION: move victim at once to fresh air and keep him warm, but not hot; call a physician immediately; nasal passages may be irrigated from a gently flowing hose. INGESTION: induce vomiting by giving large quantities of warm salt water; have a physician see the patient at once. SKIN: flush with large quantities of flowing water following by washing of skin surfaces with soap and water; remove all contaminated clothing promptly; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as antimony); *Short-Term Exposure Limits*:

Data nat available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 675 mg/kg; *Late Toxicity*:; *Vapor (Gas) Irritant Characteristics*: Data nat available; *Liquid or Solid Irritant Characteristics*: Data nat available; *Odor Threshold*: Data nat available.

Antimony Trifluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: SbF_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 178.75; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 558, 292, 565; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 4.38 at 21°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved respirator; rubber gloves; *Symptoms Following Exposure*: Resemble those of lead and arsenic poisoning. ACUTE POISONING: irritation of the mouth, nose, stomach and intestines; vomiting, purging with bloody stools; slow pulse and low blood pressure; slow, shallow breathing; coma and convulsions sometimes followed by death from cardiac and respiratory exhaustion. CHRONIC POISONING: dryness of throat; pain on swallowing; occasional vomiting and persistent nausea; susceptibility to fainting; diarrhea, loss of appetite and weight; giddness; dermatitis, either pustilar or ulcerative; anemia; *General Treatment for Exposure*: If any symptoms, however slight, are noticed, the affected individual should be removed from contact with chemical and placed under the care of the physician who is versed in the treatment necessary; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (guinea pig); *Late Toxicity*: Data not avavlable; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: Not pertinent.

Antimony Trioxide — (i) Chemical Designations — *Synonyms*: Diantimony Trioxide; Exitelite; Flowers of antimony; Senarmontite; Valentinite; Weisspiessglanz; *Chemical Formula*: Sb_2O_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 291.50; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 5.2 at 25 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; safety goggles; dust mask; *Symptoms Following Exposure*: Inhalation causes inflammation of upper and lower respiratory tract, including pneumonitis. Ingestion causes irritation of the mouth, nose, stomach and intestines; vomiting, purging with bloody stools; slow puls and low pressure; slow, shallow breathing; coma and convulsions sometimes followed by death. Contact with eyes causes conjunctivitis. Contact with skin causes dermatitis and rhinitis; *General Treatment for Exposure*: If any of the symptoms of poisoning, evenslight, are noticed, the affected individual should be removed from contact with the chemical and placed under care of a physician. INGESTION: induce vomiting. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as antimony); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; oral rat LD_{50} 20,000 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Arsenic Acid — (i) Chemical Designations — *Synonyms*: Arsenic Pentoxide; Orthoarsenic Acid; *Chemical Formula*: As_2O_5 or $H_3AsO_4 \cdot \frac{1}{2}H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; a concentarted water solution is sometimes shipped; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 229.8; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.2 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Calamine lotion and zinc oxide powder on hands and other skin areas; rubber gloves; Bu. Mines approved dust respirator; *Symptoms Following Exposure*: Ingestion causes irritations

of stomach, weakness, other gastrointestinal symptoms. Overdose can cause arsenic poisoning, but symptoms are delayed; *General Treatment for Exposure*: Get medical attention after all exposures to this compound. Be alert for arsenic poisoning symptoms. SKIN: wash well with soap and water. INGESTION: induce vomiting; drink freely lime water, milk, or raw egg; give a cathartic; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 as arsenic; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} 48 mg/kg (young rats); *Late Toxicity*: Arsenic compounds may be carcinogenic; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Odorless.

Arsenic Disulfide — (i) Chemical Designations — *Synonyms*: Realgar; Red arsenic Glass; Red Arsenic Sulfide; Red Orpiment; Ruby Arsenic; *Chemical Formula*: As_2S_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Red-brown; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 214; *Boiling Point at 1 atm.*: 1.049, 565, 838; *Freezing Point*: 585, 307, 580; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 3.5 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Approved respirator; goggles; rubber gloves; clean protective clothing; *Symptoms Following Exposure*: (Acute and subacute poisoning are not common). Repeated inhalation causes irritation of nose, laryngitis, mild bronchitis. Ingestion causes weakness, loss of appetite, gastrointestinal disturbances, peripheral neuritis, occasional hepatitis. Contact with eyes causes irritation. Irritates skin, especially where moist; if not treated, may cause ulceration; *General Treatment for Exposure*: Consult physician after all overexposure to this compound. INHALATION: move to fresh air. INGESTION: induce vomiting by giving warm salt water; repeat until vomit is clear. EYES: flush with water for at least 15 min. SKIN: wash well with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} < 50 mg/kg; *Late Toxicity*: Possible skin and lung cancer; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Arsenic Trichloride — (i) Chemical Designations — *Synonyms*: Arsenic (iii) Trichloride; Arsenic Chloride; Arsenous Chloride; Butter of Arsenic; Caustic Arsenic Chloride; Caustic Oil of Arsenic; Fuming Liquid Arsenic; *Chemical Formula*: $AsCl_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 181.3; *Boiling Point at 1 atm.*: 266.4, 130.2, 403.4; *Freezing Point*: 9, -13, 260; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 2.156 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 88.31, 49.06, 2.054; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Safety goggles and face shield; acid-type canister gas mask; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact of liquid with eyes or skin causes severe irritation. Ingestion causes weakness and severe irritation of mouth and stomach. Overdose can cause arsenic poisoning, but symptoms are delayed; *General Treatment for Exposure*: Get medical attention after all exposures to the compound. Be alert fro arsenic poisoning symptoms. INHALATION: remove to fresh air; give artificial respiration if needed. EYES: flush with water for at least 15 min. SKIN: flush with water. INGESTION: give large amounts of water, then induce vomiting; give lime water, milk, or raw egg; give a cathartic; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD50 138 mg/kg; fatal human dose 70-180 mg, depending on weight; *Late Toxicity*: Arsenic compounds may be carcinogenic; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Arsenic Trioxide — (i) Chemical Designations — *Synonyms*: Arcenous Acid; Arcenous Acid Anhydride; Arcenous Oxide; Arsenic Sesquioxide; White Arsenic; *Chemical Formula*: As_2O_3; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Like garlic; none; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 197.8; *Boiling Point at 1*

atm.: 855, 457, 730; *Freezing Point*: 599, 315, 588; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 3.7 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical cartridge approved respirator; protective gloves, eye protection; full protective coveralls; *Symptoms Following Exposure*: Ingestion causes irritation of mucous membrane, weakness, loss of appetite, gastrointestinal disturbances. Overdose can cause arsenic poisoning, but symptoms are delayed; *General Treatment for Exposure*: Get medical attention after all exposures to this compound. Be alert for arsenic poisoning symptoms. SKIN: wash thoroughly with soap and water; remove contaminated clothing and shower with soap and water; irritations, except for milder cases which disappear in a day or two, should have medical attention. INGESTION: vomiting should be induced and a physician should be called at once; drink freely of lime water, sweet milk, or raw eggs, followed by castor oil or any brisk cathartic; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral mouse LD_{50} 45 mg/kg; *Late Toxicity*: Arsenic compounds may be carcinogenic; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Arsenic Trisulfide — (i) Chemical Designations — *Synonyms*: Arsenic Yellow; King's Gold; King's Yellow; Orpiment; Yellow Arsenic Sulfide; *Chemical Formula*: As_2S_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow - orange; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 246; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 572, 300, 573; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 3.43 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles; rubber gloves; clean protective clothing; *Symptoms Following Exposure*: (Acute and sub-acute poisoning are not common.) Repeated inhalation causes irritation of nose, laryngitis, mild bronchitis. Ingestion causes weakness, loss of appetite, gastrointestinal disturbances, peripheral neuritis, occasional hepatitis. Contact with eyes causes irritation. Irritates skin, especially where moist; if not treated, may cause ulceration; *General Treatment for Exposure*: Consult physician after all overexposures to this compound. INHALATION: move to fresh air. INGESTION: induce vomiting by giving warm salt water; repeat until vomit is clear. EYES: flush with water for at least 15 min. SKIN: wash well with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} < 50 mg/kg; *Late Toxicity*: Possible skin and lung cancer; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Asphalt — (i) Chemical Designations — *Synonyms*: Asphalt Cements; Asphaltic Bitumen; Bitumen; Petroleum Asphalt; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Dark brown to black; *Odor*: Tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* 1.00 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing; face and eye protection when handling hot material; *Symptoms Following Exposure*: Contact with skin may cause dermatitis. Inhalation of vapors may cause moderate irritation of nose and throat. Hot liquid burns skin; *General Treatment for Exposure*: Severe burns may result from contact with hot asphalt. If molten asphalt strikes the exposed skin, coll the skin immediately by quenching with cold water. A burn should be covered with a sterile dressing, and the patient shoild be taken immediately to a hospital; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Ggrade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: None observed; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Asphalt Blending Stocks: Roofers Flux — (i) Chemical Designations — *Synonyms*: Asphaltum Oil; Flux Oil; Petroleum Tailings; Residual Oil; Road Oil; *Chemical Formula*: Data not available; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Brown to black; *Odor*: Tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Data not available; *Boiling Point at 1 atm.*: Data not available; *Freezing Point*: 20 to 110, -7 to 43, 266 to 316; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity:* 1.11 to 50°C (liquid); *Vapor (Gas) Density*: Data not available; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing; face and eye protection; *Symptoms Following Exposure*: Inhalation of vapors from semi-solid materials causes moderate irritation of nasal and upper respiratory tract passages. Aspiration causes slow onset and low degree of chemical pneumonitis with clinical symptoms of lower respiratory tract irritation. Ingestion produces irritation of gastrointestinal tract; *General Treatment for Exposure*: INHALATION OR ASPIRATION: treatment usually unnecessary. INGECTION: do NOT induce vomiting; do NOT lavage; administer 2-4 oz of olive oil and 1-2 oz of activated charcoal. EYES: wash with plenty of water. SKIN: wipe off material and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None observed; *Vapor (Gas) Irritant Characteristics*: Vapors cause irritation of eyes or respiratory system if present in high concentration; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree chemical burns on short exposure. May cause secondary chemical burns on long exposure.; *Odor Threshold*: No data available.

Atrazine — (i) Chemical Designations — *Synonyms*: 2-Chloro-4-Ethylamino-6-Isopropylamino-S-Triazine, Aatrex Herbicide; *Chemical Formula*: $C_8H_{14}N_5Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: No data; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 215.7; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 347, 175, 348; *Critical Temperature*: Not Pertinent; *Critical Pressure*: Not Pertinent; Specific Gravity: 20°C: 1.2 at 20 °C (solid); *Vapor (Gas) Density*: Not Pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not Pertinet; *Latent Heat of Vaporization*: Not Pertinent; *Heat of Combustion*: -9500, -5300, -220; *Heat of Decomposition*: Not Pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles and rubber gloves; *Symptoms Following Exposure*: Irritation of eyes and skin. If ingested, irritates mouth and stomach.; *General Treatment for Exposure*: EYES - Flush with copious amounts of water for at least 15 to 20 minutes. SKIN - Wash with larges amounts of water. INGESTION - Induce vomiting and give saline laxative and supportive therapy; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: Oral rat LD_{50} = 3080 mg/kg; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat.; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree chemical burns on short exposure and may cause second-degree burns on long exposure; *Odor Threshold*: No data.

Azinphosmethyl — (i) Chemical Designations — *Synonyms*: O-O-Dimethyl S-[(4-Oxo-1,2,3-Benzotriazine-3(4H)-yl)Methyl] Phosphorodithioate, Gurthion Insecticide, Gusathion Insecticide; *Chemical Formula*: $C_{10}H_{12}N_3O_3PS_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Brown; *Odor*: No data; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 317; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 163, 73, 346; *Critical Temperature*: Not Pertinent; *Critical Pressure*: Not Pertinent; Specific Gravity: 1.4 at 20°C (solid); *Vapor (Gas) Density*: Not Pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not Pertinent; *Latent Heat of Vaporization*: Not Pertinent; *Heat of Combustion*: -8600, -4800, -200; *Heat of Decomposition*: Not Pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, protective goggles, and rubber gloves; *Symptoms Following Exposure*: Dust irritates eyes. Inhalation or ingestion causes sweating, constriction of pupils of the eyes, asthmatic conditions, cramps, weakness, convulsions, collapse; *General Treatment for Exposure*: INHALATION - Remove victim to frsh air; keep warm, and seek physician. EYES - Flush with fresh running water for at least 15 min. SKIN - Flush with water and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: Oral rat LD_{50} = 11 ~ 18.5 mg/kg; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

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Barium Carbonate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $BaCo_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 197.35; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.3 at 20°C(solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; *Symptoms Following Exposure*: (Ingestion only): excessive salvation, vomiting, severe abdominal pain, and violent purging with watering and bloody stools; a slow and often irregular pulse and a transient elevation in arterial blood pressure; tinnitus, giddiness and vertigo; muscle twitchings, progressing to convulsions and/or paralysis; dilated pupils with impaired accommodation; confusion and increasing somnolence, without coma; collapse and death from respiratory failure and cardiac arrest; *General Treatment for Exposure*: Rapid oral administration of a soluble sulfate in water, such as magnesium or sodium sulfate(2 oz),alum (4 mg), or very dilute sulfuric acid (30 ml of a 10 % solution diluted to 1 qt). These agents precipitate barium as the insoluble sulfate. Gastric lavage or induced emesis. Seek medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50}0.5 to 5 g/kg (rabbit, rat, guinea pig); *Late Toxicity*: None observed; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Barium Chlorate — (i) Chemical Designations — *Synonyms*: Barium Chlorate Monohydrate; *Chemical Formula*: $Ba(ClO_3)_2 H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 332 (monohydrate); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 777, 414,687; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3,18 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust respirator (U.S. Bureau of Mines approved); rubberized shoes and gloves; coveralls or other suitable outer clothing; *Symptoms Following Exposure*: Inhalation causes irritation of upper respiratory system. Contact with eyes or skin causes irritation. Ingestion causes abdominal pain, nausea and vomiting diarrhea, pallor, blueness, shortness of breath, excessive salvation, convulsive tremors, slow, hard pulse, elevated blood pressure, unconsciousness. Hemorrhages may occur in the stomach, intestines, and kidneys. Muscular paralysis may follow; *General Treatment for Exposure*: Get medical attention. Alert doctor to possibility of barium poisoning, particularly if compound was swallowed. INHALATION: remove to fresh air. EYES: flush with copious quantities of water for at least 15 min; get medical attention. SKIN: flush with water. INGESTION: induce vomiting and call a physician; have victim drink aqueous 10% solution of magnesium or sodium sulfate; for severe intoxication, calcium or a magnesium salt may have to be given I.V. with caution; treatment otherwise is supportive and symptomatic; *Toxicity by Inhalation (Threshold Limit Value)*: 0,5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Barium poisoning; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Barium Nitrate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $Ba(NO_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 261.35; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 1,098, 592, 865; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.24 at 23°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust respirator; rubber gloves and shoes; suitable coveralls; *Symptoms Following Exposure*: Inhalation or contact with eyes or skin causes irritation. Ingestion causes excessive salivation, vomiting, colic, diarrhea, convulsive tremors, slow, hard pulse, elevated

blood pressure. Hemorrhages may occur in the stomach, intestines, and kidneys, Muscular paralysis may follow; *General Treatment for Exposure*: Get medical attention. Alert doctor to possibility of barium poisoning, particularly if compound was swallowed. Inhalation: remove to fresh air. Eyes: flush with water for at least 15 min. Skin: flush with water. Ingestion: oral administration of a aqueous 10% solution of magnesium or sodium sulfate; in severe intoxication, calcium or magnesium salt may have to be given I.V. with caution; treatment otherwise is supportive and symptomatic; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50}=355 mg/kg; *Late Toxicity*: Barium poisoning; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Barium Perchlorate — (i) Chemical Designations — *Synonyms*: Barium Perchlorate Trihydrate; *Chemical Formula*: $Ba(ClO_4)$-$3H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 390.35; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 941, 505, 778; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: Not pertinent; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust respirator; rubber gloves and shoes; suitable coveralls; *Symptoms Following Exposure*: Inhalation or contact with eyes or skin causes irritation. Ingestion causes excessive salivation, vomiting, colic, diarrhea, convulsive tremors, slow, hard pulse, and elevated blood pressure; hemorrhages may occur in the stomach, intestines and kidneys; muscular paralysis may follow; *General Treatment for Exposure*: Get medical attention. Alert doctor to possibility of barium poisoning, particularly if compound was swallowed. INHALATION: remove to fresh air. EYES: flush with water for at least 15 min. Skin: flush with water. Ingestion: oral administration of aqueous 10% solution of magnesium or sodium sulfate; for severe intoxication, calcium or magnesium salt may have to be given and i.v. with caution; treatment otherwise is supportive and symptomatic; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Barium poisoning; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Barium Permanganate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $Ba(MnO_4)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Dark purple to red; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 375; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.77 at 20 C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust respirator; rubber gloves and shoes; *Symptoms Following Exposure*: Inhalation or contact with eyes or skin causes irritation. Ingestion causes abdominal pain, nausea, vomiting, pallor, shortness of breath; *General Treatment for Exposure*: Get medical attention. Alert doctor to possibility of barium poisoning, particularly if compound was swallowed. INHALATION: remove to fresh air. EYES: flush with copious amount of water for 15 min. SKIN: wash with copious amount of water. INGESTION: induce vomiting, give a 10% water solution of Epsom salt; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Barium poisoning; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Barium Peroxide — (i) Chemical Designations — *Synonyms*: Barium Dioxide; Barium Superoxide; Barium Binoxide; *Chemical Formula*: BaO_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Light grayish-tan; grayish-white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 169.4; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 842, 450, 723; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4,96 at 20°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat*

of Combustion: Not pertinent; *Heat of Decomposition*: -194, -108, -4.52; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Toxic gas respirator; liquid-proof PVC gloves; chemical safety goggles, full cover clothing; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membranes, throat and nose. Contact with eyes or skin causes severe burns. Ingestion causes severe salivation, vomiting, colic, diarrheas, convulsive tremors, slow, hard pulse, and elevated blood pressure; hemorrhages may occur in the stomach, intestines, and kidneys; muscular paralysis may follow; *General Treatment for Exposure*: Get medical attention. Alert doctor to possibility of barium poisoning, particularly if compound was swallowed. INHALATION: remove to fresh air. EYES: flush with copious amount of water for 15 min. SKIN: flush with water. INGESTION: oral administration of aqueous 10% solution of magnesium or sodium sulfate; for severe intoxication, calcium or magnesium salt may have to be given i.v. with caution; treatment otherwise is supportive and symptomatic; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Barium poisoning; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Benzaldehyde — (i) Chemical Designations — *Synonyms*: Benzoic Aldehyde, Oil of Bitter Almond; *Chemical Formula*: C_6H_5CHO; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pure yellow; *Odor*: Like almonds; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 106.12; *Boiling Point at 1 atm.*: 354, 179, 452; *Freezing Point*: Not pertinent; *Critical Temperature*: 666, 352, 625; *Critical Pressure*: 316, 21.5, 2.18; *Specific Gravity*: 1.046 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.1; *Latent Heat of Vaporization*: 156, 86.5, 3.62; *Heat of Combustion*: -13,730, -7,630, -319.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles and chemical protective clothing.; *Symptoms Following Exposure*: Inhalation of concentrated vapor can irritate eyes, nose and throat. Liquid is irritating to the eyes. Prolonged contact with skin causes irritation.; *General Treatment for Exposure*: SKIN, EYE CONTACT: Move the victim to fresh air and contact doctor immediately. Wash contaminated skin area with water. Flush eyes with fresh running water for at least 15 minutes. INGESTION: Induce vomiting and call a doctor.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: LD_{50} 0.5 to 5 g/kg; *Late Toxicity*:; *Vapor (Gas) Irritant Characteristics*: Vapors can cause sever irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at very low concentrations.; *Liquid or Solid Irritant Characteristics*: Represents minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.; *Odor Threshold*: 0.042 ppm.

Benzene — (i) Chemical Designations — *Synonyms*: Benzol, Benzole; *Chemical Formula*: C_6H_6; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Aromatic; Pleasant aromatic odor, characteristic odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 78.11; *Boiling Point at 1 atm.*: 176, 80.1, 353.3; *Freezing Point*: 42.0, 5.5, 278.7; *Critical Temperature*: 552.0, 288.9, 562.1; *Critical Pressure*: 710, 48.3, 4.89; *Specific Gravity*: 0.879 at 20 °C (liquid); *Vapor (Gas) Density*: 2.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.061; *Latent Heat of Vaporization*: 169, 94.1, 3.94; *Heat of Combustion*: -17460, -9698, -406.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Hydrocarbon vapor canister, supplied air respirator or a hose mask; hydrocarbon insoluble rubber or plastic gloves; chemical goggles or face splash shield; hydrocarbon-insoluble apron such as neoprene.; *Symptoms Following Exposure*: Dizziness, excitation, pallor, followed by flushing, weakness, headache, breathlessness, chest constriction. Coma and possible death.; *General Treatment for Exposure*: SKIN: Flush with water followed by soap and water; remove contaminated clothing and wash skin. EYES: Flush with plenty of water until irritation subsides. INHALATION: Remove from exposed environment immediately. Call a physician. If breathing is irregular or stopped, start resuscitation, administer oxygen.; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Exposure Limits*: 75 ppm for 30 minutes; *Toxicity by Ingestion*: LD_{50} 50 ~ 500 mg/kg; *Late Toxicity*: Leukemia; *Vapor (Gas) Irritant Characteristics*: If present in high concentrations, vapors may cause irritation of eyes or respiratory system. Effect is usually temporary.; *Liquid or Solid Irritant Characteristics*: Represents minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin.; *Odor Threshold*: 4~7 ppm.

Benzene Hexachloride — (i) Chemical Designations — *Synonyms*: BHC, 1,2,3,4,5,6-Hexachlorocyclohexane Lindane; *Chemical Formula*: $C_6H_6Cl_6$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Light tan to dark brown; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 290.83; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.891 at 19 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory protection; ensure handling in a well ventilated area.; *Symptoms Following Exposure*: Hyperirritability and central nervous system excitation; notably vomiting, restlessness, muscle spasms, ataxia, clonic and tonic convulsions. Occasional dermatitis and urticaria.; *General Treatment for Exposure*: Gastric lavage and saline cathartics (not oil laxatives because they promote abortion). Sedatives: pentobarbital or phenobarbitol in amounts adequate to control convulsions. Calcium gluconate intravenously may be used in conjunction with sedatives to control convulsions. Keep patient quiet. Do not use epinephrine because ventricular fibrillation may result; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: 1 mg/m^3 for 30 minutes; *Toxicity by Ingestion*: LD_{50} 0.5 ~ 5 g/kg (Technical Mixture); LD_{50} 50 ~ 500 mg/kg (rat) (Gamma Isomer - Lindane); *Late Toxicity*: Mutagen to human lymphocytes; *Vapor (Gas) Irritant Characteristics*: Moderately irritating. Workers will not usually tolerate moderate to high concentrations.; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, the chemical may cause smarting or reddening of skin.; *Odor Threshold*: No data.

Benzene Phosphorous Dichloride — (i) Chemical Designations — *Synonyms*: Phenyl Phosphonous Dichloride, Phenylphosphine Dichloride, Dichlorophenylphosphine; *Chemical Formula*: $C_6H_5PCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid and pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 179.0; *Boiling Point at 1 atm.*: 430, 221, 494; *Freezing Point*: -60, -51, 222; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.140 at 25 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,200, -4,500, -190; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus (SCBA); acid-type canister mask; goggles and face shield, rubber gloves and chemical protective clothing.; *Symptoms Following Exposure*: Inhalation causes irritation of the nose and throat; pulmonary edema may develop following severe exposure. Contact with skin or eyes causes sever burns. Ingestion causes sever burns of mouth and stomach.; *General Treatment for Exposure*: Seek immediate medical attention following all exposures to this chemical. INHALATION: Remove victim to fresh air; if breathing has stopped, start mouth to mouth resuscitation. EYES: Flush with clean running water for at least 15 minutes. Do not use any oils or ointments. SHIN: Flush with water; wash with soap and water. INGESTION: Give victim large amounts of milk or water. Do not induce vomiting. If victim begins to vomit, give milk or beaten eggs at one-hour intervals.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: No data; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Benzene Phosphorous Thiodichloride — (i) Chemical Designations — *Synonyms*: Benzenethiophosphonyl Chloride, Phenylphosphonothioic Dichloride, Phenylphosphine Thiodichloride; *Chemical Formula*: $C_6H_5PSCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Acrid and pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 211; *Boiling Point at 1 atm*: 518, 270, 543; *Freezing Point*: -11.2, -24.0, 249.2; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.378 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -7700, -4300, -180; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: SCBA or acid-type canister mask; *Symptoms Following Exposure*: Inhalation of vapor irritates nose and throat; pulmonary edema may result. Contact with eyes or skin causes severe irritation. Ingestion causes severe irritation of mouth and stomach.; *General Treatment for Exposure*: Get medical attention following

all exposures to this chemical. INHALATION: Remove victim to fresh air. EYES: Flush with fresh running water for at least 15 minutes.; do not apply oils or ointments. SKIN: Flush with water, followed by washing with soap and water. INGESTION: Give victim large amounts of water or milk, eggs or olive oil.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: No data; *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Benzoic Acid — (i) Chemical Designations — *Synonyms*: Benzenecarboxylic Acid, Carboxybenzene, Dracyclic Acid; *Chemical Formula*: C_6H_5COOH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Faint, pleasant; slightly aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 122.12; *Boiling Point at 1 atm.*: 480.6, 249.2, 522.4; *Freezing Point*: 252.1, 122.3, 395.5; *Critical Temperature*: 894, 479, 752; *Critical Pressure*: 660, 45, 4.6; *Specific Gravity*: 1.316 at 28 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; when melted material is present, use eye protection and organic respirator for fumes; *Symptoms Following Exposure*: Dust is irritating to eyes and nose. At elevated temperatures, fumes may cause irritation of eyes, respiratory system and skin.; *General Treatment for Exposure*: Remove victim to fresh air. EYE CONTACT: Flush eyes with water.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: LD_{50} 0.5 ~ 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, the chemical may cause smarting or reddening of skin. Dust may irritate nose and eyes; *Odor Threshold*: Not pertinent.

Benzonitrile — (i) Chemical Designations — *Synonyms*: Benzoic Acid Nitrile, Cyanobenzene, Phenylcyanide; *Chemical Formula*: C_6H_5CN; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Almond-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 103.12; *Boiling Point at 1 atm.*: 376, 191, 464; *Freezing Point*: 9.0, -12.8, 260.4; *Critical Temperature*: 799.2, 426.2, 699.4; *Critical Pressure*: 611, 41.6, 4.22; *Specific Gravity*: 1.01 at 25 °C (liquid); *Vapor (Gas) Density*: 3.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.091; *Latent Heat of Vaporization*: 157.7, 87.6, 3.67; *Heat of Combustion*: -15,100, -8,400, -351; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; chemical resistant splash-proof goggles; rubber boots; chemical protective clothing for splash protection, chemical cartridge type respirator or other suitable protection against vapor must be worn when working in poorly ventilated areas or where overexposure by inhalation could occur.; *Symptoms Following Exposure*: Personnel can be overexposed to this chemical by ingestion, absorption through the skin, or inhalation. The earliest symptoms of cyano-compound intoxication may be weakness, headaches, confusion, and occasionally nausea and vomiting. The respiratory rate and depth will usually be increased at the beginning and at later stages become slow and gasping. Blood pressure is usually normal, especially in mild or moderately severe cases, although the pulse rate is usually more rapid than normal.; *General Treatment for Exposure*: INHALATION: Remove patient to fresh air; seek immediate medical attention. INGESTION: Call physician immediately. Until doctor arrives, take the following steps: a) Provide for inhalation by amyl nitrate vapor from ampules crushed in a handkerchief and held to nose of victim. b) Induce vomiting unless patient is unconscious. (Gastric lavage should be employed by, or under the supervision of a physician). c) Keep patient warm and quiet until medical attention arrives. EYES: Immediately flush with large volumes of fresh water for ate least 15 minutes. SKIN: Wash thoroughly at once, without scrubbing, with large amounts of soap and water. OTHER: Exposed personnel should be checked periodically for chronic toxic effects.; *Toxicity by Inhalation (Threshold Limit Value)*: No data; *Short-Term Exposure Limits*: No data; *Toxicity by Ingestion*: LD_{50} = 800 mg/kg (rat); *Late Toxicity*: No data; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Benzophenone — (i) Chemical Designations — *Synonyms*: Benzoylbenzene, Diphenyl Ketone, Diphenyl methanone, alpha-Oxodiphenylmethane, alpha-Oxoditane; *Chemical Formula*: $C_6H_5COC_6H_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid or solid; *Color*: White; *Odor*: Characteristic; **(iii) Phy-**

sical and Chemical Properties — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 182; *Boiling Point at 1 atm.*: 581.9, 305.5, 578.7; *Freezing Point*: 118.2, 47.9, 321.1; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.085 at 50°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 126.0, 70.0, 2.93; *Heat of Combustion*: -15,400, -8,550, -358; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Ingestion causes gastrointestinal disturbances. Contact causes eye irritation and, if prolonged, irritation of skin; *General Treatment for Exposure*: INHALATION: remove to fresh air. Ingestion: get medical attention. EYES: flush with water for at least 15 min; get medical attention if irritation persists. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; acute oral rat $LD_{50} \geq 10{,}000$ mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Benzoyl Chloride — (i) Chemical Designations — *Synonyms*: Benzenecarbonyl Chloride; *Chemical Formula*: C_6H_5COCL; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; may become slightly brownish on standing; *Odor*: Pungent characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 140.57; *Boiling Point at 1 atm.*: 387, 197.3, 470.5; *Freezing Point*: 30.9, -0.6, 272.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.211 at 25° C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -10,030, -5570, -233.2; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full protecting clothing, including full-face respirator for acid gases and organic vapors (yellow GMC canister), close fitting goggles, nonslip rubber gloves, plastic apron, face shield; *Symptoms Following Exposure*: INHALATION: may irritate eyes, nose and throat. INGESTION: causes acute discomfort. SKIN: causes irritation and burning; *General Treatment for Exposure*: INHALATION: remove to fresh air; administer oxygen with patient in sitting position. INGESTION: give water; call physician at once; give milk. EYES: flush with water for 15 min, get medical attention; SKIN: wash with plenty of soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Cause second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Benzyl Alcohol — (i) Chemical Designations — *Synonyms*: Benzenecarbinol,; alpha-Hydroxytoluene; Phenylcarbinol; Phenylmethanol; Phenylmethyl Alcohol; *Chemical Formula*: $C_6H_5CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 108.13; *Boiling Point at 1 atm.*: 401, 205, 478; *Freezing Point*: 4.5, -15.3, 257.9; *Critical Temperature*: 757. 403, 676; *Critical Pressure*: 663, 45.0, 4.57; *Specific Gravity*: 1.050 at 15/15°C(liquid); *Vapor (Gas) Density*: 3.73; *Ratio of Specific Heats of Vapor (Gas)*: 1.070; *Latent Heat of Vaporization*: 193, 107, 4.48; *Heat of Combustion*: -14,850, -8,260, -345; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, chemical safety goggles; *Symptoms Following Exposure*: Inhalation of vapor may cause irritation of upper respiratory tract. Prolonged or excessive inhalation may result in headache, nausea, vomiting and diarrhea. In severe cases, respiratory stimulation followed by respiratory and muscular paralysis, convulsions, narcosis and death may result. Ingestion may produce severe irritation of the gastrointestinal tract, followed by nausea, vomiting, cramps and diarrhea; tissues ulceration may result. Contact with eyes causes local irritation, Material can be absorbed through skin with anesthetic or irritant effect; *General Treatment for Exposure*: INHALATION: remove victim from contaminated atmosphere; call physician immediately. INGESTION: induce vomiting and contact a physician. EYES: flush with plenty of water for 15 min, and contact a physician. SKIN: flush with water, wash with soap and water, obtain medical attention in case of irritation or central nervous system depression; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity*

by Ingestion: Grade 2; oral rat LD_{50} = 1,230 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 5.5 ppm.

Benzylamine — (i) Chemical Designations — *Synonyms*: Alpha-Aminotoluene, Phenylmethyl Amine; *Chemical Formula*: $C_6H_5CH_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Strong ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 107.16; *Boiling Point at 1 atm.*: 364.1, 184.5, 457.7; *Freezing Point*: -51, -46, 227; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.98 at 20°C (liquid); *Vapor (Gas) Density*: 3.70; *Ratio of Specific Heats of Vapor (Gas)*: 1.070; *Latent Heat of Vaporization*: 164, 91, 3.8; *Heat of Combustion*: -16,260; -9,040; -378; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles of face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of vapor causes irritation of mucous membranes of the nose and throat, and lung irritation with respiratory distress and cough. Headache, nausea, faintness and anxiety can occur. Exposure to vapor produces eye irritation with lachrymation, conjunctivitis, and corneal edema resulting in halos around lights. Direct local contact with liquid is known to produce severe and sometimes permanent eye damage and skin burns. Vapors may also produce primary skin irritation and dermatitis; *General Treatment for Exposure*: INHALATION: remove victim from exposure, if breathing is difficult, administer oxygen, if breathing has stopped, begin artificial respiration. EYES or SKIN: wash with copious amounts of water for 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Benzyl Bromide — (i) Chemical Designations — *Synonyms*: Alpha-Bromotoluene; Omega-Bromotoluene; Bromotoluene, Alpha; *Chemical Formula*: $C_6H_5CH_2Br$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Very sharp, pungent, like tear gas; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 171.0; *Boiling Point at 1 atm.*: 388, 198, 471; *Freezing Point*: 25.0, -3.9, 269.3; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.441 at 22°C (liquid); *Vapor (Gas) Density*: 5.9; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 120, 66.4, 2.78; *Heat of Combustion*: -9,000; -5,000; -210; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat; severe exposure may cause pulmonary edema. Vapors cause severe eyes irritation; liquid can burn eyes. Skin contact cause irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: irrigate with copious amount of water for 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Benzyl n-Butyl Phthalate — (i) Chemical Designations — *Synonyms*: Butyl Benzyl Phthalate, Phthalic Acid, Benzyl Butyl Ester; *Chemical Formula*: $C_{19}H_{21}O_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Slight characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 313; *Boiling Point at 1 atm.*: 698, 380, 643; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.12 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -14,550, -8,090, -338; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves and goggles; *Symptoms Following Exposure*: Prolonged contact with liquid causes some irritation of eyes and skin; *General Treatment for Exposure*: EYES: flush with water. SKIN: wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; oral rat LD_{50} = 13,500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard, harmless to skin; *Odor Threshold*: Data not available.

Benzyl Chloride — (i) Chemical Designations — *Synonyms*: alpha-Chlorotoluene; omega-Chlorotoluene; Chlorotoluene, alpha; *Chemical Formula*: $C_6H_5CH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Pungent, irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 126.6; *Boiling Point at 1 atm.*: 354.9, 179.4, 452.6; *Freezing Point*: -38.6, -39.2, 234.0; *Critical Temperature*: 772, 411, 684; *Critical Pressure*: 567, 38.5, 3.91; *Specific Gravity*: 1.10 at 25°C (liquid); *Vapor (Gas) Density*: 4.36; *Ratio of Specific Heats of Vapor (Gas)*: 1.0689; *Latent Heat of Vaporization*: 130, 70, 2.9; *Heat of Combustion*: -12,000, -6,700, -280; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles or face shield, self-contained breathing apparatus, positive-pressure hose mask, industrial canister-type gas mask, or chemical cartridge respirator; rubber gloves, protective clothing; *Symptoms Following Exposure*: Inhalation causes severe irritation of upper respiratory tract with coughing, burning of the throat, headache, dizziness, and weakness; lung damage and pulmonary edema may occur after severe exposure; chronic irritation of the upper respiratory tract may occur after prolonged and repeated exposure to vapors. Immediate and severe eye irritation may result from contact with the liquid or vapor; prolonged or permanent eye damage may result. Vapors irritate skin and liquid may cause severe burns. Ingestion may cause immediate and severe burns of the mouth and throat, and gastrointestinal tract; nausea, vomiting, cramps, and diarrhea may follow; gastrointestinal damage and systemic effects may result; *General Treatment for Exposure*: INHALATION: remove victim from contaminated atmosphere; if breathing has ceased, start mouth-to-mouth resuscitation; oxygen, if available, should be administered only by an experienced person when authorized by a physician; keep patient warm and comfortable; call a physician immediately. EYES: immediately flush with large quantities of running water for a minimum of 15 min; hold eyelids apart during irrigation to ensure flushing of the entire surface of the eye and lids with water; do not attempt to neutralize with chemical agents; obtain medical attention as soon as possible; oils or ointments should not be used unless directed by a physician; continue irrigation for an additional 15 min, if physician is not available. SKIN: immediately flush affected area with water; remove contaminated clothing under shower, continue washing with water, do not attempt to neutralize with chemical agents; obtain medical attention if irritation persists. INGESTION: give large amounts of water; do not induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50}=1,231 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: 0.047 ppm.

Benzyl Chloroformate — (i) Chemical Designations — *Synonyms*: Carbobenzoxy Chloride; Chloroformic Acid, Benzyl Ester;; Benzylcarbonyl Chloride; Benzyl Chlorocarbonate; *Chemical Formula*: $C_6H_5CH_2OCOCl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Irritating; sharp, penetrating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 170.6; *Boiling Point at 1 atm.*: 306, 152, 425; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 20°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 90, 50, 2.1; *Heat of Combustion*: -10,000, -5,700, -240; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus or acid-type canister mask; goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes mucous membrane irritation. Eyes are irritated by excessive exposure to vapor. Liquid causes severe irritation of eyes and irritates skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure, support respiration, call physician. EYES: irrigate with copious amounts of water for 15 min. SKIN: flush with large quantities of water; wash with soap and water. INGESTION: give large amounts of water, do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause second-degree on long exposure; *Odor Threshold*: Data not available.

Benzyldimethyloctadecylammonium Chloride — (i) Chemical Designations — *Synonyms*: Benzyldimethylstearylammonium Chloride; Dimethylbenzyloctadecylammonium Chloride; Dimethyloctadecylbenzylammonium Chloride; Octadecyldimethylbenzylammonium Chloride; *Chemical Formula*: $(C_6H_5CH_2)(CH_3)_2(C_{18}H_{37})NCl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or viscous liquid; *Color*: White; *Odor*: Mild; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 411; *Boiling Point at 1 atm.*: Not pertinent (decomposes at 120°C); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1.1 at 20°C(solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Ingestion causes gastrointestinal disturbances. Contact with chemical eyes and skin and may damage eyes; *General Treatment for Exposure*: INGESTION: do not induce vomiting; give large quantities of fluid and call physician immediately. EYES: flush with plenty of water for at least 15 min; call a physician. SKIN: remove contaminated clothing; flush skin with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Grade 2; oral rat LD_{50}=4,000 mg/kg; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Benzyltrimethylammonium Chloride — (i) Chemical Designations — *Synonyms*: BTMAC; Trimethylbenzylammonium Chloride; *Chemical Formula*: $C_6H_5CH_2N(CH_3)_3Cl$-H_2O; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Light yellow; *Odor*: Mild almond; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 172 (solute); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.07 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and rubber gloves; *Symptoms Following Exposure*: Ingestion causes gastrointestinal disturbances. Contact with liquid irritates eyes and may irritate skin; *General Treatment for Exposure*: INGESTION: give large amount of water, get medical attention. SKIN: flush well with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50}-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Beryllium Chloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $BeCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to green; *Odor*: Sharp, acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 79.9; *Boiling Point at 1 atm.*: 968, 520, 793; *Freezing Point*: 824, 440, 713; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.90 at 25°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory protection; gloves; freshly laundered clothing; chemical safety goggles; *Symptoms Following Exposure*: Inhalation causes pneumonitis, nasopharyngitis, tracheobronchitis, dyspnea, chromic cough. Ingestion causes irritation of mouth and stomach. Contact with dust causes conjunctival inflamation of eyes and irritation of skin. Any dramatic, unexplained weigh loss should be considered as a possible first indication of beryllium disease; *General Treatment for Exposure*: INHALATION: chest x-ray should be taken immediately for evidence of pneumonitis. EYES: flush with water for at least 15 min; if irritation persists, get medical attention. SKIN: cuts or puncture wounds in which beryllium may be embedded under the skin should be thoroughly cleansed immediately by a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 0.002 mg/m^3 (as beryllium); *Short-Term Exposure Limits*: 0.025 mg/m^3 less than 30 min; *Toxicity by Ingestion*: Grade 3; oral rat LD = 86 mg/kg; *Late Toxicity*: Be produces a chromic systematic disease that primarily affects the lung but also can involve other organs such as lymph nodes, liver, bones, and kidney; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Beryllium Fluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: BeF_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 47; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressurem., MN/m²)*: Not pertinent; *Specific Gravity*: 1.99 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Respiratory protection; gloves; goggles; *Symptoms Following Exposure*: Any dramatic weight loss should be considered as possible first indication of beryllium disease. Inhalation causes irritation of nose, throat and lungs, severe pneumonitis, and/or pulmonary edema. Ingestion causes fatigue, weakness, loss of appetite. Contact with eyes causes severe irritation and burns. Contact with skin causes dermatitis and non-healing ulcers; *General Treatment for Exposure*: INHALATION: move to fresh air, chest x-ray should be taken immediately to detect pneumonitis, if exposure has been severe. INGESTION: induce vomiting, get medical attention. EYES: flush with water for at least 15 min; get medical attention. SKIN: flush with water; get medical attention if skin has been broken; *Toxicity by Inhalation (Threshold Limit Value)*: 0.002 mg/m³ (as beryllium); *Short-Term Exposure Limits*: 0.025 mg/m³, less than 30 min.; *Toxicity by Ingestion*: Grade 3; oral LD = 100 mg/kg (mouse); *Late Toxicity*: Berylliosis of lungs may occur from 3 months to 15 years after exposure. Chromic systemic diseases of the liver, spleen, kidney, and other organs may also occur; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Beryllium Metallic — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Be; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 9.01; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.85 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -28000, -15560, -652; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical cartridge respirator; clean work clothes daily; gloves and eye protection.; *Symptoms Following Exposure*: Any dramatic, unexplained weight loss should be considered as possible first indication of beryllium disease. The dust is extremely toxic when inhaled; symptoms include coughing, shortness of breath, and acute or chronic lung disease. There is no record of illness from ingestion of beryllium. Contact with dust causes conjuctival inflammation of the eyes and dermatitis; *General Treatment for Exposure*: INHALATION: acute disease may require hospitalization with administration of oxygen; chest x-ray should be taken immediately. EYES: Flush with water followed by washing with soap and water; all cuts, scratches or other injuries should receive prompt medical attention.; *Toxicity by Inhalation (Threshold Limit Value)*: 0.002 mg/m³; *Short-Term Exposure Limits*: 0.025 mg/m³ for 5 minutes; *Toxicity by Ingestion*: LD_{50} 50 ~ 500 mg/kg; *Late Toxicity*: Beryllium disease may occur in the lungs, lymph nodes, liver, spleen, kidney, and other organs.; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Beryllium Nitrate — (i) Chemical Designations — *Synonyms*: Beryllium Nitrate Trihydrate; *Chemical Formula*: $Be(NO_3)_2 \cdot 3H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 205.1; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.56 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective* Equipment: Respiratory protection; gloves; freshly laundered clothing; chemical safety goggles; *Symptoms Following Exposure*: Any dramatic, unexplained weight loss should be considered as possible first indication of beryllium disease. Inhalation causes pneumonitis, nasopharyngitis, tracheobronchitis, dyspnea, chronic cough. Ingestion causes anorexia, fatigue, weakness, malaise. Contact with eyes causes dermatitis and non-healing ulcers; *General Treatment for Exposure*: INHALATION: remove to fresh air; take chest x-ray immediately to check the pneumonitis.

INGESTION: induce vomiting; get medical attention. EYES: flush with water for at least 15 min.; get medical attention. SKIN: cuts or puncture wounds in which beryllium may be embedded under the skin should be thoroughly cleansed immediately by a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 0.02 mg/m^3 (as beryllium); *Short-Term Exposure Limits*: 0.025 mg/m^3 less then 30 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: May cause chronic systemic disease of the lung as well as other organs such as liver, spleen, lymph nodes, bone and kidney; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Beryllium Oxide — (i) Chemical Designations — *Synonyms*: Beryllia; Bromellite; *Chemical Formula*: BeO; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 25; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.0 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory protection; gloves; freshly laundered clothing; chemical safety goggles; *Symptoms Following Exposure*: Any dramatic, unexplained weight loss should be considered as possible first indication of beryllium disease. Other symptoms include anorexia, fatigue, weakness, malaise. Inhalation causes pneumonitis, nasopharyngitis, tracheobronchitis, dyspnea, chronic cough. Contact with dust causes conjunctival inflammation of eyes and irritation of skin; *General Treatment for Exposure*: INHALATION: take chest x-ray immediately to check the pneumonitis. INGESTION: induce vomiting; get medical attention. EYES: flush with water for at least 15 min.; get medical attention. SKIN: cuts or puncture wounds in which beryllium may be embedded under the skin should be thoroughly cleansed immediately by a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 0.002 mg/m^3 (as beryllium); *Short-Term Exposure Limits*: 0.025 mg/m^3 less than 30 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Beryllium disease may occur in lymph nodes, liver, spleen, kidney, etc. as well as lung; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Beryllium Sulfate — (i) Chemical Designations — *Synonyms*: Beryllium Sulfate Tetrahydrate; *Chemical Formula*: $BeSO_4 \cdot 4H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 177.14; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.71 at 11 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory protection; gloves; freshly laundered clothing; chemical safety goggles; *Symptoms Following Exposure*: Any dramatic, unexplained weight loss should be considered as possible first indication of beryllium disease. Other symptoms include anorexia, fatigue, weakness, malaise. Inhalation causes pneumonitis, nasopharyngitis, tracheobronchitis, dyspnea, chronic cough. Contact with eyes causes conjunctival inflammation. Contact with skin causes dermatitis of primary irritant or sensitization type; causes ulcer formation when in contact wit cuts; *General Treatment for Exposure*: INHALATION: take chest x-ray immediately to check for evidence of pneumonitis. INGESTION: induce vomiting; get medical attention. EYES: flush with water for at least 15 min.; get medical attention. SKIN: cuts or puncture wounds in which beryllium may be embedded under the skin should be thoroughly cleansed immediately by a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 0.002 mg/m^3 (as beryllium); *Short-Term Exposure Limits*: 0.025 mg/m^3 less than 30 min.; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 82 mg/kg; *Late Toxicity*: Beryllium disease may occur in the lymph nodes, liver, spleen, kidney, etc., as well as lung; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Bismuth Oxychloride — (i) Chemical Designations — *Synonyms*: Basic Bismuth Chloride; Bismuth Chloride Oxide; Bismuth Subchloride; Bismuthyl Chloride; Pearl White; *Chemical Formula*: BiOCl; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1*

atm.: Solid; *Molecular Weight*: 260.4; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 7.7 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; protective gloves; dust mask; *Symptoms Following Exposure*: Contact with yes causes mild eye irritation and can cause skin rashes; *General Treatment for Exposure*: EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50} >21.5 g/kg (rat); *Late Toxicity*:; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Bisphenol A — (i) Chemical Designations — *Synonyms*: 2,2-Bis(4-Hydroxyphenyl)Propane; p,p'-Dihydroxydiphenyldimethylmethane; 4,4'-Isopropylidenediphenol; Ucar Bisphenol HP; *Chemical Formula*: p-$HOC_6H_4C(CH_3)_2C_6H_4OH$-p; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to cream; *Odor*: Very weak phenolic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 228.28; *Boiling Point at 1 atm*: Not pertinent; *Freezing Point*: 315, 157, 430; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.195 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust mask and clean, body-covering clothing sufficient to prevent excessive or repeated exposure to dust, fumes, or solutions. Safety glasses with side shields; *Symptoms Following Exposure*: Dust irritating to upper respiratory passages; may cause sneezing; *General Treatment for Exposure*: SKIN: wash with soap and plenty of water. Avoid wearing contaminated clothing. EYES: promptly flush with plenty of water for at least 15 min. and get medical help. INGESTION: if large amounts are swallowed, induce vomiting promptly and get medical help promptly. No known antidote; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Lowered hemoglobin and erythrocyte (red blood cell) counts below normal in rats; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Bisphenol A Diglycidyl Ether — (i) Chemical Designations — *Synonyms*: 4,4'Isopropylidenediphenol-Epichlorohydrin Resin; Bisphenol A-Epichlorohydrin Condensate; 2,2-Bis(p-hydroxyphenyl)Propane, Diglycidyl Ether; *Chemical Formula*: $C_{21}H_{24}O_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Amber; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 340; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.16 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -14,900, -8,300, -350; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; goggles; protective clothing and protective creams. Good personal hygiene is necessary, with instruction of personnel and adequate cleaning facilities; *Symptoms Following Exposure*: Contact with liquid irritates eyes. Prolonged or repeated contact with skin causes irritation and dermatitis; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: remove chemical with water or waterless skin cleaner; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5-15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Odorless.

Boiler Compound, Liquid — (i) Chemical Designations — *Synonyms*: Alkaway Liquid Alkaline Deruster; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to brown; *Odor*: None to mild; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >220, >104, >377;

Freezing Point: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.48 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Contact of liquid with eyes causes severe caustic burns. Also causes caustic burns of skin if not washed off immediately. Ingestion causes caustic burns of mouth and stomach; *General Treatment for Exposure*: Basic treatment is identical with that for caustic potash solutions. EYES: flush with water for at least 15 min.; call a doctor. SKIN: flush with water; wash with soap and water. INGESTION: give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Boric Acid — **(i) Chemical Designations** — *Synonyms*: Boracic Acid; Orthoboric Acid; *Chemical Formula*: H_3BO_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 and 1 atm.*: Solid; *Molecular Weight*: 61.83; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.51 at 14°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles; *Symptoms Following Exposure*: Although no adverse effects have been reported from inhaling boric acid dust, it is absorbed through mucous membranes. Ingestion of 5 grams or more may irritate gastrointestinal tract and affect central nervous system. Contact with dust or aqueous solutions may irritate eyes; no chronic effects have been recognized, but continued contact should be avoided. Dust and solutions are absorbed through burns and open wounds but not through unbroken skin; *General Treatment for Exposure*: INHALATION: remove from contaminated atmosphere. INGESTION: obtain medical attention as soon as possible; if the patient is conscious, induce vomiting by giving warm salty water (2 tablespoons of table salt to a pint of water) or warm soapy water; if this measure is unsuccessful, vomiting may be induced by ticking the back of the patient's throat with a finger; vomiting should be encouraged about three times or until the vomitus is clear; additional water may be given to wash out the stomach. EYES: immediately flush the eyes with large quantities of running water for a minimum of 15 min.; hold the eyelids apart during the irrigation to ensure flushing of the entire surface of the eye and lids with water; obtain medical attention as soon as possible; continue the irrigation for an additional 15 min. if the physician is not available. SKIN: immediately flush affected area with water; remove contaminated clothing under the shower; continue washing with water - do not attempt to neutralize with chemical agents; obtain medical attention unless burn is minor; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3 (as boric oxide); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 2.660 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Boron Tribromide — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: BBr_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 250.5; *Boiling Point at 1 atm.*: 196, 91, 364; *Freezing Point*: -51, -46, 227; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.645 at 20°C (solid); *Vapor (Gas) Density*: 8.64; *Ratio of Specific Heats of Vapor (Gas)*: 1.140; *Latent Heat of Vaporization*: 52, 29, 1.2; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety glasses or face mask, rubber gloves, and respiratory protection; *Symptoms Following Exposure*: Inhalation causes severe irritation of mucous membranes. Ingestion causes burns of mouth and stomach. Contact with eyes or skin causes severe burns; *General Treatment for Exposure*: Get medical attention for all exposures to this chemical. INHALATION: remove from exposure; support respiration. INGESTION: give large amounts of water. EYES: flush with water for at least 15 min. SKIN: wash thoroughly with water; launder clothing before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: Data

not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Boron Trichloride — (i) Chemical Designations — *Synonyms*: Boron Chloride; *Chemical Formula*: BCl_3; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid and irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 117.2; *Boiling Point at 1 atm.*: 54.3, 12.4, 285.6; *Freezing Point*: -161, -107, 166; *Critical Temperature*: 352, 178, 451; *Critical Pressure*: 566, 38.5, 3.90; *Specific Gravity*: 1.35 at 11°C (liquid); *Vapor (Gas) Density*: 4; *Ratio of Specific Heats of Vapor (Gas)*: 1.1470; *Latent Heat of Vaporization*: 68.8, 38.2, 1.60; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical goggles; rubber protective clothing and gloves; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes edema and severe irritation of the upper respiratory system. Contact with liquid causes acid burns of eyes and severe burns of skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove to fresh air; give oxygen or apply artificial respiration; keep warm; call a doctor at once; observe for pulmonary edema. EYES: wash with plenty of water for 15 min.; consult an eye specialist. SKIN: wash off with plenty of water. INGESTION: do not induce vomiting; give large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and cause eye or lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Decomposes in moist air, releasing hydrochloric acid and decomposition products. Hydrochloric acid - 1 ppm.

Bromine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Br_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Dark red; red-brown; *Odor*: Sharp, harsh, penetrating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 159.81; *Boiling Point at 1 atm.*: 138, 58.8, 332; *Freezing Point*: 19, -7.2, 266; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.12 at 20 C (liquid); *Vapor (Gas) Density*: 5.5 at 20°C; *Ratio of Specific Heats of Vapor (Gas)*: 1.3; *Latent Heat of Vaporization*: 80.6, 44.8, 1.88; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical safety goggles, face shield; self-contained air-line canister mask; rubber suit; *Symptoms Following Exposure*: SKIN: contact with liquid or vapor may cause acne and slow-healing ulcers. INHALATION: induces severe irritation of the respiratory passages and pulmonary edema. Probable lethal oral dose fro an adult is 1 ml. A brief exposure to 1000 ppm may be fatal; *General Treatment for Exposure*: SKIN AND EYES: wash well with water and sodium bicarbonate solution. RESPIRATORY SYSTEM: if there is obstruction to breathing establish airway by pulling tongue forward, inserting an airway tube, or doing a tracheotomy; begin artificial respiration; if difficulty in breathing is a result of pulmonary edema, treatment should be carried out with the patient in the sitting position. Administration of oxygen is most important; INGESTION: do not induce vomiting. Have victim drink water and milk; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm; *Short-Term Exposure Limits*: 0.4 ppm for 30 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Causes severe eye or throat irritations which cause eye or lung injury; cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: 3.5 ppm.

Bromine Pentafluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: BrF_5; **(ii) Observable Characteristics** - *Physical State (as normally shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Highly irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 174.9; *Boiling Point at 1 atm.*: 106, 41, 314; *Freezing Point*: -76, -60, 213; *Critical Temperature*: 387, 197, 470; *Critical Pressure*: Data not available; *Specific Gravity*: 2.48 at 20°C (liquid); *Vapor (Gas) Density*: 6.03; *Ratio of Specific Heats of Vapor (Gas)*: 1.089 at 25°C; *Latent Heat of Vaporization*: 76.8, 42.7, 1.79; *Heat of Combustion*: Not pertinent; *Heat of Decom position*: Not pertinent; **(iv) Health Hazards Information**

— *Recommended Personal Protective Equipment*: Self-contained breathing apparatus, acid suit and gloves; *Symptoms Following Exposure*: Chemical is highly corro sive and toxic. Inhalation causes severe burns of mucous membrane. Ingestion causes severe burns of mouth. Contact with eyes or skin causes severe burns; *General Treatment for Exposure*: get medical attention immediately for any exposure to this chemical, even if no adverse effects are evident. INHALATION: remove victim from area; apply artificial respiration if breathing has ceased. INGESTION: give large amount of water. EYES: wash with copious amounts of water for 15 min. SKIN: wash with large amounts of water and follow with lime water; remove contaminated clothing; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Bromine Trifluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: BrF_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to gray-yellow; *Odor*: Extremely irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 136.9; *Boiling Point at 1 atm.*: 258.4, 125.8, 399; *Freezing Point*: 47.8, 8.8, 282; *Critical Temperature*: 621, 327, 600; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.81 at 20°C (liquid); *Vapor (Gas) Density*: 4.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.1428; *Latent Heat of Vaporization*: 130, 74, 3.1; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; complete protective clothing; safety glasses; face shield; *Symptoms Following Exposure*: Inhalation causes severe irritation of upper respiratory system. Contact with liquid or vapor causes severe burns of eyes and can cause ulcers and blindness. Contact with skin causes severe burns. Ingestion causes severe burns of mucous membranes; *General Treatment for Exposure*: Get immediate medical attention for all exposures. INHALATION: remove from exposure; support respiration. EYES: irrigate with copious amounts of water for at least 15 min. SKIN: wash with large amounts of water for at least 15 min., then rinse with sodium bicarbonate or lime solution; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm (suggested); *Short-Term Exposure Limits*: 50 ppm/30 min.; 100 ppm/3 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Bromobenzene — (i) Chemical Designations — *Synonyms*: Monobromobenzene; Phenyl Bromide; Bromobenzol; *Chemical Formula*: C_6H_5Br; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 157; *Boiling Point at 1 atm.*: 313, 156, 429; *Freezing Point*: -23.1, -30.6, 242.6; *Critical Temperature*: 747, 397, 670; *Critical Pressure*: 655, 44.6, 4.52; *Specific Gravity*: 1.49 at 25° C (liquid); *Vapor (Gas) Density*: 5.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.0931; *Latent Heat of Vaporization*: 104, 58, 2.4; *Heat of Combustion*: -8,510, -4,730, -198; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: goggles or face shield; rubber gloves and apron; *Symptoms Following Exposure*: Contact with liquid causes irritation of eyes and mild irritation of skin. Ingestion causes mild irritation of mouth and stomach; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water. INGESTION: induce vomiting; consult a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Brucine — (i) Chemical Designations — *Synonyms*: Brucine Dihydrate; 10,11-Dimethoxystrychnine; *Chemical Formula*: $C_{23}H_{26}N_2O_4$ or $C_{23}H_{26}N_2O_4 \cdot 2H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 394.4; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 352, 178, 451; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -13,400, -7,440, -311; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Chemicals is toxic

if inhaled, swallowed, or absorbed through skin. Inhalation produces intense bitter taste. Ingestion causes nausea, vomiting, restlessness, excitement, twitching, and (rarely) convulsions. Contact with dust irritates eyes; *General Treatment for Exposure*: INHALATION: remove victim from exposure. INGESTION: induce vomiting; get medical attention at once. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral rat LD_{50} 1 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Butadiene, Inhibited — (i) Chemical Designations — *Synonyms*: Biethylene; 1,3-Butadiene; Bivinyl; Divinyl; Vinylethylene; *Chemical Formula*: $CH_2=CHCH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Gas; *Color*: Colorless; *Odor*: Mildly aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 54.09; *Boiling Point at 1 atm.*: 24.1, -4.4, 268.8; *Freezing Point*: -164, -108.9, 164.3; *Critical Temperature*: 306, 152, 425; *Critical Pressure*: 628, 42.7, 4.32; *Specific Gravity*: 0.621 at 20°C (liquid); *Vapor (Gas) Density*: 1.9 at 20°C; *Ratio of Specific Heats of Vapor (Gas)*: 1.1; *Latent Heat of Vaporization*: 180, 100, 4.19; *Heat of Combustion*: -19,008, -10,560, -442.13; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical-type safety goggles; rescue harness and life line for those entering a tank or enclosed storage space; hose mask with hose inlet in a vapor-free atmosphere; self-contained breathing apparatus; rubber suit; *Symptoms Following Exposure*: Slight anesthetic effect at high concentrations; causes "frostbite" from skin contact; slight irritation to eyes and nose in high concentrations; *General Treatment for Exposure*: remove from exposure immediately. Call a physician. INHALATION: if breathing is irregular or stopped, start resuscitation, administer oxygen. SKIN: remove contaminated clothing and wash affected skin area. EYES: irrigate with water for at 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 1,000 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin because of frostbite; *Odor Threshold*: 4 mg/m^3.

Butane — (i) Chemical Designations — *Synonyms*: n-Butane; *Chemical Formula*: n-C_4H_{10}; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 58.12; *Boiling Point at 1 atm.*: 31.1, -0.48, 272.72; *Freezing Point*: -216, -138, 135; *Critical Temperature*: 306, 152, 425; *Critical Pressure*: 550.8, 37.47, 3.796; *Specific Gravity*: 0.60 at 0°C (liquid); *Vapor (Gas) Density*: 20 at 20°C; *Ratio of Specific Heats of Vapor (Gas)*: 1.092; *Latent Heat of Vaporization*: 170, 92, 3.9; *Heat of Combustion*: -19,512, -10,840, -453.85; *Heat of Decompo sition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus and safety goggles; *Symp toms Following Exposure*: high exposure produces drowsi ness but no other evidence of systemic effect; *General Treatment for Exposure*: ORAL AND ASPIRATION: no treatment required. INHALATION: guard against self-injury if stuporous, confused, or anesthetized. Apply artificial respiration if not breathing. Avoid administration of epinephrine or other sympathomimetic amines. Prevent aspirations of vomitus by proper positioning of the head. Give symptomatic and supportive treatment; *Toxicity by Inhalation (Threshold Limit Value)*: 500 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Character istics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly from the skin. Some frostbite possible; *Odor Threshold*: 6.16 ppm.

1,4-Butanediol — (i) Chemical Designations — *Synonyms*: 1,4-Dihydroxylbutane; Tetramethyleneglycol; *Chemical Formula*: $HOCH_2(CH_2)_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 90.12; *Boiling Point at 1 atm.*: 442, 228, 501; *Freezing Point*: 68.2, 20.1, 293.3; *Critical Temperature*: 716, 380, 653; *Critical Pressure*: 720, 49, 5.0; *Specific Gravity*: 1.017 at 20°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,900, -6630, -277; *Heat of Decomposition*: Not perti-

nent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection; *Symptoms Following Exposure*: Ingestion of large amounts needed to produce any symptoms; *General Treatment for Exposure*: SKIN OR EYES: wash off immediately with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

1,4-Butenediol — (i) Chemical Designations — *Synonyms*: cis-2-Butene-1,4-diol; 1,4-Dihydroxy-2-Butene; *Chemical Formula*: $HOCH_2CH=CHCH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 88.11; *Boiling Point at 1 atm.*: 453, 234, 507; *Freezing Point*: 45, 7, 280; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.07 at 25°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -10,800, -5980, -250; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: SKIN OR EYE CONTACT: flush well with water. Consult physician in cases of skin irritation, eye contact, or accidental ingestion; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

n-Butyl Acetate — (i) Chemical Designations — *Synonyms*: Acetic Acid, Butyl Ester; Butyl Acetate; Butyl Ethanoate; *Chemical Formula*: $CH_3COO(CH_2)_3CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; agreeable fruity (in low concentrations); non residual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.16; *Boiling Point at 1 atm.*: 259, 126, 399; *Freezing Point*: -100, -73.5, 199.7; *Critical Temperature*: 582.6, 305.9, 579.1; *Critical Pressure*: 455, 31, 3.1; *Specific Gravity*: 0.875 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.058; *Latent Heat of Vaporization*: 133, 73.9, 3.09; *Heat of Combustion*: -13,130, -7294, -305.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: All-purpose canister mask, chemical safety goggles, rubber gloves; *Symptoms Following Exposure*: SKIN: prolonged or frequently repeated exposures may lead to drying. INHALATION: headaches, dizziness, nausea, irritation of respiratory passages and eyes; *General Treatment for Exposure*: EYES: in cause of contact, flush with water for at least 15 min. INHALATION: remove from exposure immediately. Call a physician. If breathing is irregular or stopped, start resuscitation, administer oxygen. INGESTION: induce vomiting and call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 150-200 ppm; *Short-Term Exposure Limits*: 300 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 10 ppm.

sec-Butyl Acetate — (i) Chemical Designations — *Synonyms*: Acetic Acid, sec-Butyl Ester; *Chemical Formula*: $CH_3COOCH(CH_3)CH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.16; *Boiling Point at 1 atm.*: 234, 112, 385; *Freezing Point*: -100, -73.5, 199.7; *Critical Temperature*: 550, 288, 561; *Critical Pressure*: 469, 32, 3.2; *Specific Gravity*: 0.872 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.061; *Latent Heat of Vaporization*: 130, 74, 3.1; *Heat of Combustion*: -13,100, -7300, -305; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister or air-supplied mask; chemical goggles or face splash shield; *Symptoms Following Exposure*: Headaches, dizziness, nausea, irritation of respiratory passage and eyes; *General Treatment for Exposure*: INHALATION: if victim is overcome by vapors, remove from exposure immediately; call a physician; if breathing is irregular or stopped, start resuscitation and administer oxygen. EYES: flush with

water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

iso-Butyl Acrylate — (i) Chemical Designations — *Synonyms*: Acrylic Acid, Isobutyl Ester; *Chemical Formula*: $CH_2=CHCOOCH_2CH(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, fragrant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 128.17; *Boiling Point at 1 atm.*: 280.2, 137.9, 411.1; *Freezing Point*: -78.0, -61.1, 212.1; *Critical Temperature*: 599, 315, 588; *Critical Pressure*: 440, 30, 3.0; *Specific Gravity*: 0.889 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.044; *Latent Heat of Vaporization*: 130, 71, 3.0; *Heat of Combustion*: -13,500, -7500, -314; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; rubber gloves; chemical goggles; *Symptoms Following Exposure*: Moderate toxicity when swallowed. Contact with eyes causes minor irritation no worse than that caused by hand soap; *General Treatment for Exposure*: INHALATION: move victim to fresh air at once; give oxygen if breathing is difficult or artificial respiration if breathing has stopped; call a doctor. INGESTION: make victim vomit by sticking a finger down the throat or by giving strong, warm water to drink; get medical attention. SKIN AND EYES: remove chemical by flushing with plenty of clean, running water; remove contaminated clothing and wash exposed skin with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

n-Butyl Acrylate — (i) Chemical Designations — *Synonyms*: Acrylic Acid, Butyl Ester, Butyl Acrylate, Butyl 2-Propenoate; *Chemical Formula*: $CH_2=CHCOO-(CH_2)_3CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic acrylic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 128.17; *Boiling Point at 1 atm.*: 299.8, 148.8, 422; *Freezing Point*: -83, -64, 209; *Critical Temperature*: 621, 327, 600; *Critical Pressure*: 426, 29, 2.9; *Specific Gravity*: 0.899 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.08; *Latent Heat of Vaporization*: 120, 66.4, 2.78; *Heat of Combustion*: -13,860, -7,700, -322.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus, rubber gloves, acid goggles; *Symptoms Following Exposure*: Vapor is irritating when breathed at high concentrations. Contact with liquid causes irritation of skin and burning of eyes; *General Treatment for Exposure*: INHALATION: remove to fresh air; administer artificial respiration or oxygen if indicated; call a physician. SKIN AND EYES: wash with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: LD_{50} 100 ppm, 4 hr; *Toxicity by Ingestion*: Grade 2; 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

n-Butyl Alcohol — (i) Chemical Designations — *Synonyms*: Butanol; Butyl Alcohol; 1-Butanol; 1-Hydroxybutane; n-Propylcarbinol; *Chemical Formula*: $CH_3(CH_2)_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Alcohol-like; pungent; strong; characteristic; mildly alcoholic, non residual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 74.12; *Boiling Point at 1 atm.*: 243.9, 117.7, 390.9; *Freezing Point*: -129, -89.3, 183.9; *Critical Temperature*: 553.6, 289.8, 563; *Critical Pressure*: 640.2, 43.55, 4.412; *Specific Gravity*: 0.810 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.083; *Latent Heat of Vaporization*: 256, 142, 5.95; *Heat of Combustion*: -14,230, -7,906, -331.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor

canister or air-supplied mask; chemical goggles or face splash shield; *Symptoms Following Exposure*: Anesthesia, nausea, headache, dizziness, irritation of respiratory passages. Mildly irritating to the skin and eyes; *General Treatment for Exposure*: INHALATION: remove from exposure immediately; call a physician; if breathing is irregular or has stopped, start resuscitation and administer oxygen. INGESTION: induce vomiting and call a physician. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 150 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 2.5 ppm.

sec-Butyl Alcohol — (i) Chemical Designations — *Synonyms*: 2-Butanol; Butylene Hydrate; 2-Hydroxybutane; Methylethylcarbinol; *Chemical Formula*: $CH_3CH_2CH(OH)CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 74.12; *Boiling Point at 1 atm.*: 211, 99.5, 372.7; *Freezing Point*: -174.5, -114.7, 158.5; *Critical Temperature*: 505.0, 262.8, 536; *Critical Pressure*: 608.4, 41.39, 4.193; *Specific Gravity*: 0.807 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.080; *Latent Heat of Vaporization*: 243, 135, 5.65; *Heat of Combustion*: -15,500, -8,600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister or air-supplied mask; chemical goggles or face splash shield; *Symptoms Following Exposure*: Headache, dizziness, and respiratory irritation. Liquid is severely irritating to the eyes and may cause eyeburn; *General Treatment for Exposure*: INHALATION: remove from exposure immediately; calla physician; if breathing is irregular or has stopped, start resuscitation and administer oxygen. INGESTION: induce vomiting and call a physician. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 150 ppm; *Short-Term Exposure Limits*: 200 ppm for 60 min.; *Toxicity by Ingestion*: Grade 1; 5 -15 g/kg (rat-single oral dose); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

tert-Butyl Alcohol — (i) Chemical Designations — *Synonyms*: 2-Methyl-2-Propanol; Trimethylcarbinol: *Chemical Formula*: $(CH_3)_3COH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid. Sometimes freezes below 75°F; *Color*: Colorless; *Odor*: Characteristic; camphor-like; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 74.12; *Boiling Point at 1 atm.*: 181, 82.6, 355.8; *Freezing Point*: 78.3, 25.7, 298.9; *Critical Temperature*: 451, 233, 506; *Critical Pressure*: 576, 39.2, 3.97; *Specific Gravity*: 0.78 at 26 °C (liquid); *Vapor (Gas) Density*: 2.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.080; *Latent Heat of Vaporization*: 234, 130, 5.44; *Heat of Combustion*: -14,000, -7,780, -325.7; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister mask, rubber gloves, and goggles; *Symptoms Following Exposure*: Vapor is narcotic in action and irritating to respiratory passages. Liquid is irritating to skin and eyes; *General Treatment for Exposure*: INHALATION: remove victim from exposure and restore breathing. SKIN AND EYES: remove liquid from skin with water. Flush eyes with water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 150 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

n-Butylamine — (i) Chemical Designations — *Synonyms*: 1-Aminobutane; Butylamine; Mono-n-butylamine; Norvalamine; *Chemical Formula*: $CH_3(CH_2)_3NH_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Fish-like; ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 73.14; *Boiling Point at 1 atm.*: 171.3, 77.4, 350.6; *Freezing Point*: -56, -49, 224; *Critical Temperature*: 484, 251, 524; *Critical Pressure*: 603, 41, 4.16; *Specific Gravity*: 0.741 at 20°C (liquid); *Vapor (Gas) Density*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.071; *Latent Heat of Vaporization*: 180, 100, 4.2; *Heat*

of Combustion: -17,595, -9,775, -409; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask; rubber gloves; coverall goggles; face shield; butyl rubber apron; *Symptoms Following Exposure*: Inhalation causes irritation, nausea, vomiting, headache, faintness, severe coughing and chest pains; can cause lung edema. Ingestion causes severe irritation of mouth and stomach. Contact with eyes causes severe irritation and edema of the cornea. Contact with skin causes burns; absorption through skin may cause nausea, vomiting and shock; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; call a physician; give oxygen if breathing is difficult; if not breathing, give artificial respiration. INGESTION: give large amounts of water; get medical attention. EYES: flush with water for at least 15 min.; get medical care. SKIN: remove contaminated clothing; flush skin with plenty of water at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: 5 ppm, 5 min.; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

sec-Butylamine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $CH_3CH_2CH(CH_3)NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 73.1; *Boiling Point at 1 atm.*: 145, 63, 336; *Freezing Point*: -155, -104, 169; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.721 at 20°C (liquid); *Vapor (Gas) Density*: 2.52; *Ratio of Specific Heats of Vapor (Gas)*: 1.073 at 20°C; *Latent Heat of Vaporization*: 178.09, 98.94, 4.160; *Heat of Combustion*: -17,600, -9,780, -409; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles; rubber gloves and apron; respiratory protective equipment; non-sparking shoes; *Symptoms Following Exposure*: Inhalation causes irritation of burns of the respiratory system; exposure to concentrated vapors and cause asphyxiation. Ingestion causes burns of mouth and stomach. Contact with eyes causes lachrymation, conjunctivitis, burns, corneal edema. Contact with skin causes irritation or burns, dermatitis; *General Treatment for Exposure*: INHALATION: remove patient from exposure; keep him quiet; contact physician. INGESTION: give large amount of water; induce vomiting; consult a physician. EYES: flush thoroughly with water for 15 min.; call physician immediately. SKIN: remove all contaminated clothing; flood affected area with large quantities of water; consult a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 380 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

tert-Butylamine — (i) Chemical Designations — *Synonyms*: 2-Aminoisobutane; 2-Amino-2-Methylpropane; 1,1-Dimethylethylamine; TBA; Trimethylaminomethane; *Chemical Formula*: $(CH_3)_3CNH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 73.14; *Boiling Point at 1 atm.*: 113, 45, 318; *Freezing Point*: Not pertinent; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.696 at 20°C (liquid); *Vapor (Gas) Density*: 8.13; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 167, 92.8, 3.88; *Heat of Combustion*: -17,600, -9,790, -410; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose, mouth, and lung. Ingestion causes irritation of mouth and stomach. Contact with liquid causes severe irritation of eyes and moderate irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air; give artificial respiration if breathing has stopped. INGESTION: give large amounts of water and induce vomiting. EYES: immediately flush with water for at least 15 min.; get medical attention. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 180 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Butylene — (i) Chemical Designations — *Synonyms*: 1-Butene; *Chemical Formula*: $CH_3CH_2CH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Sweetish; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 56.10; *Boiling Point at 1 atm.*: 20.7, -6.3, 266.9; *Freezing Point*: -297, -183, 90; *Critical Temperature*: 295.5, 146.4, 419.6; *Critical Pressure*: 584, 39.7, 4.02; *Specific Gravity*: 0.595 at 20°C (liquid); *Vapor (Gas) Density*: 1.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.104; *Latent Heat of Vaporization*: 168, 93.4, 3.91; *Heat of Combustion*: -19,487, -10,826, -453.26; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles, gloves, self-contained breathing apparatus or organic canister; *Symptoms Following Exposure*: May act as an asphyxiate or slight anesthetic at high vapor concentrations. Vapor concentrations are not usually a hazard at room temperature except in enclosed spaces; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and supply resuscitation. Call a doctor. EYES AND SKIN: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are non-irritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly. May cause frostbite; *Odor Threshold*: Data not available.

Butylene Oxide — . (i) Chemical Designations — *Synonyms*: 1-Butene Oxide; 1,2-Butylene Oxide; *alpha*-Butylene Oxide; 1,2-Epoxybutane; *Chemical Formula*: $C_2H_5CHCH_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72; *Boiling Point at 1 atm.*: 145 63, 336; *Freezing Point*: <-58, <-50, <223; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.826 at 25°C (liquid); *Vapor (Gas) Density*: 2.49; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 180, 100, 4.2; *Heat of Combustion*: -15,200, -8,470, -354; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Clean protective clothing; rubber gloves; chemical worker's goggles; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation: intolerable odor and irritation; respiratory injury may occur at higher levels. Ingestion causes irritation of mouth and stomach. Contact with either liquid or vapor may cause burns of eyes. Liquid produces frostbite-type of skin burn if free to evaporate; if confined to skin, burn may cause skin sensitization; not readily absorbed in toxic amounts; *General Treatment for Exposure*: INHALATION: if any ill effects occur, immediately remove person to fresh air and get medical help; if breathing stops, start artificial respiration. INGESTION: induce vomiting promptly and get medical help. EYES: promptly flush with plenty of water for at least 15 min. and get medical help. SKIN: promptly flush with plenty of water; remove all contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 1,410 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

tert-Butyl Hydroperoxide — (i) Chemical Designations — *Synonyms*: Cadox TBH; *Chemical Formula*: $(CH_3)_3C{\cdot}O{\cdot}OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 90.12; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: -31, -35, 238; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.880 at 25 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -13,000, -7,200, -300; *Heat of Decomposition*: -675, -375, -15.7; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles, well-fitting gloves, barrier creams; *Symptoms Following Exposure*: Liquid causes severe burns of skin and eyes; *General Treatment for Exposure*: INGESTION: induce vomiting and follow with gastric lavage. INHALATION: remove individual from contaminated atmosphere; give artificial respiration and oxygen if needed. SKIN, EYES AND MUCOUS MEMBRANE CONTACT: flood affected tissues with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; 50 to 500 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteris-*

tics: Powerful irritant of skin and eyes; *Odor Threshold*: Data not available.

n-Butyl Mercaptan — (i) Chemical Designations — *Synonyms*: 1-Butanethiol; Thiobutyl Alcohol; *Chemical Formula*: $CH_3CH_2CH_2CH_2SH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Strong skunk-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 90.2; *Boiling Point at 1 atm.*: 209.3, 98.5, 371.7; *Freezing Point*: -176.2, -115.7, 157.5; *Critical Temperature*: 554, 290, 563; *Critical Pressure*: 572, 38.9, 3.94; *Specific Gravity*: 0.841 at 20°C (liquid); *Vapor (Gas) Density*: 3.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.0770 at 16°C; *Latent Heat of Vaporization*: 154.0, 85.58, 3.583; *Heat of Combustion*: -16,601, -9,223, -386; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves, goggles; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes loss of sense of smell; muscular weakness, convulsions, and respiratory paralysis may follow prolonged exposure. Contact of liquid with eyes or ski causes slight irritation. Ingestion causes nausea; *General Treatment for Exposure*: INHALATION: remove victim from contaminated atmosphere; give artificial respiration and oxygen if needed; observe for signs of pulmonary edema. EYES: wash with plenty of water; see a physician. SKIN: wash with soap and water. INGESTION: induce vomiting and follow with gastric lavage; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 1,500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.001 ppm.

n-Butyl Methacrylate — (i) Chemical Designations — *Synonyms*: Methacrylic Acid, Butyl Ester; Butyl Methacrylate; Butyl 2-Methacrylate; n-Butyl alpha-Methyl Acrylate; Butyl 2-Methyl-2-Propenoate; *Chemical Formula*: $CH_2=C(CH_3)COOCH_2CH_2CH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Moderate acrylate; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 142.2; *Boiling Point at 1 atm.*: 325, 163, 436; *Freezing Point*: < 32, < 0, < 273; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.8975 at 20°C; *Vapor (Gas)* Density: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -14,800, -8,230, -344; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; impervious gloves; chemical splash goggles; *Symptoms Following Exposure*: Inhalation may cause nausea because of offensive odor. Contact with liquid causes irritation of eyes and mild irritation of skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove to fresh air; give oxygen or artificial respiration as required. EYES: flush with copious amounts of water for 15 min. and consult physician. SKIN: wash with soap and water. INGESTION: induce vomiting; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50} > 15 g/kg; *Late Toxicity*: Birth defects in rats (gross and skeletal abnormalities); *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

p-tert-Butylphenol — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $1,4\text{-}(CH_3)_3CC_6H_4OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 150; *Boiling Point at 1 atm.*: 463.1, 239.5, 512.7; *Freezing Point*: 210, 99, 372; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.037 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -16,900, -9,410, -394; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical worker's goggles; clean, body-protecting clothing; *Symptoms Following Exposure*: Inhalation of vapors causes irritation of respiratory system. Ingestion causes irritation of mouth and stomach. Contact with eyes causes burns. Contact with dry skin produces no significant irritation, but wet skin is subject to moderate irritation, even a mild burn; *General Treatment for Exposure*: INHALATION: move to fresh air; begin artificial respiration if breathing have ceased. INGESTION: force milk or water and then immediately induce vomiting; treat symptomatically. EYES: immediately flush eyes with plenty of water for at least 15 min., get medical attention promptly. SKIN: flush with plenty of water; remove grossly contaminated cloth-

ing; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 3,250 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Butyltrichlorosilane — (i) Chemical Designations — *Synonyms*: n-Butyltrichlorosilane; *Chemical Formula*: $CH_3CH_2CH_2CH_2SiCl_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, hydrochloric acid-like; pungent and irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 191.5; *Boiling Point at 1 atm.*: 288, 142, 415; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.16 at 20°C (liquid); *Vapor (Gas) Density*: 6.5; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 81, 45 1.9; *Heat of Combustion*: -4,300, -2,400, -100; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection; rubber gloves, chemical worker's goggles, and other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation of vapor irritates upper respiratory system. Contact of liquid with eyes or skin causes severe burns. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure*: Seek medical attention after all exposures to this compound. INHALATION: remove to fresh air; apply artificial respiration if required. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: do not induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

1,4-Butynediol — (i) Chemical Designations — *Synonyms*: 2-Butyne-1,4-Diol; 1,4-Dihydroxy-2-Butyne; *Chemical Formula*: $HOCH_2C{\equiv}CCH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or 35% aqueous solution; *Color*: Solid: colorless to pale yellow; Solution: straw to amber color; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 36.09; *Boiling Point at 1 atm.*: 460, 238, 511; *Freezing Point*: 140, 58, 331; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.07 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,020, -6,120, -256.2; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Neoprene rubber gloves and safety goggles or face shield; *Symptoms Following Exposure*: May cause dermatitis; *General Treatment for Exposure*: SKIN: wash affected skin area thoroughly with water. EYES: immediately wash with water for at least 15 min. and get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

iso-Butyraldehyde — (i) Chemical Designations — *Synonyms*: Isobutyric Aldehyde; Isobutyraldehyde; Isobutylaldehyde; 2-Methylpropanal; *Chemical Formula*: $(CH_3)_2CHCHO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72.11; *Boiling Point at 1 atm.*: 147, 64.1, 337.3; *Freezing Point*: -112, -80, 193; *Critical Temperature*: 464, 240, 513; *Critical Pressure*: 600, 41, 4.2; *Specific Gravity*: 0.791 at 20°C (liquid); *Vapor (Gas) Density*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.093; *Latent Heat of Vaporization*: 180, 98, 4.1; *Heat of Combustion*: -13,850, -7,693, -322.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Appropriate protective clothing, including rubber gloves, rubber shoes and protective eyewear; *Symptoms Following Exposure*: Vapor is irritating to the eyes and mucous membranes; *General Treatment for Exposure*: EYES: immediately flush with plenty of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If

spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.047.

n-Butyraldehyde — (i) Chemical Designations — *Synonyms*: Butanal; Butyraldehyde; Butyric Aldehyde; Butyl Aldehyde; *Chemical Formula*: $CH_3CH_2CH_2CHO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent aldehyde; pungent and intense; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72.11; *Boiling Point at 1 atm.*: 167, 74.8, 348; *Freezing Point*: -142, -96.4, 176.8; *Critical Temperature*: 484, 251, 524; *Critical Pressure*: 590, 40, 4.1; *Specific Gravity*: 0.803 at 20°C; *Vapor (Gas) Density*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.089; *Latent Heat of Vaporization*: 184, 102, 4.27; *Heat of Combustion*: -15,210, -8,450, -353.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves, and organic canister gas mask; *Symptoms Following Exposure*: Inhalation will cause irritation and possibly nausea, vomiting, headache, and loss of consciousness. Contact with eyes causes burns. Skin contact may be irritating; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if breathing has stopped, give artificial respiration; if breathing is difficult, give oxygen; call a doctor at once. SKIN AND EYES: immediately flush with water for at least 15 min.; get medical attention for eyes; remove contaminated clothing and wash underlying skin; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; 5-15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.0046 ppm.

n-Butyric Acid — (i) Chemical Designations — *Synonyms*: Butanic Acid; Butanoic Acid; Butyric Acid; Ethylacetic Acid; Propanecarboxylic Acid; *Chemical Formula*: $CH_3CH_2CH_2COOH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Clear; *Odor*: Rancid, disagreeable; strong, penetrating, like rancid butter; **(iii) Physical and Chemical Properties** — *Physical State at 15 and 1 atm.*: Liquid; *Molecular Weight*: 88.1; *Boiling Point at 1 atm.*: 327, 164, 437; *Freezing Point*: 23, -5, 268; *Critical Temperature*: 671, 355, 628; *Critical Pressure*: 764, 52, 5.3; *Specific Gravity*: 0.958 at 20°C; *Vapor (Gas) Density*: 3.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.079 at 20°C; *Latent Heat of Vaporization*: 167, 92.7, 3.88; *Heat of Combustion*: -10,620, -5,900, -247; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; rubber gloves; vapor-proof plastic goggles; impervious apron and boots; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membrane and respiratory tract; may cause nausea and vomiting. Ingestion causes irritation of mouth and stomach. Contact with eyes may cause serious injury. Contact with skin may cause burns; chemical is readily absorbed through the skin and may cause damage by this route; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give oxygen if breathing is difficult; call a physician. INGESTION: give large amount of water and induce vomiting. EYES: irrigate with water for 15 min. and get medical attention. SKIN: flush affected areas immediately and thoroughly with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 2,940 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 0.001 ppm.

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Cacodylic Acid —(i) Chemical Designations — *Synonyms*: Hydroxydimethylarsine Oxide; Dimethylarsenic Acid; Ansar; Silvisar 510; *Chemical Formula*: $(CH_3)_2AsOOH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; water solutions may be dyed blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 138; *Boiling Point at 1 atm.*: > 392, >200, >473; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 (est.) At 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6,000, -3,300, -140; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended*

Personal Protective Equipment: Dust respirator; goggles, protective clothing; *Symptoms Following Exposure*: Chemical is essentially non-irritating in contact with skin or eyes. Ingestion causes arsenic poisoning, but symptoms are delayed; *General Treatment for Exposure*: Be alert for delayed arsenic poisoning symptoms. EYES or SKIN: flush with water. INGESTION: induce vomiting and call a physician at once; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50}=700 mg/kg; *Late Toxicity*: Arsenic poisoning; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Cadmium Acetate —(i) Chemical Designations — *Synonyms*: Cadmium Acetate Dihydrate; *Chemical Formula*: $Cd(C_2H_3O_2)_2 2H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 266.52; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.34 at 20° (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*:; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, seek medical attention. INGESTION: induce vomiting; allay gastrointestinal irritation by swallowing milk or egg whites at frequent intervals; perform gastric lavage; seek medical attention. EYES: flush with water for at least 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m (as cadmium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} <50 mg/kg; *Late Toxicity*:; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cadmium Bromide — (i) Chemical Designations — *Synonyms*: Cadmium Bromide Tetrahydrate; *Chemical Formula*: CdBr4H_2O; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 344.27; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles, or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes coughing, sneezing symptoms of lung damage. Ingestion produces severe toxic symptoms, both kidney and liver injures may occur. Contact with dust causes eye irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, seek medical attention. INGESTION: induce vomiting; allay gastrointestinal irritation by swallowing milk or egg whites at frequent intervals; perform gastric lavage; seek medical attention. EYES: flush with water for at least 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3; (as cadmium) *Short-Term Exposure Limits*:; *Toxicity by Ingestion*: Grade 4; LD_{50}; >50 mg/kg; *Late Toxicity*: Delayed liver, lung and kidney damage has followed respiratory exposures to cadmium salts in industry; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cadmium Chloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $CdCl_2$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Crystalline solid; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 228.35; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.05 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses, rubber gloves, and respirator with proper filter; *Symptoms Following Exposure*: Ingestion causes gastroenteric distress, pain and prostration. Sensory disturbances, liver injury, and convulsions have been observed in severe intoxications; *General Treatment for Exposure*: INGESTION: induce vomiting and follow with gastric lavage, a saline catharic, and demulcents. Consider using atropine, opiates, and fluid therapy. $CaNa_2$ EDTA has been effective in acutely poisoned animals and in a few humans. BAL has been found sufficiently effective in animal experiments, to justify its use in human intoxication. Since the BAL-cadmium com-

plex has a nephrotoxic action, the physician will have to decide whether or not to use this drug.; *Toxicity by Inhalation (Threshold Limit Value)*: 2 ppm; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 4; LD_{50} below 50 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first degree burns on short exposure; may cause second degree burns on long exposure; *Odor Threshold*: Not pertinent.

Cadmium Fluoroborate — (i) Chemical Designations — *Synonyms*: Cadmium Fluoborate; *Chemical Formula*: $Cd(BF_4)_2$-H_2O; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 286; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.60 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves and apron; safety glasses and face shield; *Symptoms Following Exposure*: Ingestion produces severe toxic symptoms; both kidney and liver injures may occur; may be fatal. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove patient to fresh air; seek medical attention. INGESTION: call a physician at once; if victim is conscious, induce vomiting by giving a tablespoon of salt in a glass of warm water and repeat until vomit is clear; give milk or whites of eggs beaten with water; keep patient warm and quiet. EYES: flush with plenty of water and get medical attention. SKIN: flush with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as cadmium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 250 mg/kg (rat); *Late Toxicity*: Delayed liver, kidney, and lung damage has followed respiratory exposure to cadmium salts in industry; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Cadmium Nitrate — (i) Chemical Designations — *Synonyms*: Cadmium Nitrate Tetrahydrate; *Chemical Formula*: $Cd(NO_3)_2$ $4H_2O$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 308.47; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 138; 59; 332; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.45 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, safety goggles, dust mask; *Symptoms Following Exposure*: Inhalation of fumes can produce coughing, chest constriction, headache, nausea, vomiting, pneumonitis. Chronic poisoning is characterized by emphysema and kidney injury. Ingestion causes gasrtrointestinal disturbances and sever toxic symptoms; both kidney and liver injures may occur. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove patient to fresh air; seek medical attention. INGESTION: give large amounts of water and induce vomiting, give milk or egg whites; seek medical attention. EYES: flush with copious amounts of water for 15 min; consult a physician. SKIN: Wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as cadmium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral mouse LD_{50} = 100 mg/kg; *Late Toxicity*:; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cadmium Oxide — (i) Chemical Designations — *Synonyms*: Cadmium Fume; *Chemical Formula*: CdO; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Yellow-brown to brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 128.4; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 6.95 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*:; *Symptoms Following Exposure*: A single exposure to cadmium oxide fumes can cause severe or fatal lung irritation; chronic poisoning is characterized by lung injury (emphysema) and kidney disfunction. Ingestion produces severe toxic effects, both kidney and liver injures may occur. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION; if there has been known exposure to dense cadmium oxide fume or if cough, chest tightness, or respiratory distress occur after

possible exposure, place patient at bed rest and call a physician. INGESTION: induce vomiting, stop irritation by giving milk or egg whites at frequent intervals; perform gastric lavage; seek medical attention. EYES: flush with water for at least 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Exposure Limits*: 0.1 mg/m^3, 30 min; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50}=72 mg/kg; *Late Toxicity*:; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cadmium Sulfate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $CdSO_4$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 208.46; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.7 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator; goggles, rubber gloves; *Symptoms Following Exposure*: Inhalation may cause dryness of throat, coughing, constriction in chest, and headache. Ingestion may cause salvation, vomiting, abdominal pains or diarrhea. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove victim from exposure and call a physician. INGESTION; induce vomiting, then allay irritation with milk or egg whites given at frequent intervals; perform gastric lavage; seek medical attention, EYES: flush with water for at least 10 in; consult a physician. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as cadmium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*:; *Late Toxicity*: Delayed liver, kidney, and lung damage has followed respiratory exposure to cadmium salts in industry; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Calcium Arsenate — (i) Chemical Designations — *Synonyms*: Cucumber Dust; Tricalcium Arsenate; Tricalcium Orthoarsenate; *Chemical Formula*: $Ca_3(AsO_4)_2$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 398; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.62 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation causes respiratory irritation. Ingestion causes irritation of mouth and stomach. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give victim one tablespoonful of salt in glass of water; repeat until vomit is clear; the give two tablespoonfuls of Epsom salt or milk of magnesia and force fluids; call a physician in all cases of suspected poisoning. EYES: flush with water for at least 15 min. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral rat LD_{50}=20 mg/kg; *Late Toxicity*: Arsenic compounds may cause skin and lung cancer; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Calcium Carbide — (i) Chemical Designations — *Synonyms*: Acetylenogen; Carbide; *Chemical Formula*: CaC_2; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Gray to bluish black; *Odor*: Garlic-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 64.10; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.22 at 18°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles and (for those exposed to unusually dusty operations) a respirator such as those approved by the U.S. Bureau of Mines for "nuisance dusts"; *Symptoms Following Exposure*: Eye and skin irritation; *General Treatment for Exposure*: INHALATION OF DUST: remove from further exposure and call a doctor. SKIN: wash with plenty of water. EYES: flush with clean running water an eye wash fountain for at least 15 min. And get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-*

Term Exposure Limits: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Calcium Chlorate — i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $Ca(ClO_3)_2$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 207; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 644, 340, 613; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.710 at 0°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust respirator; coveralls or other protective clothing; *Symptoms Following Exposure*: Inhalation of dust causes irritation of upper respiratory system. Dust irritates eyes and skin. Ingestion causes abdominal pain, nausea, vomiting, diarrhea, pallor, shortness of breath, unconsciousness; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: induce vomiting and get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50}=4,500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Calcium Chloride — (i) Chemical Designations — *Synonyms*: Calcium Chloride, Anhydrous; Calcium Chloride Hydrates; *Chemical Formula*: $CaCl_2 \cdot xH_2O$ where x=o to 6; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid or water solution; *Color*: White to off-white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 110.99 (solute); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.15 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses or face shield, dust-type respirator, rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes (particularly by dust) causes irritation and possible transient corneal injury. Contact of solid with dry skin causes mild irritation, even a superficial burn; *General Treatment for Exposure*: INHALATION; move to fresh air, if discomfort persists, get medical attention. INGESTION; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: EYES: promptly flood with water and continue washing for at least 15 min.; consult an ophthalmologist. SKIN: flush with water; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50}=1,000 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Calcium Chromate — (i) Chemical Designations — *Synonyms*: Calcium Chromate (VI); Calcium Chromate Dihydrate; Gelbin Yellow Ultramarine; Steinbuhl Yellow; *Chemical Formula*: $CaCrO_4 \cdot 2H_2O$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 192.1; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion causes severe circulatory collapse and chronic nephritis. Contact with eyes causes irritation. Contact with skin may cause dermatitis and ulcers; *General Treatment for Exposure*: INHALATION: remove to fresh air. INGESTION: give large amounts of water; induce vomiting. EYES: flush with water for at least 15 min. SKIN: treat local injuries like acid burns; scrub with dilute (2%) sodium hyposulfite solution; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3: LD_{50} 50 - 50 mg/kg; *Late Toxicity*: Lung cancer may develop; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Calcium Cyanide — (i) Chemical Designations — *Synonyms*: Cyanide of Calcium; Cyanogas G-Fumigant, Cyanogas A-Dust; *Chemical Formula:* $Ca(CN)_2$ plus inert ingredients; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to grey to black; *Odor*: Compound reacts with moisture in air to form hydrogen cyanide gas, which has a characteristic almond-like odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 92; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.853 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus and full protective clothing, including rubber footwear; *Symptoms Following Exposure*: Inhalation or ingestion causes headache, nausea, vomiting, and weakness, high concentrations are rapidly fatal; *General Treatment for Exposure*: Call a doctor immediately. INHALATION: break amyl nitrite pearl in cloth and hold lightly under nose for 15 sec; repeat 5 times at 15 sec. intervals; use artificial respiration if breathing stops. EYES: flush with water for 15 min.; do not allow water to enter nose or mouth; SKIN: flush with water; do not allow water to enter nose or mouth. INGESTION: break an amyl nitrite pearl in a cloth and hold lightly under nose for 15 sec.; if patient is conscious, induce vomiting and repeat until vomit is clear; repeat inhalation of amyl nitrite 5 times at 15 sec. intervals; use artificial respiration if breathing has stopped; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3 (as cyanide); *Short-Term Exposure Limits*: 5 mg/m^3 for 30 min; *Toxicity by Ingestion*: Grade 4; oral LD_{50}=39 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data nor available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Calcium Fluoride — (i) Chemical Designations — *Synonyms*: Fluospar, Fluorspar; *Chemical Formula*: CaF_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Gray; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 78.08; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.18 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: For dust only; *Symptoms Following Exposure*: Little acute toxicity; *General Treatment for Exposure*: Usually no treatment needed; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion:*; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Calcium Hydroxide — (i) Chemical Designations — *Synonyms*: Slaked Lime; *Chemical Formula*: $Ca(OH)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 74.09; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.24 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust-proof goggles and mask; *Symptoms Following Exposure*: Dust irritates eyes, nose and throat; *General Treatment for Exposure*: INGESTION: have victim drink milk and water. Do NOT induce vomiting. EYES: flush with a gentle stream of water for at least 10 min. And consult an ophthalmologist for further treatment without delay. SKIN: wash off the lime and consult a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Calcium Hypochlorite — (i) Chemical Designations — *Synonyms*: HTH; HTH Dry Chlorine; Neutral Anhydrous Calcium Hypochlorite; Sentry; *Chemical Formula*: $Ca(OCl)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Like bleaching powder; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 174.98; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.35 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*:

Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, dust mask; *Symptoms Following Exposure*: INHALATION: hypochlorous acid fumes cause sever respiratory tract irritation and pulmonary edema. INGESTION: pain and inflamation of mouth, pharynx, esophagus, and stomach, erosion of mucous membranes, chiefly of the stomach; vomiting (hemorrhaging may cause vomitus to resemble coffee ground); circulatory collapse with cold and clammy skin, cyanosis and shallow respirations; confusion, delirum, coma; edema of pharynx, glottis and larynx, with stridor and obstruction; perforation of esophagus of stomach, with mediastinitis or peritonitis. SKIN CONTACT: may cause vesicular eruptions and eczematoic dermatitis; *General Treatment for Exposure*: INGESTION: swallow immediately milk, egg white, starch paste, milk of magnesia, aluminum hydroxide gel. Avoid sodium bicarbonate because of the release of carbon dioxide. Do not use acidic antidotes; cautious gastric lavage with tap water or a 1% solution of sodium thiosulfate; milk of magnesia (1 oz.) left in the stomach is useful as a mild antacid, adsorbent, demulcent, and catharic; demulcents, such as starch, egg white, milk, gruel; opiates for the control of pain. Treat shock vigorously with intravenous fluids. Prompt surgical intervention when indicated, e.g. tracheotomy, gastrectomy. SKIN: wash with liberal quantities of water and apply a paste of baking soda; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Irritates eyes, skin and mucous membranes; *Odor Threshold*: Not pertinent.

Calcium, Metallic — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Ca; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Silvery; turns to greyish white on exposure to air; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 40.2; *Boiling Point at 1 atm.*: 2.714, 1.490, 1.763; *Freezing Point*: 1.562, 850, 1.123; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.55 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6790; -3,770; -158; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and rubber gloves; *Symptoms Following Exposure*: Contact with eyes or skin produces caustic burns; *General Treatment for Exposure*: EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Calcium Nitrate — (i) Chemical Designations — *Synonyms*: Calcium Nitrate Tetrahydrate; *Chemical Formula*: $Ca(NO_3)_2 \cdot 4H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 164; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 1.042, 561, 934; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.50 at 18 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator and rubber gloves; *Symptoms Following Exposure*: Dust causes mild irritation of eyes; *General Treatment for Exposure*: EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Calcium Oxide — (i) Chemical Designations — *Synonyms*: Quicklime; Unslaked Lime; *Chemical Formula*: CaO; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White yo grey; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 56.08; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point;* Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.3 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves, goggles, and any type of respirator prescribed for fine dust; *Symptoms Following Exposure*: Cause burns on mucous mem-

brane and skin. Inhalation of dust causes sneezing; *General Treatment for Exposure*: INGESTION: if victim is conscious, have him drink water or milk. Do NOT induce vomiting. SKIN and EYES: flush with water and seek medical help; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Exposure Limits*: 10 mg/m^3 for 30 min; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: Not pertinent.

Calcium Peroxide — (i) Chemical Designations — *Synonyms*: Calcium Dioxide; *Chemical Formula*: CAO_2; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: Yellow-white; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 72.1; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.92 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: -135, -75, -3.1; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Toxic dust respirator; general-purpose gloves; chemical safety goggles; full cover clothing; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Dust also irritates eyes and skin on contact and irritates mouth and stomach if ingested; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: flush with water for 15 min. And consult a physician. SKIN: flush with water. INGESTION: dive large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Calcium Phosphate — (i) Chemical Designations — *Synonyms*: (a) MCP; Monocalcium Phosphate, Monohydrate; Acid Calcium Phosphate, Calcium Superphosphate; Calcium Biphosphate; Primary Calcium Phosphate (b) DCP; Dicalcium Phosphate (Anhydrous or Dihydrate); Dibasic Calcium Phosphate; Calcium Monohydragen Phosphate; Secondary Calcium Phosphate (c) TCP; Calcium Phosphate Tribasic (d) Calcium Pyrophosphate; *Chemical Formula*: (a) $CaH_4(PO_4)_2 \cdot H_2O$; (b) $CaHPO_4$ or $CaHPO_4 \cdot H_2O$; (c) $Ca(PO_4)_2$; (d) $Ca_2P_2O_7$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Monocalcium Phosphate: 252.16; Dicalcium Phosphate: 136.06; Calcium Pyrophosphate: 254; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2-3 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles, and gloves; *Symptoms Following Exposure*: Inhalation of MCP or DCP may cause irritation of upper respiratory tract; prolonged inhalation of concentrated pyrophosphate may cause a deposit of DCP in the lungs. Ingestion of large quantities of any form of calcium phosphate may cause nausea, vomiting, cramps, and diarrhea; MCP may also result from contact with any of these phosphates; prolonged or repeated exposure to MCP may lead to chronic conjunctivitis. Contact with skin by MCP may cause local irritation or chronic dermatitis; prolonged or repeated contact with concentrated aqueous slurries of DCP may cause local irritation; *General Treatment for Exposure*: INHALATION: move to clean air; see physician in case of persistent coughing, expectoration, chest pain, or shortness of breath. INGESTION: get medical attention quickly; induce vomiting by giving large amounts of water or warm salty water, or by tickling back of patient's throat; continue until vomitus is clear; follow with milk, eggs, or olive oil to soothe stomach. EYES: immediately flush with large quantities of running water for at least for 15 min., holding eyelids apart to ensure thorough flushing of eyes and lids; do not attempt to neutralize with chemical agent; get medical attention for persistent irritation; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; $LD_{50} > 15$ g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Tribasis is odorless.

Calcium Phosphide — (i) Chemical Designations — *Synonyms*: Photophor; *Chemical Formula*: Ca_3P_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Grey; *Odor*: Musty, like acetylene; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 182.2; *Boiling Point at 1 atm.*: Decomposes;

Freezing Point: (approx.) 2,910; 1,600; 1,810; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.51 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; protective gloves and clothing; goggles; *Symptoms Following Exposure*: Inhalation or ingestion causes faintness, weakness, nausea, vomiting. External contact with eyes causes irritation of eyes and skin.; *General Treatment for Exposure*: INHALATION: remove to fresh air, call a physician and alert to possibility of phosphine poisoning. EYES or SKIN: flush with water, call a physician to alert to possibility of phosphine poisoning; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 1-100 mg/m^3.

Calcium Resinate — (i) Chemical Designations — *Synonyms*: Calcium Abietate; Calcium Resinate, Flushed; Calcium Rosin; Limed Wood Rosin; Metallic Resinate; *Chemical Formula*: $Ca(OOCC_{19}H_{29})_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Amber; very dark brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 643 (approx.); *Boiling Point at 1 atm.*: > 600, > 316, > 589; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.13 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; gloves; *Symptoms Following Exposure*: Inhalation of fumes may cause irritation of nose and throat. Contact with eyes causes irritation. Contact of molten material with skin causes burns; *General Treatment for Exposure*: INHALATION: move victim to fresh air; get medical help immediately. INGESTION: give large amounts of water; induce vomiting. EYES: flush immediately with cold water; get medical help immediately. SKIN: if molten chemical burns skin, apply cold water immediately; get medical help for burn treatment; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Camphene — (i) Chemical Designations — *Synonyms*: 2,2-Dimethyl-3-Methylenenorbornane; 3,3-Dimethyl-2-Methylenenorcamphane; *Chemical Formula*: $Ca_{10}H_{16}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Camphoraceous; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 136; *Boiling Point at 1 atm.*: 310; 154; 427; *Freezing Point*: 122; 50; 323; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.87 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -19,400, -10,800, -452; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves and face shield; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes and skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; call a physician immediately. EYES: flush immediately with clean, cool water; SKIN: wash with alcohol, follow with soap and water wash; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Camphor Oil — (i) Chemical Designations — *Synonyms*: Liquid Impure Camphor; Liquid Gum Camphor; *Chemical Formula*: $C_{10}H_{16}O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; brown; blue; *Odor*: Like camphor; fragrant and penetrating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid (liquid if even slightly impure); *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: > 392, > 200, > 473; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.923 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recom-*

mended Personal Protective Equipment: Eye protection; *Symptoms Following Exposure*: Within 5 to 90 minutes after swallowing, the following may be noted: nausea and vomiting; feeling of warmth; headache; confusion, vertigo, excitement, restless, delirium, and hallucinations; increased muscular excitability, tremors, and jerky movements; epileptiform convulsions, followed by depression (convulsions sometimes occur early in the syndrome and may be severe, but they do not have the grave prognosis strychnine convulsions); coma; central nervous depression may at times be the primary clinical response; death results from respiratory failure or from status epilepticus; slow convalescence (days or weeks), often with persistent gastric distress; *General Treatment for Exposure*: For an oral intoxication, administer gastric lavage, cathartics, diuretics, and sedatives. Control convulsions with a short acting barbiturate, chloral hydrate, or ether. Do NOT use analeptics or opiates; *Toxicity by Inhalation (Threshold Limit Value)*: 2 ppm; *Short-Term Exposure Limits*: 3 ppm for 30 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Caprolactam, Liquid — (i) Chemical Designations — *Synonyms*: Aminocaproic Lactam; epsilon-Caprolactam; Hexahydro-2H-Azepin-2-One; 2-Ketohexamethyleneimine; *Chemical Formula*: $HNCH_2(CH_2)_4CO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Colorless; *Odor*: Mild; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 113; *Boiling Point at 1 atm.*: 515; 268; 541; *Freezing Point*: 154, 68, 341; *Critical Temperature*: 944.4; 506.9; 780.1; *Critical Pressure*: 660, 45, 4.6; *Specific Gravity*: 1.02 at 77°C (liquid); *Vapor (Gas) Density*: 3.9; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization:* 209, 116, 4.85; *Heat of Combustion*: -13,700, -7,640, -320; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gas-mask or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes coughing or mild irritation. Contact with hot liquid will burn eyes and skin; *General Treatment for Exposure*: INHALATION: remove patient to fresh air. EYES: wash with copious amount of water for at least 15 min.; call physician. SKIN: wash with water: call physician in case of thermal burn; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50}=2,140 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: 0.3 mg/m^3.

Captan — (i) Chemical Designations — *Synonyms*: N[(Trichloromethyl)thio]-4-Cyclohexene-1,2-Dicarboximide; N-Trichloromethylthio-cis-Δ^4-Cyclohexwne-1,2-Dicarboximide; Orthocide; Vanicide; *Chemical Formula*: $C_9H_8Cl_3NO_2S$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to buff; *Odor*: Slight pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 300.6; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 338, 170, 443; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.74 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -7,100, -3,940, -165; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; rubber gloves and goggles; *Symptoms Following Exposure*: Vapor irritates eyes. Ingestion causes depression, lachrymation, labored respiration, diarrhea; *General Treatment for Exposure*: Remove from exposure; keep airways open; administer artificial respiration if necessary. EYES: flush with water for 15 min, and get medical attention. SKIN: wash with soap and water. INGESTION: maintain respiration; induce vomiting (lavage stomach if patient is unconscious); give symptomatic and supportive treatment; save agent and vomitus for laboratory examination; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50}=480 mg/kg; *Late Toxicity*: None observed in several species; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Carbaryl — (i) Chemical Designations — *Synonyms*: 1-Naphthyl N-Methylcarbamate; Sevin; *Chemical Formula*: $C_{12}H_{11}NO_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Off-white; *Odor*: Weak; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 288, 142, 415; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.23 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not

pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: SKIN AND EYE CONTACT: flood affected tissues with water. INGESTION: induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Exposure Limits*: Dust, 30 mg/m^3 for 30 min; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat LD_{50} 0.51 g/kg); *Late Toxicity*: Liver damage to rats at high dose by mouth; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: No hazard; *Odor Threshold*: Not pertinent.

Carbolic Oil — (i) Chemical Designations — *Synonyms*: Middle Oil; Liquefied Phenol; *Chemical Formula*: C_6H_5OH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless, darkens on exposure to light; *Odor*: Sweet, tar-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 84.11; *Boiling Point at 1 atm.*: 358.2; 181.8; 455.0; *Freezing Point*: < 105.6; < 40.9; < 314.1; *Critical Temperature*: 790.0, 421.1, 694.3, *Critical Pressure*: 889, 60.5, 6.13; *Specific Gravity*: 1.04 at 41°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.089; *Latent Heat of Vaporization*: 129.6; 72.0; 3.014; *Heat of Combustion*: -13,401, -7,445, -311.707; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Fresh air mask for confined areas; rubber gloves; protective clothing; full face shield; *Symptoms Following Exposure*: Will burn eyes and skin. The analgesic action may cause loss of pain sensation. Readily absorbed through skin, causing increased heart rate, convulsions, and death; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, keep quiet and warm. If breathing stops, start artificial respiration. INGESTION: do NOT induce vomiting. Give milk, egg whites, or large amounts of water. Get medical assistance. No known antidote. EYES and SKIN: remove contaminated clothing. Flush eyes with water for 15 min. or until physician arrives. Wash skin with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Causes cancer in experimental animals; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentration unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 0.05 ppm.

Carbon Dioxide — (i) Chemical Designations — *Synonyms*: Carbonic Acid Gas; Carbonic Anhydride; *Chemical Formula*: CO_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquefied compessed gas or solid ("Dry Ice"); *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 44.0; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: -109.3, -78.5, 194.7; *Critical Temperature*: 88, 31, 304; *Critical Pressure*: 1.07; 72.9; 7.40; *Specific Gravity*: 1.56 at -79° (solid); *Vapor (Gas) Density*: 1.53; *Ratio of Specific Heats of Vapor (Gas)*: 1.0474; *Latent Heat of Vaporization*: 150, 83, 3.5; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus in excessively high CO_2 concentration areas. For handling liquid or solid, wear safety goggles or face shield, insulated gloves, long-sleeved shirt, and trousers worn outside boots or over high-top shoes to shed spilled liquid; *Symptoms Following Exposure*: Inhalation causes increased respiration rate, headache, subtle physiological changes for up to 5% concentration and prolonged exposure. Higher concentrations can cause unconsciousness and death. Solid can cause cold contact burns. Liquid or cold gas can cause freezing injury to skin or eyes similar to a burn; *General Treatment for Exposure*: INHALATION: move victim to fresh air. skin: treat burns from contact with solid in same way as frostbite; *Toxicity by Inhalation (Threshold Limit Value)*: 5000 ppm; *Short-Term Exposure Limits*: 30,000 ppm for 60 min.; *Toxicity by Ingestion*: Not pertinent (gas with low boiling point); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Carbon Bisulfide — (i) Chemical Designations — *Synonyms*: Carbon disulfide; *Chemical Formula*: CS_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Faint sweetish; disagreeable; offensive, like that of decaying cabbage; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 76.14; *Boiling Point at 1 atm.*: 115, 46.3, 319.5; *Freezing Point*: -168,9; -111.6; 161.6; *Critical Temperature*: 523, 273, 546; *Critical Pressure*: 1,100, 76, 7.7; *Specific Gravity*: 1.26 at 20°C (liquid); *Vapor (Gas) Density*: 2.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.292; *Latent Heat of Vaporization*: 153, 85, 3.559; *Heat of Combustion*: -5814, -3,230, -135.2; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Only self-contained breathing mask

with full face, approved by the United State Bureau of Mines, is recommended. If the vapor concentration exceeds 2% by volume or is unknown, supplied-air respiratory equipment of appropriate design with full face masks should be used by all persons entering contaminated area. Mask should be used only for emergency situation and should be located accordingly. Almost any type of industrial clothing is satisfactory. Splashed of small quantity are not harmful to fabrics, and evaporation from clothing is quite rapid. Clothing should, however, be removed and the skin washed with water. Goggles should be used when there is any danger of CS_2 splashes or spray; *Symptoms Following Exposure*: ACUTE EXPOSURE: mild to moderate irritation of skin, eyes, and mucous membranes from liquid or concentrated vapors; headache; garlicky breath, nausea, vomiting, diarrhea (even after vapor exposures), and occasionally abdominal pain; weak pulse, palpations; fatigue, weakness in the legs, unsteady gait vertigo; mania, hallucinations of sight, hearing, taste, and small in acute, massive vapor exposures; central nervous depression with respiratory paralysis; death may occur during coma or after a convulsions; *General Treatment for Exposure*: Remove victim promptly from contaminated area. Administer oxygen and artificial respiration if needed. SKIN CONTACT: wash affected areas with copious quantities of water. INGESTION: induce vomiting and follow with gastric lavage and saline cathartics; *Toxicity by Inhalation (Threshold Limit Value)*: 20 ppm; *Short-Term Exposure Limits*: 100 ppm for 30 minutes, 20 ppm for 10 minutes, 100 ppm for 30 minutes and 50 ppm for 60 minutes; *Toxicity by Ingestion*: Grade 2; rat LD_{50}=0.1 - 0.99 g/kg; *Late Toxicity*: Non-specific liver cell damage in rats; higher incidence of upper respiratory disease in humans; *Vapor (Gas) Irritant Characteristics*: Vapor cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: 0.21 ppm.

Carbon Monoxide — (i) Chemical Designations — *Synonyms*: Monoxide; *Chemical Formula*: CO; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed gas or liquefied gas; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 28.0; *Boiling Point at 1 atm.*: -312.7, -191.5, 81.7; *Freezing Point*: -326, -199, 74; *Critical Temperature:* -220, -140, 133; *Critical Pressure*: 507.5, 34.51, 3.502; *Specific Gravity*: 0.791 at -191.5°C (liquid); *Vapor (Gas) Density*: 0.97; *Ratio of Specific Heats of Vapor (Gas)*: 1.3962; *Latent Heat of Vaporization*: 92.8, 51.6, 2.16; *Heat of Combustion*: -4,343, -2,412, -101; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; safety glasses and safety shoes; Type D or Type N canister mask; *Symptoms Following Exposure*: Inhalation causes headache, dizziness, weakness of limbs, confusion, nausea, unconsciousness, and finally death. 0.04% conc., 2-3 hr. or 0.06% conc., 1 hr. - headache and discomfort; with moderate exercise, 0.1-0.2% will produce throbbing in the head in about ½ hr., and confusion of the mind, headache, and nausea in about 2 hrs. 0.20 - 0.25% usually produces unconsciousness in about ½ hr. Inhalation of a 0.4% conc. can prove fatal in less than 1 hr. Inhalation of high concentrations can cause sudden, unexpected collapse. Contact of liquid with skin will cause frostbite; *General Treatment for Exposure*: INHALATION: remove from exposure; give oxygen if available; support respiration; call a doctor. SKIN: if burned by liquid, treat as frostbite; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: 400 ppm, 15 min.; *Toxicity by Ingestion*: Not pertinent (gas with low boiling point); *Late Toxicity*: Toxicity from overexposure persists for many days; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Carbon Tetrachloride — (i) Chemical Designations — *Synonyms*: Benzinoform; Necatorina; Perchloromethane; Tetrachloromethane; *Chemical Formula*: CCl_4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweetish, aromatic; moderately strong ethereal; somewhat resembling that of chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 153.83; *Boiling Point at 1 atm.*: 170, 76.5, 349.7; *Freezing Point*: -9.4, -23, 250.2; *Critical Temperature*: 541, 283, 556; *Critical Pressure*: 660, 45, 4.6; *Specific Gravity*: 1.59 at 20°C (liquid); *Vapor (Gas) Density*: 5.3; *Ratio of Specific Heats of Vapor (Gas)*: 1.111; *Latent Heat of Vaporization*: 84.2, 46.8, 1.959; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister with full face mask; protective clothing; rubber gloves; *Symptoms Following Exposure*: Dizziness, incoordination, anesthesia; may be accompanied by nausea and liver damage. Kidney damage also occurs, often producing decrease or stopping of urinary output; *General Treatment for Exposure*: EYES OR SKIN: flush with plenty of water; for eyes, get medical attention. Remove

contaminated clothing and wash before reuse. INHALATION: immediately remove to fresh air, keep patient warm and quiet and get medical attention promptly. Start artificial respiration if breathing stops. INGESTION: induce vomiting and get medical attention promptly. No specific antidote known; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: 25 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Causes severe liver damage and death if ingested; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Greater than 10 ppm.

Carene — (i) Chemical Designations — *Synonyms*: 3-Carene; Isodiprene; 4,7,7-Trimethyl-3-norcarene; 3,7,7-Trimethylbicyclo[0.1.4]hept-3-ene; *Chemical Formula*: $C_{10}H_{16}$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet, pungent, like turpentine; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 136; *Boiling Point at 1 atm.*: 338, 170, 443; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.860 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -19,370, -10,760, -450; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic canister or air-supplied mask; goggles or face-shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes headache, confusion, respiratory distress. Ingestion irritates entire digestive system and may injure kidneys; if liquid enters lungs, it causes severe pneumonitis. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move victim to fresh air; call a doctor; administer artificial respiration and oxygen if required. INGESTION: give large amounts of water and induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 4.8 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Catechol — (i) Chemical Designations — *Synonyms*: 1,2-Benzenediol; Catechin; 1,2-Dihydroxybenzene; ortho-Dihydroxybenzene; Oxyphenic Acid; Pyrocatechin; Pyrocatechinic Acid; Pyrocathechol; Pyrocathechuic Acid; *Chemical Formula*: 1,2-HOC_6H_4OH; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 110.11; *Boiling Point at 1 atm.*: 473.9, 245.5, 418.7; *Freezing Point*: 219.7, 104.3, 377.5; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.344 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,200, -6,220, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust respirator if required; rubber gloves, apron, and boots; face shield; *Symptoms Following Exposure*: Inhalation of dust or mists may cause irritation of eyes, nose, and throat. Ingestion may cause convulsions and respiratory failure. Contact with eyes causes burns and possible permanent impairment of vision. Prolonged or repeated contact with skin may cause burn; *General Treatment for Exposure*: INHALATION: if ill effect occur, get medical attention. INGESTION: promptly give milk or plenty of water and induce vomiting; get medical attention promptly; no specific antidote known. EYES AND SKIN: immediately flush with plenty of water for at least 15 min.; for eyes get medical attention promptly; remove and wash all contaminated clothing before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Causes tumors in mice; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Caustic Potash Solution — (i) Chemical Designations — *Synonyms*: Potassium Hydroxide Solution; Lye; *Chemical Formula*: $KOH—H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >266, >130, >403; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.45 - 1.50 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat*

of Vaporization: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Wide-brimmed hat and close-fitting safety goggles equipped with rubber side shields; long sleeved cotton shirt or jacket with buttoned collar and buttoned sleeves; rubber or rubber-coated canvas gloves. (Shirt sleeves should be buttoned over the gloves so that any spilled material will run down the outside). Rubber safety-toe shoes or boots and cotton overalls. (Trouser cuffs should be worn outside of boots). Rubber apron; *Symptoms Following Exposure*: Causes severe burns of eyes, skin, and mucous membranes; *General Treatment for Exposure*: (Act quickly!) EYES: flush with water for at least 15 min. SKIN: flush with water, than rinse with dilute vinegar (acetic acid). INGESTION: give water and milk. Do not induce vomiting. Call physician immediately, even if injury seems minor; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Toxicity by Ingestion*: oral rat LD_{50} = 365 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: This chemical is a sever skin irritant. Can cause second- and third-degree chemical burns on short contact and is very injurious to the eyes.; *Odor Threshold*: Not pertinent.

Caustic Soda Solution — (i) Chemical Designations — *Synonyms*: Sodium Hydroxide Solution, Lye; *Chemical Formula*: NaOH-H_2O; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >266, >130, >403; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.5 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Wide-brimmed hat; safety goggles with rubber side shields; tight fitting cotton clothing; rubber gloves under shirt cuffs; rubber boots and apron; *Symptoms Following Exposure*: Causes severe burns to eyes, skin, and mucous membranes; *General Treatment for Exposure*: Fast response is important. EYES: flush with water for at least 15 minutes. SKIN: flush with water thoroughly and then rinse with dilute vinegar (acetic acid). INGESTION: Give victim water and milk. Do not induce vomiting. Call physician immediately, even when injury seems slight; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: oral rabbit LD_{50} = 500 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree chemical burns on short contact and is very injurious to eyes; *Odor Threshold*: Not pertinent.

Charcoal — (i) Chemical Designations — *Synonyms*: Mineral Carbon, Activated Charcoal; *Chemical Formula*: C; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Powder, pumps, grains or sticks; *Color*: Black; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 12; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: 14,100, 7,830, 328; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; *Symptoms Following Exposure*: No significant symptoms; *General Treatment for Exposure*: No treatment required; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Non-toxic; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: Not pertinent.

Chlordane — (i) Chemical Designations — *Synonyms*: Chlordan, 1,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-Hexahydro-4,7-Methanoindene, Texichlor; *Chemical Formula*: $C_{10}H_6Cl_8$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Brown; *Odor*: Penetrating; aromatic; slightly pungent, like chlorine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 409.8; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical* Temperature: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.6 at 25 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -4,000, -2,200, -93; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Use respirators for spray, fogs, mists or dust; goggles; rubber

gloves; *Symptoms Following Exposure*: Moderately irritating to eyes and skin. Ingestion, absorption through skin, or inhalation of mist or dust may cause excitability, convulsions, nausea, vomiting, diarrhea, and local irritation of the gastrointestinal tract; *General Treatment for Exposure*: INHALATION: Administer victim oxygen and give fluid therapy; do not give epinephrine, since it may induce ventricular fibrillation; enforce complete rest. EYES: flush with water for at least 15 minutes. SKIN: wash off skin with large amounts of fresh running water and wash thoroughly with soap and water. Do not scrub infected area of skin. INGESTION: induce vomiting and follow with gastric lavage and administration of saline cathartics; ether and barbiturates may control convulsions; oxygen and fluid therapy are also recommended. Do not give epinephrine. Since no specific antidotes are known, symptomatic therapy must be accompanied by complete rest.; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: 2 mg/m^3 for 30 min; *Toxicity by Ingestion*: oral LD_{50} = 283 mg/kg (rat); *Late Toxicity*: Possible liver damage; loss of appetite or weight.; *Vapor (Gas) Irritant Characteristics*: No data; *Liquid or Solid Irritant Characteristics*: No data; *Odor Threshold*: No data.

Chlorine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Cl_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Greenish yellow; *Odor*: Characteristic choking; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 70.91; *Boiling Point at 1 atm.*: -29.4, -34.1, 239.1; *Freezing Point*: -150, -101, 172; *Critical Temperature*: 291, 144, 417; *Critical Pressure*: 1118, 76.05, 7.704; *Specific Gravity*: 1.424 at 15°C (liquid); *Vapor (Gas) Density*: 2.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.325; *Latent Heat of Vaporization*: 124, 68.7, 2.87; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Quick-opening safety shower and eye fountain; respiratory equipment approved fro chlorine service. Wear safety goggles at all times when in vicinity of liquid chlorine; *Symptoms Following Exposure*: Eye irritation, sneezing, copious salvation, general excitement and restlessness. Irritation may persists for several days. High concentrations cause respiratory distress and violent coughing, often with retching. Death may result from suffocation; *General Treatment for Exposure*: INHALATION: remove victim from source of exposure; call a doctor; support respiration; administer oxygen. EYES: flush with copious amounts of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: 3 ppm for 5 min.; *Toxicity by Ingestion*: Not pertinent; ingestion unlikely (chlorine is gas above -34.5°C); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 3.5 ppm.

Chlorine Trifluoride — (i) Chemical Designations — *Synonyms*: CTF; *Chemical Formula*: ClF_3; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Gas: colorless. Liquid: greenish-yellow; *Odor*: Acrid; strong, pungent, sweetish; sweet and irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 92.5; *Boiling Point at 1 atm.*: 53, 11.6, 284.8; *Freezing Point*: -105, -76.1, 197.1; *Critical Temperature*: 307, 153, 426; *Critical Pressure*: 837, 56.9, 5.77; *Specific Gravity*: 1.85 at 11°C (liquid); *Vapor (Gas) Density*: 3.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.2832; *Latent Heat of Vaporization*: 128, 71.2, 2.98; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Neoprene gloves and protective clothing made of glass fiber and Teflon, including full hood; self-contained breathing apparatus with full face mask; *Symptoms Following Exposure*: Inhalation causes extreme irritation of respiratory tract; pulmonary edema may result. Vapors are very irritating to eyes and skin; liquid causes severe burns; *General Treatment for Exposure*: Call physician at once after any exposure to this compound. INHALATION: remove victim to fresh air and keep him quiet; give artificial respiration if breathing has stopped; give oxygen; enforce rest for 24 hours. EYES: flush with water for at least 15 min.; get medical attention, but do not interrupt flushing for at least 10 min. SKIN: flush with water, then with 2-3% aqueous ammonia, then again with water; apply ice-cold pack of saturated Epsom salt or 70% ethyl alcohol; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm (ceiling point); *Short-Term Exposure Limits*: 0.1 ppm for 5 min.; *Toxicity by Ingestion*: Grade 4; $LD_{50} < 50$ mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant, causes

second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Chloroacetophenone — (i) Chemical Designations — *Synonyms*: Phenacyl Chloride; omega-Chloroacetophenone; alpha-Chloroacetophenone; Phenyl Chloromethyl Ketone; Tear Gas; Chloromethyl Phenyl Ketone; *Chemical Formula*: $C_6H_5COCH_2Cl$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: White to pale yellow; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 154.6; *Boiling Point at 1 atm.*: 477, 247, 520; *Freezing Point*: 68 - 138, 20 - 59, 293 - 332; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.32 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -9,340, -5,190, -217; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full-face organic canister mask; self-contained breathing apparatus; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes tearing, burning of the eyes and difficulty in breathing; high concentrations may lead to development of acute pulmonary edema after latencies of 8 hrs. to several days; possible systemic manifestations include agitation, coma, contraction of pupils of eyes, loss of reflexes. External contact causes irritation of the skin and eyes. Ingestion causes agitation, coma, contraction of pupils of eye, loss of reflexes; *General Treatment for Exposure*: INHALATION: remove victim from contaminated atmosphere at once; give artificial respiration and oxygen, if necessary; watch for pulmonary edema for several days. EYES: flush with water; do not rub. SKIN: flush with water. INGESTION: get medical attention; watch for development of pulmonary edema for several days; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 52 mg/kg (rat); *Late Toxicity*: Fatty infiltration of liver; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.016 ppm.

Chloroacetyl Chloride — (i) Chemical Designations — *Synonyms*: Chloracetyl Chloride; *Chemical Formula*: $ClCH_2COCl$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to slightly yellow; *Odor*: Sharp; pungent; extremely irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 112.9; *Boiling Point at 1 atm.*: 221, 105, 378; *Freezing Point*: -8.5, -22.5, 250.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: 1.423 at 20°C (liquid); *Specific Gravity*: 1.42 at 20°C (liquid); *Vapor (Gas) Density*: 3.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.1191; *Latent Heat of Vaporization*: 166, 92, 3.85; *Heat of Combustion*: -4,000, -2,000, -90; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-type canister mask; self-contained breathing apparatus (full face); rubber gloves and full protective clothing; *Symptoms Following Exposure*: Inhalation causes severe irritation of upper respiratory system. External contact causes severe irritation of eyes and skin. Ingestion causes severe irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from exposure; support respiration; call physician. EYES: wash with copious amounts of water for 15 min.; call physician. SKIN: wash with large amounts of water; treat burns as required. INGESTION: do not induce vomiting; give large amounts of water; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating, such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

p-Chloroaniline — (i) Chemical Designations — *Synonyms*: 1-Amino-4-chlorobenzene; 4-Chlorophenylamine; 4-Chloroaniline; *Chemical Formula*: $4\text{-}ClC_6H_4NH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Yellowish, white; cream to tan color (darkens on storage); *Odor*: Slightly sweetish; characteristic amine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 127.6; *Boiling Point at 1 atm.*: 446, 230, 503; *Freezing Point*: 158, 70, 343; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.43 at 19°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,000, -6,000, -250; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; chemical goggles; protective clothing; dust respirator; *Symptoms Following Exposure*:

Inhalation or ingestion causes bluish tint to fingernails, lips, and ears indicative of cyanosis; headache, drowsiness, and nausea, followed by unconsciousness. Liquid can be absorbed through the skin and cause similar symptoms. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove victim from exposure immediately; if needed, administer oxygen; refer to physician. EYES: flush with water for at least 15 min. SKIN: remove victim from exposure immediately; remove contaminated clothing; wash contacted area with copious amounts of water and soap; if needed, administer oxygen; refer to physician. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 300 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

4-Chlorobutyronitrile — (i) Chemical Designations — *Synonyms*: 4-Chlorobutyronitrile (Practical, mixture with 4-Bromobutyronitrile); *Chemical Formula*: $CH_2ClCH_2CH_2CN + CH_2BrCH_2CH_2CN$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Liquid; *Color*: White to pale yellow; *Odor*: Data not available; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 103.55; *Boiling Point at 1 atm.*: 374, 190, 463; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 20°C (liquid); *Vapor (Gas) Density*: 3.57; *Ratio of Specific Heats of Vapor (Gas)*: 1.080 at 20°C; *Latent Heat of Vaporization*: 185, 103, 4.31; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air supply mask or self-contained breathing apparatus for repeated handling large amounts; rubber gloves; safety goggles; *Symptoms Following Exposure*: Chemical is moderately toxic. Inhalation causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes causes irritation. Can penetrate the skin on prolonged contact; only slightly irritating; *General Treatment for Exposure*: INHALATION: move victim to fresh air; administer artificial respiration if required; call a doctor. INGESTION: give large amounts of water; induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50-400 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Chloroform — (i) Chemical Designations — *Synonyms*: Trichloromethane; *Chemical Formula*: $CHCl_3$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant, sweet; ethereal; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 119.39; *Boiling Point at 1 atm.*: 142, 61.2, 334.4; *Freezing Point*: -82.3, -63.5, 209.7; *Critical Temperature*: 506, 263.2, 536.4; *Critical Pressure*: 790, 54, 5.5; *Specific Gravity*: 1.49 at 20°C (liquid); *Vapor (Gas) Density*: 4.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.146; *Latent Heat of Vaporization*: 106.7, 59.3, 2.483; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical goggles. 50 ppm to 2%: suitable full-face gas mask. Above 2%: suitable self-contained system; *Symptoms Following Exposure*: Headache, nausea, dizziness, drunkenness, narcosis; *General Treatment for Exposure*: INHALATION: if ill effects develop, get victim to fresh air, keep him warm and quiet, and get medical attention. If breathing stops, start artificial respiration. INGESTION: induce vomiting and get medical attention. No known antidote; treat symptoms. EYES: flush with plenty of water for at least 15 min. and get medical attention. SKIN: wash with soap and water, remove contaminated clothing and free of chemical; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm for 10-hour work day; *Short-Term Exposure Limits*: 50 ppm for 10 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 205-307 ppm.

Chlorohydrins (Crude) — (i) Chemical Designations — *Synonyms*: Crude Epichlorohydrin; *Chemical Formula*: $O{\bullet}CH_2{\bullet}CH{\bullet}CH_2Cl$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Yellow to colorless; *Odor*: Pungent; like chloroform; garlic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Tempera-*

ture: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.18 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 142, 78.8, 3.30; *Heat of Combustion*: -8100, -4500, -190; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister mask or air pack; protective goggles; protective gloves; *Symptoms Following Exposure*: May cause central nervous system depression. Vapor is irritating to eyes, nose and throat. Headache, nausea, vomiting, collapse if swallowed. Liquid irritates skin; *General Treatment for Exposure*: INHALATION: remove to fresh air, keep warm and quiet. Get medical attention at once. If breathing stops, start artificial respiration. INGESTION: induce vomiting and call physician. Do NOT induce vomiting if unconscious. No specific antidote known. EYES AND SKIN: flush with water for at least 15 min. and get medical attention. Remove contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: 10 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 10 ppm.

Chloromethyl Methyl Ether — (i) Chemical Designations — *Synonyms*: Monochloromethyl Ether; Methyl Chloromethyl Ether, Anhydrous; *Chemical Formula*: $ClCH_2OCH_3$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 80.5; *Boiling Point at 1 atm.*: 140, 60, 333; *Freezing Point*: -154.3, -103.5, 169.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.07 at 25°C (liquid); *Vapor (Gas) Density*: 2.8; *Ratio of Specific Heats of Vapor (Gas)*: 1.1195; *Latent Heat of Vaporization*: 154, 85.6, 3.58; *Heat of Combustion*: -7,300, -4,100, -170; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes throat, fever, chills, difficulty in breathing. Contact of liquid with eyes causes severe burns and necrosis. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; call physician. EYES: flush with water for at least 15 min.; call physician. SKIN: wash with large amounts of water. INGESTION: do NOT induce vomiting; give large amounts of water; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 817 mg/kg (rat); *Late Toxicity*: Considered to be lung cancer-producing; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

p-Chlorophenol — (i) Chemical Designations — *Synonyms*: 4-Chlorophenol; *Chemical Formula*: 1,4-ClC_6H_4OH; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Colorless to straw; *Odor*: Strong medicinal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 128.6; *Boiling Point at 1 atm.*: 428, 220, 493; *Freezing Point*: 109, 43, 316; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.31 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 160, 89, 3.7; *Heat of Combustion*: -9,330, -5,180, -217; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; face shield; boots and apron; respiratory protection; *Symptoms Following Exposure*: Inhalation causes headache, dizziness, weak pulse. Ingestion cause irritation of mouth and stomach; headache, dizziness, weak pulse. Contact with eyes causes severe irritation and burn; if absorbed, causes some symptoms as inhalation; *General Treatment for Exposure*: INHALATION: move to fresh air; get medical attention promptly if any symptoms develop. INGESTION: do not induce vomiting unless advised by a physician; give large amounts of milk, egg whites, or water and get medical help immediately; no specific antidote known. EYES: immediately flush with water for at least 15 min. SKIN: flush in safety shower while removing all contaminated clothing; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid*

Irritant Characteristics: Data not available; *Odor Threshold*: 30 ppm.

Chloropicrin, Liquid — (i) Chemical Designations — *Synonyms*: Trichloronitromethane; Nitrochloroform; Picfume; Nitrotrichloromethane; *Chemical Formula*: Cl_3CNO_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Intensely irritating, lachrymator; intense and penetrating odor which causes a pronounced secretion of tears; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 164.4; *Boiling Point at 1 atm.*: 234, 112, 385; *Freezing Point*: -83, -64, 209; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.64 at 25°C (liquid); *Vapor (Gas) Density*: 5.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.0991; *Latent Heat of Vaporization*: 103, 57.3, 2.4; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic-type canister mask; goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes nausea, eye watering, vomiting, bronchitis, and pulmonary edema. Vapor is a powerful tear gas. Liquid irritates and burns skin and causes severe burns of eyes. Ingestion causes severe irritation of mouth and stomach; *General Treatment for Exposure*: Get medical attention following all exposures to this compound. INHALATION: remove victim from exposure; support respiration. EYES: flush with copious quantities of water for at least 15 min. SKIN: wash with water for 15 min. INGESTION: do NOT induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 250 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye or lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and very injurious to the eyes; *Odor Threshold*: 1.1 ppm.

Chlorosulfonic Acid — (i) Chemical Designations — *Synonyms*: Chlorsulfonic Acid; *Chemical Formula*: $ClSO_3H$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Sharp, acrid, penetrating, pungent; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.53; *Boiling Point at 1 atm.*: 311, 155, 428; *Freezing Point*: -112, -80, 193; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.75 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 198, 110, 4.6; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Acid-proof goggles or a rubber hood, long rubber gloves, rubber shoes, long rubber apron, shift and trousers of wool or acrylic fiber, and hat with a brim. For emergency use involving considerable exposure, a complete rubber suit with hood, gloves and boots of rubber should be used. In case of fire use self-contained breathing apparatus; *Symptoms Following Exposure*: INHALATION: vapor extremely irritating to lung and mucous membranes. Vapor has such a sharp and penetrating odor that inhalation of severely toxic quantities is unlikely unless it is impossible to escape the fumes. EYES OR SKIN: liquid acid will severely burn body tissue; *General Treatment for Exposure*: Call a physician in all cases. INHALATION: remove victim to fresh air; if he is not breathing, apply artificial respiration; give oxygen if breathing is difficult; do not induce vomiting. SKIN: flush with plenty of water for at least 15 min. while removing contaminated clothing and shoes; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: 5 ppm for 5 min.; 30 ppm for 10 min.; 10 ppm for 60 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Severe eye and throat irritant. Can cause eye or lung injury and cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: 1-5 ppm.

4-Chloro-o-Toluidine — (i) Chemical Designations — *Synonyms*: 2-Amino-5-chlorotoluene; 5-Chloro-2-aminotoluene; 4-Chloro-2-methylaniline; Fast Red TR Base; Red TR Base; *Chemical Formula*: $2\text{-}CH_3\text{-}4\text{-}ClC_6H_3NH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Grayish-white; *Odor*: Weak, fishy; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 141.6; *Boiling Point at 1 atm.*: 466, 241, 514; *Freezing Point*: 77, 25, 298; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not

pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; goggles; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation, ingestion, or skin contact causes bluish tint in fingernails, lips, and ears. Headache, drowsiness, and nausea also occur. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give oxygen if needed; get medical attention. EYES: flush with water for at least 15 min. SKIN: wash immediately with soap and water. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 464 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Chromic Anhydride — (i) Chemical Designations — *Synonyms*: Chromic Acid; Chromic Oxide; Chromium Trioxide; *Chemical Formula*: CrO_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Dark red; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 100.01; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.70 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and respirator. (Special chromic acid filters are available for respirators to prevent inhalation of dust or mist); *Symptoms Following Exposure*: Very irritating to eyes and respiratory tract. Ingestion causes severe gastrointestinal symptoms. Contact with eyes or skin causes burns; prolonged contact produces dermatitis ("chrome sores"); *General Treatment for Exposure*: INGESTION: call a physician; do NOT induce vomiting. SKIN OR EYES: wash eyes throughly for at least 15 min.; flush contacted skin areas with water; remove contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Lung cancer; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: Not pertinent.

Chromyl Chloride — (i) Chemical Designations — *Synonyms*: Chromium (VI) Dioxychloride; Chromium Oxychloride; *Chemical Formula*: CrO_2Cl_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Dark red; *Odor*: Acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 154.9; *Boiling Point at 1 atm.*: 241, 116, 389; *Freezing Point*: -141.7, -96.5, 176.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.96 at 20°C (liquid); *Vapor (Gas) Density*: 5.3; *Ratio of Specific Heats of Vapor (Gas)*: 1.2832; *Latent Heat of Vaporization*: 113, 62.6, 2.62; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus (full face); rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation causes severe irritation of upper respiratory system. Contact with eyes or skin causes irritation and burning. Ingestion causes burning of mouth and stomach; *General Treatment for Exposure*: Get medical attention following all exposures to this compound. INHALATION: remove from exposure; support respiration. EYES: flush with copious quantities of water for 15 min. SKIN: flush with water for 15 min. INGESTION: do NOT induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; $LD_{50} < 50$ mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Cause second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Citric Acid — (i) Chemical Designations — *Synonyms*: 2-Hydroxy-1,2,3-Propane-Tricarboxylic Acid; beta-Hydroxytricarballylic Acid; beta-Hydroxytricarboxylic Acid; *Chemical Formula*: $HOC(CH_2CO_2H)_2CO_2H$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 192.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 307, 153, 426; *Critical Temperature*: Not pertinent; *Critical*

Pressure: Not pertinent; *Specific Gravity*: 1.54 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -4,000, -2,220, -93; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush immediately with physiological saline or water; get medical care if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; oral LD_{50} 11.7 g/kg (rat); *Late Toxicity*: Chronic effects in humans are unknown; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cobalt Acetate — (i) Chemical Designations — *Synonyms*: Cobalt (II) Acetate; Cobalt Acetate Tetrahydrate; Cobaltous Acetate; *Chemical Formula*: $Co(C_2H_3O_2)_2 \cdot 4H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Pink; *Odor*: Slight acetic acid odor; vinegar-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 249.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 284, 140, 413; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.71 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; rubber gloves; goggles or face shield; protective clothing; *Symptoms Following Exposure*: Inhalation causes shortness of breath and coughing; permanent disability may occur. Ingestion causes pain and vomiting. Contact with eyes causes irritation. Contact with skin may cause dermatitis; *General Treatment for Exposure*: INHALATION: move to fresh air; if breathing has stopped, begin artificial respiration. INGESTION: give large amounts of water; induce vomiting. EYES: flush with water for at least 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3 (as cobalt); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 - 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cobalt Chloride — (i) Chemical Designations — *Synonyms*: Cobalt (II) Chloride; Cobaltous Chloride; Cobaltous Chloride Dihydrate; Cobaltous Chloride Hexahydrate; *Chemical Formula*: $CoCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Pink to red; *Odor*: Very slight acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 237.9; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 187, 86, 359; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.924 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; side-shield goggles; Bu. of Mines respirator; protective clothing; *Symptoms Following Exposure*: Inhalation causes respiratory disease, shortness of breath, and coughing; permanent disability may occur. Ingestion causes pain, vomiting, and diarrhea. Contact causes irritation of eyes and may cause skin rash; *General Treatment for Exposure*: INHALATION: move victim to fresh air; if breathing has stopped, begin artificial respiration and call a doctor. INGESTION: give large amount of water; induce vomiting. EYES: flush with water at least 15 min.; consult physician if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3 (as cobalt); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cobalt Nitrate — (i) Chemical Designations — *Synonyms*: Cobalt (II) Nitrate; Cobaltous Nitrate; Cobaltous Nitrate Hexahydrate; *Chemical Formula*: $Co(NO_3)_2 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Red; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 291.04; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 131, 55, 328; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.54 at 20°C (solid); *Vapor (Gas) Density*: Not

pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator; rubber gloves; safety goggles; protective clothing; *Symptoms Following Exposure*: Inhalation causes shortness of breath and coughing; permanent disability may occur. Ingestion causes pain and vomiting. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; if breathing has stopped, begin artificial respiration and call a doctor. INGESTION: give large amounts of water; induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} ~400 mg/kg (rabbit); *Late Toxicity*: Causes malignant tumors in rabbits; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Cobalt Sulfate — (i) Chemical Designations — *Synonyms*: Bieberite; Cobalt (II) Sulfate; Cobaltous Sulfate Heptahydrate; *Chemical Formula*: $CoSO_4 \cdot 7H_2O$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Rose, pink; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 281.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.948 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator; goggles; protective gloves; *Symptoms Following Exposure*: Inhalation causes shortness of breath and coughing; permanent disability may occur. Ingestion causes pain and vomiting. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; if breathing has stopped, begin artificial respiration and call a doctor. INGESTION: give large amount of water; induce vomiting; calla doctor. EYES: flush with water for at least 15 min.; consult a physician if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3 (as cobalt); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Collodion — (i) Chemical Designations — *Synonyms*: Cellulose Nitrate Solution; Nitrocellulose Solution; Pyroxylin Solution; Box Toe Gum; Nitrocellulose Gum; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Viscous liquid; *Color*: Colorless; *Odor*: Depends on solvent used; often that of ether; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 93, 34, 307; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.772 at 25 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; rubber gloves; goggles or face shield; *Symptoms Following Exposure*: High concentration of ether fumes may cause narcosis, loss of consciousness and respiratory paralysis if inhaled. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; initiate artificial respiration if breathing has stopped; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 400 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50} > 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Copper Acetate — (i) Chemical Designations — *Synonyms*: Acetic Acid; Cupric Salt; Crystallized Verdigris; Cupric Acetate Monohydrate; Neutral Verdigris; *Chemical Formula*: $Cu(C_2H_3O_2)_2 \cdot H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Bluish green; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 199.65; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 239, 115, 388; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.9 at 20°C

(solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation of dusts causes irritation of throat and lungs. Ingestion of large amounts causes violent vomiting and purging, intense pain, collapse, coma, convulsions, and paralysis. Contact with solutions irritates eyes; contact with solid causes severe eye surface injury and irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min.; get medical attention if injury was caused by solid. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 - 5 g/kg (rat); *Late Toxicity*: Causes degeneration of liver in dogs; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Acetoarsenite — (i) Chemical Designations — *Synonyms*: Imperial Green; Moss Green; Vienna Green; Meadow Green; Paris Green; Mitis Green; Kings Green; Parrot Green; *Chemical Formula*: $3Cu(AsO_2)_2 \cdot Cu(C_2H_3O_2)_2$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Emerald green; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 1014; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; impervious gloves; goggles or face shield; *Symptoms Following Exposure*: Dust causes eye irritation. Ingestion causes gastric disturbance, tremors, muscular cramps, and nervous collapse which may lead to death; *General Treatment for Exposure*: Following ingestion or unusually severe exposure to dust, get medical attention. Alert doctor to possibility of arsenic poisoning. EYES: flush with water for at least 15 min. SKIN: wash throughly with soap and water. INGESTION: give copious drafts of water and induce repeated vomiting. Give cathartic of 2 oz. Epsom salt in water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} 22 mg/kg (rat); *Late Toxicity*: Arsenic poisoning; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Copper Arsenite — (i) Chemical Designations — *Synonyms*: Cupric Arsenite; Swedish Green; Scheele's Green; Cupric Green; Copper Orthoarsenite; *Chemical Formula*: $CuHAsO_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Green; yellowish green; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 277.4; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Dust irritates eyes. Ingestion causes gastric disturbance, tremors, muscular cramps, and nervous collapse that may cause death; *General Treatment for Exposure*: Following ingestion or unusually severe exposure to dust, get medical attention. Alert doctor to possibility of arsenic poisoning. EYES: flush with water for 15 min. SKIN: wash with soap and water. INGESTION: give large amounts of water; induce vomiting; give cathartic, such as 2 oz. of Epsom salt in water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Arsenic poisoning; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Copper Bromide — (i) Chemical Designations — *Synonyms*: Cupric Bromide, Anhydrous; *Chemical Formula*: $CuBr_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Black; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 223.35; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 928, 498, 771; *Critical*

Temperature: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.77 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of throat and lungs. Ingestion of large amounts causes violent vomiting and purging, intense pain, collapse, coma, convulsions, and paralysis. Contact with solutions causes eye irritation; contact with solid causes severe eye surface injury and skin irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min.; get medical attention if injury was caused by solid. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Chloride — (i) Chemical Designations — *Synonyms*: Cupric Chloride Dehydrate; Eriochalcite (anhydrous); *Chemical* Formula: $CuCl_2H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Green; Blue-green; blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 170.48 (dihydrate); *Boiling Point at 1 atm*: Not pertinent; *Freezing Point*: not pertinent; *Critical Temperature*: not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.54 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator; rubber gloves; safety goggles; *Symptoms Following Exposure*: Inhalation causes coughing and sneezing. Ingestion causes pain and vomiting. Contact with solution irritates eyes: contact with solid causes severe eye surface injury and skin irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water; induce vomiting; get medical attention. EYES: flush with water for 15 min.; consult with physician if the injury was caused by solid. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50}50-500mg/kg; *Late Toxicity*: causes liver damage in rabbits; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Cyanide — (i) Chemical Designations — *Synonyms*: Cupricin; Cuprous Cyanide; *Chemical Formula*: CuCN; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: powder; *Color*: white; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm*: Solid; *Molecular Weight*: 89.56; *Boiling Point at 1 atm*: Not pertinent; *Freezing Point*: Not pertinent; *Critical* Temperature: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.92 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; protective goggles or face mask; protective clothing; *Symptoms Following Exposure*: Following severe exposure to dust, symptoms of cyanide poisoning may develop (see ingestion). Ingestion causes anxiety, confusion, dizziness, sudden convulsion, and paralysis. Contact with eyes causes irritation; *General Treatment for Exposure*: Get medical attention after all exposures to this substance. INHALATION: remove victim to fresh air. INGESTION: if breathing has stopped, begin artificial respiration immediately; administer by inhalation amyl nitrite pearls for 15 - 30 seconds of every minute, while a sodium nitrite solution is being prepared; discontinue amyl nitrite and immediately inject intravenously 10 ml of a 3% sol. Of sodium nitrite (nonsterile if necessary) over a period of 2 to 4 min.; do not remove needle; through same needle infuse 50 ml of a 25% aqueous soln. Of sodium thiosulfate; injection should take about 10 min. (Concentrations of 5-50% are permissible if total dose is approx. 12 grams). Oxygen therapy may be of value in combination with the above. If symptoms recur, repeat injections of nitrite and thiosulfate at half the above doses. EYES: flush with water for at least 15 min. SKIN: flush with water wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3 (as cyanide); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} < 50 mg/kg; *Late* Toxicity: Data not available; *Vapor (Gas) Irritant Charac-*

teristics: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Fluoroborate — (i) Chemical Designations — *Synonyms*: Copper Borofluride Solution; Copper (II) Fluoborate Solution; Cupric Fluoborate Solution; *Chemical Formula*: $Cu(BF_4)_2$-H_2O; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Liquid; *Color*: Clear, dark blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 237.16 (solute only); *Boiling Point at 1 atm.*: 121/100/373; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.54 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber apron and gloves; *Symptoms Following Exposure*: Inhalation of mist irritates nose and throat. Ingestion causes pain and vomiting. Contact causes severe irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water and induce vomiting if required. EYES: flush with water for at least 15 min.; get medical attention if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 - 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Iodide — (i) Chemical Designations — *Synonyms*: Cuprous Iodine; Marshite; *Chemical Formula*: CuI; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: Beige; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 190.4; *Boiling Point at 1 atm.*: 2,354, 1,290, 1,563; *Freezing Point*: 1,121, 605, 878; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.62 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion of copper salts produces violent vomiting and purging, intense pain, collapse, coma, convulsion, and paralysis. Contact with eyes or skin causes irritation.; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water: induce vomiting; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 - 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Naphthenate — (i) Chemical Designations — *Synonyms*: Paint Drier; *Chemical Formula*: Mixture; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Dark green; *Odor*: Like gasoline: slight aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: 310 - 395, 154 - 202, 427 - 475; *Freezing Point*: Not pertinent; *Critical* Temperature: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.93 ~ 1.05 at 25 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -17,600, -9,800, -410; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; plastic gloves (as for gasoline); *Symptoms Following Exposure*: Vapor causes mild irritation of eyes and mild irritation of respiratory tract if inhaled. Ingestion causes irritation to stomach. Aspiration causes severe lung irritation and rapidly developing pulmonary edema; central nervous system excitement followed by depression; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. EYES: wash with copious amounts of water for at least 15 min. SKIN: wipe off and wash with soap and water. INGESTION: do NOT induce vomiting; guard against aspiration to lungs. ASPIRATION: enforce bed rest; give oxygen: call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 500 ppm; *Short-Term Exposure* Limits: Data not available; *Toxicity by Ingestion*: Grade 1; oral rat LD_{50}=4 - 6 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are non-irritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing

and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Copper Nitrate — (i) Chemical Designations — *Synonyms*: Cupric Nitrate Trihydrate; Gerhardite; *Chemical Formula*: $Cu(NO_3)$-$3H_2O$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 241.60; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 237.1, 114.5, 387.7; *Critical Temperature*: Non pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.32 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation causes irritation of throat and lungs. Ingestion of large amounts causes violent vomiting and purging, intense pain, collapse, coma, convulsion, and paralysis. Solution irritates eyes: contact with solid causes severe eye surface injury and skin irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 minutes; get medical attention if injury was caused by solid. SKIN: flush with water. *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Oxalate — (i) Chemical Designations — *Synonyms*: Cupric Oxalate Hemihydrate; *Chemical Formula*: CuC_2O_4-$\frac{1}{2}H_2O$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Bluish white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 160.6; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion of very large amounts may produce symptoms of oxalate poisoning; watch for edema of the glottis and delayed constriction of esophagus. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION; remove to fresh air; if exposure has been prolonged watch for symptoms of oxalate poisoning (nausea, shock, collapse, and convulsions). INGESTION: give large amounts of water; induce vomiting; get medical attention. EYES: flush with water foe at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Copper Sulfate — (i) Chemical Designations — *Synonyms*: Blue Vitriol; Copper Sulfate Pentahydrate; Cupric Sulfate; Sulfate of Copper; *Chemical Formula*: $CuSO_4$-$5H_2O$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: Blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 249.7; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.29 at 15 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Filtering masks to minimize inhalation of dust; *Symptoms Following Exposure*: INGESTION: copper sulfate may induce severe gastroenteric anuria, hematuria, anemia, increase in white blood cells, icterus, coma, respiratory difficulties, and circulatory failure; *General Treatment for Exposure*: INGESTION: induce vomiting and administer gastric leverage; give a saline cathartic, fluid therapy, and transfusions if required; calcium disodium EDTA has been found moderately effective. SKIN AND EYES: wash affected tissues with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (rat); *Late Toxicity*: Causes liver, kidney and testicular damage in rats; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Causes

smarting of the skin and first degree burns on short exposure; may cause second degree burns on long exposure; *Odor Threshold*: Not pertinent.

Corn Syrup — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.4 at 37°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: None; *Symptoms Following Exposure*: Not toxic; *General Treatment for Exposure*: None; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Coumaphos — (i) Chemical Designations — *Synonyms*: CO-RAL; O,O-Diethyl O-(3-chloro-4-methyl-2-oxo-(2H)1-benzopyran-7-yl)phosphorothinate; *Chemical Formula*: $C_{14}H_{16}ClO_5PS$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Slight odor of sulfur compounds; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 362.5; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 199, 93, 366; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.474 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor respirator; rubber gloves; goggles; *Symptoms Following Exposure*: Inhalation or ingestion causes sense of tightness in chest, sweating, contracted pupils of eyes, stomach pains, vomiting, diarrhea. Pulmonary edema may develop as long as 12 hours after acute exposures. Contact with eyes causes irritation; overexposure may cause same symptoms as inhalation. Irritates skin; *General Treatment for Exposure*: Get medical attention after all overexposure to this substance. Atropine sulfate and 2-PAM are antidotes. INHALATION: remove to fresh air; support respiration; keep patient quiet until medical help arrives; observe for development of pulmonary edema, even after 12 hours. INGESTION: induce vomiting; give water and again induce vomiting; give aqueous slurry of medical charcoal. EYES: flush with water for at least 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} = 16 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.02 ppm.

Creosote, Coal Tar - (i) Chemical Designations — *Synonyms*: Cresote Oil; Dead Oil; *Chemical Formula*: Mixture; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Yellow to brown to black; *Odor*: Creosote or tarry; aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: >356, >180, >353; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.05-1.09 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est). - 12,500, -6,900, -290; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: All-service canister mask; rubber gloves; chemical safety goggles and/or shield; overalls or a neoprene apron; barrier creams; *Symptoms Following Exposure*: Vapors cause moderate irritation of nose and throat. Liquid cause severe burns of eyes and reddening and itching of skin. Prolonged contact with skin can cause burns. Ingestion causes salivation, vomiting, respiratory difficulties, thready pulse, vertigo, headache, loss of pupillary reflexes, hypothermia, cyanosis, mild convulsions; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration, preferably mouth-to-mouth; if breathing is difficult, give oxygen; call a physician. EYES: flush immediately with plenty of water for at least 15 min. And call a physician. SKIN: wipe with vegetable oil or margarine; then wash with soap and water. INGESTION: have victim drink water or milk; do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity*

by Ingestion: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Repeated exposures may cause cancer of skin; *Vapor (Gas) Irritant Characteristics*: Vapor cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Fairy severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

Cresols — (i) Chemical Designations — *Synonyms*: Cresylic Acids; Hydroxytoluenes; Methylphenols; Oxytoluenes; Tar Acids; *Chemical Formula*: $CH_3C_6H_4OH$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid or solid; *Color*: Colorless or dark to yellow; *Odor*: Sweet, tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 108.13; *Boiling Point at 1 atm.*: >350, >177, >450; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.03 - 1.07 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.073; *Latent Heat of Vaporization*: (est.) 200, 110, 4.6; *Heat of Combustion*: -14,720 to -14,740, -8,180 to -8,190, -342.5 to -342.9; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister unit; rubber gloves; chemical safety goggles; face shield; coveralls and/or rubber apron; rubber shoes or boots; *Symptoms Following Exposure*: Vapors cause irritation of eyes, nose, and throat. Contact with skin or eyes causes severe burns. Chemical is rapidly absorbed through skin; *General Treatment for Exposure*: Call a physician. INHALATION: remove to fresh air. INGESTION: have victim drink water or milk; do NOT induce vomiting. SKIN OR EYES: flush immediately with plenty of water for at least 15 min.; remove contaminated clothing immediately and wash before reuse; discard contaminated shoes.; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat, rabbit); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 5 ppm.

Cresyl Glycidyl Ether — (i) Chemical Designations — *Synonyms*: Cresol, Epoxypropyl Ether; Tolyl Epoxypropyl Ether; Tolyl Glycidyl Ether; *Chemical Formula*: $CH_3C_6H_4$-O-CH_2-CH-CH_2-O; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 164; *Boiling Point at 1 atm.*: 498, 259, 532; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.09 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: (est.) -16,500, -9190, -384; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister mask or air pack; rubber gloves; goggles or face shield; body-covering clothing; *Symptoms Following Exposure*: Contact with eyes causes irritation. Contact with skin causes primary irritation and allergic sensitization; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for at least 15 min.; get medical attention. SKIN: immediately wash off with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Crotonaldehyde — (i) Chemical Designations — *Synonyms*: Beta-Methylacrolein; Crotenaldehyde; Crotonic Aldehyde; Trans-2-Butenal; *Chemical Formula*: $CH_3CH{=}CHCHO$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Yellow; *Odor*: Tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 70.09; *Boiling Point at 1 atm.*: 216.0, 102.2, 375.4; *Freezing Point*: -100, -75, 198; *Critical Temperature*: 563, 295, 568; *Critical Pressure*: 630=43=4.4; *Specific Gravity*: 0.852 at 20°C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*:; *Latent Heat of Vaporization*: 200, 111, 4.65; *Heat of Combustion*: -14,000, -7760, -325; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask for concentrations above 2% by volume; plastic gloves; goggles; eye bath and safety shower; *Symptoms Following Exposure*: INHALATION: vapor is exceedingly irritating, causing coughing, chest pain, nausea, vomiting, and collapse. CONTACT WITH SKIN OR EYES: may cause burns and systemic illness. Contact of liquid or vapors with eyes causes burns;

General Treatment for Exposure: INHALATION: remove victim to fresh air; give oxygen if breathing is difficult; call a physician. INGESTION: have victim drink water or milk; do NOT induce vomiting. SKIN OR EYES: immediately flush with plenty of water for at least 15 min.; physician should see cases of eye irritation from vapor or liquid; *Toxicity by Inhalation (Threshold Limit Value)*: 2 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3: LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 0.13 ppm.

Cumene — (i) Chemical Designations — *Synonyms*: Cumol; Isopropylbenzene; *Chemical Formula*: $C_6H_5CH(CH_3)_2$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong, slightly irritant; fragrant; aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 120.19; *Boiling Point at 1 atm.*: 306.3, 152.4, 425.6; *Freezing Point*: -140.9, -96.1, 177.1; *Critical Temperature*: 676.2, 357.9, 631.1; *Critical Pressure*: 465.5, 31.67, 3.208; *Specific Gravity*: 0.866 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.059; *Latent Heat of Vaporization*: 134, 74.6, 3.12; *Heat of Combustion*: -17,710, -9,840, -412.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: As necessary to avoid skin exposure. If concentration in air is greater than 1000 ppm, use self-contained breathing apparatus; *Symptoms Following Exposure*: narcotic action with long-lasting effects; depressant to central nervous system; *General Treatment for Exposure*: INHALATION: move patient immediately to fresh air; administer artificial respiration or oxygen if necessary; seek medical attention. SKIN OR EYES: wash exposed skin surfaces thoroughly; flush eyes thoroughly with water for 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50}50 to 500 mg/kg; *Late Toxicity*: None reported; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 1.2 ppm.

Cumene Hydroperoxide — (i) Chemical Designations — *Synonyms*: alpha-Dimethylbenzene Hydroperoxide; Dimethylbenzyl Hydroperoxide; Isopropylbenzene Hydroperoxide: Cumyl Hydroperoxide; CHP; *Chemical Formula*: C6H5C(OOH)(CH3)2-$C_6H_5CH(CH_3)_2$ (mixture); **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Sharp, irritant, aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 16, -9, 264; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.03 at 25 C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*:(est.) -13,300, -7,400,-310; *Heat of Decomposition*: -855, -475, -19.9; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained or air-line breathing apparatus; solvent-resistant rubber gloves; chemical splash goggles; rubber apron; rubber or PVC clothing; full face shield; *Symptoms Following Exposure*: Inhalation of vapor causes headache and burning throat. Liquid causes severe irritation of eyes; on skin, causes burning, throbbing sensation, irritation, and blisters. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: Get medical attention after all exposures to this compound INHALATION: remove victim and administer artificial respiration and oxygen if necessary. EYES: flush with water for 15 min. SKIN: wash several times with soap and water; treat as burn. INGESTION: induce vomiting and follow with gastric lavage; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50}=382 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cupriethylenediamine Solution — (i) Chemical Designations — *Synonyms*: Cupriethylene Diamine Hydroxide Solution; *Chemical Formula*: $Cu(OH)_2$-$NH_2CH_2NH_2$-H_2O; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Blue or dark purple (may contain red or blue sediment); *Odor*: Like ammonia, fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*:(approx.) 212, 100, 373; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est). >1.1 at 20 C (liquid); *Vapor (Gas) Den-*

sity: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; organic canister mask; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation of vapor irritates mucous membrane and may cause asthma. Liquid causes severe irritation of eyes and possible corneal injury. Contact with skin causes irritation. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; call physician. EYES: wash with large amounts of water. INGESTION: give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cyanoacetic Acid — (i) Chemical Designations — *Synonyms*: Cyanacetic Acid; Malonic Mononitrile; *Chemical Formula*: $CNCH_2COOH$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 85.06; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 151, 66, 339; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*:
-6,300, -3,500, -146; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact irritates eyes and may irritate skin; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cyanogen — (i) Chemical Designations — *Synonyms*: Ethanedenitrite; Dicyan; Oxalic Acid Dinitrile; Oxalonitrile; Dicyanogen; *Chemical Formula*: $(CN)_2$; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Characteristic almond-like; pungent, penetrating; may not be sufficiently strong to provide an adequate warning; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 52.0; *Boiling Point at 1 atm.*: -6.1, -21.1, 252.1; *Freezing Point*: -18.2, -27.9, 245.3; *Critical Temperature*: 259.9, 126.6, 399.8; *Critical Pressure*: 857, 58.2, 5.91; *Specific Gravity*: 0.954 at -21 °C (liquid); *Vapor (Gas) Density*: 1.8; *Ratio of Specific Heats of Vapor (Gas)*: 1.205 at 25 °C; *Latent Heat of Vaporization*: 200, 111, 4.65; *Heat of Combustion*: -9.059, -5.033, -210.6; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; rubber gloves; rubber protective clothing; rubber-soled shoes; *Symptoms Following Exposure*: Vapor irritates eyes and causes giddiness, headache, fatigue, and nausea if inhaled; *General Treatment for Exposure*: In general, treatment is similar to that used following exposure to hydrogen cyanide. INHALATION: move victim to fresh air and let him lie down; do not permit him to exert himself; remove contaminated clothing but keep patient covered and comfortably warm; summon a physician; break an amyl nitrite pearl in a cloth and hold it lightly under the victim's nose for 15 seconds; repeat five times at about 15 sec. Intervals; use artificial respiration if breathing has stopped. EYES: flush with water for at least 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: 5 mg/m_3 for 30 sec; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cyanogen Bromide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: BrCN; **(ii) Observable Characteristics—** *Physical State (as normally shipped)*: Solid; *Color*: Colorless; *Odor*: Penetrating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 105.93; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 120 to 124, 49 to 51, 322 to 324; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.015 at 20 °C; *Vapor (Gas) Density*: 3.6; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat*

of Combustion: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical cartridges respirator, goggles, protective clothing, rubber gloves; *Symptoms Following Exposure*: Same symptoms as hydrogen cyanide. Because it irritates the eyes, throat, and lungs severely, it is unlikely that anyone would voluntarily remain in areas with a high enough concentration to exert a cyanide effect; *General Treatment for Exposure*: Call a physician. INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration, preferable mouth-to-mouth; if symptoms of cyanide poisoning are observed, administer amyl nitrite as instructed for HCN. INGESTION: have victim drink water or milk; do not induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 ppm (suggested); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Workers exposed to solutions may develop dermatitis; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third degree burns on short contact; very injurious to the eyes; *Odor Threshold*: Data not available.

Cyanogen Chloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: CNCl; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Acrid, choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 61.48; *Boiling Point at 1 atm.*: 55.6, 13.1, 286.3; *Freezing Point*: 20, -6.9, 266.3; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.222 at 0°C (liquid); *Vapor (Gas) Density*: 2.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.229; *Latent Heat of Vaporization*: 191.3, 106.3, 4.451; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical cartridge respirator, goggles, protective clothing; *Symptoms Following Exposure*: Similar in toxicity and mode of action to hydrogen cyanide, but is much more irritating. Can cause a market irritation of the respiratory tract with a hemorrhagic exudate of the bronchi and trachea and pulmonary edema. It is improbable that anyone would voluntarily remain in the areas with a high enough concentration to exert a typical nitrile effect; *General Treatment for Exposure*: INHALATION: support respiration and administer oxygen; call a doctor; if nitrile effect is seen, administer amyl nitrite. INGESTION: have victim drink water or milk; do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: >0.5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Long term exposure causes dermatitis, loss of appetite, headache, upper respiratory irritation in humans; *Vapor (Gas) Irritant Characteristics*: vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentration; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: 1 ppm.

Cyclohexane — (i) Chemical Designations — *Synonyms*: Hexahydrobenzene; Hexamethylene; Hexanaphthene; *Chemical Formula*: $(CH_2)_6$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: resembling benzene; mild, sweet, resembling chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 84.16; *Boiling Point at 1 atm.*: 177.3, 80.7, 353.9; *Freezing Point* 43.8, 6.6, 279.8; *Critical Temperature*: 536.5, 280.3, 553.5; *Critical Pressure*: 591, 40.2, 4.07; *Specific Gravity*: 0.779 at 20°C (liquid); *Vapor (Gas) Density*: 2.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.087; *Latent Heat of Vaporization*: 150, 85, 3.6; *Heat of Combustion*: -18,684, -10,380, -434.59; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Hydrocarbon vapor canister, supplied-air or hose mask, hydrocarbon-insoluble rubber or plastic gloves, chemical goggles or face splash shield, hydrocarbon-insoluble rubber or plastic apron; *Symptoms Following Exposure*: Dizziness, with nausea and vomiting. Concentrated vapor may cause unconsciousness and collapse; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if breathing stops, apply artificial respiration and administer oxygen. SKIN OR EYE CONTACT: remove contaminated clothing and gently flush affected areas with water for 15 min. Calla physician; *Toxicity by Inhalation (Threshold Limit Value)*: 300 ppm; *Short-Term Exposure Limits*: 300 ppm for 60 min; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Cyclohexanol — (i) Chemical Designations — *Synonyms*: Adronal; Anol; Cyclohexyl Alcohol; Hexalin; Hexahydrophenol; Hydroxycyclohexane; *Chemical Formula*: $(CH_2)_5CHOH$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Solid or liquid; *Color*: Colorless to faintly yellow; *Odor*: Like camphor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 100.16; *Boiling Point at 1 atm.*: 322, 161, 434; *Freezing Point*: 74.5, 23.6, 296.8; *Critical Temperature*: 666, 352, 625; *Critical Pressure*: 540, 37, 3.7; *Specific Gravity*: 0.947 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.071; *Latent Heat of Vaporization*: 196, 109, 4.56; *Heat of Combustion*: -16,000, -8910, -373; *Heat of Decomposition)*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Narcosis - depression of the central nervous system tending to produce sleep or unconsciousness; *General Treatment for Exposure*: Eye contact is more hazardous than inhalation, skin irritation, or ingestion. Flush eyes with water and remove victim to fresh air; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin an first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Cyclohexanone — (i) Chemical Designations — *Synonyms*: Anone; Hytrol O; Nadone; Pimelic Ketone; Sextone; *Chemical Formula*: $(CH_2)_5CO$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to slightly yellow; *Odor*: Like peppermint and acetone; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.15; *Boiling Point at 1 atm.*: 312.4, 155.8, 429.0; *Freezing Point*: -24.2, 31.2, 242.0; *Critical Temperature*: 673, 356, 629; *Critical Pressure*: 560, 38, 3.8; *Specific Gravity*: 0.945 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.084; *Latent Heat of Vaporization*: 160, 91, 3.8; *Heat of Combustion*: -15,430, -8570, -358.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles; *Symptoms Following Exposure*: Inhalation of vapors from hot material can cause narcosis. The liquid may cause dermatitis; *General Treatment for Exposure*: Immediately flush eyes with plenty of water; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 50 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: 0.12 ppm.

Cyclohexanone Peroxide — (i) Chemical Designations — *Synonyms*: 1-Hydroperoxycyclohexyl 1-Hydroperoxycyclohexyl Peroxide; Hydroperoxycyclohexyl Hydroperoxycyclohexyl Peroxide; Cadox HDP; Luperco JDB-50-T; Dicyclohexanone Diperoxide; *Chemical Formula*: $C_6H_{10}(OOH)\cdot OO\cdot C_6H_{10}OH$ in dibutyl phthalata; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid or paste; *Color*: Colorless or white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.05 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -14,000, -7,900, -330; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Irritates eyes and skin on contact. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: Flush with water for at least 15 min.; get medical attention. SKIN: wipe off and wash with soap and water; get medical attention if irritation occurs. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late* Toxicity: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Cyclohexenyltrichlorosilane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $C_6H_9SiCl_3$; **(ii) Observable Characteristics**— *Phy-*

sical State (as normally shipped): Liquid; *Color*: Colorless; *Odor*: Sharp, hydrochloric-acid-like; pungent and irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 215.6; *Boiling Point at 1 atm.*: >300, >149, >422; *Freezing Point*: (est.) <77, <25, <248; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.23 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -78, -43, -1.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor type air respirator; rubber gloves; chemical worker goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membrane. Contact with eyes or skin causes severe burns. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: get medical attention immediately following all exposures to this compound. INHALATION: remove from exposure; support respiration. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50}=2,830 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Cyclohexylamine — (i) Chemical Designations — *Synonyms*: Amynocyclohexane; Hexahydroaniline; *Chemical Formula*: $(CH_2)_5CHNH_2$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 99.18; *Boiling Point at 1 atm.*: 274.1, 134.5, 407.7; *Freezing Point*: 0.1, -17.7, 255.5; *Critical Temperature*: 648, 342, 615; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.865 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 158, 87.6, 3.67; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: rubber gloves; chemical goggles, approved Bureau of Mines respirator for organic vapors; *Symptoms Following Exposure*: Cyclohexylamine is strongly caustic. Inhalation of vapors and contact of liquid with skin and eyes causes severe burns; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting. EYES: flush with water for at least 15 min. and obtain immediate medical attention. SKIN: immediately remove contaminated clothing and flush skin with large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: 300 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50}50 to 500 mg/kg; *Late Toxicity*: Produced cancer of the bladder in the rat; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: Data not available.

Cyclopentane — (i) Chemical Designations — *Synonyms*: Pentamethylene; *Chemical Formula*: C_5H_{10}; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; mild, sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 70.1; *Boiling Point at 1 atm.*: 120.7, 49.3, 322.5; *Freezing Point*: -137.0, -93.9, -179.3; *Critical Temperature*: 461.5, 238.6, 511.8; *Critical Pressure*: 654, 44.4, 4.51; *Specific Gravity*: 0.74 at 20°C (liquid); *Vapor (Gas) Density*: 2.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.1217; *Latent Heat of Vaporization*: 179, 94, 3.9; *Heat of Combustion*: -19,990, -11,110, -465; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Hydrobarbon canister, supplied air, or hose mask; rubber or plastic gloves; chemical goggles or face shield; *Symptoms Following Exposure*: Inhalation causes dizziness, nausea, and vomiting; concentrated vapor may cause unconsciousness and collapse. Vapor causes slight smarting of eyes. Contact with liquid causes irritation of eyes and may irritate skin if allowed to remain. Ingestion causes irritation of stomach. Aspiration produces severe lung irritation and rapidly developing pulmonary edema; central nervous excitement followed by depression; *General Treatment for Exposure*: INHALATION: remove to fresh air; if breathing stops, apply artificial respiration and administer oxygen. EYES: flush with water for at least 15 min.; call a physician. SKIN: flush well with water, then wash with soap and water. INGESTION: do NOT induce vomiting; guard against aspiration into lungs. ASPIRATION: enforce bed rest; give oxygen; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: 300 ppm

for 60 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Cyclopropane — (i) Chemical Designations — *Synonyms*: Trimethylene; *Chemical Formula*: C_3H_6; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Sweet, slightly pungent, not irritating; characteristic odor, like light petroleum solvent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 42.1; *Boiling Point at 1 atm*: -27.2=-32.9=240.3; *Freezing Point*: -197.3, -127.4, 145.8; *Critical Temperature*: 256.5, 124.7, 397.9; *Critical Pressure*: 798, 54.2, 5.50; *Specific Gravity*: 0.676 at -33°C (liquid); *Vapor (Gas) Density*: 1.48; *Ratio of Specific Heats of Vapor (Gas)*: 1.1790; *Latent Heat of Vaporization*: 203, 113, 4.73; *Heat of Combustion*: -21,247, -11,804, -493.88; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high concentrations of vapor; safety or face shield; *Symptoms Following Exposure*: Inhalation causes some analgesia, anesthesia, pupil dilation, shallow depth of respirations, decreasing muscle tone. Contact with liquid may cause frostbite; *General Treatment for Exposure*: INHALATION: remove promptly to fresh air; if symptoms of asphyxiation persist, administer artificial respiration and oxygen; treat symptomatically thereafter. SKIN: If frostbite has occurred, apply warm water, treat burn; *Toxicity by Inhalation (Threshold Limit Value)*: 400 ppm (suggested); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

p-Cumene — (i) Chemical Designations — *Synonyms*: Cymol; p-Isopropyltoluene; Isopropyltoluol 1-Methyl-4-Isopropyl-benzene; Methyl Propyl Benzene; *Chemical Formula*: $p\text{-}CH_3C_6H_4CH(CH_3)_2$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; aromatic, solvent-type; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 134.2; *Boiling Point at 1 atm.*: 351, 177, 450; *Freezing Point*: -90.2, -67.9, 205.3; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.857 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 122, 67.8, 2.84; *Heat of Combustion*: -18,800, -10,400, -437; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained or air-line breathing apparatus; solvent-resistant rubber gloves; chemical splash goggles; *Symptoms Following Exposure*: Inhalation causes impairment of coordination, headache. Contact with liquid causes mild irritation of eyes and skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area; administer artificial respiration if necessary; call physician. SKIN: wipe off liquid; wash well with soap and water. INGESTION: induce vomiting; get medical attention *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50}=4,750 mg/kg. Oral human TD_{LO} (lowest toxic dose)=86 mg/kg (affects central nervous system); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

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Dalapon — (i) Chemical Designations — *Synonyms*: 2,2-Dichloropropanoic Acid; alpha, alpha-Dichloropropioic Acid; 2,2-Dichloropropionic Acid; *Chemical Formula*: CH_3CCl_2COOH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 143; *Boiling Point at 1 atm.*: 374, 190, 463; *Freezing Point*: 46, 8, 281; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 1.39 at 23°C (liquid); *Vapor (Gas) Density*: 4.9; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protecting clothing, including goggles, gloves and boots; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes sever irritation of nose, mouth and lungs. Ingestion causes severe irritation

of mouth and stomach. Contact with eyes or skin causes irritation and burns; *General Treatment for Exposure*: INHALATION: move to fresh air; if patient is not breathing, give artificial respiration; keep patient quiet; get medical attention. INGESTION: give large amounts of water; get medical attention. EYES: flush with water for at least 15 min.;get medical attention. SKIN: flush with water; get medical attention if irritation persists; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50}=3.65 g/kg (mouse), 7.57 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 2500 mg/m^3.

DDD — (i) Chemical Designations — *Synonyms*: 1,1-Dichloro-2,2-bis(p-Chlorophenyl) Ethane; Dichlorodiphenyldichloroethane; TDE; *Chemical Formula*: $(4\text{-}ClC_6H4)_2\text{-}CH\text{-}Cl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 320; *Boiling Point at 1 atm.*:Not pertinent (decomposes); *Freezing Point*: 234, 112, 385; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.476 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Ingestion causes vomiting and delayed symptoms similar to those caused by DDT. Contact with eyes causes irritation; *General Treatment for Exposure*: INGESTION: treatment should be given by a physician and is similar to that given following ingestion of DDT. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data nor available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50}=1.2 g/kg (mouse), 3.4 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

DDT — (i) Chemical Designations — *Synonyms*: Dichlorophenyltrichloroethane; p, p'-DDT; 1, 1, 1-Trichloro-2, 2-bis(p-Chlorophenyl) Ethane; *Chemical Formula*: $(p\text{-}ClC_6H_4)_2CHCCl_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 354.5; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 226,108, 381; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.56 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Very large doses are followed promptly by vomiting, due to local gastric irritation; delayed emesis of diarrhea may occur. With smaller doses, symptoms usually appear 2-3 hours after ingestion. These include tingling of lips, tongue and face; malaise, head ache, sore throat, fatigue, coarse tremors of neck, head and eye lids; apprehension, ataxia and confusion. Convulsions may alternate with periods of coma and partial paralysis. Vital signs are essentially normal, but in severe poisoning the pulse may be irregular and abnormally slow; ventricular fibrillation and sudden death may occur at any time during acute phase . Pulmonary edema usually indicates solvent intoxication; *General Treatment for Exposure*: INGESTION; treatment should be done by a physician. In usually includes gastric lavage and administration of saline cathartic; phenobarbital, and parenteral fluids. Patient should be kept quiet and under observation for at least 24 hours; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50}50 to 500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Decaborane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $B_{10}H_{14}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 122.3; *Boiling Point at 1 atm.*: 415, 213, 486; *Freezing Point*: 210, 99, 372; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.94 at 25°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*:

-28,669, -15,944, -667.10; *Heat of Decomposition*: -279, -155, -6.49; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus or positive-pressure hose mask; rubber-boots or overshoes; clothing made of material resistant to decaborane; rubber gloves; chemical-type goggles or face shield; *Symptoms Following Exposure*: (The onset of symptoms is frequently delayed until one or two days after exposure.) Inhalation or ingestion causes headache, nausea, light headedness, drowsiness, nervousness, lack of coordination, and tremor; muscle spasms and generalized convulsions may occur. Dust irritates eyes and skin and may give same systemic symptoms as for inhalation if left on skin; *General Treatment for Exposure*: Get medical attention after all exposures to this compound. Symptoms may be delayed for 48 hours. INHALATION: move patient to fresh air; keep him warm and quiet. EYES: flush with water for at least 15 min. SKIN: immediately wash with soap and plenty of water. INGESTION: if victim is conscious, give a tablespoonful of salt in a glass of warm water and repeat until vomit is clear. *Note to physician:* Treat symptomatically; administration of methacarbamol or other muscle relaxant may be helpful immediately following exposure and in the absence of symptoms; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50}=40 mg/kg (mouse); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.05 ppm.

Decahydronaphthalene — (i) Chemical Designations — *Synonyms*: Bicyclo [4.4.0] Decane; Naphthalane; Perhydronaphthlene; Dec; Decalin; De Kalin; Naphthane; *sic-* or *trans*-Decahydronaphthalene; *Chemical Formula*: $C_{10}H_{18}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Aromatic, like turpentine; mild, characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 138.2; *Boiling Point at 1 atm.*: 383, 195, 468; *Freezing Point*: -44, -42, 231; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.89 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130, 71, 3.0; *Heat of Combustion*: -19,200, -10,700, -447; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air mask or self-contained breathing apparatus if in enclosed tank; rubber gloves or protective cream; goggles or face shield; *Symptoms Following Exposure*: Inhalation or ingestion irritates nose and throat, causes numbness, headache, vomiting; urine may become blue. Irritates eyes. Liquid de-fats skin and causes cracking and secondary infection; eczema may develop; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: flush with water for at least 15 min. SKIN: wash with water and mild soap. INGESTION: give emetic such as warm salt water, followed by a mild catharic; direct physician to conserve liver and kidney function; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm (suggested); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50}=4,170 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Decaldehyde — (i) Chemical Designations — *Synonyms*: Aldehyde C-10; Capraldehyde; Capric Aldehyde; Decanal; n-Decyl Aldehyde; *Chemical Formula*: $CH_3(CH_2)_8CHO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 145.3; *Boiling Point at 1 atm.*: 404 to 410, 207 to 210, 480 to 483; *Freezing Point*: 64, 18, 291; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.830 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.036; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -424; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing and chemical goggles; *Symptoms Following Exposure*: On direct contact can produce eye and skin irritation; *General Treatment for Exposure*: CONTACT WITH EYES AND SKIN: wash with water for 15 min; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50}>33.3 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Skin effects thought to be minor; *Odor Threshold*: 0.168 ppm.

1,Decene — (i) Chemical Designations — *Synonyms*: alpha-Decene; *Chemical Formula*: $CH_2=CH(CH_2)_7CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** —

Physical State at 15 °C and 1 atm.: Liquid; *Molecular Weight*: 140.2; *Boiling Point at 1 atm.*: 339.1, 170.6, 443.8; *Freezing Point*: -87.3, -66.3, 206.9; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.741 at 20°C (liquid); *Vapor (Gas) Density*: 4.8; *Ratio of Specific Heats of Vapor (Gas)*: 1.039; *Latent Heat of Vaporization*: 119, 65.9, 2.76; *Heat of Combustion*: -19,107, -10,615, -444.43; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister or air-supplied mask, goggles or face shield; *Symptoms Following Exposure*: Vapors may produce slight irritation of eyes and respiratory tract if present in high concentration. May also act as a slight anesthetic at high concentrations; *General Treatment for Exposure*: CONTACT WITH EYES OR SKIN: splashes in the eye should be removed by thorough flushing with water. Skin areas should be washed with soap and water. Contaminated clothing should be laundered before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Slight smarting of eyes and respiratory system at high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

n-Decyl Alcohol — (i) Chemical Designations — *Synonyms*: Alcohol C-10; Capric Alcohol; 1-Decanol; Dytol S-91; Lorol-22; Nonylcarbinol; *Chemical Formula*: $CH_3(CH_2)_8CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Faint alcoholic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 158.29; *Boiling Point at 1 atm.*: 446, 230, 503; *Freezing Point*: 44, 6.9, 280.1; *Critical Temperature*: 801, 427, 700; *Critical Pressure*: 320, 22, 2.2; *Specific Gravity*: 0.840 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.035; *Latent Heat of Vaporization*: (est.) 130, 74, 3.1; *Heat of Combustion*: -18,000, -9980, 418; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Direct contact can produce eye irritation; low general toxicity; *General Treatment for Exposure*: CONTACT WITH EYES: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

n-Decylbenzene — (i) Chemical Designations — *Synonyms*: Decylbenzene; 1-Phenyldecane; *Chemical Formula*: $C_6H_5(CH_2)_9CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 218; *Boiling Point at 1 atm.*: 572, 300, 573; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.855 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 103.8, 57.67, 2.413; *Heat of Combustion*: -18,400, -10,200, -427; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of vapor causes slight irritation of nose and throat. Aspiration of liquid into lungs causes coughing, distress, and pulmonary edema. Ingestion causes irritation of stomach. Contact with vapor or liquid causes irritation of eyes and mild irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water. SKIN: wipe off; flush with water; wash with soap and water. ASPIRATION: enforce bed rest; administer oxygen; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Demeton — (i) Chemical Designations — *Synonyms*: O,O-Diethyl-O(and S)[2-(ethylthio) ethyl] Phosphorothioates; Mixture of O- and S-[2-(Ethylthio)ethyl] Phosphorothioic Acid, O,O-Diethyl Ester; Systox and Isosystox Mixture; *Chemical Formula*: $C_8H_{19}O_3PS_2$—C_8H_{10} mixture; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Amber; *Odor*: Offensive sulfur-compound odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 258; *Boiling Point at 1 atm.*: >248, >140, >413; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not

pertinent; *Specific Gravity*: 1.1 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor respirator in confines areas; rubber or latex gloves; splash goggles, rubber boots; *Symptoms Following Exposure*: Inhalation causes headache, vertigo, blurred vision, lachrymation, salivation, sweating, muscular weakness and ataxia, dyspnea, diarrhea, abdominal cramps, vomiting, coma, pulmonary edema, and death. Ingestion causes nausea, vomiting, muscle twitching, coma. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: *Speed is essential. Call a physician after all overexposure to demeton.* INHALATION; move to fresh air; if needed, begin artificial respiration. INGESTION: Administer milk, water, or salt water and induce vomiting repeatedly. EYES: flush with water for at least 15 min. SKIN: flush and wash exposed skin areas thoroughly with water; remove contaminated clothing under a shower; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Exposure Limits*: 0.5 mg/m^3, 30 min.; *Toxicity by Ingestion*: Grade 4; oral LD_{50}=1.7 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

2,4-D Esters — (i) Chemical Designations — *Synonyms*: Butoxyethyl 2,4-Dichlorophenoxyacetate; Butyl2,4-Dichlorophenoxyacetate; 2,4-Dichlorophenoxyacetic Acid, Butoxyethyl Ester; 2,4-Dichlorophenoxyacetic Acid, Isopropyl Ester; Isopropyl 2,4-Dichlorophenoxy Acetate; *Chemical Formula*: 2,4-$Cl_2C_6H_3OCH_2COOR$, where R=C_4H_9, C_3H_7, or $CH_2CH_2OC_4H_9$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Brown; amber; *Odor*: May have odor of fuel oil; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 234 ~ 291; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.088 ~ 1.237 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Face shield or goggles; rubber gloves; *Symptoms Following Exposure*: Contact with eyes may cause mild irritation; *General Treatment for Exposure*: INGESTION: if large amounts are swallowed, induce vomiting and get medical help. EYES: flush with plenty of water and see a doctor. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2 or 3: LD_{50} 320-617 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dextrose Solution — (i) Chemical Designations — *Synonyms*: Corn Sugar Solution; Glucose Solution; Grape Sugar Solution; *Chemical Formula*: $C_6H_{12}O_6$—H_2O; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Clear, colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm*: >212, >100, >373; *Freezing Point*: <32, <0, <273; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 1.20 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: None needed; *Symptoms Following Exposure*: No toxicity; *General Treatment for Exposure*: None needed; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Diacetone Alcohol — (i) Chemical Designations — *Synonyms*: Diacetone; 4-Hydroxy-4-Metrhyl-2-Pentanone; Tyranton; *Chemical Formula*: $CH_3C(OH)(CH_3)$-CH_2COCH_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.16; *Boiling Point at 1 atm.*: 336.6, 169.2, 442.4; *Freezing Point*: -45.0, -42.8, 230.4; *Critical Temperature*: 633, 334, 607; *Critical Pressure*: 380, 36, 3.6; *Specific Gravity*: 0.938 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats*

of Vapor (Gas): 1.052; *Latent Heat of Vaporization*: 150, 85, 3.6; *Heat of Combustion*: (est.) -13,000, -7,250, -303; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister, rubber gloves, goggles; *Symptoms Following Exposure*: Vapor is irritant to the mucous membrane of the eye and respiratory tract. Inhalation can cause dizziness, nausea, some anesthesia. Very high concentration have a narcotic effect. The liquid is not highly irritating to the skin but can cause dermatitis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. Give artificial respiration if breathing has stopped. EYES OR SKIN: wash affected skin areas with water; flush eyes with water and get medical care if discomfort persists; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: 150 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Di-n-Amyl Phthalate — (i) Chemical Designations — *Synonyms*: Diamyl Phthalate; Dipentyl Phthalate; Phthalic Acid, Diamyl Ester; Phthalic Acid, Dipentyl Ester; *Chemical Formula*: $C_6H_4(COOC_5H_{11})_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 306; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.82 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140, 76, 3.2; *Heat of Combustion*: -13,900, -7,720, -323; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of vapors from very hot material mazy cause headache, drowsiness, and convulsions. Hot vapors may irritate eyes; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water. SKIN: wipe off; flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Causes birth defects in rats (skeletal and gross abnormalities); *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Diazinon — (i) Chemical Designations — *Synonyms*: O,O-Diethyl O-(-Isopropyl-6-Methyl-4-Pyrimidinyl) Phosphorothioate; O,O-DiethylO-2-Isopropyl-4-Methyl-6-Pyrimidyl Thiophosphate; Diethyl 2-Isopropyl-4-Methyl-6-Pyrimidyl Thionophosphate; Alpha-Tox; Saralex; Spectracide; *Chemical Formula*: $C_{12}H_{21}N_2O_3PS$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid, or liquid solution; *Color*: Amber to dark brown; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 304.4; *Boiling Point at 1 atm.*: Very high, decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.117 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.)-12,000, -6,500, -270; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Ingestion or prolonged inhalation of mist causes headache, giddiness, blurred vision, nervousness, weakness, cramps, diarrhea, discomfort in the chest, sweating, miosis, tearing, salivation and other excessive respiratory tract secretion, vomiting, cyanosis, papilledema, uncontrollable muscle twitches, convulsions, coma, loss of reflexes, and loss of spincter control. Liquid irritates eyes and skin; *General Treatment for Exposure*: INHALATION: remove to fresh air; keep warm; get medical attention at once. EYES: flush with plenty of water for at lest 15 min. and get medical attention. SKIN: wash contaminated area with soap and water. INGESTION: get medical attention ay once; give water slurry of charcoal; Do NOT give milk or alcohol; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; oral LD_{50}=76 mg/kg (rat); *Late Toxicity*: May be mutagenic; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dibenzoyl Peroxide — (i) Chemical Designations — *Synonyms*: Benzoyl Peroxide; Benzoyl Superoxide; BP; BPO; Lucidol-70, Oxylite; *Chemical Formula*: $C_6H_5CO{\cdot}O{\cdot}O{\cdot}COC_6H_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*:

White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 242.22; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 217, 103, 376; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.334 at 15 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles, face shield, rubber gloves; *Symptoms Following Exposure*: CONTACT WITH EYES OR SKIN: irritates eyes. Prolonged contact may irritate skin; *General Treatment for Exposure*: INGESTION: administer an emetic to induce vomiting and call a physician. CONTACT WITH EYES OR SKIN; do not use oils or ointments; flush eyes with plenty of water and get medical attention; wash skin with plenty of soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Di-n-Butylamine — (i) Chemical Designations — *Synonyms*: 1-Butanamine, N-butyl; Dibutylamine; *Chemical Formula*: $(C_4H_9)_2NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 129.25; *Boiling Point at 1 atm.*: 319.3, 159.6, 432.8; *Freezing Point*: -80, -62, 211; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.759 at 20°C (liquid); *Vapor (Gas) Density*: 4.5; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130, 72.3, 3.03; *Heat of Combustion*: -18,800, -10,440, -436.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose, throat, and lungs; coughing; nausea; headache. Ingestion causes irritation of mouth and stomach. Contact with eyes causes irritation. Contact with skin causes irritation and dermatitis; *General Treatment for Exposure*: INHALATION: move from exposure; if breathing has stopped, start artificial respiration. INGESTION: give large amounts of water. EYES: irrigate with water for 15 min. get medical attention for possible eye damage. SKIN: wash with large amounts of water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 360 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Di-n-Butyl Ether — (i) Chemical Designations — *Synonyms*: n-Dibutyl Ether; n-Butyl Ether; Butyl Ether; 1-Butoxybutane; Dibutyl Ether; Dibutyl oxide; *Chemical Formula*: $C_4H_9OC_4H_9$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, ether-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 130.2; *Boiling Point at 1 atm.*: 288, 142, 415; *Freezing Point*: -139.7, -95.4, 177.8; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.767 at 20°C (liquid); *Vapor (Gas) Density*: 4.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.0434; *Latent Heat of Vaporization*: 120, 68, 2.8; *Heat of Combustion*: -17,670, -9,820, -411; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Liquid irritates eyes and may irritate skin on prolonged contact. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: after contact with liquid, flush with water for at least 15 min. SKIN: wipe off, wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; oral LD_{50} 7,400 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Di-n-Butyl Ketone — (i) Chemical Designations — *Synonyms*: 5-Nonanone; *Chemical Formula*: $CH_3(CH_2)_3CO(CH_2)_3CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: White to light yellow; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 142; *Boiling Point at 1 atm.*: 370, 188, 461; *Freezing Point*: 21, -6, 267; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not

pertinent; *Specific Gravity*: 0.822 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 161, 89.6, 3.75; *Heat of Combustion*: -16,080, -8,930, -374; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air; administer artificial respiration if needed. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dibutylphenol — (i) Chemical Designations — *Synonyms*: 2,6-Di-tert-butylphenol; *Chemical Formula*: 2,6-(t-$C_4H_9)_2C_6H_3OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or liquid; *Color*: Colorless; light straw; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 206.3; *Boiling Point at 1 atm.*: 487, 253, 526; *Freezing Point*: 97, 36, 309; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.914 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,000, -9,800, -410; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Irritates eyes and (on prolonged contact) skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wipe off, wash well with soap and water. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; oral LD_{50} (2,6 Di-sec-butyl phenol); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dibutyl Phthalate — (i) Chemical Designations — *Synonyms*: Butyl Phthalate; DBP; Phthalic Acid, Dibutyl Ester; RC Plasticizer DBP; Witcizer 300; *Chemical Formula*: $O\text{-}C_6H_4[COO(CH_2)_3CH_3]_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Slights characteristic ester odor; mild; practically none; slightly aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 278.35; *Boiling Point at 1 atm.*: 635, 335, 608; *Freezing Point*: -31, -35, 238; *Critical Temperature*: 932, 500, 773; *Critical Pressure*: 250, 17, 1.7; *Specific Gravity*: 1.049 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion (Btu/lb, cal/g, × 10^5 J/kg)*: -13,300, -7,400, -310; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection; *Symptoms Following Exposure*: Vapors from very hot material may irritate eyes and produce headache, drowsiness, and convulsions; *General Treatment for Exposure*: Remove fresh air. Wash affected skin areas with water. Flush eyes with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Birth defects in rats; polyneuritis in humans; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

o-Dichlorobenzene — (i) Chemical Designations — *Synonyms*: 1,2-Dichlorobenzene; Downtherm E; Orthodichlorobenzene; *Chemical Formula*: o-$C_6H_4Cl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Aromatic; characteristic aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 147.01; *Boiling Point at 1 atm.*: 356.9, 180.5, 453.7; *Freezing Point*: 0.3, -17.6, 255.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.306 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.080; *Latent Heat of Vaporization*: 115, 63.9, 2.68; *Heat of Combustion*: -7,969, -4,427, -185.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor-acid gas respirator; neoprene or vinyl gloves; chemical safety spectacles, face shield, rubber footwear, apron, protective clothing; *Symptoms Following Exposure*: Chronic inhalation of mist vapors may result in damage to lungs, liver, and kidneys. Acute vapor exposure can cause symptoms ranging from coughing to central

nervous system depression and transient anesthesia. Irritating to skin, eyes, and mucous membranes. May cause dermatitis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, keep him quiet and warm, and call a physician promptly. INGESTION: no known antidote; treat symptomatically; induce vomiting and get medical attention promptly. EYES AND SKIN: flush with plenty of water; get medical attention for eyes; remove contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: 50 ppm for 15 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Causes liver and kidney damage in rats. Effects unknown in humans; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 4.0 ppm; 50 ppm.

p-Dichlorobenzene — (i) Chemical Designations — *Synonyms*: Dichloricide; Paradow; Paradi; Paramoth; Paradichlorobenzene; Santochlor; *Chemical Formula*: p-$C_6H_4Cl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 147.01; *Boiling Point at 1 atm.*: 345.6, 174.2, 447.4; *Freezing Point*: 130, 53, 326; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.458 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full face mask fitted with organic vapor canister for concentrations over 75 ppm; clean protective clothing; eye protection; *Symptoms Following Exposure*: INHALATION: irritation of upper respiratory tract; over-exposure may cause depression and injury to liver and kidney. EYES: pain and mild irritation; *General Treatment for Exposure*: INHALATION: if any ill effects develop, remove patient to fresh air and get medical attention. If breathing stops, give artificial respiration. EYES: flush with plenty of water and get medical attention if ill effects develop. SKIN AND INGESTION: no problem likely; *Toxicity by Inhalation (Threshold Limit Value)*: 75 ppm; *Short-Term Exposure Limits*: 50 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 15 - 30 ppm.

Di-(p-Chlorobenzoyl) Peroxide — (i) Chemical Designations — *Synonyms*: Bis-(p-chlorobenzoyl)peroxide; p-Chlorobenzoyl Peroxide; p,p`-Dichlorobenzoyl Peroxide; Di-(4-chlorobenzoyl)peroxide; Cadox PS; *Chemical Formula*: $(p\text{-}ClC_6H_4COO)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; or paste in silicone fluid and dibutyl phthalate; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 311.1; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -9,000, -5,000, -210; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Irritates eyes and (on prolonged contact) skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: EYES: wash with water for at least 15 min.; consult a doctor. SKIN: wash with soap and water. INGESTION: induce vomiting and call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Dichlorobutene — (i) Chemical Designations — *Synonyms*: 1,4-Dichloro-2-butene; 2-Butylene Dichloride; 1,4-Dichloro-2-butylene; cis-1,4-Dichloro-2-butene; trans-1,4-Dichloro-2-butene; *Chemical Formula*: $ClCH_2CH{=}CHCH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; sweet, pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 125.0; *Boiling Point at 1 atm.*: 313, 156, 429; *Freezing Point*: cis: -54, -48, 225; trans: 37, 3, 276; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.112 at 20°C (liquid); *Vapor (Gas) Density*: 4; *Ratio of Specific Heats of Vapor (Gas)*: 1.0874; *Latent Heat of Vaporization*: 130, 73, 3.1; *Heat of Combustion*: -17,500,

-9,720, -407; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; chemical splash goggles; rubber boots and apron; barrier cream; organic canister mask; *Symptoms Following Exposure*: Inhalation of vapor irritates nose and throat. Contact with eyes causes intense irritation and tears. Contact of liquid with skin causes severe blistering and dermatitis. Ingestion causes severe irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure; provide low-pressure oxygen if required; keep under observation until edema is ruled out. EYES: irrigate immediately for 15 min.; call physician. SKIN: wash immediately and thoroughly with soap and water; treat as a chemical burn. INGESTION: induce vomiting; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} (1,4-dichloro-2-butene) 89 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dichlorodifluoromethane — (i) Chemical Designations — *Synonyms*: Eskimon 12; Genetron 12; F-12; Halon 122; Freon 12; Isotron 12; Frigen 12; Ucon 12; *Chemical Formula*: CCl_2F_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Odorless; slight; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 120.91; *Boiling Point at 1 atm.*: -21.6, -29.8, 243.4; *Freezing Point*: -251.9, -157.7, 115.5; *Critical Temperature*: 233.2, 111.8, 385; *Critical Pressure*: 598, 40.7, 4.12; *Specific Gravity*: 1.35 at 15°C (liquid); *Vapor (Gas) Density*: 4.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.129; *Latent Heat of Vaporization*: 140, 77.9, 3.26; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, goggles; *Symptoms Following Exposure*: INHALATION: some narcosis when 10% in air is breathed; *General Treatment for Exposure*: Remove patient to non-contaminated area and apply artificial respiration if breathing has stopped; call a physician immediately; oxygen may be given; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm; *Short-Term Exposure Limits*: 5000 ppm for 60 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None, except at very high concentrations, which may irritates lungs; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly; *Odor Threshold*: Data not available.

1,2-Dichloroethylene — (i) Chemical Designations — *Synonyms*: Acetylene Dichloride; sym-Dichloroethylene; Dioform; cis- or trans-1,2-Dichloroethylene; *Chemical Formula*: ClCH=CHCl; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Ethereal, slightly acrid; pleasant, chloroform-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 97.0; *Boiling Point at 1 atm.*: cis: 140, 60, 333; trans: 118, 48, 321; *Freezing Point*: cis: -114, -81, 192; trans: -58, -50, 223; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.27 at 25°C (liquid); *Vapor (Gas) Density*: 3.34; *Ratio of Specific Heats of Vapor (Gas)*: 1.1468; *Latent Heat of Vaporization*: 130, 72, 3.0; *Heat of Combustion*: -4,847.2, -2,692.9, -112.67; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; safety goggles; air supply mask or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes nausea, vomiting, weakness, tremor, epigastric cramps, central nervous depression. Contact with liquid causes irritation of eyes and (on prolonged contact) skin. Ingestion causes slight depression to deep narcosis; *General Treatment for Exposure*: INHALATION: remove from further exposure; if breathing is difficult, give oxygen; if victim is not breathing, give artificial respiration, preferably mouth-to-mouth; give oxygen when breathing is resumed; call a physician. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water. INGESTION: give gastric lavage and cathartics; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 770 mg/kg (rat); *Late Toxicity*: Produces liver and kidney injury in experimental animals; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dichloroethyl Ether — (i) Chemical Designations — *Synonyms*: Bis(2-chloroethyl) Ether; 2,2'-Dichloroethyl Ether; Dichlorodiethyl Ether; Di-(2-chloroethyl) Ether; Chlorex; DCEE; beta,beta'-Dichloroethyl Ether; *Chemical Formula*: $(ClCH_2CH_2)_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet, like chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 143.0; *Boiling Point at 1 atm.*: 353, 178, 451; *Freezing Point*: -62, -52, 221;

Critical Temperature: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 20°C (liquid); *Vapor (Gas) Density*: 4.93; *Ratio of Specific Heats of Vapor (Gas)*: 1.0743; *Latent Heat of Vaporization*: 143, 79.5, 3.33; *Heat of Combustion*: -7,530, -4,180, -175; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation of vapor causes irritation of nose, coughing, nausea. Liquid irritates eyes and causes mild irritation of skin. (Can be absorbed in toxic amounts through the skin). Ingestion causes irritation of mouth and stomach, symptoms of systemic poisoning; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; call physician if needed. EYES: irrigate with copious quantities of water for 15 min.; call physician. SKIN: wipe off, wash well with soap and water. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: 35 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 75 mg/kg (rat); *Late Toxicity*: Said to be carcinogenic; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: Data not available.

Dichloroethyl Ether — (i) Chemical Designations — *Synonyms*: Bis(2-chloroethyl) Ether; 2,2'-Dichloroethyl Ether; Dichlorodiethyl Ether; Di-(2-chloroethyl) Ether; Chlorex; DCEE; beta,beta'-Dichloroethyl Ether; *Chemical Formula*: $(ClCH_2CH_2)_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet, like chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 143.0; *Boiling Point at 1 atm.*: 353, 178, 451; *Freezing Point*: -62, -52, 221; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 20°C (liquid); *Vapor (Gas) Density*: 4.93; *Ratio of Specific Heats of Vapor (Gas)*: 1.0743; *Latent Heat of Vaporization*: 143, 79.5, 3.33; *Heat of Combustion*: -7,530, -4,180, -175; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation of vapor causes irritation of nose, coughing, nausea. Liquid irritates eyes and causes mild irritation of skin. (Can be absorbed in toxic amounts through the skin). Ingestion causes irritation of mouth and stomach, symptoms of systemic poisoning; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; call physician if needed. EYES: irrigate with copious quantities of water for 15 min.; call physician. SKIN: wipe off, wash well with soap and water. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: 35 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; oral LD_{50} 75 mg/kg (rat); *Late Toxicity*: Said to be carcinogenic; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: Data not available.

Dichloromethane — (i) Chemical Designations — *Synonyms*: Methylene Chloride; Methylene Dichloride; *Chemical Formula*: CH_2Cl_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant, aromatic; like chloroform; sweet, ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 84.93; *Boiling Point at 1 atm.*: 104, 39.8, 313; *Freezing Point*: -142, -96.7, 176.5; *Critical Temperature*: 473, 245, 518; *Critical Pressure*: 895, 60.9, 6.17; *Specific Gravity*: 1.322 at 20°C (liquid); *Vapor (Gas) Density*: 2.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.199; *Latent Heat of Vaporization*: 142, 78.7, 3.30; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister mask, safety glasses, protective clothing; *Symptoms Following Exposure*: INHALATION: anesthetic effects, nausea and drunkenness. SKIN AND EYES: skin irritation, irritation of eyes and nose; *General Treatment for Exposure*: INHALATION: remove from exposure. Give oxygen if needed. INGESTION: no specific antidote. SKIN AND EYES: remove contaminated clothing; wash skin or eyes if affected; *Toxicity by Inhalation (Threshold Limit Value)*: 500 ppm; *Short-Term Exposure Limits*: 100 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 205-307 ppm.

2,4-Dichlorophenol — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $HOC_6H_3Cl_2$-2,4; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 163.01; *Boiling Point at 1 atm.*: 421, 216, 489; *Freezing Point*: 110, 45, 318; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.40 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Bu. Mines approved respirator, rubber gloves, chemical goggles; *Symptoms Following Exposure*: Tremors, convulsions, shortness of breath, inhibition of respiratory system; *General Treatment for Exposure*: Inhalation - rest. Ingestion - drink water, epsom salt solution; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

2,4-Dichlorophenoxyacetic Acid — (i) Chemical Designations — *Synonyms*: 2,4-D; *Chemical Formula*: $2,4\text{-}Cl_2C_6H_3OCH_2COOH$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White to tan; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 221.0; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 286, 141, 314; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.563 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -7,700, -4,300, -180; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Protective dust mask; rubber gloves; chemical gloves; *Symptoms Following Exposure*: Dust may irritate eyes. Ingestion causes gastroentric distress, diarrhea, mild central nervous system depression, dysphagia, and possible transient liver and kidney injury; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wash well with soap and water. INGESTION: induce vomiting and follow with gastric lavage and supportive therapy; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 375 mg/kg (rat), 80 mg/kg (human); *Late Toxicity*: Causes birth defects in some laboratory animals; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Dichloropropane — (i) Chemical Designations — *Synonyms*: 1,2-Dichloropropane; Propylene Dichloride; *Chemical Formula*: $CH_3CHClCH_2Cl$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.9; *Boiling Point at 1 atm.*: 206, 96.4, 369.6; *Freezing Point*: -148, -100, 173; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.158 at 20°C (liquid); *Vapor (Gas) Density*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.094; *Latent Heat of Vaporization*: 122, 67.7, 2.83; *Heat of Combustion*: 7,300, 4,100, 170; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air supply in confined area, rubber gloves, chemical goggles, protective coveralls and rubber footwear; *Symptoms Following Exposure*: Contact with skin or eyes may cause irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. SKIN OR EYES: wash skin thoroughly with soap and water. Flush eyes with water for 15 min. Call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 75 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Dichloropropene — (i) Chemical Designations — *Synonyms*: 1,3-Dichloropropene; Telone; *Chemical Formula*: $ClCH_2CH{=}CHCl$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet; like chloroform; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 110.98; *Boiling Point at 1 atm.*: 170, 77, 350; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.116; *Latent Heat of Vaporization*: 113,

62.8, 2.63; *Heat of Combustion*: 6,900, 3,900, 160; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: An approved full face mask equipped with a fresh black canister meeting specifications of the U.S. Bureau of Mines for organic vapors, a full face self-contained breathing apparatus, or full face air-supplied respirator; *Symptoms Following Exposure*: Smarting of skin and eyes. Prolonged contact of liquid with skin may cause second-degree burns; *General Treatment for Exposure*: INHALATION: remove patient to fresh air, keep warm and quiet; call physician immediately; give artificial respiration if breathing has stopped. INGESTION: call physician immediately. Induce vomiting by givingan emetic, e.g., 2 tablespoons table salt in glass of warm water. SKIN OR EYES: immediately remove contaminated clothing and shoes. Wash skin with soap and plenty of water. For eyes, flush immediately with plenty of water for at least 15 min. Call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

4,4'-DichloroalphaTrichloromethylbenzhydrol — (i) Chemical Designations — *Synonyms*: 1,1-Bis(p-chlorophenyl)-2,2,2-trichloroethanol; Di-(p-chlorophenyl) Trichloromethylcarbinol; Dicofol; Kelthane; Kelthanethanol; *Chemical Formula*: $(ClC_6H_4)_2C(OH)CCl_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Powder, semi-solid, or liquid; *Color*: White to gray solid, red to black semi-solid, brown liquid; *Odor*: Solid have slight characteristic odor; liquid has odor of the solvent xylene; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 470.5; *Boiling Point at 1 atm.*: (Data apply to xylene solution; solid decomposes) 282, 139, 412; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20°C (solid); < 0.9 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus if exposed to vapors; rubber gloves; splash goggles; *Symptoms Following Exposure*: Inhalation or ingestion causes nausea, headache, weight loss, convulsions, possible kidney and liver damage. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; apply artificial respiration and oxygen if indicated. EYES: wash for 15 min. with water; call a physician. SKIN: wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 575 mg/kg (rat), 1,810 mg/kg (rabbit); *Late Toxicity*: Suppresses immune reactions in rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dicyclopentadiene — (i) Chemical Designations — *Synonyms*: Dicy; 3a,4,7,7a-Tetrahydro-4,7-methanoindene; *Chemical Formula*: $C_{10}H_{12}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Camphor-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 132.31; *Boiling Point at 1 atm.*: 338, 170, 443; *Freezing Point*: 41, 5, 278; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.978 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,800, -10,400, -437; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask in confined areas, rubber gloves, safety glasses; *Symptoms Following Exposure*: Vapor irritates mucous membranes and respiratory tract, causes nausea, vomiting, headache, and dizziness. Direct contact irritates eyes; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area and call physician if unconscious; if breathing is irregular or stopped, give oxygen and start resuscitation. EYES OR SKIN: flush with plenty of water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 75-100 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 0.82 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: < 0.003 ppm.

Dieldrin — (i) Chemical Designations — *Synonyms*: HEOD; endo,exo-1,2,3,4,10,10-Hexachloro-6,7-expoxy-

1,4,4a,5,6,7,8,8a-octahydro-1,4:5,8-dimethanonaphthalene; *Chemical Formula*: $C_{12}H_8Cl_6O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Buff to light brown; *Odor*: Mild chemical; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 380.93; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 349, 176, 449; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.75 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: U.S. Bu. Mines approved respirator; clean rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Inhalation, ingestion, or skin contact causes irritability, convulsions and/or coma, nausea, vomiting, headache, fainting, tremors. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; give oxygen and artificial respiration as required. INGESTION: induce vomiting and get medical attention. EYES: flush with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.25 mg/m^3; *Short-Term Exposure Limits*: 1 mg/m^3 for 30 min.; *Toxicity by Ingestion*: Grade 4; oral LD_{50} 46 mg/kg (rat), 65 mg/kg (dog); *Late Toxicity*: Banned by EPA in October 1974 because of alleged "imminent hazard to human health" as a potential carcinogen in man; *Vapor (Gas) Irritant Characteristics*: Data not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.041 ppm.

Diethanolamine — (i) Chemical Designations — *Synonyms*: Bist(2-hydroxyethyl)amine; DEA; 2,2'-Dihydroxydiethyl Amine; Di(2-hydroxyethyl)amine; 2,2'-Iminodiethanol; *Chemical Formula*: $(HOCH_2CH_2)_2NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild ammoniacal; faint, fishy; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 105.14; *Boiling Point at 1 atm.*: 515.1, 268.4, 541.6; *Freezing Point*: 82, 28, 301; *Critical Temperature*: 828, 442, 715; *Critical Pressure*: 470, 32, 3.2; *Specific Gravity*: 1.095 at 28°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.053; *Latent Heat of Vaporization*: 266, 148, 6.20; *Heat of Combustion*: -10,790, -6,000, -251; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full face mask or amine vapor mask only, if required; clean body covering clothing, chemical goggles; *Symptoms Following Exposure*: Irritation of eyes and skin. Breathing vapors may cause coughing, a smothering sensation, nausea, headache; *General Treatment for Exposure*: INHALATION: no problem likely. Get medical attention if ill effects develop. INGESTION: induce vomiting if large amounts are swallowed and call a physician. Treat symptomatically. No known antidote. EYES: flush with plenty of water for at least 15 min. and get medical attention promptly. SKIN: flush with water . Wash contaminated clothing before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Diethylamine — (i) Chemical Designations — *Synonyms*: DEN; *Chemical Formula*: $(CH_3CH_2)_2NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Ammoniacal; sharp, fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 73.14; *Boiling Point at 1 atm.*: 132, 55.5, 328.7; *Freezing Point*: -57.6, -49.8, 223.4; *Critical Temperature*: 434.3, 223.5, 496.7; *Critical Pressure*: 538, 36.6, 3.71; *Specific Gravity*: 0.708 at 20°C (liquid); *Vapor (Gas) Density*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.079; *Latent Heat of Vaporization*: 170, 93, 3.9; *Heat of Combustion*: -17,990, -9,994, -418.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles, rubber gloves, and apron; *Symptoms Following Exposure*: Irritation and burning of eyes, skin and respiratory system. High concentration of vapor can cause asphyxiation; *General Treatment for Exposure*: In case of contact, flush skin or eyes with plenty of water for at least 15 min.; for eyes, get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Exposure Limits*: 100 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.14 ppm.

Diethylbenzene — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $C_6H_4(C_2H_5)_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic aromatic; like benzene; like toluene; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 134.21; *Boiling Point at 1 atm.*: 356, 180, 453; *Freezing Point*: <160, <70, <343; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.86 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140, 77, 3.2; *Heat of Combustion*: -17,800, -9,890, -414; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Self-contained breathing apparatus, safety goggles; *Symptoms Following Exposure*: High vapor concentrations produce eye and respiratory tract irritation, dizziness, depression. Liquid irritates and may blister skin; can cause corneal injury to eye; *General Treatment for Exposure*: INHALATION: remove to fresh air and start artificial respiration. INGESTION: do NOT induce vomiting; call a doctor. EYES AND SKIN: flush with water for at least 15 min. Wash skin with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} 1.2 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes and respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Diethyl Carbonate — (i) Chemical Designations — *Synonyms*: Carbonic Acid Diethyl Ester; Ethyl Carbonate; Eufin; *Chemical Formula*: $(CH_3CH_2)_2CO_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant, etheral; mild and nonresidual; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 118.13; *Boiling Point at 1 atm.*: 260.2, 126.8, 400; *Freezing Point*: -45, -43, 230; *Critical Temperature:* Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.975 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.110; *Latent Heat of Vaporization*: 130, 73, 3.1; *Heat of Combustion*: -9,760, -5,420, -227; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Protective clothing; rubber gloves and goggles; organic vapor canister of air mask; *Symptoms Following Exposure*: High vapor concentrations can cause headache, irritation of eyes and respiratory tract, dizziness, nausea, weakness, loss of consciousness; *General Treatment for Exposure*: INHALATION: remove from exposure; administer artificial respiration and oxygen if needed. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors may cause slight smarting of eyes; *Liquid or Solid Irritant Characteristics*: Minimum hazard; *Odor Threshold*: Data not available.

Diethylene Glycol — (i) Chemical Designations — *Synonyms*: Bis(2-hydroxyethyl)ether; Diglycol; β,β'-Dihydroxydiethyl Ether; 3-Oxa-1,5-pentanediol; 2,2'-Oxybisethanol; *Chemical Formula*: $(HOCH_2CH_2)_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Practically odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 106.12; *Boiling Point at 1 atm.*: 473, 245, 518; *Freezing Point*: 20, -8, 265; *Critical Temperature*: 766, 408, 681; *Critical Pressure*: 680, 46, 4.7; *Specific Gravity*: 1.118 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 270, 150, 6.28; *Heat of Combustion*: -9,617, -5,343, -223.7; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Full face mask with canister for short exposures to high vapors levels; rubber gloves; goggles; *Symptoms Following Exposure*: Ingestion of large amounts may cause degeneration of kidney and liver and cause death. Liquid may cause slight skin irritation; *General Treatment for Exposure*: INHALATION: no problem likely. If any ill defects do develop, get medical attention. INGESTION: induce vomiting if ingested. No known antidote; treat symptomatically. EYES AND SKIN: flush with water. If any ill defects occur, get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm (suggested); *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg (rat); *Late Toxicity*: Kidney and liver damage; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Diethylene Glycol Dimethyl Ether — (i) Chemical Designations — *Synonyms*: Bis(2-methoxyethyl)ether; Poly-Solv; *Chemical Formula*: $(CH_3OCH_2CH_2)_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild

ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 134.12; *Boiling Point at 1 atm.*: 324, 162, 435; *Freezing Point*: -94, -70, 203; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.945 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130, 74, 3.1; *Heat of Combustion*: -11,300, -6,260, -262; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Vinyl (not rubber) gloves; safety goggles; *Symptoms Following Exposure*: INGESTION (severe cases): nausea, vomiting, abdominal cramps, weakness progressing to coma; *General Treatment for Exposure*: INGESTION: give water and induce vomiting; oxygen and artificial respiration as needed; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Diethyleneglycol Monobutyl Ether — (i) Chemical Designations — *Synonyms*: Butoxydiethylene Glycol; Butoxydiglycol; Diglycol Monobutyl Ether; Butyl "Carbitol"; Dowanol DB; Poly-Solv DB; *Chemical Formula*: $C_4H_9OCH_2CH_2OCH_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, characteristic; pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 162.2; *Boiling Point at 1 atm.*: 448, 231, 504; *Freezing Point*: -90, -68, 205; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.954 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130, 74, 3.1; *Heat of Combustion*: -14,000, -7,900, -330; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles or face shield; *Symptoms Following Exposure*: Inhalation for brief periods has no significant effect. Contact with liquid causes moderate irritation of eyes and corneal injury. Prolonged contact with skin causes only minor irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air; if ill effects are observed, call a doctor. EYES: immediately flush with plenty of water for at least 15 min. SKIN: wash well with soap and water. INGESTION: give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 2 g/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Diethyleneglycol Monobutyl Ether Acetate — (i) Chemical Designations — *Synonyms*: 2-(2-Butoxyethoxyl)ethyl Acetate; Diglycol Monobutyl Ether Acetate; Butyl "Carbitol" Acetate; Ektasolve DB Acetate; *Chemical Formula*: $C_4H_9OCH_2CH_2OCH_2CH_2OCOCH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, non-residual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 204.3; *Boiling Point at 1 atm.*: 475, 246, 519; *Freezing Point*: -27, -33, 240; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.985 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 106, 59, 2.5; *Heat of Combustion*:-13,000, -7,400, -310; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Face shield or safety glasses; protective gloves; air mask for prolonged exposure to vapor; *Symptoms Following Exposure*: Prolonged breathing of vapor may cause irritation and nausea. Contact with liquid any cause mild irritation of eyes and skin. Can be absorbed through skin in toxic amounts; *General Treatment for Exposure*: INHALATION: move victim to fresh air; if breathing has stopped, administer artificial respiration. EYES: flush with water for at least 15 min. SKIN: wash skin with large amounts of water for 15 min.; call physician if needed. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Because of high boiling point (246°C), hazards from inhalation are minimal; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 2.34 g/kg; *Late Toxicity*: Kidney damage noted in animals following repeated contact with skin; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Diethylene Glycol Monoethyl Ether — (i) Chemical Designations — *Synonyms*: Carbitol; Diethylene Glycol Ethyl Ether; Dowanol DE; 2-(2-Ethoxyethoxy)ethanol; Ethoxy Diglycol; Poly-Solv DE; *Chemical Formula*: $CH_3CH_2OCH_2CH_2OCH_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid;

Color: Colorless; *Odor*: Weakly fruity; mild and characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 134.17; *Boiling Point at 1 atm.*: 396, 202, 475; *Freezing Point*: -105, -76, 197; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.99 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 150, 85, 3.6; *Heat of Combustion*: -11,390, -6,330, -265; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles; *Symptoms Following Exposure*: None expected; *General Treatment for Exposure*: SKIN AND EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Diethylene Glycol Monomethyl Ether — (i) Chemical Designations — *Synonyms*: Diethylene Glycol Methyl Ether; Dowanol DM; 2-(2-Methoxyethoxy)ethanol; Methyl Carbitol; Poly-Solv DM; *Chemical Formula*: CH_3OCH_2-$CH_2OCH_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; faint characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 120.15; *Boiling Point at 1 atm.*: 381, 194, 467; *Freezing Point*: -120, -85, 188; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.025 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 120.15; *Latent Heat of Vaporization*: 160, 90, 3.8; *Heat of Combustion*: -10,830, -6,020, -252; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles; *Symptoms Following Exposure*: Liquid may irritate eyes; *General Treatment for Exposure*: SKIN OR EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Diethylenetriamine — (i) Chemical Designations — *Synonyms*: Bis(2-aminoethyl)amine; 2,2'-Diaminodiethylamine; *Chemical Formula*: $NH_2(CH_2)_2NH(CH_2)_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light amber; yellow; *Odor*: Strong ammoniacal; mildly ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 103.17; *Boiling Point at 1 atm.*: 405, 207, 480; *Freezing Point*: -38, -39, 234; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.954 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -13,300, -7,390, -309; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Amine respiratory cartridge mask; rubber gloves; splash-proof goggles; *Symptoms Following Exposure*: Prolonged breathing of vapors may cause asthma. Liquid burns skin and eyes. A skin rash can form; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. INGESTION: do NOT induce vomiting; give large quantities of water; give at least one ounce of vinegar in an equal amount of water; get medical attention. SKIN: flush with plenty of water for at least 15 min. and get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: 10 ppm.

Di(2Ethylhexyl) Phosphoric Acid — (i) Chemical Designations — *Synonyms*: Bis-(2-ethylhexyl) Hydrogen Phosphate; Di-(2-ethylhexyl) Phosphate; Di-(2-ethylhexyl) Acid Phosphate; *Chemical Formula*: $[CH_3CH_2CH_2$-$CH_2CH(C_2H_5)CH_2O]_2POOH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Amber; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 322.4; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: <-76, <-60, <213; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.977 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -13,970, -7,760, -325; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Contact with

liquid irritates eyes and may cause serious injury; consult an eye specialist. Also causes skin irritation on contact. Ingestion produces irritation similar to that caused and call a physician; *General Treatment for Exposure*: EYES: immediately flush with plenty of water for at least 15 min.; see a physician. SKIN: immediately flush with plenty of water for at least 15 min.; see a physician. SKIN: immediately flush with plenty of water for at least 15 min. INGESTION: induce vomiting and call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause second-degree burns on long exposure; *Odor Threshold*: Data not available.

Diethyl Phthalate — (i) Chemical Designations — *Synonyms*: 1,2-Benzenedicarboxylic Acid, Diethyl Ester; Ethyl Phthalate; Phthalic Acid, Diethyl Ester; *Chemical Formula*: $C_6H_4(COOC_2H_5)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Slight characteristic ester odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 222; *Boiling Point at 1 atm.*: 569.3, 298.5, 571.7; *Freezing Point*: 27, -3, 270; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.12 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 170, 96, 4.0; *Heat of Combustion*: -10,920, -6,070, -254; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Symptoms unlikely from any form of exposure; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: flush with water. SKIN: flush with water, wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 1,000 mg/kg (rabbit); *Late Toxicity*: Prolonged inhalation of heated vapor produces irritation of upper respiratory tract in humans; *Vapor (Gas) Irritant Characteristics*: Odorless; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Diethylzinc — (i) Chemical Designations — *Synonyms*: Zinc Diethyl; Ethyl Zinc; Zinc Ethyl; *Chemical Formula*: $(C_2H_5)_2Zn$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Not pertinent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 123.5; *Boiling Point at 1 atm.*: 255, 124, 397; *Freezing Point*: -18, -28, 245; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.207 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 120, 68, 2.8; *Heat of Combustion*: -11,700, -6,495, -272; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Cartridge-type or fresh air mask for fumes or smoke; PVC fire-retardant or asbestos gloves; full face shield, safety glasses, or goggles; fire-retardant coveralls as standard wear; for special cases, use asbestos coat or rain suit; *Symptoms Following Exposure*: Inhalation of mist or vapor causes immediate irritation of nose and throat; excessive or prolonged inhalation of fumes from ignition or decomposition may cause "metal fume fever" (sore throat, headache, fever, chills, nausea, vomiting, muscular aches, perspiration, constricting sensation in lungs, weakness, sometimes prostration); symptoms usually last 12-24 hrs., with complete recovery in 24 - 48 hrs. EYES are immediately and severely irritated on contact with liquid, vapor, or dilute solution; without thorough irrigation, cornea may be permanently damaged. Moisture in skin combines with chemical to cause thermal and acid burns; tissue may be scarred without prompt treatment. Ingestion is unlikely but would cause immediate burns at site of contact; pain, nausea, vomiting, cramps, and diarrhea may follow; if untreated, tissue may be scarred without prompt treatment. Ingestion is unlikely but would cause immediate burns at site of contact; pain, nausea, vomiting, cramps, and diarrhea may follow; if untreated, tissue may become ulcerated; *General Treatment for Exposure*: INHALATION: move victim to fresh air and call doctor immediately; give mouth-to-mouth resuscitation if needed; keep victim warm and comfortable; oxygen should be given only by experienced person, and only on doctor's instructions. EYES: flush with large amounts of running water for at least 15 min., holding eyelids apart to insure thorough washing; get medical attention as soon as possible; do not use chemical neutralizers, and avoid oils or ointments unless prescribed by doctor. SKIN: flush affected area with large amounts of water; do not use chemical neutralizers; get medical attention if irritation persists. INGESTION: do NOT induce vomiting; have victim drink large amounts of water or milk immediately; if vomiting occurs, give more fluids; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas)*

Irritant Characteristics: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

1,1-Difluoroethane — (i) Chemical Designations — *Synonyms*: Ethylidene Difluoride; Ethylidene Fluoride; Refrigerant 152a; *Chemical Formula*: CH_3CHF_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Faint; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 66.05; *Boiling Point at 1 atm.*: 52.3, 11.3, 248.5; *Freezing Point*: -179, -117, 156; *Critical Temperature*: 236.3, 113.5. 386.6; *Critical Pressure*: 652, 44.37, 4.50; *Specific Gravity*: 0.95 at 20°C (liquid); *Vapor (Gas) Density*: 2.3; *Ratio of Specific Heats of Vapor (Gas)*: 1.141; *Latent Heat of Vaporization*: 140.5, 78.03, 3.265; *Heat of Combustion*: -7,950, -4,420, -185; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Individual breathing devices with air supply; neoprene gloves; protective clothing; eye protection; *Symptoms Following Exposure*: Inhalation of concentrated gas will cause suffocation. Contact will liquid can damage eyes because of low temperature. Frostbite may result from contact with liquid; *General Treatment for Exposure*: INHALATION: remove to fresh air; use artificial respiration if necessary. EYES: get medical attention promptly if liquid has entered eyes. SKIN: soak in lukewarm water (for frostbite); *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent (boils at -24.7°C); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Difluorophosphoric Acid, Anhydrous — (i) Chemical Designations — *Synonyms*: Difluorophosphorus Acid; *Chemical Formula*: $HOPOF_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, very irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 103.0; *Boiling Point at 1 atm.*: 241, 116, 389; *Freezing Point*: -139, -95, 178; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.583 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140, 77, 3.2; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air line mask or self-contained breathing apparatus; full protective clothing; *Symptoms Following Exposure*: Inhalation causes severe irritation of upper respiratory tract. Contact with liquid causes severe irritation of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: Get medical exposure attention as soon as possible following exposures to this compound. INHALATION: remove victim from exposure and support respiration. EYES: wash with copious volumes of water for at least 15 min. INGESTION: if victim is conscious, have him drink large amounts of water followed by milk or milk of magnesia; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Diheptyl Phthalate — (i) Chemical Designations — *Synonyms*: Phthalic Acid, Diheptyl Ester; *Chemical Formula*: $C_6H_4(COOC_7H_{15})_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 362; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -16,850, -9,370, -392; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of vapors from very hot material may cause headache, drowsiness, and convulsions. Contact with eyes may cause irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water. SKIN: wipe off; flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Diisobutylcarbinol — (i) Chemical Designations — *Synonyms*: 2,6 Dimethyl-4-heptanol; *Chemical Formula*:

$[(CH_3)_2CHCH_2]_2CHOH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 144.26; *Boiling Point at 1 atm.*: 352, 178, 451; *Freezing Point*: -85, -65, 208; *Critical Temperature:* Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.812 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140, 76, 3.2; *Heat of Combustion*: -17,400, -9,680, -405; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask for prolonged exposure; plastic gloves; goggles; *Symptoms Following Exposure*: None expected; *General Treatment for Exposure*: SKIN AND EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Diisobutylene — (i) Chemical Designations — *Synonyms*: 2,4,4-Trimethyl-1-pentene; *Chemical Formula*: $(CH_3)_3CCH_2C(CH_3)=CH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 112.22; *Boiling Point at 1 atm.*: 214.7, 101.5, 374.7; *Freezing Point*: -136.3, -93.5, 179.7; *Critical Temperature*: 548, 286.7, 559.9; *Critical Pressure*: 380, 25.85, 2.619; *Specific Gravity*: 0.715 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.049; *Latent Heat of Vaporization*: 110, 60, 2.5; *Heat of Combustion*: -18,900, -10,500, -440; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles; *Symptoms Following Exposure*: Low general toxicity; may act as simple asphyxiate in high vapor concentrations; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Liver and kidney damage in exp. animals; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Diisobutyl Ketone — (i) Chemical Designations — *Synonyms*: DIBK; sym-Diisopropylacetone; 2,6-Dimethyl-4-heptanone; Isovalerone; *Chemical Formula*: $(CH_3)_2CH-CH_2COCH_2CH(CH_3)_2$ or $C_9H_{18}O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild; characteristic ketonic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 142.23; *Boiling Point at 1 atm.*: 325, 163, 436; *Freezing Point*: -43, -42, 231; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.806 at 20°C (liquid); *Vapor (Gas) Density*: 4.9; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 121, 67, 2.8; *Heat of Combustion*: -16, 040, -8,910, -373; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask in confined areas; plastic gloves; face shield and safety glasses; *Symptoms Following Exposure*: Inhalation of vapors causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Vapor irritates eyes. Contact with liquid irritates skin; *General Treatment for Exposure*: INHALATION: move to fresh air; give oxygen if breathing is difficult; call a physician. EYES: flush with plenty of water. SKIN: wipe off; flush with plenty of water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Exposure Limits*: 50 ppm, 30 min.; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 1.4 g/kg (mouse), 5.75 g/kg (rat); *Late Toxicity*: Causes increased liver and kidney weights in rats, decreased liver weights in guinea pigs; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Diisodecyl Phthalate — (i) Chemical Designations — *Synonyms*: Phthalic Acid, Bis(8-methylonyl)ester; Phthalic Acid, Diisodecyl Ester; Plasticizer DDP; *Chemical Formula*: $C_{28}H_{46}O_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Faint; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 446.7 (theor.); *Boiling Point at 1 atm.*: Very high; *Freezing Point*: -58, -50, 223; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.967 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -16,600, -9,220, -386; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards**

Information — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: No symptoms reported for any rate of exposure; *General Treatment for Exposure*: INGESTION: call physician. EYES: flush with water; call physician. SKIN: wipe off; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Diisopropanolamine — (i) Chemical Designations — *Synonyms*: 2,2'-Dihydroxydipropylamine; 1,1'-Iminodi-2-propanol; *Chemical Formula*: $[CH_3CH(OH)CH_2]NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid or solid; *Color*: Colorless; *Odor*: Fishy; ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 133.19; *Boiling Point at 1 atm.*: 479.7, 248.7, 521.9; *Freezing Point*: 108, 42, 315; *Critical Temperature*: 750, 399, 672; *Critical Pressure*: 529, 36, 3.6; *Specific Gravity*: 0.99 at 42°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 185, 103, 4.31; *Heat of Combustion*: -12,300, -6860, -287; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full face mask or amine vapor mask only if required; clean, body-covering clothing, rubber gloves, apron, boots and face shield; *Symptoms Following Exposure*: Vapor concentrations too low to irritate unless exposure is prolonged. Liquid will burn eyes and skin; *General Treatment for Exposure*: INHALATION: if ill effects occur, remove person to fresh air and get medical help. INGESTION: if swallowed and patient is conscious and not convulsing, promptly give milk or water, then induce vomiting; get medical help. No specific antidote known. EYES AND SKIN: immediately flush with plenty of water for at least 15 min. For eyes, get medical help promptly. Remove and wash contaminated clothing before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Diisopropylamine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $[(CH_3)_2CH]_2NH$ or $C_6H_{15}N$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Amine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 101.19; *Boiling Point at 1 atm.*: 183, 83.9, 357.1; *Freezing Point*: -141.3, -96.3, 176.9; *Critical Temperature*: 480.2, 249, 522.2; *Critical Pressure*: 400, 30, 3; *Specific Gravity*: 0.717 at 20°C (liquid); *Vapor (Gas) Density*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.064; *Latent Heat of Vaporization*: 121, 67.5, 2.82; *Heat of Combustion*: -19,800, -11,000, -460; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask; plastic gloves; goggles; rubber apron; *Symptoms Following Exposure*: Inhalation of vapors causes irritation, sometimes with nausea and vomiting; can also cause burns to the respiratory system. Ingestion causes irritation of mouth and stomach. Vapor irritates eyes; liquid causes severe burn, like caustic. Contact with skin causes irritation; *General Treatment for Exposure*: INHALATION: move victim to fresh air and keep him quiet and comfortably warm; give oxygen if breathing is difficult; call a physician. INGESTION: induce vomiting by giving a large volume of warm salt water; consult a physician. EYES: immediately flush eyes with plenty of water for at least 15 min., then get medical care. SKIN: flush with water; remove contaminated clothing and wash skin; if there is any redness or evidence of burning; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: Mouse LCL_0 5,000 ppm for 20 min.; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 0.7 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: Data not available.

Diisopropylbenzene Hydroperoxide — (i) Chemical Designations — *Synonyms*: Isopropylcumyl Hydroperoxide; *Chemical Formula*: $(CH_3)_2CHC_6H_4C(CH_3)_2$-$OOH + (CH_3)_2CHC_6H_4CH(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Sharp, disagreeable; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 194.26; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: <15, <-9, <264; *Critical Temperature:* Not pertinent; *Critical Pressure*: Not pertinent; *Specific*

Gravity: 0.956 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Solvent-resistant gloves; chemical-resistant apron; chemical goggles or face shield; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes or skin causes throbbing sensation and irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; call a doctor. EYES: flush with water for 15 min., holding eyelids open; call physician. SKIN: wash several times with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dimethylacetamide — (i) Chemical Designations — *Synonyms*: N,N-Dimethylacetamide, Acetic Acid, Dimethylamide; *Chemical Formula*: $CH_3CON(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak, fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 87.1; *Boiling Point at 1 atm.*: 331, 166, 439; *Freezing Point*: -4, -20, 253; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.943 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 214, 119, 4.98; *Heat of Combustion*: -12,560, -6,980, -292; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Liquid causes mild irritation of eyes and skin. Ingestion causes depression, lethargy, confusion and disorientation, visual and auditory hallucinations, perceptual distortions, delusions, emotional detachment, and affective blunting; *General Treatment for Exposure*: EYES: flush with plenty of water for 15 min.; get medical attention. SKIN: flush with plenty of water for 15 min. INGESTION: induce vomiting and follow with gastric lavage and saline cathartics; treatment for liver and kidney injury is supportive and symptomatic; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; oral LD_{50} 5.63 g/kg (rat); *Late Toxicity*: May produce chronic liver and kidney damage; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 46.8 ppm.

Dimethylamine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(CH_3)_2NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Fishy; strongly ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 45.08; *Boiling Point at 1 atm.*: 44.42, 6.9, 280.1; *Freezing Point*: -134, -92.2, 181; *Critical Temperature*: 328.3, 164.6, 437.8; *Critical Pressure*: 770, 52.4, 5.31; *Specific Gravity*: 0.671 at 6.9°C (liquid); *Vapor (Gas) Density*: 1.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.139; *Latent Heat of Vaporization*: 252.9, 140.5, 5.882; *Heat of Combustion*:-16,800, -9340, -391; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles and full face shield; molded rubber acid gloves; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation at high concentration (>100 ppm) causes nose and throat irritation progressing all the way to pulmonary edema. Eye and skin irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and calla physician; if breathing has stopped, administer artificial respiration and oxygen; keep victim warm and quiet; do not give stimulants. EYES: flush continuously and thoroughly with water for at least 15 min. SKIN: remove contaminated clothing immediately; flush affected area with large amounts of water and then wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: 20 ppm for 5 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: 0.047.

Dimethyldichlorosilane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(CH_3)_2SiCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, like hydrochloric acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 129; *Boiling Point at 1 atm.*: 158.8, 70.5, 343.7; *Freezing Point*: -122, -86, 187; *Critical Temperature:* Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.07 at 25°C (liquid); *Vapor (Gas) Density*: 4.4; *Ratio of Specific Heats of Vapor (Gas)*:

Data not available; *Latent Heat of Vaporization*: 100, 58, 2.4; *Heat of Combustion*: -6,000, -3,300, -140; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor type respiratory protection; rubber gloves; chemical worker's goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation irritates mucous membranes. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure and support respiration; call physician if needed. EYES: flush with water for 15 min.; obtain medical attention immediately. SKIN: flush with water; obtain medical attention immediately. INGESTION: if victim is conscious, give large amounts of water followed by milk or milk of magnesia; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Dimethyl Ether — (i) Chemical Designations — *Synonyms*: Methyl Ether; Wood Ether; *Chemical Formula*: CH_3OCH_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid under pressure; *Color*: Colorless; *Odor*: Chloroform-like; sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 46.1; *Boiling Point at 1 atm.*: -12.5, -24.7, 248.5; *Freezing Point*: -222.7, -141.5, 131.7; *Critical Temperature*: 260.4, 126.9, 400.1; *Critical Pressure*: 780, 53, 5.4; *Specific Gravity*: 0.724 at -24.7°C (liquid); *Vapor (Gas) Density*: 1.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.1456; *Latent Heat of Vaporization*: 200, 111, 4.65; *Heat of Combustion*: -13,450, -7,480, -313; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Mask for organic vapors; plastic or rubber gloves; safety glasses; *Symptoms Following Exposure*: Inhalation produces some anesthesia (but less than that of ethyl ether), blurring of vision, headache, intoxication, loss of consciousness. Liquid or concentrated vapor irritates eyes. Contact of liquid with skin may cause frostbite; *General Treatment for Exposure*: INHALATION: remove from exposure and support respiration; call physician. EYES: wash with water for at least 15 min.; consult an eye specialist. SKIN: treat frostbite by use of warm water or by wrapping the affected part blanket; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dimethylformamide — (i) Chemical Designations — *Synonyms*: N,N-Dimethylformamide, DMF; *Chemical Formula*: $HCON(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Slight amine odor; essentially odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 73.09; *Boiling Point at 1 atm.*: 307, 153, 426; *Freezing Point*: -78, -61, 212; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.950 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.101; *Latent Heat of Vaporization*: 248, 138, 5.78; *Heat of Combustion*: -11,280, -6267, -262.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses or face shield; rubber apron and boots; *Symptoms Following Exposure*: Irritation of eyes, skin and nose. May cause nausea; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing; give artificial respiration; for difficult breathing give oxygen; call a physician. SKIN OR EYES: flush with plenty of water while removing contaminated clothing and shoes; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity*: Causes abortions in pregnant rats, possibly in humans also; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation, such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure; *Odor Threshold*: 100 ppm.

Dimethylhexane Dihydroperoxide, Wet — (i) Chemical Designations — *Synonyms*: 2,5-Dihydroperoxy-2,5-dimethylhexane; 2,5-Dimethylhexane-2,5-dihydroperoxide; *Chemical Formula*: $C_8H_{16}(OOH)_2—H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Wet solid; *Color*: White; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 178.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing*

Point: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove from exposure; call a doctor. EYES: wash with large amount of water for at least 15 min. SKIN: wash with large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

1,1-Dimethylhydrazine — (i) Chemical Designations — *Synonyms*: Dimazine; UDMH; unsym-Dimethylhydrazine; *Chemical Formula*: $(CH_3)_2N{\bullet}NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp ammoniacal; fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 60.11; *Boiling Point at 1 atm.*: 146, 63.3, 336.5; *Freezing Point*: -71, -57, 216; *Critical Temperature*: 480, 249, 522; *Critical Pressure*: 865, 53.5, 5.40; *Specific Gravity*: 0.791 at 20°C (liquid); *Vapor (Gas) Density*: 2.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.152; *Latent Heat of Vaporization*: 261, 145, 6.07; *Heat of Combustion*: -14,170, -7,870, -329.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, boots and apron; plastic face shield. Gas mask with ammonia canister protects for 30 min. against 1% concentration; for longer periods or higher concentrations, use self-contained breathing apparatus; *Symptoms Following Exposure*: Breathing of vapor causes pulmonary irritation, delayed gastrointestinal irritation, tremors, and convulsions. Contact with skin or mucous membranes causes chemical burns. Can be absorbed through skin to cause systemic intoxication and convulsions; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area, give artificial respiration and oxygen if needed; watch for signs of pulmonary edema; enforce absolute rest. INGESTION: do NOT induce vomiting; hospitalize. SKIN OR EYES: flood with water and treat as alkaline burn; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 ppm; *Short-Term Exposure Limits*: 100 ppm for 10 min.; 50 ppm for 30 min.; 30 ppm for 60 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (rat, mouse); *Late Toxicity*: Mild anemia, upper respiratory irritation, and muscle tremors in dogs following chronic exposure; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: 6 - 14 ppm.

Dimethylpolysiloxane — (i) Chemical Designations — *Synonyms*: Poly(dimethylsiloxane); Dimethylsilicone Oil; Dimethyl Silicone Fluids; Silicone Fluids; *Chemical Formula*: $(CH_3)_3Si\text{-}O\text{-}[Si(CH_3)_2O]_n\text{-}Si(CH_3)_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >300, >149, >422; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.98 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,000, -6,200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles; *Symptoms Following Exposure*: Contact of liquid with eyes may cause temporary discomfort. Does not irritate skin. Harmless when ingested; *General Treatment for Exposure*: Except for eye contact, exposures generally do not require treatment; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Dimethyl Sulfate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(CH_3)_2SO_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: No characteristic odor; slight, not distinctive; weak onion; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 126.13; *Boiling Point at 1 atm.*: 371.8, 188.8, 462; *Freezing Point*: -25.2, -31.8, 241.4; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent;

Specific Gravity: 1.33 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles; self-contained breathing apparatus; safety hat; rubber suit; rubber shoes; rubber gloves; safety shower and eye wash fountain; *Symptoms Following Exposure*: Severe irritation of eyes, eyelids, respiratory tract and skin. Dry, painful cough; foamy, white sputum; difficulty in breathing; malaise and fever; inflammation and edema of lungs; *General Treatment for Exposure*: Contact with dimethyl sulfate liquid or vapor (> 1 ppm) requires immediate treatment. Call a physician, even if there is no evidence of injury, as symptoms may not appear for several hours. INHALATION: get victim to fresh air immediately; administer 100% oxygen, even if no injury is apparent, and continue for 30 min. each hour for 6 hours; give artificial respiration if breathing is weak or fails, but do not interrupt oxygen therapy; if victim's coughing prevents use of a mask, use oxygen tent under atmospheric pressure. INGESTION: do NOT induce vomiting. SKIN: wash thoroughly. EYE: flush with running water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; 50 to 500 mg/kg (rat); *Late Toxicity*: Causes birth defects in rats (malignant tumors in nervous system); *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: Data not available.

Dimethyl Sulfide — (i) Chemical Designations — *Synonyms*: DMS; Methanethiomethane; Methyl Sulfide; 2-Thiapropane; *Chemical Formula*: $(CH_3)_2S$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to straw; *Odor*: Ethereal, permeating; disagreeable; offensive; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 62.1; *Boiling Point at 1 atm.*: 99, 37, 310; *Freezing Point*: -144, -98, 175; *Critical Temperature*: 444, 229, 502; *Critical Pressure*: 826, 56.1, 5.69; *Specific Gravity*: 0.85 at 20°C (liquid); *Vapor (Gas) Density*: 2.14; *Ratio of Specific Heats of Vapor (Gas)*: 1.1277 at 16°C; *Latent Heat of Vaporization*: 194, 108, 4.52; *Heat of Combustion*: -13,200, -7,340, -307; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator with organic vapor canister; rubber or plastic gloves; goggles or face shield; *Symptoms Following Exposure*: Inhalation causes moderate irritation of upper respiratory system. Contact of liquid with eyes causes moderate irritation. Repeated contact with skin may extract oils and result in irritation. Ingestion causes nausea and irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air at once; enforce rest, and keep warm; get medical attention immediately. EYES: flush with water for at least 15 min.; if irritation persists, get medical attention. SKIN: flush with plenty of water and wash thoroughly; get treatment for any lasting irritation. INGESTION: if large amounts are swallowed, induce vomiting by ticking the back of the throat with the finger or by giving an emetic such as two tablespoons of common salt in a glass of warm water; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 535 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure and may cause second-degree burns on long exposure; *Odor Threshold*: 0.001 ppm.

Dimethyl Sulfoxide — (i) Chemical Designations — *Synonyms*: DMSO; Methyl Sulfoxide; *Chemical Formula*: CH_3SOCH_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Slight; almost odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 78.13; *Boiling Point at 1 atm.*: 372, 189, 462; *Freezing Point*: 65.5, 18.6, 291.8; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.101 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 259, 144, 6.03; *Heat of Combustion*: -10,890, -6,050, -253.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Butyl rubber gloves, safety goggles. Respiratory filter if airborne sprays or drops are present; *Symptoms Following Exposure*: Slight eye irritation; *General Treatment for Exposure*: Wash eyes and skin with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not

available; *Toxicity by Ingestion*: Grade 0; above 15 g/kg; *Late Toxicity*: Causes damage to eye in dogs, pigs, rats, and rabbits; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Dimethyl Terephthalate — (i) Chemical Designations — *Synonyms*: Terephthalic Acid, Dimethyl Ester; *Chemical Formula*: 1,4-$CH_3OOCC_6H_4COOCH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or liquid; *Color*: Colorless; *Odor*: None; weak aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 194.2; *Boiling Point at 1 atm.*: 540, 282, 555; *Freezing Point*: 284, 140, 413; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 121, 67.2, 2.81; *Heat of Combustion*: -10,310, -5,727, -239,6; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Molten DMT: goggles, face shield, gauntlets, and protective clothing. Solid: dust mask, goggles; *Symptoms Following Exposure*: Molten DMT will cause severe burns on skin on contact; *General Treatment for Exposure*: EYES: flush dust from eyes with water. SKIN: wash with soap and water. If burned by molten DMT, flush area immediately with cold water for at least 15 min.; apply ice pack for at least 30 min.; do not try to rub DMT off a burn or remove clothing that DMT has penetrated, because this will remove underlying skin; seek prompt medical treatment for significant burns; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 4,390 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Dimethylzinc — (i) Chemical Designations — *Synonyms*: Zinc Dimethyl; Zinc Methyl; Methyl Zinc; *Chemical Formula*: $(CH_3)_2Zn$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Not pertinent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 95.4; *Boiling Point at 1 atm.*: 113, 45, 318; *Freezing Point*: -44, -42, 231; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.39 at 10.5 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 134.9, 74.95, 3.138; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Cartridge-type or fresh air mask for fumes or smoke; PVC fire-retardant or asbestos gloves; full face shield, safety glasses, or goggles; fire-retardant coveralls as standard wear; for special cases, use asbestos coat or rain suit; *Symptoms Following Exposure*: Inhalation of mists or vapor causes immediate irritation of upper respiratory tract. Excessive or prolonged inhalation of fumes from ignition or decomposition may cause "metal fume fever" (sore throat, headache, fever, chills, nausea, vomiting, muscular aches, perspiration, constricting sensation in lungs, weakness, sometimes prostration). Symptoms usually last 12-24 hrs. Eyes are immediately and severely irritated by liquid, vapor, or dilute solutions. If not removed by thorough flushing with water, chemical may permanently damage cornea. Skin will undergo thermal and acid burns when chemical reacts with moisture in skin. Unless washed quickly, skin may be scarred. Treat dilute solutions with same precautions as concentrated liquid. Ingestion, while unlikely, would cause immediate burns at site of contact. Nausea, vomiting, cramps, and diarrhea may follow. Tissues may ulcerate if not treated; *General Treatment for Exposure*: INHALATION: highly unlikely, as liquid or vapor either ignites spontaneously or reacts with moisture to form methane and zinc oxide. Move victim to clean air and administer mouth-to-mouth resuscitation if breathing has ceased; give oxygen only when authorized by physician; keep victim warm and comfortable; call physician immediately. EYES: immediately flush with large amounts of water for at least 15 min., holding eyelids apart to insure thorough irritation; use oils or ointments only when directed by physician, and do not attempt to neutralize with chemicals; get medical attention as soon as possible. SKIN: immediately flush affected area with large volumes of water; do not attempt to neutralize with chemicals; get medical attention if irritation persists. INGESTION: highly unlikely, as liquid or vapor either ignites spontaneously or reacts with moisture to form methane and zinc oxide. Do NOT induce vomiting; immediately dilute material by giving large amounts of water or milk; if vomiting occurs, give more fluids; when vomiting ceases, milk or olive oil may be given for their soothing effect; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not

pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

2,4-Dinitroaniline — (i) Chemical Designations — *Synonyms*: 2,4-Dinitraniline; *Chemical Formula*: $NH_2C_6H_3(NO_2)_2$-2,4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Slight musty; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 183.12; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 368, 187, 460; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.615 at 15°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; butyl rubber gloves; eye goggles; plastic lab coat; protective shoes; *Symptoms Following Exposure*: May cause headache, nausea, stupor. Irritating to skin and mucous membrane; *General Treatment for Exposure*: INHALATION: artificial respiration if necessary. INGESTION: induce vomiting; give universal antidote; get prompt medical care. SKIN AND EYES: remove victim from exposure; wash exposed skin with warm water and soap; flush eyes with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; oral rate LD_{50} 418 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first degree burns on short exposure; may cause second degree burns on long exposure; *Odor Threshold*: Not pertinent.

m-Dinitrobenzene — (i) Chemical Designations — *Synonyms*: 1,3-Dinitrobenzene; 1,3-Dinitrobenzol; m-DNB; meta-Dinitrobenzene; Dinitrobenzol; *Chemical Formula*: $1,3\text{-}C_6H_4(NO_2)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Weak; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 168.1; *Boiling Point at 1 atm.*: 556, 291, 564; *Freezing Point*: 194, 90, 363; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.58 at 18°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -7,378, -4,099, -171.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; rubber gloves; protective clothing; *Symptoms Following Exposure*: Inhalation or ingestion causes loss of color, nausea, headache, dizziness, drowsiness, and collapse. Eyes are irritated by liquid. Stains skin yellow; if contact is prolonged, can be absorbed into blood and cause same symptoms as for inhalation; *General Treatment for Exposure*: INHALATION: remove from exposure; get medical attention for methemoglobinemia. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water. INGESTION: induce vomiting, if conscious; give gastric lavage and saline cathartic; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} 42 mg/kg; *Late Toxicity*: May cause liver damage, anemia, neuritis; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dinitrocresols — (i) Chemical Designations — *Synonyms*: 2,6-Dinitro-p-cresol; 3,5-Dinitro-o-cresol; 4,6-Dinitro-o-cresol; *Chemical Formula*: $CH_3\text{—}C_6H_2(NO_2)_2(OH)$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 198; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 176-187, 80-86, 353-359; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1.1 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -7,050, -3,920, -164; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective clothing; rubber gloves; *Symptoms Following Exposure*: Very high fever is prominent sign of intoxication following absorption of a toxic dose of dinitro-o-cresol. Inhalation of dust may cause same symptoms as ingestion. Ingestion causes a feeling of well-being, profuse sweating, yellow urine, increased basal metabolism, marked thirst, vomiting, convulsions, coma, and death. Contact with eyes causes irritation. Contact with skin causes local necrosis and dangerous systemic effects. Note: Some authorities recommend that all exposed workers have blood tests regularly to determine the

level of this substance. Further contact should be avoided if the level exceeds 20 micrograms per gram; *General Treatment for Exposure*: INHALATION: apply ice packs to promote heat loss; replace fluids and electrolytes; allay anxiety. INGESTION: same as for inhalation; also, give large amounts of water and induce vomiting; get medical attention. EYES: flush with water for at least 15 min. SKIN: wash thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m_3; *Short-Term Exposure Limits*: 1 mg/m^3, 30 min.; *Toxicity by Ingestion*: Grade 4; $LD_{50} < 50$ mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

2,4-Dinitrophenol — (i) Chemical Designations — *Synonyms*: Aldifen; alpha-Dinitrophenol; 1-Hydroxy-2,4-dinitrobenzene; *Chemical Formula*: $HOC_6H_3(NO_2)_2$-2,4; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Musty; sweet; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 184.1; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 235, 113, 386; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.68 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; butyl rubber gloves; goggles; lab coat; protective shoes; *Symptoms Following Exposure*: Liver damage, metabolic stimulant, dermatitis, dilation of pupils; *General Treatment for Exposure*: Remove victim from contaminated area and wash exposed skin with soap and water. Administer oxygen if respiratory problems develop. Refer to a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} below 50 mg/kg; *Late Toxicity*: Produces clouding of lens of eye (cataracts) in animals and humans, birth defects in chick embryos; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: Data not available.

2,4-Dinitrotoluene — (i) Chemical Designations — *Synonyms*: 2,4-Dinitrotoluol; 1-Methyl-2,4-dinitrobenzene; DNT; *Chemical Formula*: $2,4\text{-}(NO_2)_2C_6H_3CH_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid or liquid; *Color*: Yellow (liquid); yellow to red (solid); *Odor*: Weak; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 182.1; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 158, 70, 343; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.379 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 170, 93, 3.9; *Heat of Combustion*: -8,305, -4,614, -193.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-line mask or self-contained breathing apparatus; safety goggles and face shield; rubber gloves and boots; protective clothing; *Symptoms Following Exposure*: Ingestion or overexposure to vapors from hot liquid can cause loss of color, nausea, headache, dizziness, drowsiness, collapse. Hot liquid can burn eyes and skin. Prolonged skin contact with solid can give same symptoms as after inhalation or ingestion; *General Treatment for Exposure*: INHALATION: remove victim from exposure; get medical attention fro methemoglobinemia. EYES: flush with copious amounts of water and get medical attention. SKIN: wash well with soap and water. INGESTION: induce vomiting, if victim is conscious; give gastric lavage and saline cathartic; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 1.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} 30 mg/kg (rat); *Late Toxicity*: May cause liver damage, anemia, neuritis; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dioctyl Adipate — (i) Chemical Designations — *Synonyms*: Adipic Acid, Bis(2-ethylhexyl) Ester; Adipol 2EH; Di(2-ethylhexyl) Adipage; DOA; *Chemical Formula*: $C_8H_{17}OOC(CH_2)_4COOC_8H_{17}$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild characteristic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 371; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.928 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -15,430, -8,580, -359; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: None required; *Symptoms Following Exposure*: Low toxicity; no reports of injury in industrial handling; *General Treatment for Exposure*: SKIN AND EYES: wipe

off and wash skin with soap and water. Treat like lubricating oil. Flush eyes with water. Remove to fresh air; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Dioctyl Phthalate — (i) Chemical Designations — *Synonyms*: Bis(2-ethylhexyl) Phthalate; Di(2-ethylhexyl) Phthalate; DOP; Octoil; Phthalic Acid, Bis(2-ethylhexyl) Ester; *Chemical Formula*: $o\text{-}C_6H_4[COOCH_2CH(C_2H_5)(CH_2)_3CH_3]_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Very slight, characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 390.6; *Boiling Point at 1 atm.*: 727, 386, 659; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.980 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -15,130, -8410, -352; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Not required; *Symptoms Following Exposure*: Produces no ill effects at normal temperatures but may give off irritating vapor at high temperature; *General Treatment for Exposure*: Leave contaminated area; wash skin with soap and water; flush eyes with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg (rat); *Late Toxicity*: Not established; *Vapor (Gas) Irritant Characteristics*: Nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Dioctyl Sodium Sulfosuccinate — (i) Chemical Designations — *Synonyms*: Aerosol Surfactant; Alrowet D65; Bis(2-ethylhexyl)sodium Sulfosuccinate; Di(2-ethylhexyl) Sulfosuccinate, Sodium Salt; Sodium Dioctyl Sulfosuccinate; *Chemical Formula*: $C_8H_{17}OOCCH_2CH(SO_3Na)COOC_8H_{17}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Waxy solid or water solution; *Color*: Colorless or off-white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 444; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: (solid form) 311, 155, 428; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.1 at 20 °C (solid or liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles; rubber gloves; dust respirator; *Symptoms Following Exposure*: Liquid is strong irritant to eye and may irritate to eye and may irritate skin by removing natural oils. Ingestion causes diarrhea and intestinal bloating; *General Treatment for Exposure*: EYES: irrigate with copious volumes of water for at least 15 min.; call physician. SKIN: rinse off with water. INGESTION: drink large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 1,900 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

1,4-Dioxane — (i) Chemical Designations — *Synonyms*: Di (Ethylene Oxide); Dioxan; p-Dioxane; *Chemical Formula*: $CH_2CH_2OCH_2CH_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild; somewhat alcoholic; like butyl alcohol; ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 88.11; *Boiling Point at 1 atm.*: 214.3, 101.3, 374.5; *Freezing Point*: 53.2, 11.8, 285.2; *Critical Temperature*: 597, 314, 587; *Critical Pressure*: 755, 51.4, 5.21; *Specific Gravity*: 1.036 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.1; *Latent Heat of Vaporization*: 178, 98.6, 4.13; *Heat of Combustion*: -11,590, -6,440, -269.6; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Fresh air mask; rubber gloves; goggles; safety shower and eye bath; *Symptoms Following Exposure*: No significant irritation from brief exposure of skin; prolonged or repeated exposure may cause a rash or burn and absorption of toxic amounts leading to serious injury of liver and kidney. Chemical has poor warning properties; illness may be delayed. Moderately irritating to eyes; overexposure may cause corneal injury; *General Treatment for Exposure*: INHALATION: promptly remove victim to fresh air, keep him quiet and warm, and call

physician; start artificial respiration if breathing stops. INGESTION: if large amounts are swallowed, quickly induce vomiting and get medical attention; no specific antidote known. SKIN AND EYES: flush with plenty of water for 15 min.; remove contaminated clothing and wash before reuse; get medical attention for eyes and if ill effects occur from skin contact; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 100 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (guinea pig: 3.90 g/kg); *Late Toxicity*: Causes cancer in rats; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 620 mg/m^3.

Dipentene — (i) Chemical Designations — *Synonyms*: Limonene; para-Mentha-1,8-diene; Phellandrene; Terpinene; delta-1,8-Terpodiene; *Chemical Formula*: $C_{10}H_{16}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant, pine-like; lemon-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 136.2; *Boiling Point at 1 atm.*: 352, 178, 451; *Freezing Point*: -40, -40, 233; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.842 at 21°C (liquid); *Vapor (Gas) Density*: 4.9; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140, 77, 3.2; *Heat of Combustion*: -19,520, -10,840, -454; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Solvent-resistant gloves; safety glasses or face shield; self-contained breathing apparatus for high vapor concentrations; *Symptoms Following Exposure*: Liquid irritates eyes; prolonged contact with skin causes irritation. Ingestion causes irritation of gastrointestinal tract; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area; administer artificial respiration if necessary; call physician. EYES: flush with water for 15 min.; call physician. SKIN: wash with soap and water. INGESTION: induce vomiting; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 4,600 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Diphenylamine — (i) Chemical Designations — *Synonyms*: Anilinobenzene; N-Phenylaniline; *Chemical Formula*: $(C_6H_5)_2NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or liquid; *Color*: Very pale tan; amber to brown; *Odor*: Characteristic, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 169.2; *Boiling Point at 1 atm.*: 576, 302, 575; *Freezing Point*: 127, 53, 326; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.068 at 61°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -16,300, -9,060, -379; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator; safety goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation may irritates mucous membranes. Overexposure, including ingestion of solid or skin contact, may cause fast pulse, hypertension, and bladder trouble. Contact with dust irritates eyes; *General Treatment for Exposure*: INHALATION: move victim to fresh air. INGESTION: get medical attention; observe for methemoglobinemia. EYES: flush with plenty of water and see physician. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 2,000 mg/kg (rat); *Late Toxicity*: Causes birth defects in rats (polycystic kidneys); *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Diphenyldichlorosilane — (i) Chemical Designations — *Synonyms*: Dichlorodiphenylsilane; Dichlorodiphenylsilicane; Dichloride Diphenylsilicon; *Chemical Formula*: $(C_6H_5)_2SiCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, hydrochloric acid-like; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 253; *Boiling Point at 1 atm.*: 579, 304, 577; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 106, 59, 2.5; *Heat of Combustion*: -11,000, -6,200, -260;

Heat of Decomposition: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor type respiratory protection; rubber gloves; chemical goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation irritates mucous membranes. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from exposure; support respiration; call physician if needed. EYES: flush with water for 15 min.; obtain medical attention immediately. SKIN: flush with water, obtain medical attention for acid burns. INGESTION: give large amounts of water, if victim is conscious; give milk, or milk of magnesia; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Diphenyl Ether — (i) Chemical Designations — *Synonyms*: Phenyl Ether; Diphenyl Oxide; Phenoxybenzene; *Chemical Formula*: $C_6H_5OC_6H_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak geranium; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 170.2; *Boiling Point at 1 atm.*: 495, 257, 530; *Freezing Point*: 81, 27, 300; *Critical Temperature*: 921, 494, 767; *Critical Pressure*: 478, 32.5, 3.30; *Specific Gravity*: 1.07 at 27°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130, 72, 3.0; *Heat of Combustion*: -15,520, -8,620, -361; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation may cause nausea because of disagreeable odor. Contact of liquid with eyes causes mild irritation. Prolonged exposure of skin to liquid causes reddening and irritation. Ingestion produces nausea; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water. INGESTION: induce vomiting and get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} 3,370 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.1 ppm.

Diphenylmethane Diisocyanate — (i) Chemical Designations — *Synonyms*: Carwinate 125 M; Diphenylmethane-4,4`-diisocyanate; Hylene M50; MDI; Methylenebis(4-phenylisocyanate); Multrathane M; Nacconate 300; Vilrathane 4300; *Chemical Formula*: $(p\text{-}OCNC_6H_4)_2CH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Colorless to light yellow; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 250.3; *Boiling Point at 1 atm.*: 738, 392, 665; *Freezing Point*: 100, 37.7, 311; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Mask or respirator of type approved by U.S. Bu. Mines (above 135°C); clean rubber gloves; chemical goggles; clean waterproof or freshly laundered protective clothing (coveralls, rubber boots, caps, etc.); *Symptoms Following Exposure*: Breathlessness, chest discomfort, and reduced pulmonary function; *General Treatment for Exposure*: INHALATION: treat symptomatically; give oxygen. Call a physician. SKIN: wash with soap and water. Rubbing alcohol helpful. EYE: flush with water at least 15 min. Call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 0.02 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Severe irritation of eyes and throat; can cause eye and lung injury. Cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Di-n-Propylamine — (i) Chemical Designations — *Synonyms*: N-n-Propyl-1-propanamine; *Chemical Formula*: $(CH_3CH_2CH_2)_2NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 101.19; *Boiling Point at*

1 atm.: 228.7, 109.3, 382.5; *Freezing Point*: -81, -63, 210; *Critical Temperature*: 531, 277, 550; *Critical Pressure*: 456, 31.0, 3.14; *Specific Gravity*: 0.738 at 20°C (liquid); *Vapor (Gas) Density*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: No data; *Latent Heat of Vaporization*: 143, 79.5, 3.33; *Heat of Combustion*: -18,750, -10,420, -436.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; butyl rubber gloves; butyl rubber apron; face shield; *Symptoms Following Exposure*: Inhalation causes severe coughing and chest pain due to irritation of air passages; can cause lung edema; may also cause headache, nausea, faintness, and anxiety. Ingestion causes irritation and burning of mouth and stomach. Contact with eyes causes severe irritation and edema of the cornea. Contact with skin causes severe irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing; give artificial respiration; if breathing is difficult, give oxygen; call a physician. INGESTION: give large amount of water; get medical attention. EYES: flush with water for 15 min.; get medical attention for burns. SKIN: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral rat LD_{50} 200 mg/kg (rat), 800 mg/kg (mouse); *Late Toxicity*: Causes degenerative changes in liver and kidney of rats and rabbits; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Dipropylene Glycol — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(CH_3CHOHCH_2)_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: liquid; *Color*: Colorless; *Odor*: Practically none; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 134.17; *Boiling Point at 1 atm.*: 420, 232, 505; *Freezing Point*: >-40, >-40, >233; *Critical Temperature*: 720, 382, 655; *Critical Pressure*: 529, 36, 3.6; *Specific Gravity*: 1.023 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.0; *Latent Heat of Vaporization*: 170, 96, 4.0; *Heat of Combustion*: -11,650, -6470, -271; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses with side shields or goggles; shower and eye bath; *Symptoms Following Exposure*: Minor eye irritation; *General Treatment for Exposure*: EYES: irrigate briefly with water; if any ill defects, get medical attention. SKIN AND INGESTION: if any ill defects develop, get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Distillates: Flashed Feed Stocks — (i) Chemical Designations — *Synonyms*: Petroleum Distillate; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58-275, 14-135, 287-408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.71-0.75 at 15°C (liquid); *Vapor (Gas) Density*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.054; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: INHALATION: irritation of upper respiratory tract; dizziness, headache, coma, respiratory arrest; cardiac arrhythmias may occur. ASPIRATION: severe lung irritation, coughing, pulmonary edema, signs of bronchopneumonia; acute central nervous system excitation, followed by depression. INGESTION: irritation of mouth and stomach, other symptoms as above; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration, administer oxygen. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was swallowed; guard against aspiration into lungs. EYES: wash with copious amounts of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Exposure Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Distillates: Straight Run — (i) Chemical Designations — *Synonyms*: Petroleum Distillate; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58 - 275, 14 - 135, 287 - 408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.731 at 16°C (liquid); *Vapor (Gas) Density*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.054; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: INHALATION: irritation of upper respiratory tract; dizziness, headache, coma, respiratory arrest; cardiac arrhythmias may occur. ASPIRATION: severe lung irritation, coughing, pulmonary edema, signs of bronchopneumonia; acute central nervous system excitation, followed by depression. INGESTION: irritation of mouth and stomach; other symptoms as above; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration and administer oxygen. ASPIRATION: enforce bed rest and administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was swallowed; guard against aspiration into lungs. EYES: wash with plenty of water. SKIN: remove by wiping and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Exposure Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Dodecanol — (i) Chemical Designations — *Synonyms*: Dodecyl Alcohol; Lauryl Alcohol; *Chemical Formula*: $CH_3(CH_2)_{10}CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Typical fatty alcohol odor; sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 186.33; *Boiling Point at 1 atm.*: 498, 259, 532; *Freezing Point*: 75, 24, 297; *Critical Temperature*: 763, 406, 679; *Critical Pressure*: 280, 19, 1.9; *Specific Gravity*: 0.831 at 24°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.030; *Latent Heat of Vaporization*: 110, 62, 2.6; *Heat of Combustion*: -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical gloves; chemical goggles; *Symptoms Following Exposure*: Liquid will cause burning of the eyes and may irritate skin; *General Treatment for Exposure*: SKIN AND EYES: wash exposed areas with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (humans); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Dodecene — (i) Chemical Designations — *Synonyms*: Dodecene(non-linear); Propylene Tetramer; Tetrapropylene; *Chemical Formula*: $C_{12}H_{24}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 168.31; *Boiling Point at 1 atm.*: 365-385, 185-196, 458-469; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.77 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -19,100, -10,600, -444; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; no respiratory protection needed if ventilation is adequate; *Symptoms Following Exposure*: No inhalation hazard expected. Aspiration hazard if ingested. Minor skin and eye irritation; *General Treatment for Exposure*: INHALATION: Remove victim to fresh air. INGESTION: do NOT induce vomiting! Do NOT lavage! Give vegetable oil and demulcents; call physician. EYE: flush with water for 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

1-Dodecene — (i) Chemical Designations — *Synonyms*: Adacene-12; alpha-Dodecylene; *Chemical Formula*: $CH_3(CH_2)_8CH=CH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 168.31; *Boiling Point at 1 atm.*: 415, 213, 486; *Freezing Point*: -31, -35, 238; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.758 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.032; *Latent Heat of Vaporization*: 110, 61.0, 2.55; *Heat of Combustion*: -18,911, -10,506, -439.87; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: No inhalation hazard expected. Aspiration hazard if ingested. Minor skin and eye irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. INGESTION: do NOT induce vomiting! Do NOT lavage! Give vegetable oil and demulcents; call physician. EYE: flush wight water for 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Dodecylbenzene — (i) Chemical Designations — *Synonyms*: Detergent Alkylate #2; n-Dodecylbenzene; Dodecylbenzene (linear); Lauryl Benzene; 1-Phenyldodecane; UCANE Alkylate 12; *Chemical Formula*: $C_6H_5(CH_2)_{11}CH_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak oily; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 240; *Boiling Point at 1 atm.*: 550, 288, 561; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.860 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 150, 82, 3.4; *Heat of Combustion*: -18,100, -10,000, -418; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Liquid causes mild irritation of eyes and may cause allergenic responses on repeated contact with skin. Ingestion causes nausea; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; get medical attention for persistent irritation. SKIN: wash with soap and water. INGESTION: do NOT induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Dodecyltrichlorosilane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $CH_3(CH_2)_{11}SiCl_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, like hydrochloric acid; pungent and irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 303.7; *Boiling Point at 1 atm.*: >300, >149, >422; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.03 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,000, -6,200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Acid-vapor type respiratory protection; rubber gloves; chemical worker's goggles; other protective equipment as necessary to protect eyes and skin; *Symptoms Following Exposure*: Inhalation irritates mucous membrane. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; call physician if needed. EYES: flush with water for 15 min.; obtain medical attention immediately. SKIN: flush with water; obtain medical attention if skin is burned. INGESTION: if victim is conscious, give large amounts of water, then milk or milk of magnesia; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid*

or Solid Irritant Characteristics: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

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Endrin — (i) Chemical Designations — *Synonyms*: 1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-endo,endo-1,4,5,8-dimethanonaphthalene; Hexadrin; Mendrin; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid (Sometimes shipped as an emulsifiable concentrate in xylene solution); *Color*: Colorless to tan; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 380.92; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 392, 200, 573; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.65 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator for spray, fog, or dust; rubber gloves and boots; *Symptoms Following Exposure*: Inhalation causes moderate irritation of nose and throat; prolonged breathing may cause same toxic symptoms as for ingestion. Contact with liquid causes moderate irritation of eyes and skin. Prolonged contact with skin may cause same toxic symptoms as for ingestion. Ingestion causes frothing of the mouth, facial congestion, convulsions, violent muscular contractions, dizziness, weakness, nausea; *General Treatment for Exposure*: Get medical attention after all exposures to this compound. INHALATION: remove from exposure. EYES: flush with water for at least 15 min. SKIN: wash with plenty of soap and water, but do not scrub. INGESTION: remove from the gastrointestinal tract, either by inducing vomiting (unless hydrocarbon solvents are involved and the amount of insecticide is well below the toxic amount) or by gastric lavage with saline solution; saline cathartic may also be beneficial; fats and oils should be avoided; sedation with barbiturates is indicated if signs of CNS irritation are present; patient should have absolute quiet, expert nursing care, and a minimum of external stimuli to reduce danger of convulsions; epinephrine is contraindicated in view of the danger of precipitating ventricular fibrillation; if material ingested was dissolved in a hydrocarbon solvent, observe patient for possible development of hydrocarbon pneumonitis; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Inhalation Limits*: 0.5 mg/m^3 for 30 min.; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 3 mg/kg (rat); *Late Toxicity*: None known; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent (solid).

Epichlorohydrin — (i) Chemical Designations — *Synonyms*: 1,Chloro-2,3-epoxypropane; Chloromethyloxirane; gamma-Chloropropylene oxide; 3-Chloro-1,2-propylene oxide; *Chemical Formula*: $O{\cdot}CH_2{\cdot}CH{\cdot}CH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent, garlic; sweet, pungent; like chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 92.53; *Boiling Point at 1 atm.*: 239.4, 115.2, 388.4; *Freezing Point*: -72.6, -58.1, 215.1; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.18 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.155; *Latent Heat of Vaporization*: 176, 97.9, 4.10; *Heat of Combustion*: -8143, -4524, -189.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister mask; protective gloves and goggles; *Symptoms Following Exposure*: Vapor is irritating to eyes, nose, and throat; may cause headache, nausea, vomiting, and central nervous system depression. Rapidly fatal if swallowed, i.e. nausea, vomiting, and collapse. Skin contact is irritating; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, keep him warm and quiet, and get medical attention immediately; if breathing stops, start artificial respiration. INGESTION: induce vomiting (but only if victim is conscious and without convulsions) and call a physician promptly; no specific antidote known. EYES OR SKIN: immediately flush with water for at least 15 min. and get medical attention; remove contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: 10 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Causes cancer in experimental animals; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: 10 ppm.

Epoxidized Vegetable Oils — (i) Chemical Designations — *Synonyms*: Drying oil epoxides, Epoxidized drying oils, Epoxidized oils; *Chemical Formula*: (O CRH CHR'COO)$_3$C$_3$H$_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Very weak; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0 at 20 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est)-13.000, -7.000, -3000; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Not pertinent; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None expected; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Ethane — (i) Chemical Designations — *Synonyms*: Methylmethane; *Chemical Formula*: C_2H_6; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid or compressed gas; *Color*: Colorless; *Odor*: Weak, sweetish; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 30.07; *Boiling Point at 1 atm.*: -127.5, -88.6, 264.6; *Freezing Point*: -279.9, -183.3, 89.9; *Critical Temperature*: 90.1, 32.3, 305.5; *Critical Pressure*: 708.0, 48.16, 4.879; *Specific Gravity*: 0.546 at -88.6°C (liquid); *Vapor (Gas) Density*: 1.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.191; *Latent Heat of Vaporization*: 211, 117, 4.90; *Heat of Combustion*: -20.293, -11.274, -472.02; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high vapor concentrations; *Symptoms Following Exposure*: In high vapor concentrations, can act as simple asphyxiant. Liquid causes severe frostbite; *General Treatment for Exposure*: Remove from Exposure, support respiration; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Not pertinent; appreciable hazard. Practically harmless to the skin because is very volatile and evaporates quickly; *Odor Threshold*: 899 ppm.

Ethoxydihydropyran — (i) Chemical Designations — *Synonyms*: 2-Ethoxy-3, 4-dihydro-2H-pyran; *Chemical Formula*: OCH=CHCH$_2$CHOC$_2$H$_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 128.17; *Boiling Point at 1 atm.*: 289, 143, 416; *Freezing Point*: -148, -100, 173; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.875 at 20° (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: (est.) 120, 69, 2.9; *Heat of Combustion*: (est.) -14,000, -7,900, -330; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with liquid irrigates eyes. Also irrigates skin on prolonged contact; *General Treatment for Exposure*: EYES: flush for at least 15 min. SKIN: wipe off; wash well with soap and water. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available;.

Ethoxylated Dodecanol — (i) Chemical Designations — *Synonyms*: Ethoxylated dodecyl alcohol, Ethoxylated lauryl alcohol, Poly(oxyethyl) dodecyl ether, Poly(oxyethyl) lauryl ether, Tergitol Nonionic TMN; *Chemical Formula*: $C_{12}H_{25}O(CH_2CH_2O)_nCH_2$ CH_2OH n=6-10 (average); **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild and pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 450-626; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 61, 16, 289; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.02 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*:(est.) -11,200, -6200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health**

Hazards Information — *Recommended Personal Protective Equipment*: Plastic gloves, goggles; *Symptoms Following Exposure*: Liquid causes eye injury and de-fats the skin, causing irritation; *General Treatment for Exposure*: Flush eyes with water for at least 15 min. Wash skin well with water. Get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; 5 - 15 g/J/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: none; *Liquid or Solid Irritant Characteristics*: Liquid causes injury. Contact with skin may cause irritation; *Odor Threshold*: Not pertinent.

Ethoxylated Nonylphenol — (i) Chemical Designations — *Synonyms*: Not pertinent; common synonyms; *Chemical Formula*: $C_9H_{19}C_6H_4O(C_2H_4O)_nH$; **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid or solid; *Color*: White; *Odor*: Mild aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: >500; *Boiling Point at 1 atm.*: Not pertinent; (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.99 - 1.07 at 25°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves and safety glasses; *Symptoms Following Exposure*: Contact with eyes causes irritation. Prolonged contact with skin causes irritation; *General Treatment for Exposure*: Not pertinent; treatment required for inhalation or ingestion. EYES: flush with copious quantities of tap water for 15 win. and seek appropriate medical attention. SKIN: wash affected areas with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50}=11.310 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ethoxylated Pentadecanol — (i) Chemical Designations — *Synonyms*: Ethoxylated pentadecyl alcohol, Poly(oxyethyl) pentadecyl ether, Terrgitol nonionic 45-S-10; *Chemical Formula*: $C_{13}H_{31}O(CH_2CH_2O)_nCH_2CH_2OH$ n=10 (average); **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 660; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 59, 15, 288; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.007 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -11,000, -6200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves, goggles; *Symptoms Following Exposure*: Liquid causes eye injury and de-fats the skin, causing irritation; *General Treatment for Exposure*: Flush eyes with water for at least 15 min. Wash the skin well with water. Get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Liquid causes eye injury. Contact with skin may cause irritation; *Odor Threshold*: Not pertinent.

Ethoxylated Tetradecanol — (i) Chemical Designations — *Synonyms*: Ethoxylated myristyl alcohol, Ethoxylated tetradecyl alcohol, Poly(oxyethil) myristyl ether, Poly(oxyethil) tetradecyl ether, tergtol Nonionic 45-S-10; *Chemical Formula*: $C_{14}H_{29}O$ (CH2CH2O)n CH2CH2OH n=5 (average); **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 660; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 59, 15, 288; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.007 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -11,000, -6200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves, goggles; *Symptoms Following Exposure*: Liquid causes eye injury and de-fats the skin, causing irritation; *General Treatment for Exposure*: Flush eyes with water for at least 15 min. Wash the skin well with water. Get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid*

Irritant Characteristics: Liquid causes eye injury. Contact with skin may cause irritation; *Odor Threshold*: Not pertinent.

Ethoxylated Tridecanol — (i) Chemical Designations — *Synonyms*: Ethoxylated tridecyl alcohol, Poly(oxyethyl) tridecyl eher, Tergitol 3-A-6 Nonionic; *Chemical Formula*: $C_{13}H_{27}O(CH_2CH_2O)_nCH_2CH_2OH$ n=5 (average); **(ii) Observable Characteristics**— *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 464; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.00 at 15°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -11,000, -6,200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves, goggles; *Symptoms Following Exposure*: Liquid causes eye injury and de-fats the skin, causing irritation; *General Treatment for Exposure*: Flush eyes with water for at least 15 min. Wash the skin well with water. Get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Liquid causes eye injury. Contact with skin may cause irritation; *Odor Threshold*: Not pertinent.

Ethoxy Triglycol — (i) Chemical Designations — *Synonyms*: Dowanol TE, Ethoxylatriethylene glycol, Triethilene glycol monoethyl ether,Triglycol monoethyl ether; *Chemical Formula*: $C_2H_5O(CH_2)_2O(CH_2)_2$. OCH_2CH_2OH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Practically odorless; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 178; *Boiling Point at 1 atm.*: 493, 256, 529; *Freezing Point*: -1.7, -18.7, 254.5; *Critical Temperature*: Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.020 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.033; *Latent Heat of Vaporization*: (est.) 125, 69, 2.9; *Heat of Combustion*: (est.) -11,000, -6,170, -258; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles and adequate protective clothing; *Symptoms Following Exposure*: No appreciable hazard in ordinary handling or use; *General Treatment for Exposure*: Wash affected parts with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Ethyl Acetate — (i) Chemical Designations — *Synonyms*: Acetic acid, ethyl ester, Acetic ester, Acetic ether, Ethyl ethanoate; *Chemical Formula*: $CH_3COOCH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant, fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 88.11; *Boiling Point at 1 atm.*: 171, 77, 350; *Freezing Point*: -117, -83, 190; *Critical Temperature*: 482, 250, 523; *Critical Pressure*: 558, 38, 3.8; *Specific Gravity*: 0.902 at 20°C (liquid); *Vapor (Gas) Density*: 3.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.080; *Latent Heat of Vaporization*: 158, 87.6, 3.67; *Heat of Combustion*: -10,110, -5,616, -235,1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister, or air mask; goggles or face shield; *Symptoms Following Exposure*: Head ache, irritation of respiratory passages and eyes, dizziness and nausea, weakness, loss of consciousness; *General Treatment for Exposure*: INHALATION: if victim is overcome, move him to fresh air immediately and call a physician; if breathing is irregular or stopped, start resuscitation and administer oxygen. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 400 ppm; *Short-Term Exposure Limits*: 1000 ppm for 15 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 1 ppm.

Ethyl Acetoacetate — (i) Chemical Designations — *Synonyms*: Acetoecetic acid, ethyl ester, Acetoacetic ester; Diacetic ether; *Chemical Formula*: $CH_3COCH_2COOC_2H_5$; **(ii) Observable Characteristics**— *Physical State (as*

normally shipped): Liquid; *Color*: Colorless; *Odor*: Agreeable, fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 130.1; *Boiling Point at 1 atm.*: 363, 184, 457; *Freezing Point*: <-112, <-80, <193; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.028 at 20°C (liquid); *Vapor (Gas) Density*: 4.48; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 160, 91, 3.8; *Heat of Combustion*: -9.349, -5.194, -217.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Liquid may cause mild irritation of eyes; *General Treatment for Exposure*: EYES: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 3.980 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ethyl Acrylate — (i) Chemical Designations — *Synonyms*: Acrylic acid, ethyl ester; Ethyl 2-propenoate; *Chemical Formula*: $CH_2{=}CHCOOCH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic acrylic odor; sharp, fragrant; acrid; slightly nauseating; sharp, ester type; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.12; *Boiling Point at 1 atm.*: 211.3, 99.6, 372.8; *Freezing Point*: -98, -72, 201; *Critical Temperature*: 534, 279, 552; *Critical Pressure*: 534, 37, 3.7; *Specific Gravity*: 0.923 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.080; *Latent Heat of Vaporization*: 149, 82.9, 3.47; *Heat of Combustion*: -11,880, -6,600, -276.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister or air-supplied mask; acid goggles; impervious gloves; *Symptoms Following Exposure*: May cause irritation and burns of eyes and skin. Exposure to excessive vapor concentration can also cause drowsiness accompanied by nausea, headache, or extreme irritation of respiratory tract; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and administer artificial respiration, if necessary. SKIN AND EYES: wash for 15 min. with copious quantities of water. Call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Exposure Limits*: 50 ppm for 15 min.; *Toxicity by Ingestion*: 25 ppm; *Late Toxicity*: Repeated Exposure may develop sensitivity; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: causes smarting of the skin and first-degree burns on short Exposure and may cause secondary burns on long Exposure; *Odor Threshold*: 0.00024 ppm.

Ethyl Alcohol — (i) Chemical Designations — *Synonyms*: Alcohol; Cologne sprit; Denatured alcohol; Ethanol; Fermentation alcohol; Grain alcohol; Spirit; Spirits of wine; *Chemical Formula*: C_2H_5OH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; Like wine or whiskey. (Denatured alcohol may be unpleasant); **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 46.07; *Boiling Point at 1 atm.*: 172.9, 78.3, 351.5; *Freezing Point*: -173, -114, 159; *Critical Temperature*: 469.6, 243.1, 516.3; *Critical Pressure*: 926, 63.0, 6.38; *Specific Gravity*: 0.790 at 20°C (liquid); *Vapor (Gas) Density*: 1.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.128; *Latent Heat of Vaporization*: 360, 200, 8.37; *Heat of Combustion*: -11,570, 6,425, -268.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: All-purpose canister; safety goggles. Avoid contact with liquid and irritation of vapors; *Symptoms Following Exposure*: Irritation of eyes, nose and throat. Headache and drowsiness may occur. Liquid causes intoxication; *General Treatment for Exposure*: INHALATION: if breathing is affected, remove victim to the fresh air; call physician; administer oxygen. Speed is of primary importance. EYES OR SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm; *Short-Term Exposure Limits*: 5000 ppm for 15 min.; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: 10 ppm.

Ethylaluminum Dichloride — (i) Chemical Designations — *Synonyms*: Aluminum ethyl dichloride; EADC; *Chemical Formula*: $C_2H_5AlCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light amber; yellow; *Odor*: Not pertinent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular*

Weight: 130.0; *Boiling Point at 1 atm.*: 381, 194, 467; *Freezing Point*: 90, 32, 305; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.227 at 35°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -5,600, -3,100, -130; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full protective clothing, preferably of aluminized glass cloth; goggles, face shield, gloves; in case of fire, all-purpose canister or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation of smoke from fire causes metal-fume fever (flu like symptoms); acid fumes irritate nose and throat. Contact with liquid (wich is not spontaneously flammable) causes severe burns of eyes and skin; *General Treatment for Exposure*: INHALATION: only fumes from fire need be considered; metal-fume fever is not critical and lasts less then 36 hrs; irritation of nose and throat by acid vapors may require treatment by a physician. EYES: flush gently with water for 15 min.; treat burns if fire occurred; get medical attention. SKIN: wash with water; treat burns caused by fire; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Metal-fume fever may develop after breathing smoke from fire; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent.

Ethylamine — (i) Chemical Designations — *Synonyms*: Aminoethane, Monoethylamine; *Chemical Formula*: $C_2H_5NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; strong ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 45.1; *Boiling Point at 1 atm.*: 61.7, 16.5; 289.7; *Freezing Point*: -114, -81, 192; *Critical Temperature*: 361, 183, 456; *Critical Pressure*: 827, 56.2, 5.70; *Specific Gravity*: 0.687 at 15°C (liquid); *Vapor (Gas) Density*: 1.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.1181; *Latent Heat of Vaporization*: 253, 146, 6.11; *Heat of Combustion*: -16,180, -8,990, -376; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Amine-type or ammonia type mask; plastic gloves; face shield and goggles; *Symptoms Following Exposure*: Inhalation causes irritation of respiratory tract and lungs; pulmonary edema may result, liquid causes severe irritation and burn of eyes and skin, and can permanently injure eyes after 15 seconds contact. Ingestion causes severe burns of mouth and stomach; can be fatal; *General Treatment for Exposure*: Get prompt medical attention for anyone overcome or injured by Exposure to this compound. INHALATION: remove victim to fresh air, keep him warm, and administer oxygen until medical help arrives. EYES: wash for 15 min. with water; avoid pressure on eyelids. SKIN: wash with soap and water; do not use ointments for at least 24 hrs; do not cover burned area with dry clothing; keep moist with physiological saline solution. INGESTION: if victim is conscious, give large amount of water, then induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: 25 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} = 400 mg/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short Exposure and may cause second- degree burns on long Exposure; *Odor Threshold*: Data not available.

Ethylbenzene — (i) Chemical Designations — *Synonyms*: EB; Phenylethane; *Chemical Formula*: $C_6H_5CH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 106.17; *Boiling Point at 1 atm.*: 277.2, 136.2, 409.4; *Freezing Point*: -139, -95, 178; *Critical Temperature*: 651.0, 343.9, 617.1; *Critical Pressure*: 523, 35.6, 3.61; *Specific Gravity*: 0.867 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.071; *Latent Heat of Vaporization*: 144, 80.1, 3.35; *Heat of Combustion*: -17,780, -9,877, -413.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; safety goggles; *Symptoms Following Exposure*: Inhalation may cause irritation of nose, dizziness, depression. Moderate irritation of eye with corneal injury possible. Irritates skin and may cause blisters; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, keep him warm, and get medical help promptly; if breathing stops give artificial respiration. INGESTION: induce vomiting only upon physician's approval; material in lung may cause chemical pneumonitis. SKIN AND EYES: wash for 15 min. with water and get medical attention; remove and

wash contaminating clothing before use; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 200 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short Exposure and may cause secondary burns on long Exposure; *Odor Threshold*: 140 ppm.

Ethyl Butanol — (i) Chemical Designations — *Synonyms*: 2-Ethyl-1-butanol; 2-Ethylbutil alcohol; sec-Hexyl alcohol; sec-Pentyl carbinol; Pseudohexyl alcohol; *Chemical Formula*: $(C_2H_5)_2CHCH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild and nonresidual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.17; *Boiling Point at 1 atm.*: 293, 146, 419; *Freezing Point*: -173, -114, 159; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.843 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 196.0, 108.9, 4.559; *Heat of Combustion*: (est.) -16,660, -9,250, -387; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Fresh-air mask; plastic gloves; coverall goggles; safety shower and eye bath; *Symptoms Following Exposure*: Liquid causes eye burn. Vapors may be mildly irritating to nose and throat; *General Treatment for Exposure*: Remove to fresh air. Remove and wash contaminated clothing. Wash affected skin areas with water. Flush eyes with water for 15 min and get medical care; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Irritates eyes; moderate irritation of skin; *Odor Threshold*: Data not available.

Ethyl Butyrate — (i) Chemical Designations — *Synonyms*: Butyric acid, ethyl ester; Butyric ether; Ethyl butanoate; *Chemical Formula*: $CH_3CH_2CH_2COOC_2H_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like apple or pineapple; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.16; *Boiling Point at 1 atm.*: 250, 121, 394; *Freezing Point*: -135, -93, 180; *Critical Temperature*: 559, 293, 566; *Critical Pressure*: 460, 31, 3.2; *Specific Gravity*: 0.879 at 20°C (liquid); *Vapor (Gas) Density*: 4.0; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 128, 71, 3.0; *Heat of Combustion*: -13,200, -7,330, -306; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: All-purpose canister mask or chemical cartridge respirator; glass or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation or ingestion causes headache, dizziness, nausea, vomiting, and narcosis. Contact with liquid irritates eyes; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and call a physician; if breathing stops give artificial respiration. INGESTION: induce vomiting and call a physician. SKIN: wash with water flush with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} = 13 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.015 ppm.

Ethyl Chloride — (i) Chemical Designations — *Synonyms*: Chloretane; Monochloretane; *Chemical Formula*: C_2H_5CL; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Ethereal; pungent, ethereal; ether-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 64.52; *Boiling Point at 1 atm.*: 54.0, 12.2, 285.4; *Freezing Point*: -213, -136; 137; *Critical Temperature*: 369, 187.2, 460.4; *Critical Pressure*: 758, 51.6, 5.23; *Specific Gravity*: 0.906 at 12.2°C (liquid); *Vapor (Gas) Density*: 2.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.155; *Latent Heat of Vaporization*: 163, 90.6, 3.79; *Heat of Combustion*: -8,100, -4,500, -188.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Neoprene rubber clothing where liquid contacts is likely; chemical worker's goggles. RESPIRATORY PROTECTION: for 1000 ppm to 2% for 1/2 hr or less, full face mask and organic vapor canister; for greater levels, self-contained breathing apparatus or equivalent; *Symptoms Following Exposure*: Vapor causes drunkenness, anesthesia, possible lung injury. Liquid may cause frostbite on eyes and skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. Get medical attention. SKIN: treat frostbite;

Toxicity by Inhalation (Threshold Limit Value): 1000 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Ethyl Chloroacetate — (i) Chemical Designations — *Synonyms*: Chloracetic acid, ethyl ester, Ethyl chloracetate; Ethyl chloroethanoate; Monochloracetic acid, ethyl ester; Monochlorethanoic acid, ethyl ester; *Chemical Formula*: $ClCH_2COOC_2H_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; light straw to tan; *Odor*: Extremely irritating; fruity; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 122.6; *Boiling Point at 1 atm.*: 289, 143, 416; *Freezing Point*: -15, -26, 247; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.15 at 20°C (liquid); *Vapor (Gas) Density*: 4.3; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 155, 86, 3.6; *Heat of Combustion*: -7,250, -4,028, 168; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister mask; rubber gloves; chemical goggles; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membrane, headache, and nausea. Contact with liquid causes extreme eye irritation and conjunctivitis; irritates skin if nit removed at once. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove patient to fresh air; get medical attention. EYES: flush with copious quantities of water for at least 15 min.; get medical attention if irritation persists. SKIN: wash with soap and water. INGESTION: give large amount of water and induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} <50 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ethyl Chloroformate — (i) Chemical Designations — *Synonyms*: Chloroformic acid, ethyl ester; Ethyl chlorocarbonate; *Chemical Formula*: $ClCOOC_2H_5$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Irritating; sharp, like hydrochloric acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 108.5; *Boiling Point at 1 atm.*: 201, 94, 367; *Freezing Point*: -114, -81, 192; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.135 at 20°C (liquid); *Vapor (Gas) Density*: 3.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.1044; *Latent Heat of Vaporization*: (est.) 140, 79, 3.3; *Heat of Combustion*: (est.) -6,900, -3,800, -160; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-line mask, self-contained breathing apparatus, or organic and canister mask; full protective clothing; *Symptoms Following Exposure*: Inhalation causes mucous membrane irritation, coughing, and sneezing. Vapor causes acid-type burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove patient to fresh air; if breathing stops give artificial respiration. Call a doctor, keep victim quiet and administer oxygen if needed. EYES: flush with water for at least 15 min.; see a doctor. SKIN: wash liberally with water for at least 15 min., then apply dilute solution of sodium bicarbonate or commercially prepared neutralizer. INGESTION: do NOT induce vomiting; give large amount of water; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} <50 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such the personnel will not usually tolerate moderate or high concentration; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short Exposure and may cause second-degree burns on long Exposure; *Odor Threshold*: Data not available.

Ethyldichlorosilane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $C_2H_5SiHCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, hydrochloric acid-like; acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 129.1; *Boiling Point at 1 atm.*: 165, 74, 347; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.092 at 20°C (liquid); *Vapor (Gas) Density*: 4.5; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: (est.) 104, 57.8, 2.42; *Heat of Combustion*: (est.) -6,500, -3,600, -

150; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation irritates mucous membranes. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: Get medical attention following all Exposures to this compound. INHALATION: remove to fresh air; give artificial respiration if required. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; give large amounts of water, followed by milk or milk of magnesia; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes severe irritation of eyes and throat and canister cause eye and lung injury. They cannot be tolerated even at low concentration; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Ethylene — (i) Chemical Designations — *Synonyms*: Ethene; Olefiant gas; *Chemical Formula*: C_2H_4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Compressed gas or liquefied gas; *Color*: Colorless; *Odor*: Slightly sweet; faint sweet; slight ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 28.05; *Boiling Point at 1 atm.*: -154.7, -103.7, 169.5; *Freezing Point*: -272.4, -169.1, 104.1; *Critical Temperature*: 49.8, 9.9, 283.1; *Critical Pressure*: 742, 50.5, 5.11; *Specific Gravity*: 0.569 at -103.8°C (liquid); *Vapor (Gas) Density*: 1.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.240; *Latent Heat of Vaporization*: 207.7, 115.4, 4.823; *Heat of Combustion*: -20,290, -11,272, -471.94; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister or air-supplied mask; *Symptoms Following Exposure*: Moderate concentration Inhalation air causes drowsiness, dizziness, and unconsciousness. Overexposure causes headache, drowsiness, muscular weakness; *General Treatment for Exposure*: Remove victim to fresh air, give artificial respiration and oxygen if breathing has stopped, and call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Simple asphyxiate; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin, but may cause frostbite; *Odor Threshold*: Data not available.

Ethylene Chlorohydrin — (i) Chemical Designations — *Synonyms*: 2-Chloroethanol; 2-Chlorethanol; 2-Chloroethyl alcohol; Ethylene chlorhydrin; Glycol chlorohydrin; *Chemical Formula*: $ClCH_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Faint, ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 80.51; *Boiling Point at 1 atm.*: 263.7, 128.7, 401.9; *Freezing Point*: -80.7, -62.6, 210.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.197 at 20°C (liquid); *Vapor (Gas) Density*: 2.8; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 221, 123, 5.15; *Heat of Combustion*: -6,487, -3,604, -150.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic mask or self-contained breathing apparatus; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of upper respiratory system, nausea, headache, delirium, coma, collapse. Liquid causes irritation of eyes and skin; prolonged contact with skin may allow penetration into body and cause same symptoms as following ingestion or inhalation. Ingestion causes nausea, headache, delirium, coma, collapse; *General Treatment for Exposure*: INHALATION: remove from Exposure; give artificial respiration if necessary; call physician. EYES: flush with copious amounts of water; call physician if contact has been prolonged. IRRITATION: give large amounts of water; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 71 mg/kg (rat); *Late Toxicity*: Damage to central nervous system and liver Inhalation humans; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ethylene Cyanohydrin — (i) Chemical Designations — *Synonyms*: 2-Cyanoethanol; Glycol cyanohydrin; 1-Hydroxy-2-cyanoethane; Hydracrylonitrile; 3-Hydroxypropanenitrile; *Chemical Formula*: $HOCH_2CH_2CN$; **(ii) Observable Characteristics** —

Physical State (as normally shipped): Liquid; *Color*: Colorless or straw-colored; *Odor*: Practically odorless; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 71.08; *Boiling Point at 1 atm.*: 445.5, 229.7, 502.9; *Freezing Point*: -51.2, -46.2, 227.0; *Critical Temperature*: 804, 429; 702; *Critical Pressure*: 720, 49, 4.9; *Specific Gravity*: 1.047 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask; plastic gloves; rubber clothing; vaporproof goggles; *Symptoms Following Exposure*: Liquid causes eye irritation. If swallowed, may cause severe kidney injury; *General Treatment for Exposure*: INGESTION: induce vomiting at once and call a physician. EYES: wash with flowing water for 15 min. SKIN: flush exposed area with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Ingestion of liquid may cause severe kidney damage; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Ethylenediamine — (i) Chemical Designations — *Synonyms*: 1,2-Diaminoethane; 1,2-Ethanediamine; *Chemical Formula*: $NH_2CH_2CH_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong ammoniacal odor; ammonia-like mild and ammoniacal odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 60.10; *Boiling Point at 1 atm.*: 243, 117, 390; *Freezing Point*: 51.8, 11.0, 284.2; *Critical Temperature*: 608, 320, 593; *Critical Pressure*: 941, 64, 6.4; *Specific Gravity*: 0.909 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.087; *Latent Heat of Vaporization*: 288, 160, 6.70; *Heat of Combustion*: -12.290, -6830, -286.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full rubber protective clothing, inc. gloves and boots; chemical worker's goggles; face shield where contact with face is likely. If necessary to enter closed area for 1/2 hr or less with mist, wear full-faced gas mask with canister approved by Bureau of Standards for use with ammonia; *Symptoms Following Exposure*: High concentration of vapor burns eyes and irritates the nose and throat. Liquid burns eyes and skin; *General Treatment for Exposure*: Get medical help immediately! INGESTION: drink large amounts of water or milk quickly, induce vomiting only if instructed by physician. EYES: flush immediately and thoroughly with flowing water for at least 15 min. SKIN: remove clothing and flush affected area with copious amounts of water, then wash with soap and water; severe Exposure may require showering; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: 20 ppm fo 5 min.; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (female rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors is moderately irritating such that personnel will no usually tolerate moderate or high vapor concentration; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: 10 ppm.

Ethylenediamine Tetracetic Acid — (i) Chemical Designations — *Synonyms*: ETDA; Endrate; Ethylenebis [iminodiacetic acid]; (Ethylenedinitrilo)tetraaceticacid; tetrine acid; Versene acid; *Chemical Formula*: $(HOOCCH_2)_2NCH_2CH_2N(CH_2COOH)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Powder; *Molecular Weight*: 164; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.86 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (as sodium or calcium salt); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Ethylene Dibromide — (i) Chemical Designations — *Synonyms*: Bromofume; 1,2-Dibromoethane; sym-Dibromoethane; Dowfume 40, W-10,W-15, W-40;

Ethylene bromide; Glycol dibromide; *Chemical Formula*: $BrCH_2CH_2Br$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mildly sweet; like chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 187.86; *Boiling Point at 1 atm.*: 268, 131, 404; *Freezing Point*: 49.6, 9.8, 283.0; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.180 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.109; *Latent Heat of Vaporization*: 82.1, 45.6, 1.91; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Canister type mask or self-contained air mask; neoprene gloves; chemical safety goggles; *Symptoms Following Exposure*: Local inflammation, blisters and ulcers on skin; irritation in lungs and organic injury of liver and kidneys; may be absorbed trough skin; *General Treatment for Exposure*: Remove from Exposure. Remove contaminated clothing. Wash skin with soap and water. Flush eyes with plenty of water. Consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: 3 mg/m^3; *Short-Term Exposure Limits*: 50 ppm for 5 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present Inhalation high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Ethylene Dichloride — (i) Chemical Designations — *Synonyms*: Brocide; 1,2-Dichlorethane; Dutch liquid; EDC; Ethylene chloride; Glycol dichloride; *Chemical Formula*: $ClCH_2CH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Ethereal; chloroform-like; ether-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.96; *Boiling Point at 1 atm.*: 182.3, 83.5, 356.7; *Freezing Point*: -32.3, -35.7, 237.5; *Critical Temperature*: 550, 288, 561; *Critical Pressure*: 735, 50, 5.1; *Specific Gravity*: 1.253 at 20°C (liquid); *Vapor (Gas) Density*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.118; *Latent Heat of Vaporization*: 138, 76.4, 3.20; *Heat of Combustion*: (est.) 3,400, 1,900, 80; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Clean, body-covering clothing and safety glasses with side shields. Respiratory protection: up to 50 ppm, none; 50 ppm to 2%, ½ hr or less, full face mask and canister; greater than 2%, self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation of vapors causes nausea, drunkenness, depression. Contact of liquid with eyes may produce corneal injury. Prolonged contact with skin may cause a burn; *General Treatment for Exposure*: INHALATION: if victim is overcome, remove him to fresh air, keep him quiet and warm, and get medical attention immediately; if breathing stops, give artificial respiration. INGESTION: induce vomiting; call a physician; treat the symptoms. EYES: flush immediately with copious amounts of flowing water for 15 min. SKIN: remove clothing and wash skin thoroughly with soap and water; wash contaminated clothing before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 50 ppm; *Short-Term Exposure Limits*: 200 ppm for 5 min. during any 3-hour period; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short Exposure; may cause secondary burns on long Exposure; *Odor Threshold*: 100 ppm.

Ethylene Glycol — (i) Chemical Designations — *Synonyms*: 1,2-Dihydroxyethane; 1,2-Ethanediol; Ethylene dihydrate; Glycol; Monoethylene glycol; *Chemical Formula*: $HOCH_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Slight odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 62.07; *Boiling Point at 1 atm.*: 387.7, 197.6, 470.8; *Freezing Point*: 8.6, -13, 260; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.115 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.095; *Latent Heat of Vaporization*: 344, 191, 8.00; *Heat of Combustion*: -7,259, -4,033, -168.9; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles; shower and eye bath; *Symptoms Following Exposure*: Inhalation of vapors is not hazardous. Ingestion causes stupor or coma, sometimes leading to fatal kidney injury; *General Treatment for Exposure*: INGESTION: induce vomiting and call a physician. SKIN AND EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat, guinea pig, mouse); *Late Toxicity*: Fatal

kidney injury may result if ingested; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Ethylene Glycol Diacetate — (i) Chemical Designations — *Synonyms*: Ethylene acetate; Ethylene diacetate; Glycol diacetate; *Chemical Formula*: CH_3COOCH_2. CH_2OCOCH_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak; fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 146.1; *Boiling Point at 1 atm.*: 375.6, 190.9; 464.1; *Freezing Point*: -42.7, -41.5, 231.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.104 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 133,74, 3.1; *Heat of Combustion*: (est.) -11,000, -6,000, -250; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation is not hazardous. Liquid causes mild irritation of eyes. Ingestion causes stupor or coma; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES AND SKIN: flush well with water. INGESTION: induce vomiting: call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; oral LD_{50} = 6.860 mg/kg (rat); *Late Toxicity*: Ingestion may cause severe injury to kidneys; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to headache skin; *Odor Threshold*: Data not available.

Ethylene Oxide — (i) Chemical Designations — *Synonyms:* 1,2-Epoxyethane Oxirane; *Chemical Formula:* CH_2CH_2O; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Sweet; characteristic ether-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 44,05; *Boiling Point at 1 atm:* 51,1, 10,6, 283,8; *Freezing Point:* -107,7, -112,6, 160,6; *Critical Temperature:* 385, 196, 469; *Critical Pressure:* 1,040, 71,0, 72; *Specific Gravity:* 0,869 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* 1,5; *Ratio of Specific Heats of Vapor (Gas):* 1.212; *Latent Heat of Vaporization:* 249.3, 138.5, 5.799; *Heat of Combustion:* -11,480, -34, -1,4; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information**- *Personal Protective Equipment:* Air-supplied mask; goggles or face shield; rubber shoes and coveralls. *Symptoms Following Exposure:* Exposure to low vapor concentrations often results in delayed nausea and vomiting. Higher concentrations produce irritation of eyes, nose, and throat; high concentrations may cause edema of lungs. Contact with skin causes blistering and burns. *Treatment for Exposure:* INHALATION: leave contaminated area immediately; if nausea and vomiting start, call a physician. SKIN OR EYES: flush immediately with plenty of water for at least 15 min. and seek medical attention. *Toxicity by Inhalation (Threshold Limit Value):* 50 ppm *Short-Term Inhalation Limits:* 200 ppm for 30 min *Toxicity by Ingestion:* Grade 3; oral rat LD_{50}=0.33 g/kg (mouse) *Late Toxicity:* Causes cancer in mice. Effects on humans unknown. *Vapor (Gas) Irritant Characteristics:* Vapor is moderately irritating such hat personnel will not usually tolerate moderate or high vapor concentrating. *Liquid or Solid Irritant Characteristics:* Fairly severe skin irritating; may cause pain and second-degree burns after a few minutes' contact. *Odor Threshold:* 50 ppm.

Ethyl Ether — (i) Chemical Designations — *Synonyms:* Anestithesia Ether; Dietyl Ether; Ethoxyethane; Dietyl Oxide; Sulfuric Ether; *Chemical Formula:* $C_2H_5OC_2H_5$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Sweet, pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 74.12; *Boiling Point at 1 atm:* 94.3, 34.6, 307.8; *Freezing Point:* -177.3, -116.3, 156.9; *Critical Temperature:* 380.3, 193.5, 466.7; *Critical Pressure*: 527, 35.9, 3.64; *Specific Gravity:* 0,714 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* 2,6; *Ratio of Specific Heats of Vapor (Gas):* 1,081; *Latent Heat of Vaporization:* 153, 84.9, 3.56; *Heat of Combustion:* -14,550, -8082, -3384; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information**- *Personal Protective Equipment:* Approved organic vapor canister mask; chemical goggles; synthetic rubber or plastic gloves. *Symptoms Following Exposure:* Vapor inhalation may causes headache, nausea, vomiting, and loss of consciousness. Contact with eyes will be irritating. Skin contact from clothing wet with the chemical may causes burns; *Treatment for Exposure:* INHALATION: remove victim to fresh air; if breathing has stopped, apply artificial respiration; if breathing is irregular, give oxygen; call a physician. EYES: flush immediately with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value):* 400 ppm; *Short-Term Inhalation Limits:* 1000 ppm for 30 min.; *Toxicity by Ingestion:* Grade 2; LD_{50} 0,5 to 5 g/kg

Late Toxicity: None; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin because it is very and evaporates quickly; *Odor Threshold:* 0,83 ppm.

2-Ethyl Hexanol — (i) Chemical Designations — *Synonyms:* 2-Ethyl-1-hexanol; 2-Ethylhexyl alcohol; *Chemical Formula:* $CH_3(CH_2)_3CH(C_2H_5)CH_2OH$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Strong; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 130,23; *Boiling Point at 1 atm:* 564,5, 184,7, 457,9; *Freezing Point:* < 158, < 70, < 343; *Critical Temperature:* 711, 377, 650; *Critical Pressure:* 512, 34.8, 3.53; *Specific Gravity:* 0.834 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 167, 92.8, 3.89; *Heat of Combustion:* -17,480, -9,710, -406.5; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Air pack or organic canister; goggles; rubber gloves. *Symptoms Following Exposure:* Anesthesia, nausea, headache, dizziness; mildly irritating to skin and eyes. *Treatment for Exposure:* INHALATION: move victim to fresh air. SKIN: wash affected areas with water. EYES: flush with water for 15 min. Get medical care. *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 2; LD_{50} 0,5 to 5 g/kg (lab animals); *Late Toxicity:* Increased excitability of central nervous system in rats and rabbits. *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* Data not available.

2-Ethyl-3-propylacrolein — (i) Chemical Designations — *Synonyms:* 2- Ethyl-2-hexenal; 2-Ethyl-3-propylacrylaldehyde; *Chemical Formula:* $CH_3(CH_2)_2CH{=}C(C_2H_5)CHO$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Yellow; *Odor:* sharp, powerful, irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 126,2; *Boiling Point at 1 atm:* 283, 175, 448; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0,857 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* -15,610, -8,670, -363; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Protective clothing; eye protection; approved respirator for high vapor concentrations. *Symptoms Following Exposure:* Vapor is irritating. Contact produces skin and eye irritation. *Treatment for Exposure:* Remove from exposure. Wash affected areas of body with water for 15 min. *Toxicity by Inhalation (Threshold Limit Value):* Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat) *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations. *Liquid or Solid Irritant Characteristics:* Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure. *Odor Threshold:* Data not available.

2-Ethylhexyl Acrylate, Inhibited — (i) Chemical Designations — *Synonyms:* Acrylic Acid, 2-Ethylhexyl Ester; 2- Ethylhexyl 2-Propenoat. *Chemical Formula:* $CH_2{=}CHCOOCH_2CH(C_2H_5)(CH_2)_3CH_3$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Sharp; mild ester-type; inoffensive; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 184,2; *Boiling Point at 1 atm:* (polymerizes) 417, 214, 487; *Freezing Point:* -130, -90, 183; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0,885 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 110, 61, 2.6; *Heat of Combustion:* -15,500, -8000, -360; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Self-contained breathing apparatus; rubber gloves; vapor-proof Chemical safety goggles; impervious apron and boots. *Symptoms Following Exposure:* Inhalation of concentrated vapor drowsiness and convulsions. Liquid causes irrigation of eyes and may irritate skin on prolonged exposure. Ingestion produces same symptoms as inhalation. *Treatment for Exposure:* INHALATION: give artificial respiration and oxygen if necessary; call a physician. EYES: immediately flush with plenty of water for at least 15 min; get medical attention. SKIN: immediately flush with plenty of water for at least 15 min. INGESTION: induce vomiting and consult a physician. *Toxicity by Inhalation (Thresh-*

old Limit Value): Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; oral rat LD_{50} = 1,540 mg/kg *Late Toxicity:* Data not available *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to eyes and throat. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* Data not available.

Ethyl Formate — (i) Chemical Designations — *Synonyms:* Ethyl Formic Ester; Ethyl Methanoate; Formic Acid, Ethyl Ester; Formic Ether; *Chemical Formula:* $HCOOC_2H_5$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Characteristic; pleasant aromatic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 74,1; *Boiling Point at 1 atm:* 129.6, 54.2, 327.4; *Freezing Point:* -110, -79, 194; *Critical Temperature:* 455, 235, 508; *Critical Pressure:* 686, 46.6, 4.73; *Specific Gravity:* 0,922 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* 2,6; *Ratio of Specific Heats of Vapor (Gas):* 1.1014; *Latent Heat of Vaporization:* 176, 98, 4,1; *Heat of Combustion:* -9,500, -5,300, -220; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Organic canister gas mask; goggles or face shield; rubber gloves. *Symptoms Following Exposure:* Inhalation of vapor causes slight irritation of the eyes and rapidly increasing irritation of the nose. High concentrations cause deep narcosis within a few minutes followed by death within a few hours. Contact with liquid causes moderate irritation of eyes and mild irritation of skin. Ingestion causes irritation of mouth and stomach; may cause deep narcosis and death if not treated. *Treatment for Exposure:* INHALATION: removes from exposure; begin artificial respiration if breathing has stopped; call physician. EYES: wash with water for 15 min.; call physician if needed. SKIN: wash with water for 15 min.; call physician if irritation persists. INGESTION: do NOT induce vomiting; get medical attention at once. *Toxicity by Inhalation (Threshold Limit Value):* 100 ppm; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 1,850 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes' contact. *Odor Threshold:* Data not available.

Ethyl Hexyl Tallate — (i) Chemical Designations — *Synonyms:* Croplas EH; *Chemical Formula:* (Mixture); **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Pale yellow; *Odor:* Mild characteristic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* Not pertinent; *Boiling Point at 1 atm:* Very high; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* (est.) 0.95 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) -17,000, -10,000, -400; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Data not available; *Symptoms Following Exposure:* Data not available; *Treatment for Exposure:* Data not available; *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* None; *Liquid or Solid Irritant Characteristics:* None; *Odor Threshold:* Not pertinent.

Ethyl Lactate — (i) Chemical Designations — *Synonyms:* Ethyl Alpha-hydroxy-propionate; Ethyl 2-hydroxypropanoate; Ethyl DL-Lactate; Lactic Acid; Ethyl Ester; *Chemical Formula:* $CH_3CHOHCOOC_2H_5$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild characteristic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 118.1; *Boiling Point at 1 atm:* 309, 154, 427; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1,03 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) -11,600, -6,500, -270; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Goggles or face shield; rubber gloves. *Symptoms Following Exposure:* Inhalation of concentrated vapor may cause drowsiness. Contact with liquid causes mild irritation of eyes and (on prolonged contact) skin. Ingestion may cause narcosis. *Treatment for Exposure:* INHALATION: remove victim to fresh air. EYES and SKIN: flush well with water. INGESTION: induce vomiting; get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 2,580 mg/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant*

Characteristics: Data not available; *Odor Threshold:* Data not available.

Ethyl Mercaptan — (i) Chemical Designations — *Synonyms:* Ethanethiol; Ethyl Sulfhydrate; Mercaptoethane; Thioethyl alcohol; *Chemical Formula:* C_2H_5SH; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless to yellow; *Odor:* Strong chunk; offensive garlic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 62,1; *Boiling Point at 1 atm:* 93,9, 34,4, 307,6; *Freezing Point:* -234, -147, 126; *Critical Temperature:* 439, 226, 499; *Critical Pressure (psia, atm, MN/m²):* 798, 54.2, 5.50; *Specific Gravity:* 0.826 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* 2.1; *Ratio of Specific Heats of Vapor (Gas):* 1.1308 at 16°C; *Latent Heat of Vaporization:* 189, 105, 4,39; *Heat of Combustion:* -15,000, -8,300, -350; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Plastic gloves; goggles or face shield. *Symptoms Following Exposure:* Inhalation of vapor causes muscular weakness, convulsions, respiratory paralysis. High concentrations may cause pulmonary irritation. Liquid irritates eyes and skin. Ingestion causes nausea and irritation of mouth and stomach. *Treatment for Exposure:* INHALATION: move victim to fresh air; if he is unconscious, give artificial respiration and oxygen; get medical attention. EYES: flush with water for at least 15 min. following contact with liquid; get medical attention if irritation persists. SKIN: wash well with water. INGESTION: induce vomiting and follow with gastric lavage; get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* 0.5 ppm *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 682 mg/kg (rat) *Late Toxicity:* May impair respiratory muckle function in warm-blooded experimental animals *Vapor (Gas) Irritant Characteristics:* Data not available *Liquid or Solid Irritant Characteristics:* Data not available *Odor Threshold:* 0.001 ppm.

Ethyl Methacrylate — (i) Chemical Designations — *Synonyms:* Ethyl 2-methacrylate; Ethyl Methacrylate-inhibited; Ethyl Alphamethylmethacrylate; Ethyl 2-methyl-2-propenoate; Methacrylic Acid, Ethyl Ester; *Chemical Formula:* $CH_2 = C(CH_3)COOC_2H_5$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Acrid acrylic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 114; *Boiling Point at 1 atm:* 243, 117, 390; *Freezing Point:* <-58, <-50, <223; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0,9151 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* 3.9; *Ratio of Specific Heats of Vapor (Gas):* 1.064; *Latent Heat of Vaporization:* 170, 96, 4.0; *Heat of Combustion:* -12,670, -7,040, -294; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Impervious gloves; splash goggles; self-contained breathing apparatus if exposed to vapors; coveralls. *Symptoms Following Exposure:* Inhalation may cause irritation of the mucous membrane. Ingestion causes irritation of mouth and stomach. Contact with liquid irritates eyes and skin. *Treatment for Exposure:* INHALATION: remove victim to fresh air; apply artificial respiration and oxygen if indicated. INGESTION: induce vomiting; call a physician. EYES: wash with copious quantities of water for 15 min.; call a physician. SKIN: flush with water; wash with soap and water *Toxicity by Inhalation (Threshold Limit Value):* Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 4 g/kg (rabbit) *Late Toxicity:* Causes birth defects in experimental animals *Vapor (Gas) Irritant Characteristics:* Data not available *Liquid or Solid Irritant Characteristics:* Data not available *Odor Threshold:* Data not available.

Ethyl Nitrite- (i) Chemical Designations — *Synonyms:* Nitrous ether; Spirit of ether nitrite; Sweet spirit of nitre *Chemical Formula:* C_2H_5ONO; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless to pale yellow; *Odor:* Aromatic; ethereal; characteristic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 75,1; *Boiling Point at 1 atm:* 63, 17, 290; *Freezing Point:* -58, -50, 223; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.900 at 15°C (liquid); *Vapor (Gas) Specific Gravity:* 2.6; *Ratio of Specific Heats of Vapor (Gas):* Data not available; *Latent Heat of Vaporization:* 229, 127, 5.32; *Heat of Combustion:* (est.) -7,800, -4,300, -180; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Self-contained breathing apparatus; goggles or face shield; rubber gloves. *Symptoms Following Exposure:* Inhalation or ingestion causes headache, increased pulse rate, decreased blood pressure, and unconsciousness. Contact with liquid irritates eyes and skin; *Treatment for Exposure:* INHALATION: remove victim from exposure; if breathing has stopped, give artificial respiration; call physician. EYES: flush with water, wash with soap and water. INGESTION: do not induce vomiting; call physician. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not avail-

able; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl Phosphorodichloridate — (i) Chemical Designations — *Synonyms:* Ethyl Dichlorophosphate; Phosphorodichloridic Acid; Ethyl Ester; *Chemical Formula:* $Cl_2(OC_2H_5)PO$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Acrid, choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 162.9; *Boiling Point at 1 atm:* 333, 167, 440; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 135 at 19°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) -4,700, -2,600, -110; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Goggles and face shield; self-contained or air-line respirator; rubber gloves, boots, and clothing. *Symptoms Following Exposure:* Inhalation of vapor irritates nose throat. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach. *Treatment for Exposure:* INHALATION: remove victim from exposure; if his breathing has stopped, start artificial respiration, call a doctor. EYES: flush with water for at least 15 min; get medical attention for burns. SKIN: flush with water; get medical attention for burns. INGESTION: do NOT induce vomiting; give large amounts of water, followed by milk or milk of magnesia. *Toxicity by Inhalation (Threshold Limit Value):* Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethylene Glycol Diethyl Ether — (i) Chemical Designations — *Synonyms:* Diethyl «Cellosolve»; 1,2-Diethoxyethane; *Chemical Formula:* $C_2H_5OCH_2CH_2OC_2H_5$; **(ii) Observable Characteristics** — *Physical State (as shipped):*Liquid; *Color:* Colorless; *Odor:* Faint, ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 118,2; *Boiling Point at 1 atm:* 252, 122, 395; *Freezing Point:* -101, -74, 199; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.8484 at 20°C; *Vapor (Gas) Specific Gravity:* 4.1; *Ratio of Specific Heats of Vapor (Gas):* 1.0504; *Latent Heat of Vaporization:* 192, 107, 4.48; *Heat of Combustion:* (est.) -15,000, -8,000, -340; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Protective goggles or face shield; rubber gloves. *Symptoms Following Exposure:* Inhalation causes irritation of nose and throat. Contact with liquid irritates eyes but has little or no effect on skin. Ingestion causes irritation of mouth and stomach. *Treatment for Exposure:* INHALATION: remove from exposure. EYES: flush with water for at least 15 min. SKIN: wash with copious amounts of water. INGESTION: drink water and get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 4.390 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethylene Glycol Dimethyl Ether — (i) Chemical Designations — *Synonyms:* Ansul Ether 121; 1,2- Dimethoxyethane; Dimethyl Cellosolve; Monoglyme; *Chemical Formula:* $CH_3OCH_2CH_2OCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild etheral; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 90.12; *Boiling Point at 1 atm:* 185.4, 85.2, 358.4; *Freezing Point:* -92, -69, 204; *Critical Temperature:* 505, 263, 536; *Critical Pressure:* 561, 38.2, 3.87; *Specific Gravity:* 0.868 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* 3.1; *Ratio of Specific Heats of Vapor (Gas):* 1.071; *Latent Heat of Vaporization:* 134, 74.6, 3.12; *Heat of Combustion:* -12,020, -6,680, -279.7; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Vinyl (not rubber) protective gloves; safety grasses or goggles. *Symptoms Following Exposure:* In ingested causes nausea, vomiting, cramps, weakness, coma. *Treatment for Exposure:* INHALATION: oxygen and artificial respiration as needed. INGESTION: gastric lavage with water or water-mineral oil. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 1; LD_{50} 5 to 15 g/kg (adult albino rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* None; *Liquid or Solid Irritant Characteristics:* None; *Odor Threshold:* Data not available.

Ethylene Glycol Monobutyl Ether Acetate — (i) Chemical Designations — *Synonyms:* 2-Butoxyethanol Acetate; 2-Butoxyethyl Acetate; Butyl «Cellosolve» Acetate; Glycol Monobutyl Ether Acetate; *Chemical Formula:* $n\text{-}C_4H_9OCH_2CH_2OCOCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Weak; fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 160.21; *Boiling Point at 1 atm:* 378.0, 192.2, 465.4; *Freezing Point:* -82.3, -63.5, 209.7: Critical Temperature: Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.942 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 157, 87.1, 3.65; *Heat of Combustion:* -13,890, -7,720, -323; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Goggles or face shield; rubber gloves. *Symptoms Following Exposure:* Inhalation of concentrated vapor may cause headache, nausea, dizziness. Liquid causes irritation of skin. Ingestion produces same symptoms as inhalation. *Treatment for Exposure:* INHALATION: remove to fresh air. EYES: flush thoroughly with water for at least 15 min. SKIN: flush thoroughly with water. INGESTION: induce vomiting; get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 3,200 mg/kg (mouse); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethylene Glycol Monobutyl Ether — (i) Chemical Designations — *Synonyms:* 2-Butoxyethanol Butyl Cellosolve Dovonol EB Glycol Butyl Ether Poly-Solv EB; *Chemical Formula:* $CH_3(CH_2)_3OCH_2CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild, characteristic; slightly rancid; mild ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 118.18; *Boiling Point at 1 atm:* 340.2, 171.2, 444.4; *Freezing Point:* -103, -75, 198; *Critical Temperature:* 694, 368, 641; *Critical Pressure:* 470, 32, 3.2; *Specific Gravity:* 0.902 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.047 *Latent Heat of Vaporization:* 157, 87.1, 3.65; *Heat of Combustion:* -13,890, -7,720, -323; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Air pack or organic canister respirator; rubber gloves; goggles; clothing to prevent body contact with liquid. *Symptoms Following Exposure:* Vapors irritate eyes and nose. Ingestion or skin contact causes headache, nausea, vomiting, dizziness. *Treatment for Exposure:* INHALATION: remove to fresh air and call a physician. SKIN OR EYES: immediately flush with plenty of water; get medical care for eyes. *Toxicity by Inhalation (Threshold Limit Value):* 50 ppm *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat) *Late Toxicity:* Data not available *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* Data not available.

Ethylene Glycol Monoethyl Ether Acetate — (i) Chemical Designations — *Synonyms:* Cellosolve acetate 2-Ethoxyethanol; Acetate 2-Ethoxyethyl; Acetate Glycol Monoethyl Ether Acetate; Poly-Solv EE acetate; *Chemical Formula:* CHOCHCHOCOCH; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild, pleasant; ester-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 132,16; *Boiling Point at 1 atm:* 313, 156, 429; *Freezing Point:* -79.1, -61.7, 211.5; *Critical Temperature:* 633, 34, 607; *Critical Pressure:* 440, 30, 3.0; *Specific Gravity:* 0.974 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.054; *Latent Heat of Vaporization:* 130, 74, 3.1; *Heat of Combustion:* -10,700, -6,000, -250; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Chemical safety goggles; *Symptoms Following Exposure:* Vapors irritate nose and eyes in high concentrations. Liquid irritates skin in prolonged or repeated contact. *Treatment for Exposure:* INHALATION: if victim is overcome, remove hit to fresh air and call physician. EYES: flush find large amounts of water. SKIN: wash exposed areas. *Toxicity by Inhalation (Threshold Limit Value):* 100 ppm *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; = LD_{50} 05 to 5 g/kg (rabbit); *Late Toxicity:* Causes kidney damage in laboratory animals. *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes and respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* 0.056 ppm.

Ethylene Glycol Monoethyl Ether — (i) Chemical Designations — *Synonyms:* Cellosolve; Dowanol EE; 2-Ethoxyethanol; Ethylene Glycol Ethyl Ether; Glycol Monoethyl ether; Poli-Solv EE; *Chemical Formula:* $HOCH_2CH_2OCH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Sweetish; mild, pleasant, ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 90.12; *Boiling Point at 1 atm:* 275.2, 135.1, 408.3; *Freezing Point:* Data not available; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.931 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.064; *Latent Heat of Vaporization:* 191, 106, 4.44; *Heat of Combustion:* -13,000, -7,4000, -310; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Organic das mask; goggles or face shield; rubber gloves. *Symptoms Following Exposure:* Some eye irritation. Inhalation of vapors causes irritation of nose. *Treatment for Exposure:* Flush eyes with water for 15 min. Flush skin with large volumes of water. Call a physician. *Toxicity by Inhalation (Threshold Limit Value):* 200 ppm; *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat, rabbit) *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on chopping and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* Data not available.

Ethylene Glycol Monomethyl Ether — (i) Chemical Designations — *Synonyms:* Dovanol EM; Glycol Monomethyl Ether; 2-Methoxyethanol Methyl Cellosolve; Poly-Solv EM; *Chemical Formula:* $CH_3OCH_2CH_2ON$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 76.10; *Boiling Point at 1 atm:* 256.1, 124.5, 397.7; *Freezing Point:* -121.2, -85.1, 188.1; *Critical Temperature:* 558, 292, 565; *Critical Pressure:* 735, 50, 5.1; *Specific Gravity:* 0.966 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.079; *Latent Heat of Vaporization:* 223, 124.5, 19; *Heat of Combustion:* No data; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* Chemical safety goggles; protective clothing; supplied-air respirator for high concentrations; safety shower and eye bath. *Symptoms Following Exposure:* Irritation of skin and eyes. Chronic exposure may also cause weakness, sleepiness, headache, gastrointestinal upset, weight loss, change of personality. *Treatment for Exposure:* SKIN OR EYES: wash affected area with water for 15 min. *Toxicity by Inhalation (Threshold Limit Value):* 25 ppm *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat, rabbit, guinea pig); *Late Toxicity:* Causes blood disorders and damage to central nervous system in humans. *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* 0.9 ppm.

Ethyleneimine — (i) Chemical Designations — *Synonyms:* Azirane; Aziridine; *Chemical Formula:* CH_2CH_2NH; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Fishy; ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 43.07; *Boiling Point at 1 atm:* 133, 56, 329; *Freezing Point:* -108, -78, 195; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0,832 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* 1.5; *Ratio of Specific Heats of Vapor (Gas):* 1.192; *Latent Heat of Vaporization:* 333, 185, 7.75; *Heat of Combustion:* -15,930, -8,850, -370.5; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Personal Protective Equipment:* If exposure is possible, wear full clothing (neoprene slicker suit, rubber boots, rubber gloves, chemical goggles). If vapors may be present, wear all purpose canister or gas mask; if vapors are known to be present, use self-contained breathing apparatus. *Symptoms Following Exposure:* Material gives inadequate warning of overexposure by respiration or skin contact. May cause vomiting and possibly death when inhaled, ingested, or absorbed through skin. Severe blistering agent; can produce third-degree chemical burns of skin. Has corrosive effect on mucous membranes and may cause scaring of esophagus if swallowed. Corrosive to eye tissue; may cause permanent corneal opacity and conjunctival scarring. Effects on eye tissue, and skin may be delayed. *Treatment for Exposure:* INHALATION: remove victim from exposure and administer oxygen; steroid therapy (by physician) is recommended. SKIN OR EYES: prompt and adequate irrigation with water (within 60 seconds of exposure) can prevent serious injury. *Toxicity by Inhalation (Threshold Limit Value):* Data not

available *Short-Term Inhalation Limits:* 5 ppm for 30 min *Toxicity by Ingestion:* Grade 4; LD below 50 mg/kg (rat) *Late Toxicity:* Causes cancer in mice. Effects on man unknown. *Vapor (Gas) Irritant Characteristics:* Vapor is moderately irritating such that personnel will not usually tolerate moderate or high concentrations.

Ethylhexaldehyde — (i) Chemical Designations — *Synonyms:* Butylethylacetaldehyde; 2-Ethylcaoroaldehyde; 2-Ethylhexaldehyde; 2-Ethylhexanal; Octyl aldehyde; *Chemical Formula:* $C_4H_9CH(C_2H_5)CHO$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild, characteristic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 128.22; *Boiling Point at 1 atm:* 327, 164, 437; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.820 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 164, 91.2, 3.82; *Heat of Combustion:* -15,860, -8,810, -369; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Rubber gloves; safety goggles or face shield; *Symptoms Following Exposure:* Inhalation may be irritating to mucous membrane; overexposure may cause dizziness and collapse. Ingestion causes irritation of mouth and stomach. Contact with eyes or skin causes irritation. *Treatment for Exposure:* INHALATION: remove victim to fresh air; give oxygen if breathing is difficult; call a doctor. EYES: irrigate immediately for 15 min., then get medical attention. SKIN: flush with water; wash with soap and water. *Toxicity by Inhalation (Threshold Limit Value):* Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 2; oral rat LD_{50} = 3,730 mg/kg *Late Toxicity:* Data not available *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary *Liquid or Solid Irritant Characteristics:* Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure. *Odor Threshold:* Data not available.

Ethylidenenorbornene — (i) Chemical Designations — *Synonyms:* 5-Ethylidenebicyclo(2,2.1)hept-2-ene; Etehylidenenorbornylene; Ethylidenenorcamphene; *Chemical Formula:* C_9H_{12}; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Like turpentine; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 120.2; *Boiling Point at 1 atm:* 297.7, 147.6, 420.8; *Freezing Point:* -112, -80, 193; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.896 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* 4.1; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Data not available; *Heat of Combustion:* (est.) -18,800, -10,450, -437; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Organic canister or air-supplied mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure:* Inhalation of vapors causes headache, confusion, and respiratory distress. Ingestion causes irritation of entire digestive system. Aspiration causes severe pneumonia. Contact with liquid causes irritation of eyes and skin. *Treatment for Exposure:* INHALATION: remove victim to fresh air; administer artificial respiration and oxygen if required; call a doctor. INGESTION: dive large amount of water and induce vomiting; get medical attention at once. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 2.83 g/kg (rat); *Late Toxicity:* Causes kidney lesions and gain in kidney and liver weights in rats; *Vapor (Gas) Irritant Characteristics:* Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin. *Odor Threshold:* 0.007 ppm.

Ethylphenyldichlorosilane — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* $C_2H_5)(C_6H_5)SiCl_2$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Sharp, like hydroshlorice acid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 205.1; *Boiling Point at 1 atm:* >300, >149, >422; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1.159 at 15°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 103, 57, 2.4; *Heat of Combustion:* (est.) -9,900, -5,500, -230; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Personal Protective Equipment:* Acid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other equipment as necessary to protect skin and eyes. *Symptoms Following Exposure:* Inhalation irritates nose

and throat. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach. *Treatment for Exposure:* INHALATION: remove victim to fresh air; give artificial respiration if needed; call physician. EYES: flush with water for 15 min; obtain medical attention immediately. SKIN: flush with water; obtain medical attention if burning has occurred. INGESTION: if victim is conscious, give large amounts of water, then induce vomiting; get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 3; LD_{50} 50 to 500 mg/kg *Late Toxicity:* Data not available *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Severe skin irritant. Causes second-and third-degree burns on short contact and is very injurious to the eyes. *Odor Threshold:* Data not available.

Ethyl-Monochloroacetic Acid — (i) Chemical Designations — *Synonyms:* Chloracetic acid; Chloracetic acid; *Chemical Formula:* $ClCH_2COOH$; **(ii) Observable Characteristics** — *Physical State (as shipped):*Liquid or Solid; *Color:* Solid: translucent white; Liquid: clear to light amber; *Odor:* Characteristic penetrating odor similar to vinegar; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 94.5; *Boiling Point at 1 atm:* 372, 189, 462; *Freezing Point:* 140, 60, 333; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.58 at 20°C (Solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 250, 139, 5.82; *Heat of Combustion:* (Solid) - 1,814, -1,008, -42.17; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Self-contained breathing apparatus; vinyl or neoprene rubber gloves; goggles and protective face shield; rubberized or acid-resistant clothing *Symptoms Following Exposure:* Inhalation causes mucous membrane irritation. Contact with liquid causes irritation and burns of the eyes and irritation and burns of skin. Ingestion causes burns of mouth and stomach. *Treatment for Exposure:* Get medical attention for all exposures to this compound. INHALATION: Remove victim to fresh air and enforce rest until medical attention is obtained. EYES: flush with running water for 15 min. SKIN: flush with water, get treatment for burns. INGESTION: Give large amount of water. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; oral LD_{50}=76.2 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause severe irritation of eyes and throat and can cause eye lung injury. They cannot be tolerated even at low concentrations. *Liquid or Solid Irritant Characteristics:* Severe skin irritation. Causes second- and third-degree burns on short contract and is very injurious to the eyes. *Odor Threshold:* 0.15 mg/m^3.

Ethyl-Monochlorodifluoromethane — (i) Chemical Designations — *Synonyms:* Chlorodifluoromethane; Eskimon-22; Genetron 22; F-22; Isotron 22; Freon-22; Uconn 22; *Chemical Formula:* $CHClF_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):*Liquefied gas; *Color:* Colorless; *Odor:* Faint ethereal; like carbon tetrachloride; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 86.48; *Boiling Point at 1 atm:* 40.9, -40.5, 232.7; *Freezing Point:* Not pertinent; *Critical Temperature:* 204.8, 96.0, 369.2; *Critical Pressure:* 716, 48.7, 4.93; *Specific Gravity*: 1.41 at -40 °C (liquid); *Vapor (Gas) Specific Gravity:* 3.0; *Ratio of Specific Heats of Vapor (Gas):* (est)1.13; *Latent Heat of Vaporization:* 101, 55.9, 2.34; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Rubber gloves; goggles. *Symptoms Following Exposure:* Inhalation at greater than 10% concentration in air may cause narcosis. Liquid may cause frostbite. *Treatment for Exposure:* Remove victim to non-contaminated area and apply artificial respiration if breathing has stopped. Calla a physician immediately. Oxygen inhalation may be utilized. *Toxicity by Inhalation (Threshold Limit Value):* 1000 ppm *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Not pertinent *Late Toxicity:* None *Vapor (Gas) Irritant Characteristics:* Vapors care nonirritation to the eyes and throat. *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin because it evaporates quickly. Liquid may cause frostbite. *Odor Threshold:* Data not available.

Ethyl-Monoethanolamine — (i) Chemical Designations — *Synonyms:* 2-Aminoethanol; beta-Aminoethyl Alcohol; Ethanolamine 2-Hydroxyethylamine; *Chemical Formula:* $HOCH_2CH_2NH_2$ **(ii) Observable Characteristics** — *Physical State (as shipped):*Liquid; *Color:* Colorless; *Odor:* Mildly ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 61.08; *Boiling Point at 1*

atm: 338, 170, 443; *Freezing Point:* 50.5, 10.3, 283.5; *Critical Temperature:* 646, 341, 614; *Critical Pressure:* 647, 44, 4.45; *Specific Gravity*: 1.016 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 360, 200, 8.37; *Heat of Combustion:* -10,710, -5950, -249; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Full face shield; goggles; eye wash facility. *Symptoms Following Exposure:* Vapor irritates eyes and nose. Liquid causes local injury to mouth, throat, digestive tract, skin, and eyes. *Treatment for Exposure:* INGESTION: induce vomiting by giving large volumes of warm salt water (2 tablespoons per glass); call a doctor. EYES: flush with water for at least 15 min.; call a doctor. SKIN: flush with water. *Toxicity by Inhalation (Threshold Limit Value):* 3 ppm *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure. *Odor Threshold:* Data not available.

Ethyl-Monoisopropanolamine — (i) Chemical Designations — *Synonyms:* 1-Amino-2-propanol; 2-Hydroxypropylamine; Isopropanolamine; *Chemical Formula:* $CH_3CH(OH)CH_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mildly ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 75.11; *Boiling Point at 1 atm:* 320, 160, 433; *Freezing Point:* 35.4, 1.9, 275.1; *Critical Temperature:* 622, 328, 601; *Critical Pressure:* 850, 58, 5.9; *Specific Gravity*: 0.961 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 272, 151, 6.32; *Heat of Combustion:* (est.) -13,900, -7,700, -322; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Full face shield; goggles; eye wash facility. *Symptoms Following Exposure:* Vapor irritates eyes and nose. Liquid causes local injury to mouth, throat, digestive tract, skin, and eyes. *Treatment for Exposure:* INGESTION: Induce vomiting by giving large volumes of warm salt water (2 tablespoons per glass); call a doctor. EYES: flush with water for at least 15 min.; call a doctor. SKIN: flush with water. *Toxicity by Inhalation (Threshold Limit Value):* 5 ppm; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Causes smarting of the skin and first-degree burns on short exposure and may cause secondary burns on long exposure. *Odor Threshold:* Data not available.

Ethyl-Morpholine — (i) Chemical Designations — *Synonyms:* Diethyleneimide Oxide; Diethylene Imidoxide; Diethylene Oximide; Tetrahydro-2H-1,4-oxazine; Tetrahydro-p-oxazine; *Chemical Formula:* $OCH_2CH_2NHCH_2CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Fishy; ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 87.12; *Boiling Point at 1 atm:* 262, 128.2, 401.4; *Freezing Point:* 23.4, -4.8, 268.4; *Critical Temperature:* 653, 345, 618; *Critical Pressure:* 794, 54, 5.47; *Specific Gravity*: 1.00 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* (est.) 1.091; *Latent Heat of Vaporization:* 182.9, 101.6, 4.254; *Heat of Combustion:* Data not available; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*.Organic vapor canister or self-contained breathing apparatus; rubber boots and gloves; goggles or face shield. *Symptoms Following Exposure:* Liquid causes skin and eye burns. Breathing vapors or absorption through skin may cause nausea and headache. *Treatment for Exposure:* INHALATION: if ill effects occur, move patient to fresh air, keep him quiet and warm, and call a physician; if breathing stops, start artificial respiration. INGESTION: . force milk or water, then immediately induce vomiting; treat symptomatically; no known antidote. SKIN OR EYES: immediately flush with plenty of water for at least 15 min.; for eyes get medical attention promptly. *Toxicity by Inhalation (Threshold Limit Value):* 20 ppm *Short-Term Inhalation Limits:* 20 ppm for 15 min. *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (guinea pig, rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary. *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin. *Odor Threshold:* 0.01 ppm.

Ethyl-Naphtha: Nitrilotriacetic Acid and Salts — (i) Chemical Designations — *Synonyms:* Disodium nitrilotriacetate; NTA; Triglycine; Trisodium nitrilotriacetate; *Chemical Formula:* $C_6H_6O_6NNa_3$, $C_6H_7O_6NNa_2$, $C_6H_9O_6N$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid *Color:* White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid *Molecular Weight:* Acid 191; Disodium 253; Trisodium 275; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*. Dust mask; rubber gloves; chemical safety goggles; *Treatment for Exposure:* EYES: flush with plenty of water; treat as mild alkaline irritation with boric acid solution; if eyes are irritated, get medical attention. SKIN: flush with plenty of water. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available. *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg; Disodium Grade 2; LD_{50} 1.2 g/kg (rat). *Late Toxicity:* Data not available. *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-NABAM — (i) Chemical Designations — *Synonyms:* Chem Bam; Disodium Ethylenebis [dithiocarbamate]; Dithane; EBDC, Sodium Salt; Ethylenebis [dithiocarbamic acid], Dicodium salt; *Chemical Formula:* $C_4H_6N_2S_4Na_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):*Solid, or 22% solution in water; *Color:* Colorless to yellow-amber; *Odor:* Slight sulfide; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 256.3; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: > 1.14 at 20°C (Solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Dust mask; self-contained breathing apparatus if compound is hot; goggles; rubber gloves. *Symptoms Following Exposure:* Contact with liquid irritates eyes and may cause mild to severe erythema of skin as well as sensitization reactions. *Treatment for Exposure:* INHALATION: Remove to fresh air;. administer artificial respiration and oxygen, if indicated. EYES flush with copious quantities of water for 15 min.; call a physician. SKIN: wash thoroughly with soap and water, INGESTION: induce vomiting and follow with gastric lavage; get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available *Short-Term Inhalation Limits:* Data not available *Toxicity by Ingestion:* Grade 3; oral LD_{50}= 395 mg/kg (rat); *Late Toxicity:* Degrades to ethylene thiourea, which may affect thyroid gland of animals. *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nitric Acid — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* HNO_3-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Acrid; sweet to acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* Not pertinent; *Boiling Point at 1 atm*: 192.0, 88.9, 362.1; *Freezing Point*: -50, -45.6, 227.6; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.49 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* (est.) 1.248; *Latent Heat of Vaporization:* 214, 119, 4.98; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*Air mask; rubber acid suit, hood, boots and gloves; chemical goggles; safety shower and eye bath. *Treatment for Exposure:* INHALATION: remove to fresh air, administer artificial respiration if required. INGESTION: drink large volumes of water; do NOT induce vomiting. SKIN OR EYES: flush with water for at least 15 min. *Toxicity by Inhalation (Threshold Limit Value):* 2 ppm *Short-Term Inhalation Limits:* 15 ppm for 5 min. *Toxicity by Ingestion:* Grade 3; LD_{50} 50 to 500 mg/kg *Late Toxicity:* None *Vapor (Gas) Irritant Characteristics:* 58-68%; Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations. 95% Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations. *Liquid or Solid Irritant Characteristics:* Severe skin irritant. Causes second- and third-degree burns on short contract and is very injurious to the eyes. *Odor Threshold:* Data not available.

Ethyl-Naphtha: 4-Nitroaniline — (i) Chemical Designations — *Synonyms:* 1-Amino-4nitrobenzene; Azoic Diazo Component-37; Fast Red 2G baze; Fast Red GG baze; p-Nitraniline; p-Nitroaniline; PNA; *Chemical Formula:* 1,4-$C_6H_4NO_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Yellow; *Odor:* Faint ammonia; slightly pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 138.1; *Boiling Point at 1 atm:* 636, 336, 609; *Freezing Point:* 295, 146, 419; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.44 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* - 9,920, -5,510, -231; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*. Bu. Mines dust canister; rubber gloves; chemical safety goggles; face shield; rubber safety shoes. *Treatment for Exposure:* INHALATION: remove victim to fresh air; administer oxygen if required; get medical attention. INGESTION: induce vomiting; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water, wash with soap and water; be sure that no compound remains in the hair or under the fingernails. *Toxicity by Inhalation (Threshold Limit Value):* 1 ppm *Short-Term Inhalation Limits:* Data not available. *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-1-Naphthylamine — (i) Chemical Designations — *Synonyms:* 1-Amino Naphthalene; Alpha-Naphthylamine; *Chemical Formula:* 1-$C_{10}H_7NH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Tan to brown; darkens on storage; *Odor:* Characteristic amine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 143.2; *Boiling Point at 1 atm:* 572, 300, 573; *Freezing Point:* 118 - 122, 48 - 50, 321 - 323; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.12 at 25°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* -15,290, -8,495, -355.4; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Complete protection for respiratory system, eyes, and skin; *Treatment for Exposure:* Persons undergoing severe exposure to this compound should have continuing medical attention for possible development of cancer. INHALATION: obtain with soap and water. INGESTION: get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} =779 mg/kg (rat), 4,000 mg/kg (mammal); *Late Toxicity:* Considered cancer-producing, particularly since it may contain up to 0.5% of 2-naphthylamine. *Vapor (Gas) Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nickel Ammonium Sulfate — (i) Chemical Designations — *Synonyms:* Ammonium Disulfatonickelate (II); Ammonium nickel sulfate; Nickel Ammonium sulfate hexahydrate; *Chemical Formula:* $NiSO_4(NH_4)_2SO_4 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Dark blue-green; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 395.00; *Boiling Point at 1 atm:* Not pertinent(decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.92 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Bu. Mines approved respiration; rubber gloves; face shield or safety goggles; protective clothing. *Treatment for Exposure:* INHALATION: move to fresh air; get medical attention if exposure has been severe. INGESTION: give large amount of water. EYES: flush with water for at least 15 min.; get medical attention if irritation persists. SKIN: wash with soap and water. *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3 (as nickel). *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg. *Late Toxicity:* Possible lung cancer; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nickel Bromide — (i) Chemical Designations — *Synonyms:* Nickel Bromide Trihydrate; *Chemical Formula:* $NiBr_2 \cdot 3H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Yellowish-green; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 272.6; *Boiling Point at 1*

atm: Not pertinent(decomposes); *Freezing Point* - Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: (est.) 4 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) - Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Bu. Mines approved respiration; rubber gloves; face shield or safety goggles; protective clothing. *Treatment for Exposure:* INHALATION: move to fresh air; get medical attention if exposure has been severe. INGESTION: give large amount of water. EYES: flush with water for at least 15 min.; get medical attention if irritation persists. SKIN: wash with soap and water. *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3 (as nickel). *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg. *Late Toxicity:* Possible lung cancer; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nickel Chloride — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* $Ni(CN)_2 \cdot nH_2O$ n=0,2,3,4; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Anhydrous: pale green; *Odor:* Weak characteristic cyanide; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* Mixture; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 2.4 at 25°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*.Dust mask; rubber gloves; goggles. *Treatment for Exposure:* Get medical help; first-aid treatment must be prompt; the compound is much less soluble than sodium or potassium cyanides, but cyanide poisoning is a possibility. EYES or SKIN: flush with water, avoid getting solution in mouth. INGESTION: start artificial respiration if breathing has stopped; inhalation of amyl nitrite and intravenous doses of sodium nitrite and sodium thiosulfate should be administered by physician. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* 5 mg/m^3 for 30 min. (as cyanide); *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nicotine Sulfate — (i) Chemical Designations — *Synonyms:* Black Leaf 40 (40% water solution); Neutral nicotine sulfate; *Chemical Formula:* $(C_{10}H_{14}N_2)_2 \cdot H_2SO_4$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Solid is off-white to yellow tan; darkens on exposure to light. Water solution may be colorless; *Odor:* Solid is odorless; water solution has odor of tobacco; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 422.5; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.15 at 20°C (Solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent *Heat of Combustion:* Not pertinent *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*. Dust mask, rubber gloves; *Treatment for Exposure:* EYES: flush with water; SKIN: wash thoroughly and immediately with water; INGESTION: call for medical aid; induce immediate and repeated vomiting; perform gastric lavage with dilute (1:10,000) solution of potassium permanganate or activated charcoal in water or milk; apply artificial respiration if breathing has stopped; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; oral LD_{50} = 55 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Not pertinent.

Ethyl-Naphtha: Coal Tar — (i) Chemical Designations — *Synonyms:* Mixture of benzene, toluene, and xylenes; *Chemical Formula:* Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless to pale yellow; *Odor:* Like benzene, toluene, and xylene; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm:* Liquid; *Molecular Weight:* Not pertinent; *Boiling Point at 1 atm:* 200 - 500, 93 - 260, 366 - 533; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* 794, 54, 5.47; *Specific Gravity*: 0.86 - 0.88 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Data not available; *Ratio of Specific Heats of Vapor (Gas):* (est.)

1.030; *Latent Heat of Vaporization:* (est.) 101, 56.2, 2.35; *Heat of Combustion:* (est.) -18,200, -10,100, -424; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Hydrocarbon vapor canister or air pack; plastic gloves; goggles or face shield; *Treatment for Exposure:* Remove from exposure. Support respiration. Call physician; *Toxicity by Inhalation (Threshold Limit Value):* 100 ppm; *Short-Term Inhalation Limits:* 75 ppm for 30 min; *Toxicity by Ingestion:* Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity:* Leukemia; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* 4.68 ppm.

Ethyl-Naphtha: Nickel Fluoroborate — (i) Chemical Designations — *Synonyms:* Nickel (II) fluoborate; Nickel fluoborate solution; *Chemical Formula:* $NiCl_2 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Clear, green; *Odor:* Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* Mixture; *Boiling Point at 1 atm:* Not pertinent; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1.5 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Safety glasses and face shield; rubber gloves; rubber apron; *Treatment for Exposure:* INGESTION: give large amount of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water. *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3 (as nickel); *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity:* Possible lung cancer *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nickel Formate — (i) Chemical Designations — *Synonyms:* Nickel formate dihydrate; *Chemical Formula:* $Ni(HCO_2)_2 \cdot 2H_2O$ **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Greenish; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 184.8; *Boiling Point at 1 atm:* Not pertinent; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 2.15 at 20 °C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Bu. Mines approved respirator; rubber gloves; face shield or safety goggles; protective clothing; *Treatment for Exposure:* INHALATION: move to fresh air; get medical attention if exposure has been severe; INGESTION: give large amount of water; EYES: flush with water for at least 15 min.; SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3 (as nickel); *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity:* Possible lung cancer; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Neohexane — (i) Chemical Designations — *Synonyms:* 2,2-Dimethylbutane; *Chemical Formula:* $CH_3C(CH_3)_2CH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 86.2; *Boiling Point at 1 atm:* 121.5, 49.7, 322; *Freezing Point:* -147.8, -99.9, 173.3; *Critical Temperature:* 420.1, 215.6, 488.8; *Critical Pressure:* 447, 30.4, 3.08; *Specific Gravity:* 0.649 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* 3.0; *Ratio of Specific Heats of Vapor (Gas):* 1.064 at 16 °C; *Latent Heat of Vaporization:* 131, 72.9, 3.05; *Heat of Combustion:* (est.) - 19,310, -10,730, -448.9; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Air-supplied apparatus or organic vapor cartridge; goggles or face shield; rubber gloves; *Treatment for Exposure:* INHALATION: remove from exposure; if breathing has stopped, begin artificial respiration; call a physician; EYES: flush with water for 15 min.; call physician if needed; SKIN: flush well with water, then wash with soap and water; INGESTION: do not induce vomiting; guard against aspiration into lungs; call a doctor; ASPIRATION: enforce bed rest; give oxygen; get medical attention. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Inges-*

tion: Data not available; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nicotine — (i) Chemical Designations — *Synonyms:* 1-Methyl-2-(3-pyridyl) Pyrrolidine; 3-(1-Methyl-2-pyrrolidyl) Pyridine; *Chemical Formula:* $C_{10}H_{14}N_2$; **(ii) Observable Characteristics** - *Physical State (as shipped):* Liquid; *Color:* Colorless to brown; *Odor:* Fishy; develops apyridine or tobacco-like odor on exposure to air; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 162.2; *Boiling Point at 1 atm:* (decomposes) 482, 250, 523; *Freezing Point*: Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.016 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* -15,836, -8,798, -368.1; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Goggles or face shield; rubber gloves; protective clothing; *Treatment for Exposure:* Speed of treatment is important following exposure to this compound. Ingestion of as little as 40 mg can be fatal; EYES: flush with water for at least 15 min.; SKIN: wash thoroughly and immediately with cold water; INGESTION: call for physician at once; give 6 - 8 tablespoons of activated charcoal as a slurry in water, give artificial respiration if breathing has stopped; *Toxicity by Inhalation (Threshold Limit Value):* 0.5 mg/m^3; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 4; oral LD_{50} = 53 mg/kg (rat), 1 mg/kg (human); *Late Toxicity:* Birth defects (skeletal) in rats; *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics:* No appreciable hazard; Practically harmless to the skin; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nickel Acetate — (i) Chemical Designations — *Synonyms:* Acetic Acid, Nickel (2+)salt; Nickel Acetate Tetrahydrate; Nickelous Acetate; *Chemical Formula:* $Ni(C_2H_3O_2)_2{\cdot}4H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Dull green; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 248.86; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.74 at 20 °C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Bu. Mines approved respiration; rubber gloves; safety goggles; protective clothing; *Treatment for Exposure:* INHALATION: remove to fresh air; get medical attention if exposure has been severe; INGESTION: give large amount of water; EYES: flush with water 15 min.; consult physician if irritation persists; SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3 (as nickel); *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg. *Late Toxicity:* Possible lung cancer. *Vapor (Gas) Irritant Characteristics:* Data not available. *Liquid or Solid Irritant Characteristics:* Data not available. *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nickel Carbonyl — (i) Chemical Designations — *Synonyms:* Nickel Tetracarbonyl; *Chemical Formula:* $Ni(CO)_4$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless or yellow; *Odor:* Musty; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 170.7; *Boiling Point at 1 atm:* 109, 43, 316; *Freezing Point:* -13, -25, 248; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.322 at 17°C (liquid); *Vapor (Gas) Specific Gravity:* 5.9; *Ratio of Specific Heats of Vapor (Gas):* Data not available; *Latent Heat of Vaporization:* 72, 40, 1.7; *Heat of Combustion:* -2,970, -1,650, -69.0; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Self-contained breathing apparatus; complete protective clothing. *Treatment for Exposure:* Medical help must be obtained following all exposures to vapor or liquid. INHALATION: oral administration of sodium diethyldithiocarbamate trihydrate (Dithiocarb); complete bed rest and positive-pressure oxygen are indicated for pulmonary edema; treatmentotherwise is symptomatic; EYES: flush with water for at least 15 min.; SKIN: wipe off, wash with soap and water; INGESTION: do not induce vomiting; *Toxicity by Inhalation (Threshold Limit Value):* 0.001 ppm.; *Short-Term Inhalation Limits:* 0.04 ppm for 5 min.; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* May produce cancer; *Vapor (Gas) Irritant Characteristics:* Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics:* Severe skin irritant.

Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold:* 1 - 3 ppm.

Ethyl-Naphtha: Nickel Sulfate — (i) Chemical Designations — *Synonyms:* Nickelous Sulfate; *Chemical Formula:* $NiCO_4$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Pale green; *Odor:* Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 154.78; *Boiling Point at 1 atm:* Decomposes; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 3.68 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Goggles; gloves; *Treatment for Exposure:* Wash all affected parts with plenty of water; *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Nose and lung cancer; *Vapor (Gas) Irritant Characteristics:* None; *Liquid or Solid Irritant Characteristics:* Repeated contact can cause dermatitis; *Odor Threshold:* Not pertinent.

Ethyl-Nitromethane — (i) Chemical Designations — *Synonyms:* Nitrocarbol; *Chemical Formula:* CH_3NO_2; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Fairly strong characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 61.04; *Boiling Point at 1 atm:* 214.2, 101.2, 374.4; *Freezing Point:* -20, -29, 244; *Critical Temperature:* 599, 315, 588; *Critical Pressure:* 915.8, 62.3, 6.311; Specific Gravity: 1.139 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.172; *Latent Heat of Vaporization:* 241, 134, 5.61; *Heat of Combustion:* -4531, -2517, -105.4; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Air mask (do NOT use organic canister); goggles; *Toxicity by Inhalation (Threshold Limit Value):* 100 ppm *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin; *Odor Threshold:* Less than 200 ppm.

Ethyl-Naphtha: Nickel Formate — (i) Chemical Designations — *Synonyms:* Nickel Nitrate Hexahydrate; *Chemical Formula:* $Ni(NO_3)_2 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Greenish; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 290.8; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 2.05 at 20 °C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Bu. Mines approved respirator; rubber gloves; face shield or safety goggles; protective clothing; *Treatment for Exposure:* INHALATION: move to fresh air; get medical attention if exposure has been severe; INGESTION: give large amount of water. EYES: flush with water for at least 15 min.; SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* 1 mg/m^3 (as nickel); *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity:* Possible lung cancer; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nitrogen Tetroxide — (i) Chemical Designations — *Synonyms:* Dinitrogen Tetroxide; Nitrogen Peroxide; Nitrogen Dioxide; Oxides of Nitrogen; Red Oxide of Nitrogen; *Chemical Formula:* N_2O_4; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Red-brown at ambient temperatures; colorless below about 14 °F; *Odor:* Pungent, acrid, mildly irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid or gas; *Molecular Weight:* 92.02; *Boiling Point at 1 atm:* 70.1, 21.2, 294; *Freezing Point:* 11.8, -11.2, 262; *Critical Temperature:* 317.0, 158.2, 431.4; *Critical Pressure:* 1470, 100, 10.1; *Specific Gravity:* 1.45 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* 3.2; *Ratio of Specific Heats of Vapor (Gas):* (est) 1.262; *Latent Heat of Vaporization:* 178, 99.1, 4.15; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Rubber gloves; safety goggles and face shield; protective cloth-

ing; acid gas canister respirator self-contained breathing apparatus; *Treatment for Exposure:* INHALATION: remove patient to fresh air and have him breathe as deeply as possible; call a doctor; enforce complete rest for 24 - 48 hours; keep warm; give oxygen if coughing starts; physician may administer morphine (10 mg.); EYES AND SKIN: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value):* 5 ppm; *Short-Term Inhalation Limits:* 25 pmm for 5 min.; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics:* Severe skin irritant. Cause second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold:* 5 ppm.

Ethyl-Naphtha: Stoddard Solvent — (i) Chemical Designations — *Synonyms:* Drycleaners' Naphtha Petroleum Solvent; Spotting Naphtha; *Chemical Formula:* Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* Not pertinent; *Boiling Point at 1 atm:* 320 - 390, 160 - 199, 433 - 472; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 0.78 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Data not available; *Ratio of Specific Heats of Vapor (Gas):* (est.) 1.030; *Latent Heat of Vaporization:* 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion:* (est.) -18,200, -10,100, -424; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Goggles or face shield (as for gasoline); *Treatment for Exposure:* INHALATION: remove patient from exposure; treat symptoms; INGESTION: do NOT induce vomiting! Call a doctor; EYES: flush with water for 15 min.; SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value):* 200 ppm; *Short-Term Inhalation Limits:* 500 ppm for 30 min.; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Solvent — (i) Chemical Designations — *Synonyms:* Light Naphtha Petroleum Solvent; *Chemical Formula:* Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped):*Liquid; *Color:* Colorless; *Odor:* Like kerosine and gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* Not pertinent; *Boiling Point at 1 atm:* 266 - 311, 130 - 155, 403 - 428; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 0.85 - 0.87 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* (est.) 1.030; *Latent Heat of Vaporization:* 130 -150, 71 - 81, 3.0 - 3.4; *Heat of Combustion:* (est.) - 18,200, -10,100, -424; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Goggles or face shield (as for gasoline); *Treatment for Exposure:* INHALATION: remove to fresh air; treat symptoms; INGESTION: do NOT induce vomiting; call a doctor; EYES: flush with water for 15 min.; SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value):* 200 ppm; *Short-Term Inhalation Limits:* 500 ppm for 30 min.; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* Data not available.

Ethyl-Naphtha: 2-Nitroaniline — (i) Chemical Designations — *Synonyms:* 1-Amino-2-nitrobenzene; Azoic Diazo Component 6; o-Nitraniline; o-Nitroaniline; ONA; *Chemical Formula:* $1,2\text{-}C_6H_4NO_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Orange; *Odor:* Musty; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 138.1; *Boiling Point at 1 atm:* 543, 284, 557; *Freezing Point:* 160, 71, 344; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity*: 1.44 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* - 10,000, -5,550, -232; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Self-contained breathing apparatus, neoprene gauntlets; safety goggles; rubber or neoprene sealed-tongue work shoes and apron; close-weave cotton coveralls capable of closing at wrist and ankle; *Treatment for Exposure:* INHALATION: remove victim to fresh air; administer oxygen if required; get medical attention; INGESTION: induce

vomiting; get medical attention; EYES: flush with water for at least 15 min.; SKIN: flush with water, wash with soap and water, be sure that no solid remains under fingernails or in hair; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 - 5 g/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nitrobenzene — (i) Chemical Designations — *Synonyms:* Essence of Mirbane; Nitrobenzol Oil of Mirbane; *Chemical Formula:* $C_6H_5NO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Light greenish-yellow; *Odor:* Like paste shoe polish; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 123.11; *Boiling Point at 1 atm:* 411.6, 210.9, 484.1; *Freezing Point:* 41.2, 5.1, 278.3; *Critical Temperature:* 836, 447, 720; *Critical Pressure:* 700, 47.62, 4.824; *Specific Gravity:* 1.204 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 150, 85, 3.6; *Heat of Combustion:* -10,420, -5,791, -242.5; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Respirator for organic vapors; rubber gloves; splash proof goggles; eyewash fountain, safety shower and medical oxygen supply; *Treatment for Exposure:* Remove to fresh air and call a physician at once. In case of contract, immediately flush skin or eyes with plenty of water for at least 15 min. If cyanosis (blue discoloration) is present, shower with soap and warm water, with special attention to scalp and fingernails. Administer oxygen until physician arrives; *Toxicity by Inhalation (Threshold Limit Value):* 1 ppm; *Short-Term Inhalation Limits:* 10 ppm for 30 min.; *Toxicity by Ingestion:* Grade 3; 50 - 500 mg/kg (dog); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics:* Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold:* 5.94 ppm.

Ethyl-Naphtha: Nitroethane — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* $CH_3CH_2NO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild, fruity; somewhat disagreeable, chloroform-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 75.07; *Boiling Point at 1 atm:* 237, 114, 387; *Freezing Point:* -130, -90, 183; *Critical Temperature:* Data not available; *Critical Pressure:* Data not available; *Specific Gravity:* 1.05 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* 2.6; *Ratio of Specific Heats of Vapor (Gas):* (est) 1.115 at 20°C; *Latent Heat of Vaporization:* 211, 117, 4.90; *Heat of Combustion:* -7,720, -4,290, -179; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Supplied air or self-contained respirator; goggles or face shield; rubber gloves; *Treatment for Exposure:* INHALATION: in case of pulmonary symptoms, give bed rest and oxygen; obtain medical attention at once; INGESTION: give large amount of water; EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* 100 ppm; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50}= 860 mg/kg (mouse); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentration unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold:* 163 ppm.

Ethyl-Naphthenic Acids — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* $R_2C\text{-}CR\text{-}CR_2\text{-}CR_2\text{-}CR\text{-}(CH_2)n\text{-}COOH$, where n=2-6; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colden to black; *Odor:* Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 200 - 250 (mixture); *Boiling Point at 1 atm:* 270 - 470, 132 - 243, 405 - 516; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.982 at 20°C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Data not available; *Heat of Combustion:* Data not available; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Safety glasses or face mask; *Treatment for Exposure:* INHALATION: remove to fresh air; INGESTION: give large amounts of water; EYES: flush immediately with plenty of water for at least with water until irritation subsides; SKIN: wash with soap and water; remove contaminated clothing and launder before reuse; *Toxicity by Inhalation (Threshold Limit*

Value): 10 mg/m^3; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} =3,000 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nitralin — (i) Chemical Designations — *Synonyms:* 4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline; Planavin; *Chemical Formula:* $C_{13}H_{19}N_3O_6S$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Light yellow to orange; *Odor:* Mild chemical; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 345.2; *Boiling Point at 1 atm:* (decomposes) >437, >225, >498; *Freezing Point:* 304, 151, 424; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* (est.) >1 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Data not available; *Heat of Decomposition:* -450, -250, -10.5; **(iv) Health Hazards** — *Personal Protective Equipment:* Dust mask, rubber gloves; *Treatment for Exposure:* No cases of clinical toxicity on record. Supportive and symptomatic medical treatment recommended if massive; EYES: flush with water; SKIN: wash thoroughly and immediately with water; INGESTION: call for medical aid; induce immedialate and repeated vomiting; perform gastric lavage with dilute (1:10,000) solution of potassium permanganate or activated charcoal in water or milk; apply artificial respiration if breathing has stopped; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; oral LD_{50} = 55 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Not pertinent.

Ethyl-Naphtha: Coal Tar — (i) Chemical Designations — *Synonyms:* Naphthalin Tar Camphor; *Chemical Formula:* $C_{10}H_8$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Coal tar; moth balis; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 128.18; *Boiling Point at 1 atm:* 424, 218, 491; *Freezing Point* 176.4, 80.2, 353.4; *Critical Temperature:* 887.4, 475.2, 748.4; *Critical Pressure:* 588, 40.0, 4.05; *Specific Gravity:* 1.145 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* (est.) 1.068; *Latent Heat of Vaporization:* 145, 80.7, 3.38; *Heat of Combustion:* -16,720, -9287, -388.8; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* U.S. Bureau of Mines approved organic vapor canister unit (USBM Type B); rubber gloves; chemical safety goggles; face shield; coveralls and/or rubber apron; rubber shoes or boots; *Treatment for Exposure:* INHALATION: remove to fresh air; SKIN OR EYES: flush immediately with plenty of water for at least 15 min.; remove contaminated clothing immediately; call a physician; *Toxicity by Inhalation (Threshold Limit Value):* 10 ppm; *Short-Term Inhalation Limits:* 15 ppm for 5 min.; *Toxicity by Ingestion:* Grade 2; oral rat LD_{50}=1780 mg/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Not liquid can cause severe burn. The solid may irritate the skin; *Odor Threshold:* Data not available.

Ethyl-Naphtha: 2-Nitrophenol — (i) Chemical Designations — *Synonyms:* 2-Hydroxynitrobenzene o-Nitrophenol; ONP; *Chemical Formula:* 1,2-$HOC_6H_4NO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Yellow; *Odor:* Peculiar aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 139.1; *Boiling Point at 1 atm:* 417, 214, 487; *Freezing Point:* 111, 44, 313; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1.49 at 20°C (solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* -8,910, -4,950, -207; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*. Self-contained breathing apparatus for fumes; rubber gloves; goggles; *Treatment for Exposure:* INHALATION or INGESTION: remove victim to fresh air; give artificial respiration; call a doctor if symptoms persist.EYES: flush with water for at least 15 min., get medical attention. SKIN: clean thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50} = 1,297 mg/kg (rat); *Late Toxicity:* Data not avail-

able; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nitric Oxide — (i) Chemical Designations — *Synonyms:* Mononitrogen Monoxide; Nitrogen Monoxide; *Chemical Formula:* NO; **(ii) Observable Characteristics** — *Physical State (as shipped):* Compressed gas; *Color:* Colorless, but becomes red-brown on contact with air because of formation of nitrogen tetroxide; *Odor:* (nitrogen tetroxide) - pungent, acrid, mildly irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 30.0; *Boiling Point at 1 atm:* -241.1, -151.7, 121.5; *Freezing Point* -262.5, -163.6, 109.6; *Critical Temperature:* 847, 453, 180; *Critical Pressure:* 940, 64, 6.5; *Specific Gravity:* Not pertinent; *Vapor (Gas) Specific Gravity:* 1.6 (nitrogen dioxide); *Ratio of Specific Heats of Vapor (Gas):* 1.400 at 15 °C; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:*. Self-contained breathing apparatus or gas mask with universal canister; *Treatment for Exposure:* Get medical attention at once following inhalation of this gas. INHALATION: if breathing has stopped, give artificial respiration with 100% oxygen; keep victim quiet and warm; keep head and chest lower than hips, to aid in drainage from lungs; alert physician to possibility of delayed pulmonary edema during 6-24 hours; *Toxicity by Inhalation (Threshold Limit Value):* 25 ppm; *Short-Term Inhalation Limits:* 100 ppm: 60 min.; 150 ppm: 30 min.; 200 ppm: 5 min.; *Toxicity by Ingestion:* Not pertinent (gas at normal temperatures); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Naphtha: VM & P — (i) Chemical Designations — *Synonyms:* Light Naphtha; Painter's Naphtha; Petroleum Solvent; *Chemical Formula:* Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped):*Liquid; *Color:* Colorless; *Odor:* Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* Not pertinent; *Boiling Point at 1 atm:* 200 - 300, 93 - 149, 366 - 422; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.75 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* Data not available; *Ratio of Specific Heats of Vapor (Gas):* (est.) 1.030; *Latent Heat of Vaporization:* 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion::* (est.) -18,200, -10,100, -424; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Goggles or face shield (as for gasoline); *Treatment for Exposure:* INHALATION: maintain respiration if required. INGESTION: do NOT induce vomiting; observe for pneumonia; support if central nervous system depression occurs. ASPIRATION: enforce rest; administer oxygen; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* 500 ppm for 30 min.; *Toxicity by Ingestion:* Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* Data not available.

Ethyl-Naphtha: Nitrogen, Liquefied — (i) Chemical Designations — *Synonyms:* Liquid nitrogen; *Chemical Formula:* N_2; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid gas; *Color:* Colorless to faint yellow; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 28.0; *Boiling Point at 1 atm:* -320.1, -195.6, 77.6; *Freezing Point:* -354, -215, -58; *Critical Temperature:* -232.6, -147.0, -126.2; *Critical Pressure:* 494, 33.5, 3.40; *Specific Gravity:* 0.807 at -195.5, (liquid); *Vapor (Gas) Specific Gravity:* 0.965; *Ratio of Specific Heats of Vapor (Gas):* 1.3962; *Latent Heat of Vaporization:* 95, 53, 2.2; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Safety glasses or face shield; insulated gloves; long sleeves; trousers worn outside boots or over high-top shoes to shed spilled liquid; self-contained breathing apparatus where insufficient air is present; *Treatment for Exposure:* INHALATION: remove to fresh air; apply artificial respiration if breathing has stopped; call physician. EYES: treat for frostbite burns caused by liquid SKIN: treat for frostbite; soak in lukewarm water; *Toxicity by Inhalation (Threshold Limit Value):* Non-toxic 100 ppm; *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Not pertinent; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* None; *Liquid or Solid Irritant Characteristics:* Frostbite; *Odor Threshold:* Not pertinent.

Ethylphenyldichlorosilane — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* $(C_2H_5)(C_6H_5)SiCl_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Sharp, like hydrochloric acid; **(iii) Physical and Chemical Properties** - *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 205,1; *Boiling Point at 1 atm:* >300, >149, >422; *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1,159 at 15 °C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 103, 57, 2,4; *Heat of Combustion:* (est.) -9,900, -5,500, -230; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** - *Personal Protective Equipment:* Acid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other equipment as necessary to protect skin and eyes; *Symptoms Following Exposure:* Inhalation irritates nose and throat. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *Treatment for Exposure:* INHALATION: remove victim to fresh air; give artificial respiration if needed; call physician. EYES: flush with water for 15 min.; obtain medical attention immediately. SKIN: flush with water; obtain medical attention if burning has occurred. INGESTION: if victim is conscious, give large amounts of water, then induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Severe skin irritant. Causes second-and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold:* Data not available.

Ethyl Phosphonothioic Dichloride, Anhydrous — (i) Chemical Designations — *Synonyms:* Ethyl phosphorodichloridothionate; Ethyl thionophosphonyl dichloride; *Chemical Formula:* $CH_3CH_2PSCl_2$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Acrid and choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 163; *Boiling Point at 1 atm:* 342, 172, 445; *Freezing Point:* <-58, <-50, <223; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1,35 at 20 °C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* -7,700, -4,280, -179; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Air mask; rubber or neoprene gloves; vapor-tight goggles; *Symptoms Following Exposure:* Inhalation of vapor causes pulmonary and eye irritation; effects on lungs may be delayed 24 hours; very similar to phosgene poisoning. Contact with liquid causes painful irritation of eyes and lachrymation; also causes severe irritation and possible damage to skin. Ingestion causes severe irritation of mouth and stomach; *Treatment for Exposure:* INHALATION: remove victim from exposure; oxygen can be used for pulmonary symptoms with decongestants; enforce complete rest, because effect may be delayed 24 hours; similar to phosgene poisoning. EYES: flush thoroughly with water and seek medical attention; apply Pontocaine drops (½%) and cortisone ointment (1%). SKIN: wash throughly with soap and water. INGESTION: give large amounts of water; induce vomiting; get medical attention; enforce rest for 24-36 hours; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0,5 to 5 g/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Zirconium Oxychloride — (i) Chemical Designations — *Synonyms:* Basic Zirconium Chloride; Zirconium Oxide Chloride; Zirconium Oxychloride Hydrate; Zirconyl Chloride; *Chemical Formula:* $ZrOCl_2 \cdot 8H_2O$ **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* Yellow to white; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 322.3; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure* Not pertinent; *Specific Gravity:* >1 at 20°C (Solid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Safety glasses or face shield; protective gloves; dust mask; *Symptoms Following Exposure:* Has only a mild pharmacological action. Inhalation of dust may irritate nose and throat. Contact

with eyes or skin causes irritation; *Treatment for Exposure:* INHALATION: move to fresh air; INGESTION: give large amount of water; EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* 5 mg/m^3 (as zirconium); *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50}= 3.5 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Ethyl-Zirconium Sulfate — (i) Chemical Designations — *Synonyms:* Disulfatozirconic Acid; Zirconium Sulfate Tetrahydrate; *Chemical Formula:* $Zr(SO_4)_2 \cdot 4H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped):* Solid; *Color:* White; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 355.4; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 3.0 at 20°C; *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure:* Has only pharmacological action. Inhalation of dust may irritate nose and throat. Contact with eyes or skin causes irritation; *Treatment for Exposure:* INHALATION: move to fresh air. INGESTION: give large amount of water. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* 5 mg/m^3 (as zirconium); *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; oral LD_{50}= 3.5 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

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Ferric Ammonium Citrate — (i) Chemical Designations — *Synonyms*: Ammonium ferric citrate, Ferric ammonium citrate (brown), Ferric ammonium citrate (green); *Chemical Formula*: Mixture of $FeC_6H_5O_7$, $(NH_4)_2HC_6H_5O_7$, and water of hydration; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Red, green, or brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent (mixture); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.8 at 20, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved respirator for nuisance dust, chemical goggles or face shield; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of mouth and stomach. Dust irritates eyes and causes mild irritation of skin on prolonged contact; *General Treatment for Exposure*: INGESTION: give large amount of water. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferric Ammonium Oxalate — (i) Chemical Designations — *Synonyms*: Ammonium ferric oxalate trihydrate, ammonium trioxalatoferrate trihydrate; *Chemical Formula*: $Fe(NH_4)_3(C_2O_4)_3 \cdot 3H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Yellowish-green; *Odor*: Slight burnt sugar odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 428; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.78 at 20, solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust respirator, rubber or plastic-coated gloves, chemical goggles or face shield; *Symptoms Following Exposure*: Inhalation of dust may cause irritation of nose and throat. Ingestion causes burning pain in throat and stomach; mucous membranes become white; may also cause vomiting, weak pulse, cardiovascular collapse, and death. Contact with dust irritates eyes and skin; may cause severe skin burns; *General Treatment for Expo-*

sure: (treat victim promptly) INHALATION: move to fresh air; get medical attention if any symptoms persist. INGESTION: give immediately a dilute solution of any soluble calcium salt such as calcium lactate, lime water, chalk, or milk; induce vomiting; get medical attention. (Watch for edema of the glottis and delayed constriction of esophagus.) EYES: flush with water and get medical attention. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferric Chloride — (i) Chemical Designations — *Synonyms*: Ferric Chloride (anhydrous), Ferric Chloride (hexahydrate), Iron (III) chloride, Iron perchloride, Iron trichloride; *Chemical Formula*: $FeCl_3$ or $FeCl_3 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Anhydrous: greenish black, Hidrate: brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 162.22 (anhydrous); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.8 at 20 °C, (anhydrous solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator if required, rubber apron and boots, chemical worker's goggles or face shield; *Symptoms Following Exposure*: Inhalation of dust may irritation nose and throat. Ingestion causes irritation of mouth and stomach. Dust irritates eyes. Prolonged contact with skin causes irritation and burns; *General Treatment for Exposure*: INGESTION: give large amounts of water; induce vomiting if large amounts have been swallowed. EYES: immediately flush with plenty of water for at least 15 min.; get medical attention promptly. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5—5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferric Glycerophosphate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: (approx.) $Fe_2[C_3H_5(OH)_2PO_4]_3 \cdot H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Greenish-brown, greenish-yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 470 (approx.); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.5 at 20 C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield, dust mask, rubber gloves; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Contact with dust irritates eyes and (on prolonged contact) skin; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting if large amounts have been swallowed. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Ferric Nitrate — (i) Chemical Designations — *Synonyms*: Ferric nitrate monahydrate, Nitric acid, iron (+3) salt; *Chemical Formula*: $Fe(NO_3)_3 \cdot 9H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Green, colorless to pale violet; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 404.02; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 117, 47, 320; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.7 at 20, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of

mouth and stomach. Dust irritates eyes and can irritate skin on prolonged contact; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water; induce vomiting if large amounts have been swallowed. EYES: flush with water; get medical attention if irritation persist. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferric Sulfate — (i) Chemical Designations — *Synonyms*: Iron sesquisulfate, Iron (III) sulfate, Iron tersulfate; *Chemical Formula*: $Fe_2(SO_4)_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Gray-white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 399.88; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.1 at 20 °C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of mouth and stomach. Dust irritates eyes and can irritate skin on prolonged contact; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting if large amounts have been swallowed. EYES: flush with water; get medical attention if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferrous Ammonium Sulfate — (i) Chemical Designations — *Synonyms*: Ammonium ferrous sulfate, Ammonium iron sulfate, Ferrous ammonium sulfate hexahydrate, Iron ammonium sulfate, Mohr's salt; *Chemical Formula*: $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Pate bluish-green; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 392.16; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.86 at 20 °C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of mouth and stomach. Dust irritates eyes and can irritate skin on prolonged contact; *General Treatment for Exposure*: INGESTION: give large amount of water; induce vomiting if large amounts have been swallowed. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg (rat); *Late Toxicity*: May cause eye degeneration in rabbits; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferrous Chloride — (i) Chemical Designations — *Synonyms*: Ferrous chloride tetrahydrate, Iron dichloride, Iron protochloride; *Chemical Formula*: $FeCl_2 \cdot 4H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Pale green; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 198; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.93 at 20, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of mouth and stomach. Dust irritates eyes and may cause skin irritation on prolonged contact; *General Treatment for Exposure*: INHA-

LATION: move to fresh air. INGESTION: if large amounts are swallowed, promptly induce vomiting and get medical help. EYES: flush with plenty of water for at least 15 min.; get medical help promptly if ill effect develop. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Grade 2, LD_{50} 0.5 - 5 g/kg (rat); *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferrous Fluoroborate — (i) Chemical Designations — *Synonyms*: Ferrous borofluoride; *Chemical Formula*: $Fe(BF_4)_2$-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow-green; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 229.5 (solute only); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) >1.1 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Ingestion causes irritation of mouth and stomach. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INGESTION: give large amount of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3 (as iron); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferrous Oxalate — (i) Chemical Designations — *Synonyms*: Ferrous oxalate dihydrate, Ferrox, Iron protoxalate, Oxalic acid (ferrous salt); *Chemical Formula*: $FeC_2O_4 \cdot 2H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Pate yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 179.9; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.3 at 20 °C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust may cause irritation of nose and throat. Ingestion causes burning pain in throat and stomach; mucous membranes turn white; can also cause vomiting, weak pulse, collapse, and death. Dust irritates eyes and may irritate skin on prolonged contact; *General Treatment for Exposure*: (must be prompt) INHALATION: move to fresh air; get medical attention if any symptoms persist. INGESTION: give immediately by mouth a dilute solution of any soluble calcium salt (calcium lactate, lime water, chalk solution, or even milk); large amounts of calcium are required; give gastric lavage with dilute lime water; consult physician. Watch for edema of the glottis and constriction of esophagus. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Ferrous Sulfate — (i) Chemical Designations — *Synonyms*: Copperas, Green vitriol, Iron(ous) sulfate, Iron vitriol; *Chemical Formula*: $FeSO_4 \cdot 7H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Green; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 169.96; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.90 at 15, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Mask if dust is present; *Symptoms Following Exposure*: INGESTION: abdominal pain, retching, diarrhea, dehydration, shock, pallor, cyanosis, rapid or weak pulse, shallow respiration, low blood pressure; *General Treatment for Expo-*

sure: INGESTION: give milk immediately and then induce vomiting by stroking the pharynx with a blunt object such as a spoon handle. Gastric lavage with 1 pint of 5% aqueous solution of mono- or disodium phosphate if promptly available; otherwise use water. Get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5—5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Fluorine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: F_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Compressed gas; *Color*: Pale yellow; *Odor*: Strong, choking, intense; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 37.99; *Boiling Point at 1 atm.*: -306, -188, 85; *Freezing Point*: -362, -219, 54; *Critical Temperature*: -199.5, -128.6, -144.6; *Critical Pressure*: 809.7, 55.08, 5.58; *Specific Gravity*: 1.5 at -188, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.362; *Latent Heat of Vaporization*: 71.6, 39.8, 1.67; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Tight-fitting chemical goggles, special clothing, not easily ignited by fluorine gas; *Symptoms Following Exposure*: Severe burning of eyes, skin and respiratory system. The burns may develop slowly after exposure; *General Treatment for Exposure*: Flush all affected parts with water for at least 15 min. Do not use ointments. Administer artificial respiration and oxygen if required; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Inhalation Limits*: 0.5 ppm for 5 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Severe burns may develop slowly after exposure; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: 0.035 ppm.

Fluosilicic Acid — (i) Chemical Designations — *Synonyms*: Fluorosilicic acid, Hexafluosilicic acid, Hydrofluosilicic acid, Hydrogen hexafluorosilicate, Sand acid, Silicofluoric acid; *Chemical Formula*: H_2SiF_6-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Transparent, straw colored, colorless; *Odor*: Acrid, sharp; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 144.09 (solute only); *Boiling Point at 1 atm.*: (water) ~212, ~100, ~373; *Freezing Point*: (typical) -24 to -4, -31 to -20, 242 to 253; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (approx.) 1.3 at 25 °C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, safety glasses, protective clothing; *Symptoms Following Exposure*: Inhalation of vapor produces severe corrosive effect on mucous membrane. Ingestion causes severe burns of mouth and stomach. Contact with liquid or vapor causes severe burns of eyes and skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention. INGESTION: give large amounts of water; do NOT induce vomiting. EYES: immediately wash with water for 15 min.; call physician. SKIN: wash affected parts with water; treat as for hydrogen fluoride burn with iced benzalkonium chloride soaks; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Fluosulfonic Acid — (i) Chemical Designations — *Synonyms*: Fluorosulfuric acid, Fluorosulfonic acid; *Chemical Formula*: FSO_3H; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Somewhat cloudy, colorless to slightly yellow; *Odor*: Choking, irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.07; *Boiling Point at 1 atm.*: 324.9, 162.7, 435.9; *Freezing Point*: -125.1, -87.3, 185.9; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.73 at 25 °C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 170, 94, 3.9; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, shoes, and clothing, goggles and face shield, acid-type

canister mask or air-line mask; *Symptoms Following Exposure*: Inhalation of fumes causes severe irritation of nose and throat. Contact of liquid with eyes or skin causes very severe burns. Ingestion causes very severe burns of mouth and stomach; *General Treatment for Exposure*: Get medical attention quickly following all exposures to this compound. INHALATION: remove victim to fresh air; if he is unconscious, give artificial respiration. EYES: flush with water until medical help arrives. SKIN: flush with water until medical help arrives; soak burned area in strong Epsom salt solution; pay particular attention to area around fingernails. INGESTION: give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and very injurious to the eyes; *Odor Threshold*: Data not available.

Formaldehyde Solution — (i) Chemical Designations — *Synonyms*: Formalin, Fyde, Formalith, Methanal, Formic aldehyde; *Chemical Formula*: $HCHO/H_2O/CH_3OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent, irritating; characteristic, pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 18-30; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.1 at 25 °C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus, chemical goggles, protective clothing, synthetic rubber or plastic gloves; *Symptoms Following Exposure*: INHALATION: vapors are irritating and will cause coughing, chest pain, nausea, and vomiting. INGESTION: causes nausea, vomiting, abdominal pain, and collapse. Contact with skin and eyes causes severe irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give oxygen if breathing is difficult; call a physician. INGESTION: induce vomiting at once and repeat until vomit is clear; then give milk or raw egg and call a physician. SKIN OR EYES: flush immediately with plenty of water for at least 15 min.; remove contaminated clothing, call a physician for eyes; *Toxicity by Inhalation (Threshold Limit Value)*: 2 ppm; *Short-Term Inhalation Limits*: 5 ppm for 5 min., 3 ppm for 60 min. (tentative); *Toxicity by Ingestion*: (Formaldehyde solution) Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel with not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure. May cause secondary burns on long exposure; *Odor Threshold*: 0.8 ppm.

Formic Acid — (i) Chemical Designations — *Synonyms*: Methanoic acid, Formylic acid; *Chemical Formula*: HCOOH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent, penetrating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 46.03; *Boiling Point at 1 atm.*: 214, 101, 374; *Freezing Point*: 47.1, 8.4, 281.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.228; *Latent Heat of Vaporization*: 216, 120, 5.02; *Heat of Combustion*: -2045, -1136, -47.56; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; chemical goggles or face shield; rubber suit, gloves, and shoes; *Symptoms Following Exposure*: Liquid causes skin and eye burns. Vapors are irritating and painful to breathe. Vapor exposure may cause nausea and vomiting; *General Treatment for Exposure*: INHALATION: move victim to fresh air; give oxygen if breathing is difficult; call a physician. INGESTION: do NOT induce vomiting; give water or milk. SKIN OR EYES: immediately flush affected area with plenty of water for at least 15 min.; get medical care for eyes; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} = 1.21 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: Data not available.

Fumaric Acid — (i) Chemical Designations — *Synonyms*: Allomaleic acid; Boletic acid; trans-Butenedioic acid; trans-1,2-Ethylenedicarboxylic acid; Lichenic acid; *Chemical Formula*: $HO_2CCH=CHCO_2H$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 116.07; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1,635 at 20 °C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -4,970, -2,760, -116; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, gloves, safety glasses, dust cap; *Symptoms Following Exposure*: Inhalation of dust may cause respiratory irritation. Compound is non-toxic when ingested. Prolonged contact with eyes or skin may cause irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water; get medical attention if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Furfural — (i) Chemical Designations — *Synonyms*: 2-Fyraldehyde, Furfurole, Fural, Pyromucic aldehyde, Furfuraldehyde, Quakeral; *Chemical Formula*: $OCH_2CH_2CH_2CHCHO$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to reddish brown; *Odor*: Almond-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 96.08; *Boiling Point at 1 atm.*: 323.1, 161.7, 434.9; *Freezing Point*: -33.7, -36.5, 236.7; *Critical Temperature*: 745, 397, 670; *Critical Pressure*: 798, 54.3, 5.50; *Specific Gravity*: 1.159 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 191, 106, 4.44; *Heat of Combustion*: -10.490, -5830, -244.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Skin and eye protection; *Symptoms Following Exposure*: Vapor may irritate eyes and respiratory system. Liquid irritates skin and may cause dermatitis; *General Treatment for Exposure*: INHALATION: general treatment for overexposure to vapors of toxic chemicals; keep airway open, give respiration and oxygen if necessary; observe for premonitory signs and symptoms of pulmonary edema. INGESTION: induce vomiting, then give gastric lavage and saline cathartics. SKIN AND MUCOUS MEMBRANES: flood affected tissues with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: 15 ppm for 15 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Causes liver damage in rats; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Furfuryl Alcohol — (i) Chemical Designations — *Synonyms*: 2-Furancarbinol, Furfuralcohol, alpha-Furylcarbinol, 2-Furylcarbinol, 2-Hydroxymethylfuran; *Chemical Formula*: $C_5H_6O_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless or amber; *Odor*: Mildly irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.1; *Boiling Point at 1 atm.*: 338, 170, 443; *Freezing Point*: 5, -15, 258; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.13 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 230, 130, 5.4; *Heat of Combustion*: -11,200, -6,200, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Inhalation causes headache, nausea, and irritation of nose and throat. Vapor irritates eyes; liquid causes inflammation and corneal opacity. Contact of skin with liquid causes dryness and irritation. Ingestion causes headache, nausea, and irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if breathing is difficult, call a physician. EYES: immediately flush with water for 15 min.; get medical attention. SKIN: wash promptly with soap and water. INGESTION: give large amount of water, and induce vomiting; follow with gastric lavage and saline cathartics; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: 50 ppm/30 min.; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 132 mg/kg (rat); *Late Toxicity*: Data not

available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 8 ppm.

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Gallic Acid — (i) Chemical Designations — *Synonyms*: Gallic acid monohydrate; 3,4,5-Trihydroxybenzoic acid; *Chemical Formula*: 3,4,5-$(HO)_3C_6H_2COOH \bullet H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 188; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.7 at 20, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6,060, -3,370, -141; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator, rubber gloves, safety goggles; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INGESTION: give large amount of water; induce vomiting. EYES: flush with water for at least 10 min.; consult a physician in irritation persists. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Gas Oil: Cracked — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent (mixture); **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow to brown; *Odor*: Like gasoline and petroleum; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 375 - 750, 190 - 399, 463 - 672; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.848 at 16, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,400, -10,200, 428; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: INHALATION: causes irritation of upper respiratory tract; simulation, then depression; dizziness, headache, incoordination, anesthesia, coma, respiratory arrest; irregular heartbeat is a complication. ASPIRATION: enforce bed rest and administer oxygen. INGESTION: give victim water or milk; do NOT induce vomiting; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: remove by wiping, then wash with soap and water; *General Treatment for Exposure*: Get medical attention. INHALATION: maintain respiration; administer oxygen if needed. ASPIRATION: enforce bed rest and administer oxygen. INGESTION: give victim water or milk; do NOT induce vomiting; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: remove by wiping, then wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single value applicable; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 0.25 ppm.

Gasolines: Automotive — (i) Chemical Designations — *Synonyms*: Motor spirit, Petrol; *Chemical Formula*: (Mixture of hydrocarbons); **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to brown; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 140 - 390, 60 - 199, 333 - 472; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.7321 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.054; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves;

Symptoms Following Exposure: Irritation of mucous membranes and stimulation followed by depression of central nervous system. Breathing of vapor may also cause dizziness, headache, and in coordination or, in more severe cases, anesthesia, coma, and, respiratory arrest. If liquid enters lungs, it will cause severe irritation, coughing, gagging, pulmonary edema, and, later, signs of bronchopneumonia and pneumonitis. Swallowing may cause irregular heartbeat; *General Treatment for Exposure*: INHALATION: maintain respiration and administer oxygen; enforce bed rest if liquid is in lungs. INGESTION: do NOT induce vomiting; stomach should be lavaged (by doctor) if appreciable quantity is swallowed. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applies; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Gasolines: Aviation — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Red, blue, green, brown, purple; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 160 - 340, 71 - 171, 344 -444; *Freezing Point*: <76, <24.4, <297.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.711 at 15 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.054; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, - 10,400, - 435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: INHALATION causes irritation of upper respiratory tract; central nervous system stimulation followed by depression of varying degrees ranging from dizziness, headache, and incoordination to anesthesia, coma, and respiratory arrest; irregular heartbeat is dangerous complication. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression. INGESTION causes irritation of mucous membranes of throat, esophagus, and stomach; stimulation followed by depression of central nervous system; irregular heartbeat; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was ingested; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applies; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Gasoline Blending Stocks: Alkylates — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58 - 275, 14 - 135, 287 - 408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.71 - 0.75 at 15 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, - 435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles; gloves; *Symptoms Following Exposure*: INHALATION causes irritation of upper respiratory tract; central nervous system stimulation followed by depression of varying degrees ranging from dizziness, headache, and incoordination. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression. INGESTION causes irritation of mucous mem-

branes of throat, esophagus, and stomach; simulation followed by depression of central nervous system; irregular heartbeat; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do not induce vomiting; lavage carefully if appreciable quantity was ingested; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Gasoline Blending Stocks: Reformates — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58 - 275, 14 - 135, 287 - 408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.7934 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: INHALATION causes irritation of upper respiratory tract; central nervous system stimulation followed by depression of varying degrees ranging from dizziness, headache, and incoordination to anesthesia, coma, and respiratory arrest; irregular heartbeat is dangerous complication. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression. INGESTION causes irritation of mucous membranes of throat, esophagus, and stomach; simulation followed by depression of central nervous system; irregular heartbeat; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was ingested; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Gasolines: Casinghead — (i) Chemical Designations — *Synonyms*: Natural gasoline; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58 - 275, 14 - 135, 287 - 408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.671 at 15 C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 170 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: INHALATION causes irritation of upper respiratory tract; central nervous system stimulation followed by depression of varying degrees ranging from dizziness, headache, and incoordination to anesthesia, coma, and respiratory arrest; irregular heartbeat is dangerous complication. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression. INGESTION causes irritation of mucous membranes of throat, esophagus, and stomach; simulation followed by depression of central nervous system; irregular heartbeat; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration; give oxygen if needed.

ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was ingested; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50}0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Gasolines: Polymer — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58 - 275, 14 - 135, 287 - 408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.71 - 0.75 at 15 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: INHALATION causes irritation of upper respiratory tract; central nervous system stimulation followed by depression of varying degrees ranging from dizziness, headache, and incoordination to anesthesia, coma, and respiratory arrest; irregular heartbeat is dangerous complication. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression. INGESTION causes irritation of mucous membranes of throat, esophagus, and stomach; simulation followed by depression of central nervous system; irregular heartbeat; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do NOT induce vomiting; lavage carefully if appreciable quantity was ingested; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50}0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Gasolines: Straight run — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 58 - 275, 14 - 135, 287 - 408; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.71-0.747 at 15 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: -18,720, -10,400, -435.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: INHALATION causes irritation of upper respiratory tract; central nervous system stimulation followed by depression of varying degrees ranging from dizziness, headache, and incoordination to anasthesia, coma, and respiratory arrest; irregular heartbeat is dangerous complication. ASPIRATION causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression. INGESTION causes irritation of mucous membranes of throat, esophagus, and stomach; simulation followed by depression of central nervous system; irregular heartbeat; *General Treatment for Exposure*: Seek medical attention. INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do not induce vomiting; lavage carefully if appreciable quantity was ingested; guard against aspiration into lungs. EYES: wash with copious quantity of water. SKIN: wipe off and wash with

soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.25 ppm.

Glutaraldehyde Solution — (i) Chemical Designations — *Synonyms*: 1,5-Pentanedial solution; *Chemical Formula*: OHC-$(CH_2)_3$-CHO (in water); **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Like rotten apples; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: >212, >100, >373; *Freezing Point*: <20, <-7, <266; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.062 - 1.124 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with liquid causes severe irritation of eyes and irritation of skin. Chemical readily penetrates skin in harmful amounts. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: EYES: immediately flush with plenty of water for at least 15 min.; get medical attention. SKIN: immediately flush with plenty of water for at least 15 min. INGESTION: give large amounts of water and induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} = 2,380 mg/kg; *Late Toxicity*: Induces contact dermatitis in some people; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Glycerine — (i) Chemical Designations — *Synonyms*: Glycerol; 1,2,3-Propanetriol; 1,2,3-Trihydroxypropane; *Chemical Formula*: $HOCH_2CH(OH)CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 92.10; *Boiling Point at 1 atm.*: Not pertinent (decomposes)554, 290, 563; *Freezing Point*: 64.2, 17.9, 291.1; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.261 at 20 C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 288, 160, 6.70; *Heat of Combustion*: -7758, -4310, -180.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, goggles; *Symptoms Following Exposure*: No hazard; *General Treatment for Exposure*: No hazard; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Glycidyl Methacrylate — (i) Chemical Designations — *Synonyms*: Glycidyl alpha-methyl acrylate; Methacrylic acid, 2,3-epoxypropyl ester; *Chemical Formula*: $CH_2=CH(CH_3)COOCH_2CHCH_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 142.2; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.073 at 20, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.043; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -10,800, -5,980, -250; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Polyethylene-coated apron and gloves and close-fitting goggles; *Symptoms Following Exposure*: The liquid irritates eyes about as much as soap. Prolonged contact with skin produces irritation and dermatitis; *General Treatment for Exposure*: SKIN: wash throughly with soap and water and treat as a chemical burn. EYES: irrigate with clear water for 15 min. and get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50}0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel

will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure. In eyes the irritation is simular to that caused by ordinary soap; *Odor Threshold*: Data not available.

Glyoxal: 40 % Solution — (i) Chemical Designations — *Synonyms*: Biformal; Biformyl; Diformyl; Ethanedial; Oxal; Oxaldehyde; *Chemical Formula*: CHO-CHO (in water); **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Weak sour; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: Data not available; *Freezing Point*: 5, -15, 258; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.29 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes some irritation of nose and throat. Contact with liquid irritates eyes and causes mild irritation of skin; stains skin yellow. (No information available on symptoms of ingestion.); *General Treatment for Exposure*: INHALATION: remove from exposure. EYES or SKIN: flood with water for 15 min. INGESTION: no information on treatment; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} = 2,020 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

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Heptachlor — (i) Chemical Designations — *Synonyms*: E 3314; 1,4,5,6,7,8,8a-Heptachlorodicyclopentadiene; 1,4,5,6,7,8,8a-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene; Velsicol; *Chemical Formula*: $C_{10}H_5Cl_7$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; light tan; *Odor*: Camphor-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 373.5; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 115 - 165, 46 - 74, 319 - 347; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.66 at 20 °C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective respirator; rubber gloves; clean clothes; *Symptoms Following Exposure*: Inhalation of dust causes irritability, tremors, and collapse. Ingestion causes nausea, vomiting, diarrhea, and irritation of the gastrointestinal tract. Contact with dust causes irritation of eyes and moderate irritation of skin; *General Treatment for Exposure*: Get medical attention following all overexposures to heptachlor. INHALATION: move to fresh air; if exposure to dust was severe, get medical attention. INGESTION: lavage stomach with warm tap water (unless convulsions are imminent); fats and oils should be avoided, as they increase the rate of absorption of all chlorinated hydrocarbons. EYES: wash repeatedly with water. SKIN: flush with water, then wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Inhalation Limits*: 2 mg/m^3 for 30 min.; *Toxicity by Ingestion*: Grade 4; oral LD_{50} = 40 mg/kg (rat); *Late Toxicity*: Liver damage may develop; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.02 ppm.

Heptane — (i) Chemical Designations — *Synonyms*: n-Heptane; *Chemical Formula*: $CH_3(CH_2)_5CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.21; *Boiling Point at 1 atm.*: 209.1, 98.4, 371.6; *Freezing Point*: -131, -90.6, 182.6; *Critical Temperature*: 513, 267, 540; *Critical Pressure*: 400, 27, 2.7; *Specific Gravity*: 0.6838 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: Data not available; *Ratio of Specific Heats of Vapor (Gas)*: 1.054; *Latent Heat of Vaporization*: 136.1, 75.61, 3.166; *Heat of Combustion*: -19,170, -10,650, -445.9; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses; gloves; similar to gasoline; *Symptoms Following Exposure*: INHA-

LATION: irritation of respiratory tract, coughing, depression, cardiac arrhytmias. ASPIRATION: severe lung irritation, pulmonary edema, mild excitement followed by depression. INGESTION: nausea, vomiting, swelling of abdomen, depression, headache; *General Treatment for Exposure*: INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; administer oxygen. INGESTION: do not induce vomiting. SKIN OR EYES: remove contaminated clothing, wipe and wash skin area with soap and water; wash eyes with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 500 ppm; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Grade 0; LD_{50} above 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 220 ppm.

Heptanol — (i) Chemical Designations — *Synonyms*: Enanthic alcohol; 1-Heptanol; Heptyl alcohol; 1-Hydroxyheptane; *Chemical Formula*: $CH_3(CH_2)_5CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak alcoholic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.20; *Boiling Point at 1 atm.*: 349, 176, 449; *Freezing Point*: -29, -34, 239; *Critical Temperature*: 680, 360, 633; *Critical Pressure*: 440,30, 3.0; *Specific Gravity*: 0.822 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Data not available; *Ratio of Specific Heats of Vapor (Gas)*: 1.049; *Latent Heat of Vaporization*: 189, 105, 4.40; *Heat of Combustion*: -18,810, -8784, -367.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles or face shield; *Symptoms Following Exposure*: Low toxicity; liquid may irritate eyes; *General Treatment for Exposure*: Flush all affected parts with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral rat LD_{50} = 1.87 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Nonirritating; *Liquid or Solid Irritant Characteristics*: Liquid may irritate eyes; it is not irritating to skin; *Odor Threshold*: 0.49 ppm.

1-Heptene — (i) Chemical Designations — *Synonyms*: Heptylene; *Chemical Formula*: $CH_3(CH_2)_4$-$CH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.18; *Boiling Point at 1 atm.*: 200.5, 93.6, 366.8; *Freezing Point*: -182, -119, 154; *Critical Temperature*: 507.4, 264.1, 537.3; *Critical Pressure*: 420, 28.57, 2.89; *Specific Gravity*: 0.697 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.057; *Latent Heat of Vaporization*: 137, 76.3, 3.20; *Heat of Combustion*: -19,377, -10,765, -450.71; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles or face shield; similar to gasoline; *Symptoms Following Exposure*: High concentrations may produce slight irritation of eyes and respiratory tract; may also act as simple asphyxiant and slight anesthetic; *General Treatment for Exposure*: Remove from exposure. Administer artificial respirator if needed; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Hexachlorocyclopentadiene — (i) Chemical Designations — *Synonyms*: Perchlorocyclopentadiene; *Chemical Formula*: C_5Cl_6; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow or greenish yellow; *Odor*: Harsh, pungent; **(iii) Physical and Chemical Properties** - *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 272.7; *Boiling Point at 1 atm.*: 462, 239, 512; *Freezing Point*: 50, 10, 283; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.71 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: 9.42; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 76, 42, 1.8; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing, including rubber gloves and rubber shoes or boots; self-contained breathing apparatus; face shield; *Symptoms Following Exposure*: Inhalation of mist is highly irritating to mucous membranes, causing lachrymation, sneezing, and salivation; pulmonary edema may occur. Ingestion causes

nausea, vomiting, diarrhea, and depression. Contact with eyes causes severe irritation. Liquid is extremely irritating to the skin, causing blistering and burning; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give artificial respiration and/or oxygen as needed. INGESTION: give large amounts of water and induce vomiting; give saline laxative. EYES: flush with water for at least 15 min.; if irritation remains, get medical attention. SKIN: wash with soap and water until no odor remains; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm (proposed); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} =0.505 mg/kg (mouse), 113 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.15-0.33 ppm.

Hexadecyl Sulfate, Sodium Salt — (i) Chemical Designations — *Synonyms*: Cetyl sodium sulfate; Sodium cetyl sulfate solution; *Chemical Formula*: CH_3-$(CH_2)_{14}CH_2OSO_3Na$-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Pasty solid or liquid; *Color*: White; *Odor*: Mild; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: Not pertinent (mixture); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1 at 20, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic or rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Contact with eyes causes mild irritation. May cause skin to dry out and become irritated; *General Treatment for Exposure*: EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Hexadecyltrimethylammonium Chloride — (i) Chemical Designations — *Synonyms*: Cetyltrimethylammonium chloride solution; *Chemical Formula*: $C_{16}H_{33}(CH_3)_3NCl$-H_2O-$(CH_3)_2CHOH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Almost clear to pale yellow; *Odor*: Like rubbing alcohol; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 319 (solute only); *Boiling Point at 1 atm.*: (isopropyl alcohol) 180, 82.3, 355.5; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (approx.) 0.9 at 25°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Ingestion may produce toxic effects. Contact with eyes or skin may cause severe damage; *General Treatment for Exposure*: INGESTION: do not induce vomiting; drink large quantities of fluid and call a physician immediately. EYES: flush with water for at least 15 min. and call a physician. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 250 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

n-Hexaldehyde — (i) Chemical Designations — *Synonyms*: Caproaldehyde; Caproic aldehyde; Capronaldehyde; n-Caproylaldehyde; Hexanal; *Chemical Formula*: $CH_3(CH_2)_4CHO$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100; *Boiling Point at 1 atm.*: 262, 128, 401; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.83 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.061 at 20°C; *Latent Heat of Vaporization*: (est.) 153, 85, 3.6; *Heat of Combustion*: (est.) -17,000, -9,430, -394; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Ingestion causes irritation of mouth and stomach. Contact with vapor or liquid irritates eyes. Liquid irritates skin; *General Treatment for Exposure*: INGESTION: give large amount of water and induce vomiting. EYES: flush with

water for at least 15 min. SKIN: wipe off; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 4,890 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Hexamethylenediamine — (i) Chemical Designations — *Synonyms*: 1,6-Diaminoxexane; 1,6-Hexanediamine; *Chemical Formula*: $NH_2(CH_2)_6NH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid (anhydrous) or liquid (70% solution); *Color*: Glassy solid; clear liquid; *Odor*: Weak, fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid (anhydrous); Liquid (10% solution); *Molecular Weight*: 116.21; *Boiling Point at 1 atm.*: 478, 205, 401; *Freezing Point*: (anhydrous) 104.9, 40.5, 313.7; (70% solution) 28, -2, 269; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (anhydrous) 0.799 at 20 °C, (liquid); (70 % solution) 0.933 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 203, 113, 4.73; *Heat of Combustion*: (est.) -12,200, -6,790, -284; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing; eye protection; *Symptoms Following Exposure*: Vapors cause irritation of eyes and respiratory tract. Liquid irritates eyes and skin, may cause dermatitis; *General Treatment for Exposure*: SKIN OR EYES: flush immediately with water for 15 min.; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Repeated exposure can cause anemia and damage kidney and liver; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 0.0041 mg/m^3.

Hexamethyleneimine — (i) Chemical Designations — *Synonyms*: Azacycloheptane; Hexahydroazepine; Homopiperidine; *Chemical Formula*: $CH_2CH_2CH_2CH_2CH_2CH_2NH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 99; *Boiling Point at 1 atm.*: 270, 132, 405; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.880 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; impervious gloves; chemical safety goggles; impervious apron and boots; *Symptoms Following Exposure*: Inhalation of vapor irritates respiratory tract; high concentrations may cause disturbance of central nervous system. Ingestion causes burns of mouth and stomach. Cause contact with liquid causes burns of eyes and skin; *General Treatment for Exposure*: INHALATION: remove victim to uncontaminated atmosphere; get medical attention. INGESTION: give large amount of water; do NOT induce vomiting; get medical attention if large amount was swallowed. EYES: flush with water for 15 min. and get medical attention. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; oral LD_{50} = 32 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Hexamethylenetetramine — (i) Chemical Designations — *Synonyms*: Aminoform; Ammoform; Hexamine; Metheneamine; Urotropin; *Chemical Formula*: $C_6H_{12}N_4$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Mild ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 140.19; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.35 at 20°C, (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -13,300, -7400, -310; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves; for dusty or spatter conditions, use dust filter respirator and goggles; *Symptoms Following Expo-*

sure: Prolonged and repeated contact may cause skin irritation; *General Treatment for Exposure*: Wash skin or eyes throughly with water. Call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (human); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Hexane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $CH_3(CH_2)_4CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 86.17; *Boiling Point at 1 atm.*: 155.7, 68.7, 341.9; *Freezing Point*: -219.3, -139.6, 133.6; *Critical Temperature*: 453.6, 234.2, 507.4; *Critical Pressure*: 436.6, 29.7, 3.01; *Specific Gravity*: 0.659 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: 3.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.063; *Latent Heat of Vaporization*: 144, 80.0, 3.35; *Heat of Combustion*: -19,246, -10,692, -447.65; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection (like gasoline); *Symptoms Following Exposure*: INHALATION causes irritation of respiratory tract, cough, mild depression, cardiac arrhythmias. ASPIRATION causes severe lung irritation, coughing, pulmonary edema; excitement followed by depression. INGESTION causes nausea, vomiting, swelling of abdomen, headache, depression; *Toxicity by Inhalation (Threshold Limit Value)*: Call a doctor. INHALATION: maintain respiration; give oxygen if needed. ASPIRATION: enforce bed rest; give oxygen if needed. INGESTION: do not induce vomiting. SKIN OR EYES: wipe off; wash skin with soap and water; wash eyes with copious amounts of water; *General Treatment for Exposure*: 500 ppm; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Very slight; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Hexanol — (i) Chemical Designations — *Synonyms*: Amylcarbinol; 1-Hexanol; Hexyl alcohol; 1-Hydroxyhexane; *Chemical Formula*: $CH_3(CH_2)_4CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet; mild; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.18; *Boiling Point at 1 atm.*: 314.8, 157.1, 430.3; *Freezing Point*: -48.3, -44.6, 228.6; *Critical Temperature*: 638.6, 337, 610.2; *Critical Pressure*: 485, 33, 3.34; *Specific Gravity*: 0.850 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.057; *Latent Heat of Vaporization*: 209, 116, 4.86; *Heat of Combustion*: -16,810, -9340, -391.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical gloves; chemical goggles; *Symptoms Following Exposure*: Liquid causes eye burns and skin irritation. Breathing vapors is not expected to cause systemic illness; *General Treatment for Exposure*: In case of contact, immediately flush skin and eyes with plenty of water. Wash eyes at least 15 min. and get medical care; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree|burns on long exposure; *Odor Threshold*: Data not available.

1—Hexene — (i) Chemical Designations — *Synonyms*: alpha-Hexene; *Chemical Formula*: $CH_3(CH_2)_3$-$CH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 84.16; *Boiling Point at 1 atm.*: 146.3, 63.5, 336.7; *Freezing Point*: -219.6, -139.8, 133.4; *Critical Temperature*: 447.4, 230.8, 504.0; *Critical Pressure*: 460, 31.3, 3.17; *Specific Gravity*: 0.673 at 20 °C, (liquid); *Vapor (Gas) Specific Gravity*: 2.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.068; *Latent Heat of Vaporization*: 140, 80, 3.3; *Heat of Combustion*: -19,134, -10,630, -445.06; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved organic vapor respirator or air-line mask; protective goggles or face shield; *Symptoms Following Exposure*: Inhalation may cause giddiness or incoordination similar to that from gasoline vapor. Prolonged exposure to high concentrations may induce loss of consciousness or death; *General*

Treatment for Exposure: SKIN OR EYES: wash exposed skin areas with soap and water; thoroughly flush eyes with water to remove any splashes; launder contaminated clothing before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 500 ppm (suggested); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Slight smarting of the eyes or respiratory system if present in high concentrations. Effect is temporary; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Hexylene Glycol — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: N_2H_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 32.05; *Boiling Point at 1 atm.*: 236.3, 113.5, 386.7; *Freezing Point*: 34.7, 1.5, 274.7; *Critical Temperature*: 716, 380, 653; *Critical Pressure*: 2130, 145, 14.7; *Specific Gravity*: 1.008 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.191; *Latent Heat of Vaporization*: 538, 299, 12.5; *Heat of Combustion*: -8345, -4636, -194.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Ammonia-type gas mask; self-contained breathing apparatus; plastic-coated or rubber gloves, clothes, and apron; safety shower must be available; *Symptoms Following Exposure*: Vapors cause itching, swelling, and blistering of eyelids, skin, nose and throat; symptoms may be delayed for several hours. Temporary blindness may occur. Liquid causes a caustic-like burn if not washed off at once. Ingestion or absorption through skin causes nausea, dizziness, headache. Severe exposure may cause death; *General Treatment for Exposure*: Call a doctor at once. INHALATION: remove to fresh air; observe for development of delayed symptoms. Keep quiet. INGESTION: do not induce vomiting; give egg whites or other emollient. SKIN OR EYES: wash with large amounts of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Inhalation Limits*: 1 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: Data not available.

Hydrazine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: N_2H_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 32.05; *Boiling Point at 1 atm.*: 236.3, 113.5, 386.7; *Freezing Point*: 34.7, 1.5, 274.7; *Critical Temperature*: 716, 380, 653; *Critical Pressure*: 2130, 145, 14.7; *Specific Gravity*: 1.008 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.191; *Latent Heat of Vaporization*: 538, 299, 12.5; *Heat of Combustion*: -8345, -4636, -194.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Ammonia-type gas mask; self-contained breathing apparatus; plastic-coated or rubber gloves, clothes, and apron; safety shower must be available; *Symptoms Following Exposure*: Vapors cause itching, swelling, and blistering of eyelids, skin, nose and throat; symptoms may be delayed for several hours. Temporary blindness may occur. Liquid causes a caustic-like burn if not washed off at once. Ingestion or absorption through skin causes nausea, dizziness, headache. Severe exposure may cause death; *General Treatment for Exposure*: Call a doctor at once. INHALATION: remove to fresh air; observe for development of delayed symptoms. Keep quiet. INGESTION: do NOT induce vomiting; give egg whites or other emollient. SKIN OR EYES: wash with large amounts of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Inhalation Limits*: 1 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (rat); *Late Toxicity*: Causes lung cancer in mice; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: 3 - 4 ppm.

Hydrochloric Acid — (i) Chemical Designations — *Synonyms*: Muriatic acid; *Chemical Formula*: HCl-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Pungent; sharp, pungent, irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling*

Point at 1 atm.: 123, 50.5, 323.8; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.19 at 20°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 178, 98.6, 4.13; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing equipment, air-line mask, or industrial canister-type gas mask; rubber-coated gloves, apron, coat, overalls, shoes; *Symptoms Following Exposure*: Inhalation of fumes results in coughing and choking sensation, and irritation of nose and lungs. Liquid causes burns; *General Treatment for Exposure*: INHALATION: remove person to fresh air; keep him warm and quiet and get medical attention immediately; start artificial respiration if breathing stops. INGESTION: have person drink water or milk; do NOT induce vomiting. EYES: immediately flush with plenty of water for at least 15 min. and get medical attention; continue flushing for another 15 min. if physician does not arrive promptly. SKIN: immediately flush skin while removing contaminated clothing; get medical attention promptly; use soap and wash area for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: 5 ppm for 5 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: 1 - 5 ppm.

Hydrofluoric Acid — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $HF-H_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to slightly yellow; *Odor*: Pungent, irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 152, 67, 340; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.258 at 25°C, (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 649, 361, 15.1; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Proper protective clothing must be worn that encapsulates the body including the face. A shower and an eye wash must be available; *Symptoms Following Exposure*: Serious and painful burns of eyes and skin; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. SKIN: if victim has come in contact with liquid or vapor, put him in a shower and call a physician. EYES: flush with water for at least 15 min. and consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: 3 ppm; *Short-Term Inhalation Limits*: 500 ppm for 60 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: Data not available.

Hydrogen Bromide — (i) Chemical Designations — *Synonyms:* Hydrobromic acid, anhydrous; Hydrogen bromide, anhydrous; *Chemical Formula:* HBr; **(ii) Observable Characteristics** — *Physical State (as shipped):* Compressed; liquefied gas; *Color:* Colorless; *Odor:* Sharp, pungent, irritating; **(iii) Physical and Chemical Properties** - *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 80.92; *Boiling Point at 1 atm:* -88.2, -66.8, 206.4; *Freezing Point:* Not pertinent; *Critical Temperature:* 193.6, 89.8, 363.0; *Critical Pressure:* 1,235, 84, 8.52; *Specific Gravity*: 2.14 at -67 °C (liquid); *Vapor (Gas) Specific Gravity:* 2.71; *Ratio of Specific Heats of Vapor (Gas):* 1.38; *Latent Heat of Vaporization:* 923, 51.3, 2.15; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Full face mask and acid gas canister, self-contained breathing apparatus: chemical goggles: rubber apron and gloves: acid-proof clothing: safety shower; *Symptoms Following Exposure:* Inhalation causes severe irritation of nose and upper respiratory tract, lung injury. Ingestion causes burns of mouth and stomach. Contact with eyes causes severe irritation and burns. Contact with skin causes irritation and burns; *Treatment for Exposure:* Get medical attention after all overexposures to this chemical. INHALATION: move victim to fresh air and keep him warm and quiet: if a qualified person is available lo give oxygen, such treatment may be helpful. INGESTION: give large amounts of water or milk: do not induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with water; treat acid burns; *Toxicity by Inhalation*

(Threshold Limit Value): 3 ppm; *Short-Term Inhalation Limits:* 5 ppm for 5 min.; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Hydrogen Chloride — (i) Chemical Designations — *Synonyms:* Hydrochloric acid, anhydrous; *Chemical Formula:* HCl; **(ii) Observable Characteristics** - *Physical State (as shipped):* Compressed liquefied gas; *Color:* Colorless to slightly yellow; *Odor:* Sharp, pungent, irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 36.42; *Boiling Point at 1 atm:* -121, -85.0, 188.2; *Freezing Point:* -175, -115, 158; *Critical Temperature:* 124.5, 51.4, 324.6; *Critical Pressure(psia, atm, MN/m²):* 1200, 81.6, 8.27; *Specific Gravity*: 1.191 at -85 °C (liquid); *Vapor (Gas) Specific Gravity:* 1.3; *Ratio of Specific Heats of Vapor (Gas):* 1.398; *Latent Heat of Vaporization:* 185, 103, 4.31; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards —** *Personal Protective Equipment:* Full face mask and acid gas canister; self-contained breathing apparatus; chemical goggles; rubber apron and gloves; acid-proof clothing; safety shower; *Symptoms Following Exposure:* Severely irritating to nose and upper respiratory tract; lung injury; *Treatment for Exposure:* INHALATION: immediately remove patient to fresh air, keep him warm and quiet, and call a physician immediately; if a qualified person is available to give oxygen, such treatment may be helpful. INGESTION: have victim drink water or milk; do NOT induce vomiting. EYES OR SKIN: immediately flush with plenty of water for at least 15 min.; for eyes get medical attention promptly; air contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value):* 5 ppm; *Short-Term Inhalation Limits:* 5 ppm for 5 min.; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors cause severe irritation eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics:* Fairly severe skin irritant; may cause pain and second-degree burns after few minutes contact; *Odor Threshold:* 1 - 5 ppm.

Hydrogen Cyanide — (i) Chemical Designations — *Synonyms*: Hydrocyanic acid; Prussic acid; *Chemical Formula*: NCH; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless to bluish white; *Odor*: Characteristic sweetish, like almond; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 27.03; *Boiling Point at 1 atm.*: 78.3, 25.7, 298.9; *Freezing Point*: 8.1, -13.3, 259.9; *Critical Temperature*: 362.3, 183.5, 456.7; *Critical Pressure*: 735, 50, 5.07; *Specific Gravity*: 0.689 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 0.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.303; *Latent Heat of Vaporization*: 444, 247, 10.3; *Heat of Combustion*: -10,560, -5864, -245.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Escape purposes only — air escape mask with 5-minute air cylinder. Work purposes- vapor-proof emergency suit or vinyl-coated coverall, plus air mask with clear-view facepiece, speaking diaphragm, demand regulator, and 30-minute air cylinder. Rubber gloves; chemical safety goggles; quick-opening safety shower; *Symptoms Following Exposure*: Irritation of throat, palpitation, difficult breathing, reddening of eyes, salivation, nausea, headache, weakness of arms and legs, giddiness-followed by collapse and convulsions; *General Treatment for Exposure*: Call a doctor. If breathing has stopped, give artificial respiration until doctor arrives. INHALATION: remove patient to fresh air. SKIN CONTACT: remove contaminated clothing and wash skin thoroughly with copious quantities of water for at least 15 min. If patient is unconscious, administer amyl nitrite by crushing a pearl (ampule) in a cloth and holding this under patient's nose for 15 seconds in every spent. Continue treatment until patient's condition improves or doctor arrives; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Inhalation Limits*: 20 ppm for 30 min.; *Toxicity by Ingestion*: Grade 4, LD_{50} less than 50 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is not very irritating but is extremely poisonous; *Liquid or Solid Irritant Characteristics*: Liquid is not irritating but is extremely if absorbed through skin or eyes; *Odor Threshold*: 1 mg/m³.

Hydrogen Fluoride — (i) Chemical Designations — *Synonyms*: Hydrofluoric acid, anhydrous; *Chemical Formula*: H_2F_2; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: pungent, irritating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 20.01; *Boiling Point at 1 atm.*: 67.1, 19.5, 292.7; *Freezing Point*: -134, -92.2, 181.0; *Critical Temperature*: 447, 230.6, 503.8; *Critical Pressure*: 1100, 74.8, 7.58; *Specific Gravity*: 0.992 at 19 °C (liquid); *Vapor (Gas) Specific Gravity*: 0.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.399; *Latent Heat of Vaporiza-*

tion: 145, 80.85, 3.37; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-resistant hat, safety goggles, face shield, jacket, overalls, gauntlet-type gloves, and boots. The goggles and face shield must have plastic lenses. There must be a shower and eye wash. Observe all precautions in the Manufacturing Chemists Association Chemical Safety Data Sheet SD-25; *Symptoms Following Exposure*: Serious and painful burns of eyes, skin and respiratory tract; pulmonary edema; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. SKIN: flush with water; consult physician. EYES: flush with water for at least 15 min.; consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: 3 ppm; *Short-Term Inhalation Limits*: 3 ppm for 15 min.; *Toxicity by Ingestion*: Oral LD_{50} = 80 mg/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: 0.03 mg/m^3.

Hydrogen, Liquefied — (i) Chemical Designations — *Synonyms*: Liquid hydrogen; para Hydrogen; *Chemical Formula*: H_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 2.0; *Boiling Point at 1 atm.*: -423, -253, 20; *Freezing Point*: -434, -259, 14; *Critical Temperature*: -400, -240, 33; *Critical Pressure*: 188, 12.8, 1.30; *Specific Gravity*: 0.071 at -253 °C (liquid); *Vapor (Gas) Specific Gravity*: 0.067; *Ratio of Specific Heats of Vapor (Gas)*: 1.3962; *Latent Heat of Vaporization*: 190.5, 105.8, 4.427; *Heat of Combustion*: -50,080, -27,823, -1164.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles or face shield; insulated gloves and long sleeves; cuffless trousers worn outside boots or over high-top shoes to shed spilled liquid; self-contained breathing apparatus containing air (never use oxygen); *Symptoms Following Exposure*: If atmosphere does not contain enough oxygen, inhalation can cause dizziness, unconsciousness, or even death. Contact of liquid with eyes or skin causes freezing similar to a burn; *General Treatment for Exposure*: The only effect of exposure to liquid hydrogen is that caused by its unusually low temperature and its action as a simple asphyxiant. INHALATION: if victim is unconscious (due to oxygen deficiency), move him to fresh air and apply resuscitation method; call physician. EYES: treat for frostbite. SKIN: treat for frostbite; soak in lukewarm water; get medical attention if burn is severe; *Toxicity by Inhalation (Threshold Limit Value)*: Gas is non-poisonous but can act as a simple asphyxiant; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent (gas with low boiling point); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Hydrogen Peroxide — (i) Chemical Designations — *Synonyms*: Peroxide, Albone, Superoxol; *Chemical Formula*: H_2O_2-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Slightly sharp; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 34.01; *Boiling Point at 1 atm.*: 257, 125, 398; *Freezing Point*: -40.5, -40.3, 232.9; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.29 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.241; *Latent Heat of Vaporization*: 542, 301, 12.6; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: -1220, -676, -28.3; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective garments, both outer and inner, made of a woven polyester fabric or of modacrylic or polyvinylidene fabrics; impermeable apron made of polyvinyl chloride or polyethylene film; neoprene gloves and boots; goggles; *Symptoms Following Exposure*: Although solutions and vapors are nontoxic, they are irritating. Vapor causes discomfort of eyes and nose. Moderately concentrated liquid causes whitening of the skin and severe stinging sensation. In most causes the stinging subsides quickly and the skin gradually returns to normal without any damage. Highly concentrated liquid can cause blistering of skin if left on for any length of time; can also cause eye damage; *General Treatment for Exposure*: Contact should be avoided, but immediate flushing with water will prevent any reaction in case of accidental contact; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation, such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Fairly severe

skin irritant. May cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Not pertinent.

Hydrogen Sulfide — (i) Chemical Designations — *Synonyms*: Sulfuretted hydrogen; *Chemical Formula*: H_2S; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid under pressure; *Color*: Colorless; *Odor*: Offensive odor, like rotten eggs; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 34.08; *Boiling Point at 1 atm.*: -76.7, -60.4, 212.8; *Freezing Point*: -117, -82.8, 190.4; *Critical Temperature*: 212.7, 100.4, 373.6; *Critical Pressure*: 1300, 88.9, 9.01; *Specific Gravity*: 0.916 at -60 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.322; *Latent Heat of Vaporization*: 234, 5.44; *Heat of Combustion*: -6552, -3640, -152.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber-framed goggles; approved respiratory protection; *Symptoms Following Exposure*: Irritation of eyes, nose and throat. If high concentrations are inhaled, hyperpnea and respiratory paralysis may occur. Very high concentrations may produce pulmonary edema; *General Treatment for Exposure*: INHALATION: remove victim from exposure; if breathing has stopped, give artificial respiration; administer oxygen if needed; consult physician. EYES: wash with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Inhalation Limits*: 200 ppm for 10 min.; 100 ppm for 30 min. and 50 ppm for 60 min.; *Toxicity by Ingestion*: Hydrogen sulfide is present as a gas at room temperature, so ingestion not likely; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 0.0047 ppm.

Hydroquinone — (i) Chemical Designations — *Synonyms*: 1,4-Benzenediol; p-Dihydroxybenzene; Hydroquinol; Pyrogentisic acid; Quinol; *Chemical Formula*: $1,4\text{-}C_6H_4(OH)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Light tan to light gray; white; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 110.11; *Boiling Point at 1 atm.*: 545, 285, 558; *Freezing Point*: 338, 170, 443; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.33 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,200, -6,220, -260; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles; respiratory protection if dust is present; *Symptoms Following Exposure*: Ingestion can cause ringing in the ears, nausea, dizziness, a sense of suffocation, increased respiration rate, vomiting, pallor, muscular twitching, headache, dyspnea, cyanosis, delirium, and collapse; the urine is green or brownish-green. Lethal adult dose is 2 grams. Direct contamination of the eye with particles of hydroquinone can cause immediate irritation and may result in ulceration of the cornea. Contact with skin may cause dermatitis; *General Treatment for Exposure*: INGESTION: induce vomiting; perform gastric lavage, and follow with a saline cathartic and demulcents; get medical attention. EYES: flush immediately with plenty of water for 15 min. and get medical attention. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 2 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 370 mg/kg (rat); *Late Toxicity*: Causes bladder cancer in mice, discoloration of eyelids and eye changes in men; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

2-Hydroxyethyl Acrylate, Inhibited -(i) Chemical Designations — *Synonyms*: beta-Hydroxyethyl acrylate; 2-Hydroxyethyl 2-propenoate; *Chemical Formula*: $CH_2{=}CHCOOCH_2CH_2OH$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet, pleasant; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.1; *Boiling Point at 1 atm.*: >346, >210, >583; *Freezing Point*: -76, -60, 213; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.10 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent: *Heat of Combustion*: (est.) -10,800, -6,000, -250; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with liquid irritates eyes and skin; *General Treatment for Exposure*: INHALATION: remove victim

from exposure; support respiration; call physician if needed. EYES: wash with large amounts of water for 15 min.; call physician. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 1,070 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Hydroxylamine Sulfate — (i) Chemical Designations — *Synonyms*: Oxammonium sulfate; *Chemical Formula*: $(NH_2OH)_2 \cdot H_2SO_4$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Crystals; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 164.14; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-resistant protective clothing, including coveralls, wrist-length gloves, cap, goggles, and dust mask; *Symptoms Following Exposure*: Inhalation of dust or ingestion may cause systemic poisoning characterized by cyanosis, methemoglobinemia, convulsions, and coma. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; seek immediate medical attention if symptoms occur. INGESTION: give large amounts of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min., and get medical attention. SKIN: flush immediately with plenty of water, then wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 - 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Hydroxypropyl Acrylate — (i) Chemical Designations — *Synonyms*: 1,2-Propanediol 1-acrylate; Propylene glycol mono-acrylate; *Chemical Formula*: $CH_3CHOHCH_2OCOCH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Slightly acrylic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 130; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.06 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: 4.5; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -12,300, -6,850, -287; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, apron, and boots; worker's goggles or face shield; *Symptoms Following Exposure*: Inhalation irritates nose and throat and causes coughing; lung injury may occur. Ingestion causes irritation and burning of mouth and stomach. Vapor irritates eyes. Contact with liquid causes severe burns of eyes and burns of skin; *General Treatment for Exposure*: INHALATION: if ill effect occurs, get patient to fresh air, keep him quiet and warm, and get medical attention; if breathing stops, start artificial respiration. INGESTION: force milk or water immediately; induce vomiting only at physician's recommendation. EYES: promptly flush with plenty of water and get medical attention if victim complains of severe irritation or burning; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 1,230 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: This chemical is a severe skin irritant. Direct contact with this chemical causes second- and third-degree chemical burns - even short contact, and is very injurious to the eyes; *Odor Threshold*: Data not available.

Hydroxypropyl Methacrylate — (i) Chemical Designations — *Synonyms*: 1,2-propanediol 1-methacrylate; Propylene glycol monomethacrylate; *Chemical Formula*: $CH_3CHOHCH_2OCOC(CH_3)=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Slight acrylic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 144; *Boiling*

Point at 1 atm.: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.06 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes coughing and irritation of nose and throat; lung injury may occur. Ingestion causes irritation and burning of mouth and stomach. Contact of vapor with eyes causes irritation. Liquid may cause severe eye burns and irritation of skin; *General Treatment for Exposure*: INHALATION: immediately remove victim to fresh air; if required, start artificial respiration and call a doctor. INGESTION: force milk or water at once; get medical attention. EYES: flush with water for at least 15 min.; get medical attention if irritation persist. SKIN: flush with copious amounts of water; seek immediate medical attention for chemical burns; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5-15 g/kg (mouse); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

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Isoamyl Alcohol — (i) Chemical Designations — *Synonyms*: Fermentation amyl alcohol; Fusel oil; Isobutylcarbinol; Isopentyl alcohol; 3-Methyl-1-butanol; Potato-spirit oil; *Chemical Formula*: $(CH_3)_2CHCH_2$-CH_2OH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild odor; alcoholic, non-residual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 88.15; *Boiling Point at 1 atm.*: 270, 132, 405; *Freezing Point*: Not pertinent; *Critical Temperature*: 585, 307, 580; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.81 at 20°C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.062; *Latent Heat of Vaporization*: 215.6, 119.8, 5.016; *Heat of Combustion*: -16,200, -9,000, -376.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Face shield to avoid splash; *Symptoms Following Exposure*: Very high vapor concentrations irritate eyes and upper respiratory tract. Continued contact with skin may cause irritation; *General Treatment for Exposure*: EYES: immediately flush with plenty of water for at least 15 min.; get medical attention. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Liquid may irritate skin; *Odor Threshold*: Data not available.

Isobutane — (i) Chemical Designations — *Synonyms*: 2-Methylpropane; *Chemical Formula*: $CH_3CH(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid under pressure; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 58.12; *Boiling Point at 1 atm.*: 10.8, -11.8, 261.4; *Freezing Point*: -427.5, -255.3, 17.9; *Critical Temperature*: 275, 135, 408; *Critical Pressure*: 529, 36.0, 3.65; *Specific Gravity*: 0.557 at 20°C (liquid); *Vapor (Gas) Specific Gravity*: 2.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.095; *Latent Heat of Vaporization*: 158, 87.5, 3.66; *Heat of Combustion*: -19.458, -10.810, -452.59; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; safety goggles; *Symptoms Following Exposure*: Central nervous system depression ranging from dizziness and incoordination to anesthesia and respiratory arrest, depending on concentrations and extent of inhalation. Irregular heartbeat is rare but is a dangerous complication at anesthetic levels; *General Treatment for Exposure*: INHALATION: protect victim against self-injure if he is stuporous, confused, or anesthetized; apply artificial respiration if breathing has stopped; avoid administration of epinephrine or other sympathomimetic amines; prevent aspiration of vomitus by proper positioning of head; give symptomatic and supportive treatment. INGESTION OR ASPIRATION: no treatment required; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to skin because it is very volatile and evaporates quickly. Some frostbite possible; *Odor Threshold*: Data not available.

Isobutyl Acetate — (i) Chemical Designations — *Synonyms*: Acetic acid, isobutyl ester; 2-Methyl-1-propyl acetate; beta-Methylpropyl ethanoate; *Chemical Formula*: $CH_3COOCH_2CH(CH_3)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Agreeable fruity odor in low concentrations, disagreeable in higher concentrations; mild, characteristic ester; nonresidual; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 116.16; *Boiling Point at 1 atm.*: 243.1, 117.3, 390.5; *Freezing Point*: -142.8, -97.1, -176.1; *Critical Temperature*: 565, 296, 569; *Critical Pressure*: 470 psia, 32, 3.2; *Specific Gravity*: 0.871 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 133, 73.7, 3.09; *Heat of Combustion*: (est.) -13,000, -7220, -302; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air pack or organic canister mask; chemical goggles; *Symptoms Following Exposure*: Vapors may irritate upper respiratory tract and cause nausea, vomiting, dizziness and loss of consciousness. Liquid irritates eyes and may irritate skin; *General Treatment for Exposure*: INHALATION: remove from exposure; if breathing is irregular or has stopped, start resuscitation and give oxygen; call a doctor. EYES: flush with water for at least 15 minutes; *Toxicity by Inhalation (Threshold Limit Value)*: 150 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Isobutyl Alcohol — (i) Chemical Designations — *Synonyms*: Isobutanol; Isopropylcarbinol; 2-methyl-1-propanol; Fermentation butyl alcohol; *Chemical Formula*: $(CH_3)_2CHCH_2OH$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Slightly suffocating; nonresidual alcoholic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 74.12; *Boiling Point at 1 atm.*: 226.2, 107.9, 381.1; *Freezing Point*: -162, -108, 165; *Critical Temperature*: 526.3, 274.6, 547.8; *Critical Pressure*: 623, 42.4, 4.30; *Specific Gravity*: 0.802 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 248, 138, 5.78; *Heat of Combustion*: -14,220, -7,900, -330.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air pack or organic canister mask; chemical goggles; *Symptoms Following Exposure*: Contact with eyes is extremely irritating and may cause burns. Breathing vapors will be irritating to the nose and throat. In high concentrations, may cause nausea, dizziness, headache, and stupor; *General Treatment for Exposure*: INHALATION: if victim is overcome by vapors, remove him from exposure immediately; call a physician; if breathing is irregular or has stopped, start resuscitation; administer oxygen. EYES: flush with water for at least 15 minutes; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: 200 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Isobutylamine — (i) Chemical Designations — *Synonyms*: 1-Amino-2-methylpropane; iso-Butylamine; Monoisobutylamine; *Chemical Formula*: $(CH_3)_2CHCH_2NH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong ammoniacal; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 73.1; *Boiling Point at 1 atm.*: 153.3, 67.4, 340.6; *Freezing Point*: -121.9, -85.5, 187.7; *Critical Temperature*: 469.4, 243.0, 516.2; *Critical Pressure*: 620, 42, 4.3; *Specific Gravity*: 0.739 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.073 at 20 °C; *Latent Heat of Vaporization*: 182, 101, 4.23; *Heat of Combustion*: -17,550, -9,760, -408; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; butyl rubber gloves; chemical face shield; butyl rubber apron; *Symptoms Following Exposure*: Inhalation causes severe coughing and chest pain due to irritation of air passages; can cause lung edema. Compound is sympathomimetic and is also a cardiac depressant and convulsant; ingestion causes nausea and profuse salivation. Contact with skin

causes severe irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration; if breathing is difficult, give oxygen; call a physician. INGESTION: give large amount of water followed by dilute vinegar or lemon juice; keep patient warm. EYES: flush with water for 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 120 mg/kg (rabbit), 250 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Isobutylene — (i) Chemical Designations — *Synonyms*: Isobutene; 2-Methylpropene; *Chemical Formula*: $(CH_3)_2C=CH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid under pressure; *Color*: Colorless; *Odor*: Mild sweetish; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 56.10; *Boiling Point at 1 atm.*: 19.6, -6.9, 266.3; *Freezing Point*: -220, -140.3, 132.9; *Critical Temperature*: 292.5, 144.7, 417.9; *Critical Pressure*: 580, 39.48, 3.99; *Specific Gravity*: 0.59 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.061; *Latent Heat of Vaporization*: 170, 94.3, 3.95; *Heat of Combustion*: -19,359, -10,755, -450.29; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical gloves and eye protection; organic vapor canister or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation of moderate concentrations causes dizziness, drowsiness, and unconsciousness. Contact with eyes or skin may cause irritation; the liquid may cause frostbite; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and apply resuscitation; call a physician promptly if victim is unconscious. EYES: if irritated, wash with water. SKIN: if irritated, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm (8 hr); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are non-irritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly. May cause frostbite; *Odor Threshold*: Data not available.

Isobutyric Acid — (i) Chemical Designations — *Synonyms*: Dimethylacetic acid; Isopropylformic acid; 2-Methylpropanoic acid; alpha-Methylpropionic acid; Propane-2-carboxylic acid; *Chemical Formula*: $(CH_3)_2CHCOOH$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Unpleasant, acrid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 88; *Boiling Point at 1 atm.*: 309, 154, 427; *Freezing Point*: -51, -46, 227; *Critical Temperature*: 637, 336, 609; *Critical Pressure*: 588, 40, 4.06; *Specific Gravity*: 0.949 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.0; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 202, 112, 4.68; *Heat of Combustion*: -10,600, -5,880, -246; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic chemical respirator; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water. EYES: flush with water for at least 15 min.; get medical attention if irritation persists. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} =280 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Isobutyronitrile — (i) Chemical Designations — *Synonyms*: IBN; Isopropyl cyanide; 2-Methilpropanenitrile; 2-Methilpropionitrile; *Chemical Formula*: $(CH_3)_2CHCN$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like almonds or benzaldehyde; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 69.1; *Boiling Point at 1 atm.*: 219, 104, 377; *Freezing Point*: Not pertinent; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.774 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.4; *Ratio of Specific Heats of Vapor (Gas)*:

Data not available; *Latent Heat of Vaporization*: 200, 110, 4.7; *Heat of Combustion*: -14,960, -8,310, -348; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles; rubber gloves; *Symptoms Following Exposure*: Inhalation, ingestion, or skin contact causes weakness, headache, confusion, nausea, vomiting; acute cyanide poisoning may result. Contact with eyes causes irritation; *General Treatment for Exposure*: Get medical attention following all overexposures to this chemical. Watch for symptoms of cyanide poisoning. INHALATION: move patient to fresh air; apply artificial respiration if breathing stops. INGESTION: break an amyl nitrite pearl in a cloth and hold lightly under patient's nose for 15 sec.; if he is conscious, induce vomiting and repeat until vomit is clear; repeat inhalation of amyl nitrite 5 times at 15-sec. intervals. EYES: flush with water for at least 15 min. SKIN: flush with water; remove contaminated clothing; destroy contaminated shoes; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 100 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Isooctaldehyde — (i) Chemical Designations — *Synonyms*: Dimethylhexanals; Isooctyl aldehyde; 6-Methyl-1-heptanal; *Chemical Formula*: $(CH_3)_2CH(CH_2)_4CHO$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 128.22; *Boiling Point at 1 atm.*: 307 - 352, 153 - 178, 426 - 451; *Freezing Point*: -180, -118, 155; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.825 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.040; *Latent Heat of Vaporization*: 140, 77, 3.2; *Heat of Combustion*: (est.) -17,000, -9600, -400; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles; *Symptoms Following Exposure*: High vapor concentrations produce eye irritation. Liquid may irritate eyes; *General Treatment for Exposure*: Remove from exposure. Wash eyes with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Isodecaldehyde — (i) Chemical Designations — *Synonyms*: Isodecaldehde, mixed isomers; Trimethylheptanals; *Chemical Formula*: $C_9H_{19}CHO$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Somewhat fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 156.28; *Boiling Point at 1 atm.*: Data not available; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.84 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing; chemical goggles; *Symptoms Following Exposure*: Low general toxicity. Liquid may irritate eyes and skin; *General Treatment for Exposure*: Wash eyes and skin with plenty of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Isodecyl Acrylate, Inhibited — (i) Chemical Designations — *Synonyms*: iso-Decyl acrylate; *Chemical Formula*: $CH_2{=}CHCOOC_{10}H_{21}$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak acrylate; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 212.4; *Boiling Point at 1 atm.*: Not pertinent (polymerizes); *Freezing Point*: -148, -100, 173; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not

pertinent; *Specific Gravity*: 0.885 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 110, 61, 2.6; *Heat of Combustion*: (est.) -16,300, -9,100, -380; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes mild irritation of nose and throat. Eyes are mildly irritated by vapor, more severely by liquid. Prolonged contact of liquid with skin may cause irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for at least 15 min. after contact with liquid. SKIN: wipe off, wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Isodecyl Alcohol — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $C_{10}H_{21}OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak alcoholic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 158.29; *Boiling Point at 1 atm.*: 428, 220, 493; *Freezing Point*: < 140, < 60, < 333; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.841 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.032; *Latent Heat of Vaporization*: (est.) 120, 67, 2.8; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles; *Symptoms Following Exposure*: Direct contact with skin can produce irritation; *General Treatment for Exposure*: Wash affected area with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are non-irritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposures; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Isohexane — (i) Chemical Designations — *Synonyms*: 2-Methylpentane; *Chemical Formula*: $CH_3CH(CH_3)CH_2CH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 86.18; *Boiling Point at 1 atm.*: 140.5, 60.3, 333.5; *Freezing Point*: -244.6, -153.7, 119.5; *Critical Temperature*: 435.7, 224.3, 497.5; *Critical Pressure*: 437, 29.7, 3.01; *Specific Gravity*: 0.653 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.062; *Latent Heat of Vaporization*: 139, 77.1, 3.23; *Heat of Combustion*: -19,147, -10,637, -445.35; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection (as for gasoline); *Symptoms Following Exposure*: Inhalation causes irritation of respiratory tract, cough, mild depression, cardiac arrhythmias. Aspiration causes severe lung irritation, coughing, pulmonary edema; excitement followed by depression. Ingestion causes nausea, vomiting, swelling of abdomen, headache, depression; *General Treatment for Exposure*: INHALATION: maintain respiration, give oxygen if needed. ASPIRATION: enforce bed rest; give oxygen. INGESTION: do NOT induce vomiting; call a doctor. EYES: wash with copious amount of water. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Isooctyl Alcohol — (i) Chemical Designations — *Synonyms*: Dimethyl-1-hexanols; 6-Methyl-1-heptanol; *Chemical Formula*: $(CH_3)_2CH(CH_2)_4CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 130.22; *Boiling Point at 1 atm.*: 367, 186, 459; *Freezing Point*: < 212, < 100, < 373; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not

pertinent; *Specific Gravity*: 0.832 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.040; *Latent Heat of Vaporization*: (est.) 140, 77, 3.2; *Heat of Combustion*: (est.) -17,400, -9650, -404,; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask in confined areas; plastic gloves; goggles; eye bath and safety shower; *Symptoms Following Exposure*: Inhalation hazard slight. Skin contact results in moderate irritation. Liquid contact with eyes causes severe irritation and possible eye damage; *General Treatment for Exposure*: Remove to fresh air. Flush skin and eye contact area at once for at least 15 min. Get medical care for eyes; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (lab animals); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Isopentane — (i) Chemical Designations — *Synonyms*: 2-Methylbutane; *Chemical Formula*: $(CH_3)_2CHCH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72.15; *Boiling Point at 1 atm.*: 82.2, 27.9, 301.1; *Freezing Point*: -255.8, -159.9, 113.3; *Critical Temperature*: 369.0, 187.2, 460.4; *Critical Pressure*: 491.0, 33.4, 3.38; *Specific Gravity*: 0.620 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.076; *Latent Heat of Vaporization*: 146, 81.0, 3.39; *Heat of Combustion*: -19,314, -10,730, -449.24; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection (as for gasoline); *Symptoms Following Exposure*: Inhalation causes irritation of respiratory tract, cough, mild depression, irregular heartbeat. Aspiration causes severe lung irritation, coughing, pulmonary edema; excitement followed by depression. Ingestion causes nausea, vomiting, swelling of abdomen, headache, depression; *General Treatment for Exposure*: INHALATION: maintain respiration, give oxygen if needed. ASPIRATION: enforce bed rest; give oxygen. INGESTION: do NOT induce vomiting; call a doctor. EYES: wash with copious amount of water. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Isophorone — (i) Chemical Designations — *Synonyms*: 3,5,5-Trimethyl-2-cyclohexene-1-one; *Chemical Formula*: $COCH=C(CH_3)CH_2C(CH_3)_2CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like camphor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 138.2; *Boiling Point at 1 atm.*: 419.5, 215.3, 488.5; *Freezing Point*: 17.4, -8.1, 265.1; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.921 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: 4.75; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 135, 75, 3.14; *Heat of Combustion*: -16,170, -8,980, -376; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus with full face mask; rubber gloves; *Symptoms Following Exposure*: Inhalation irritates eye, nose and throat; causes central depression and has some anesthetic effect. Contact of liquid with eyes causes severe irritation and possible tissue damage. Skin is irritated by liquid and may crack on prolonged contact. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim promptly from contaminated atmosphere; if breathing has stopped, give artificial respiration and oxygen. EYES: flood with water for at least 15 min.; consult an eye specialist as soon as possible. SKIN: flood with water. INGESTION: do not induce vomiting; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 2,330 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Isophthalic Acid — (i) Chemical Designations — *Synonyms*: Benzene-1,3-dicarboxylic acid; m-Phthalic acid; *Chemical Formula*: $1,3\text{-}C_6H_4(COOH)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Slightly acrid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 166; *Boiling Point at 1 atm.*: Not pertinent (sublimes); *Freezing Point*: 653, 345, 618; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.54 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,340, -4,630, -194; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: If without adequate ventilation, use respirator with dust filter, goggles, and gloves; *Symptoms Following Exposure*: May cause slight to moderate irritation of eyes, skin, and mucous membranes on prolonged contact. Ingestion may cause gastrointestinal irritation; *General Treatment for Exposure*: INHALATION: remove victim to uncontaminated area; get medical attention if complications arise. INGESTION: get medical attention if complications arise. EYES: flush with large amounts of water for 15 min.; get promptly medical attention. SKIN: wash with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 12.2 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Isoprene — (i) Chemical Designations — *Synonyms*: beta-Methylbivinyl; 2-Methyl-1,3-butadiene; *Chemical Formula*: $CH_2{=}C(CH_3)CH{=}CH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, aromatic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 68.12; *Boiling Point at 1 atm.*: 93.4, 34.1, 307.3; *Freezing Point*: -230.7, -145.9, 127.3; *Critical Temperature*: 412, 211.1, 484.3; *Critical Pressure*: 550, 37.4, 3.79; *Specific Gravity*: 0.681 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.3; *Ratio of Specific Heats of Vapor (Gas)*: 1.091; *Latent Heat of Vaporization*: 150, 85, 3.6; *Heat of Combustion*: -18,848, -10,471, -438.40; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Vapor-proof goggles; self-contained breathing apparatus; leather or rubber safety shoes; rubber gloves; *Symptoms Following Exposure*: Vapor produces no effects other than slight irritation of the eyes and upper respiratory tract. Liquid may irritate eyes; like gasoline; *General Treatment for Exposure*: INHALATION: remove victim promptly from irritating or asphyxiating atmosphere; if symptoms of asphyxiation persist, administer artificial respiration and oxygen; treat symptomatically thereafter; call a physician. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Isopropyl Acetate — (i) Chemical Designations — *Synonyms*: Acetic acid, isopropyl ester; 2-Propyl acetate; *Chemical Formula*: $CH_3COOCH(CH_3)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant, fruity; nonresidual; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.13; *Boiling Point at 1 atm.*: 191.3, 88.5, 361.7; *Freezing Point*: -92.7, -69.3, 203.9; *Critical Temperature*: 509, 265, 538; *Critical Pressure*: 529, 36, 3.65; *Specific Gravity*: 0.874 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.074; *Latent Heat of Vaporization*: 150, 81, 3.4; *Heat of Combustion*: -9420, -5230, -219; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic vapor canister or air-supplied mask; chemical goggles or face splash shield; *Symptoms Following Exposure*: Vapors irritate eyes and respiratory tract; high concentrations can be anesthetic. Liquid irritates eyes but causes no serious injury; may cause dermatitis; no serious effects if swallowed; *General Treatment for Exposure*: INHALATION: if victim is overcome by vapors, remove from exposure immediately; call a physician; if breathing is irregular or stopped, start resuscitation and administer oxygen. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 250 ppm; *Short-*

Term Inhalation Limits: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Isopropyl Alcohol — (i) Chemical Designations — *Synonyms*: Dimethylcarbinol; 2-Propanol; Isopropanol; sec-Propyl alcohol; Petrohol; Rubbing alcohol; *Chemical Formula*: $CH_3CH(OH)CH_3$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like ethyl alcohol; sharp, somewhat unpleasant; characteristic mild alcoholic; nonresidual; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 60.10; *Boiling Point at 1 atm.*: 180.1, 82.3, 355.5; *Freezing Point*: -127.3, -88.5, 184.7; *Critical Temperature*: 455.4, 235.2, 508.4; *Critical Pressure*: 691, 47.0, 4.76,; *Specific Gravity*: 0.785 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.105; *Latent Heat of Vaporization*: 286, 159, 6.66; *Heat of Combustion*: -12,960, -7,201, -301.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic vapor canister or air-supplied mask; chemical goggles or face shield; *Symptoms Following Exposure*: Vapors cause mild irritation of eyes and upper respiratory tract; high concentrations may be anesthetic. Liquid irritates eyes and may cause injury; harmless to skin; if ingested causes drunkenness and vomiting; *General Treatment for Exposure*: INHALATION: if victim is overcome by vapors, remove from exposure immediately; call a physician; if breathing is irregular or has stopped, start resuscitation and administer oxygen. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 400 ppm; *Short-Term Inhalation Limits*: 400 ppm for 10 min.; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat LD_{50}: 5.84 g/kg); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: 90 mg/m^3.

Isopropylamine — (i) Chemical Designations — *Synonyms*: 2-Aminopropane; Monoisopropylamine; iso-Propylamine; *Chemical Formula*: $(CH_3)_2CHNH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong ammoniacal; pungent, irritating, typical amine; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 59.11; *Boiling Point at 1 atm.*: 90.3, 32.4, 305.6; *Freezing Point*: -139, -95, 178; *Critical Temperature*: 396, 202, 475; *Critical Pressure*: 740, 50, 5.1; *Specific Gravity*: (est.) 0.691 at 20°C (liquid); *Vapor (Gas) Specific Gravity*: 2.04; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 193, 107, 4.48; *Heat of Combustion*: -16,940, -9,420, -394; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; butyl rubber gloves and apron; chemical face shield or safety goggles; *Symptoms Following Exposure*: Inhalation causes nose and throat irritation, severe coughing, and chest pain due to irritation of air passages; can cause lung edema and loss of consciousness. Ingestion causes nausea, salivation and severe irritation of mouth and stomach. Contact with skin causes severe irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration; give oxygen if breathing is difficult; call a physician. INGESTION: call a physician immediately; encourage the drinking of large quantities of water followed by dilute vinegar, lemon juice, cider, or other weak acids; keep patient warm. EYES: flush with water for 15 min., bolding eyelids apart; call physician as soon as possible, preferably an eye specialist. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} = 820 mg/kg (rat), 600 mg/kg (mouse); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 5 ppm.

Isopropyl Ether — (i) Chemical Designations — *Synonyms*: Diisopropyl ether; Diisopropyl oxide; 2-Isopropoxypropane; *Chemical Formula*: $(CH_3)_2CHOCH(CH_3)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless;

Odor: Sweet, slightly sharp; characteristic pungent; ethereal; like amphor and ethyl ether; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.2; *Boiling Point at 1 atm.*: 156, 69, 342; *Freezing Point*: -123, -86, 187; *Critical Temperature*: 440.4, 226.9, 500.1; *Critical Pressure*: 418, 28.4, 2.88; *Specific Gravity*: 0.724 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.0590; *Latent Heat of Vaporization*: 131, 73, 3.1; *Heat of Combustion*: -16,900, -9,390, -393; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister mask; rubber gloves; goggles; *Symptoms Following Exposure*: Inhalation causes anesthesia, nausea, dizziness, headache, and irritation of the eyes and nose. Contact of liquid with eyes causes only minor injury; repeated contact with skin will remove natural oils and may cause dermatitis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and obtain medical attention immediately; keep him warm and at rest, and give artificial respiratory if breathing stops; maintain an open airway. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 250 ppm (tentative); *Short-Term Inhalation Limits*: Grade 1; oral LD_{50} = 8,470 mg/kg (rat); *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Isopropyl Mercaptan — (i) Chemical Designations — *Synonyms*: 2-Propanethiol; Propane-2-thiol; *Chemical Formula*: $(CH_3)_2CHSH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Powerful skunk; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 76.2; *Boiling Point at 1 atm.*: 126.6, 52.5, 325.8; *Freezing Point*: -202.8, -130.5, 142.7; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.814 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.0964 at 15.6 °C; *Latent Heat of Vaporization*: 165.7, 92.1, 3.83; *Heat of Combustion*: -14,920, -8,290, -347; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes loss of sense of smell, muscular weakness, convulsions, respiratory paralysis. Ingestion causes nausea and vomiting. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move victim to fresh air; start artificial respiratory and give oxygen if required; observe for signs of pulmonary edema; get medical attention. INGESTION: give large amount of water; induce vomiting. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 1,790 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.25 ppm.

Isopropyl Percarbonate — (i) Chemical Designations — *Synonyms*: Diisopropyl percarbonate; Diisopropyl peroxydicarbonate; Isopropyl peroxydicarbonate; Peroxydicarbonic acid, bis (1-methylethyl) ester; Peroxydicarbonic acid, diisopropyl ester; *Chemical Formula*: $C_3H_7OOCOOCOOC_3H_7$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid (containers packed in "Dry Ice"); *Color*: White; *Odor*: Disagreeable; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 206.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 46 - 50, 8 - 10, 281 - 283; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.08 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,500, -4,720, -198; *Heat of Decomposition*: -670, -370, -15.5; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves and shoes; hard hat; chemical splash goggles; plastic apron; respirator (depending on solvent used); *Symptoms Following Exposure*: Inhalation overexposure unlikely, but prolonged exposure may cause lung edema. Contact with eyes may cause irritation. Solutions are severe primary skin irritants; *General Treatment for Exposure*: INHALATION: move to uncontaminated atmosphere; if breathing is difficult, give oxygen. EYES: flush with copious amounts of water. SKIN: wash off with

isopropyl alcohol and water; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Isovaleraldehyde — (i) Chemical Designations — *Synonyms*: Isovaleral; Isovaleric aldehyde; 3-Methylbutanal; 3-Methylbutyraldehyde; *Chemical Formula*: $(CH_3)_2CHCH_2CHO$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Weakly suffocating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 86.1; *Boiling Point at 1 atm.*: 198.5, 92.5, 365.7; *Freezing Point*: -60, -51, 222; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.785 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.0736; *Latent Heat of Vaporization*: (est.) 167, 93, 3.9; *Heat of Combustion*: -15,500, -8,620, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; air mask or self-contained breathing apparatus for high vapor concentrations; *Symptoms Following Exposure*: Inhalation causes chest discomfort, nausea, vomiting, and headache. Contact with eyes or skin causes irritation. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; apply artificial respiration if required; get medical attention. EYES: flush with water for at least 15 min. SKIN: wipe off, wash well with soap and water. INGESTION: induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} =3,200 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

K

Kerosene — (i) Chemical Designations — *Synonyms*: No. 1 Fuel oil; Kerosine; Illuminating oil; Range oil; JP-1; *Chemical Formula*: C_nH_{2n+2}; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless to light brown; *Odor*: Characteristic; like fuel oil; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 392 - 500, 200 - 260, 473 - 533; *Freezing Point*: -50, -45.6, 227.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.80 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 110, 60, 2.5; *Heat of Combustion*: -18,540, -10,300, -431.24; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Vapor causes slight irritation of eyes and nose. Liquid irritates stomach; if taken into lung, causes coughing, distress, and rapidly developing pulmonary edema; *General Treatment for Exposure*: ASPIRATION: enforce bed rest; administer oxygen; call a doctor. INGESTION: do not induce vomiting; call a doctor. EYES: wash with plenty of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*: 2500 mg/m^3 for 60 min.; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

L

Lactic Acid — (i) Chemical Designations — *Synonyms*: 2-Hydroxypropanoic acid; alpha-Hydroxypropionic acid; Milk acid; Racemic acid; *Chemical Formula*: $CH_3CHOHCOOH\text{-}H_20$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Sypury liquid; *Color*: Yellow to colorless; *Odor*: None or weak acidic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 90; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.20 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6,520, -3,620, -152; *Heat of*

Decomposition: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves; goggles; Self-contained breathing apparatus where high concentrations of mist are present; *Symptoms Following Exposure*: Inhalation of mist causes coughing and irritation of mucous membranes. Ingestion, even of diluted preparations, has a corrosive effect on the esophagus and stomach. Contact with more concentrated solutions can cause severe burns of eyes or skin; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water. EYES: flush with water for 15 min. SKIN: flush with water; wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 1,810 mg/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 4.0×10^{-7} ppm.

Latex, Liquid Synthetic — (i) Chemical Designations — *Synonyms*: Plastic latex; Synthetic rubber latex; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Milky; *Odor*: Each type has a characteristic odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.057 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles or face shield; *Symptoms Following Exposure*: Irritation of eyes; *General Treatment for Exposure*: EYES: flush with water for at least 15 minutes; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Contact with eyes can cause irritation; *Odor Threshold*: Not pertinent.

Lauroyl Peroxide — (i) Chemical Designations — *Synonyms*: Dilauroyl peroxide; Dodecanoyl peroxyde; *Chemical Formula*: $[CH_3(CH_2)_{10}COO]_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Faint pungent; bland, soapy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 399; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 129, 54, 327; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.91 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,300, -9,100, -380; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective goggles, gloves; *Symptoms Following Exposure*: Contact with liquid irritates eyes and skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: EYES: flush with plenty of water for 15 min. and get medical attention. SKIN: wash with soap and water. INGESTION: administer en emetic to induce vomiting and call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Weak carcinogen in mice; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lauryl Mercaptan — (i) Chemical Designations — *Synonyms*: 1-Dodecanethiol; Dodecyl mercaptan; *Chemical Formula*: $CH_3(CH_2)_{10}CH_2SH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild skunk; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 202; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 19.4, -7.0, 266.2; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.85 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: (est.) 110, 60, 2.5; *Heat of Combustion*: (est.) -18,200, -10,100, -422; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator when mist is present; rubber or vinyl gloves; chemical goggles; rubber shoes and apron; *Symptoms Following Exposure*: Liquid is irritating to skin, eyes, and mucous membranes. Ingestion may cause nausea. Repeated skin exposure can cause dermatitis and may produce a sensitizing effect; *General Treatment for Exposure*: Get medical attention for all eye exposures

and may other serious overexposures. INHALATION (mist): rinse mouth repeatedly with cold water; treatment is symptomatic. INGESTION: dilute by drinking water; if vomiting occurs, drink more water; administer saline laxative. EYES: flush thoroughly with water; ventilation by electric fan is helpful in removing last traces, especially around eyes and eyelids. SKIN: remove contaminated clothing; flush skin with water; wash exposed area with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Causes decline in kidney and liver function in rats; *Vapor (Gas) Irritant Characteristics*: Irritating concentrations of vapor unlikely, but mist can cause irritation of eyes and upper respiratory tract; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 4 mg/m^3.

Lead Acetate — (i) Chemical Designations — *Synonyms*: Lead acetate trihydrate; Neutral lead acetate; Normal lead acetate; Salt of Saturn; Sugar of lead; *Chemical Formula*: $Pb(C_2H_3O_2)_2 \cdot 3H_2O$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White (commercial grades are frequently brown or grey lumps); *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 379.3; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.55 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask and protective gloves; *Symptoms Following Exposure*: Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the ankles, is noticeable in the most serious cases. Ingestion of a large amount causes local irritation of the alimentary tract; pain leg cramps, muscle weakness, paresthesias, depression, coma, and death may follow in 1 or 2 days. Contact with eyes causes irritation; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lead Arsenate — (i) Chemical Designations — *Synonyms*: Lead arsenate, acid; Plumbous arsenate; *Chemical Formula*: $PbHASO_4$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 347.12; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.79 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust respirator; protective clothing to prevent accidental inhalation or ingestion of dust; *Symptoms Following Exposure*: Inhalation or ingestion causes dizziness, headache, paralysis, cramps, constipation, collapse, coma. Subacute doses cause irritability, loss of weight, anemia, constipation. Blood and urine concentrations of lead increase; *General Treatment for Exposure*: A specific medical treatment is used for exposure to this chemical; call a physician immediately! Give victim a tablespoon of salt in glass of warm water and repeat until vomit is clear. Then give two tablespoon of epsom salt or milk of magnesia in water, and plenty of milk and water. Have victim lie down and keep quiet; *Toxicity by Inhalation (Threshold Limit Value)*: (dust) 0.15 mg/m^3; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 4, LD_{50} below 50 mg/kg (rabbit, rat); *Late Toxicity*: Lead poisoning; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Lead Fluoroborate — (i) Chemical Designations — *Synonyms*: Lead fluoroborate; Lead fluoroborate solution; *Chemical Formula*: $Pb(BF_4)_2$-H_2O; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Faint; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.75 at 20 C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber gloves; face shield; rubber apron; *Symptoms Following Exposure*: Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the alimentary tract; pain, leg cramps, muscle weakness, paresthesias, coma, and death may follow in 1 or 2 days. Contact with skin or eyes may cause burns and/or irritation; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES: flush with copious quantities of water for 15 min. SKIN: wash area with soap and water; treat as an acid burn; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lead Fluoride — (i) Chemical Designations — *Synonyms*: Lead difluoride; Plumbous fluoride; *Chemical Formula*: PbF_2; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 245.19; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 8.24 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Respirator for heavy dust exposure; safety goggles; *Symptoms Following Exposure*: Not irritating to skin or mucous membranes; protect against chronic poisoning. Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the ankles, is noticeable in the most serious cases. Ingestion of a large amount causes local irritation of the alimentary tract; pain, leg cramps, muscle weakness, paresthesias, coma, and death may follow in 1 or 2 days. Contact with eyes causes irritation; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.15 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lead Iodide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: PbI_2; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Bright yellow; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 461.03; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 6.16 at 20 °C (solid); *Vapor (Gas) Specific*

Gravity: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask and protective gloves; *Symptoms Following Exposure*: Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the ankles, is noticeable in the most serious cases. Ingestion of a large amount causes local irritation of the alimentary tract. Pain, leg cramps, muscle weakness, paresthesias, coma, and death may follow in 1 or 2 days. Contact with eyes causes irritation; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lead Nitrate — (i) Chemical Designations — *Synonyms*: Nitric acid, lead (2+) salt; *Chemical Formula*: $Pb(NO_3)_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 331.2; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.53 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask and protective gloves; *Symptoms Following Exposure*: Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc.; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the ankles, is noticeable in the most serious cases. Ingestion of a large amount causes local irritation of the alimentary tract. Pain, leg cramps, muscle weakness, paresthesias, coma, and death may follow in 1 or 2 days. Contact with eyes causes irritation; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lead Tetraacetate — (i) Chemical Designations — *Synonyms*: Lead (IV) acetate; *Chemical Formula*: $Pb(C_2H_3O_2)_4$-CH_3COOH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Crystals wet with glacial acetic acid; *Color*: Faintly pink; *Odor*: Like acetic acid or vinegar; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 443.39; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 347, 175, 448; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.2 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the ankles, is noticeable in the most serious cases. Ingestion

of a large amount causes local irritation of the alimentary tract. Pain, leg cramps, muscle weakness, paresthesias, coma, and death may follow in 1 or 2 days. Contact with eyes cause severe irritation and can burn skin; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES: flush with water for at least 15 min. SKIN: wash contaminated skin with large amounts of water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lead Thiocyanate — (i) Chemical Designations — *Synonyms*: Lead sulfocyanate; *Chemical Formula*: $Pb(SCN)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 323.4; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.82 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Early symptoms of lead intoxication via inhalation or ingestion are most commonly gastrointestinal disorders, colic, constipation, etc; weakness, which may go on to paralysis, chiefly of the extensor muscles of the wrists and less often of the ankles, is noticeable in the most serious cases. Ingestion of a large amount causes local irritation of the alimentary tract. Pain, leg cramps, muscle weakness, paresthesias, coma, and death may follow in 1 or 2 days. Contact causes irritation of eyes and mild irritation of skin; *General Treatment for Exposure*: Remove at once all cases of lead intoxication from further exposure until the blood level is reduced to a safe value; immediately place the individual under medical care. INGESTION: give gastric lavage using 1% solution of sodium or magnesium sulfate; leave 15-30 gm magnesium sulfate in 6-8 oz. of water in the stomach as antidote and cathartic; egg white, milk, and tannin are useful demulcents; atropine sulfate and other antispasmodics may relieve abdominal pain, but morphine may be necessary. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as lead); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Linear Alcohols — (i) Chemical Designations — *Synonyms:* Dodecanol; Tridecanol; Tetradecanol; Pentadecanol; (Could be any of the above or mixturus therof); *Chemical Formula:* $CH_3(CH_2)_{10\text{-}13}CH_2OH$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquid; *Color:* Colorless; *Odor:* Mild; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid or solid; *Molecular Weight:* >186; *Boiling Point at 1 atm:* >486, >252, >525; *Freezing Point:* >66, >19, >292; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0,84 at 20 C (liquid); *Vapor (Gas) Specific Gravity:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* (est.) -18,500, -10,300, -429; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards —** *Personal Protective Equipment:* Eye protection. *Symptoms Following Exposure:* Direct contact can produce eye irritation. Low general toxicity. *Treatment for Exposure:* Wash eyes with water for at least 15 min. *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* None; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to skin. *Odor Threshold:* Data not available.

Liquefied Natural Gas — (i) Chemical Designations — *Synonyms:* LNG; *Chemical Formula:* $CH_4+C_2H_6$; **(ii) Observable Characteristics —** *Physical State (as shipped):* Liquefied gas; *Color:* Colorless; *Odor:* Mild,

sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* >16; *Boiling Point at 1 atm:* -258, -161, 112; *Freezing Point:* -296, -182,2, 91,0; *Critical Temperature:* -116, -82,2, 191,0; *Critical Pressure (psia, atm, MN/m²):* 673, 45,78, 4,64; *Specific Gravity:* 0,415-0,45 at -162°C (liquid); *Vapor (Gas) Specific Gravity:* 0,55-1,0; *Ratio of Specific Heats of Vapor (Gas):* 1,306; *Latent Heat of Vaporization:* (est.) 220, 120, 5,1; *Heat of Combustion:* -21,600 to -23,400, -12,000 to -13,000, -502,4 to 544,3; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards** — *Personal Protective Equipment:* Self-contained breathing apparatus; protective clothing if exposed to liquid. *Symptoms Following Exposure:* If concentration of gas in high enough, may cause asphyxiation. No detectable systemic effects, even at 5% concentration in air. *Treatment for Exposure:* Remove victim to open air. If the is overcome by gas, apply artificial resuscitation. *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Inhalation Limits:* Data not available; *Toxicity by Ingestion:* Not pertinent; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to the eyes and throat. *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly. May cause some frostbite. *Odor Threshold:* Data not available.

Liquefied Petroleum Gas — (i) Chemical Designations — *Synonyms*: Bottled gas; Propane-butane-(propylene) Pyrofax; LPG; *Chemical Formula*: C_3H_6-C $_5$H $_8$ C_4H_{10}; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Mild. But commercial LPG has a skunk-like odorant added as a warning; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: >44; *Boiling Point at 1 atm.*: >-40, >-40, >233; *Freezing Point*: Not pertinent; *Critical Temperature*: -142.01, -96.67, 176.53; *Critical Pressure*: 616.5, 41.94, 4.249; *Specific Gravity*: 0.51-0.58 at -50 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.130; *Latent Heat of Vaporization*: 183.2, 101.8, 4.262; *Heat of Combustion*: -19,782, -10,990, -460.13; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high concentrations of gas; *Symptoms Following Exposure*: Concentrations in air greater than 10% cause dizziness in a few minutes. 1% concentrations give the same symptom in 10 min. High concentrations cause asphyxiation; *General Treatment for Exposure*: Remove victim to open air. If he is overcome by gas, apply artificial respiration. Guard against self-injury if confused; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly. May cause frostbite; *Odor Threshold*: 5000-20,000 ppm.

Litharge — (i) Chemical Designations — *Synonyms*: Lead monoxide; Lead oxide, yellow; Lead protoxide; Massicot; Plumbous oxide; *Chemical Formula*: PbO; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Yellow to red; low-metal-content oxides; yellow to green to brown; high-metal-content oxides; gray to brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 223.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 9.5 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust or metal fume respirator; gloves; goggles; *Symptoms Following Exposure*: General symptoms of lead poisoning (delayed). Inhalation or ingestion causes abdominal pain (lead colic), metallic taste in mouth, loss of weight, pain in muscles, and muscular weakness. Dust may irritate eyes; *General Treatment for Exposure*: Consult physician after ingestion or exposure to high concentrations of dust. INGESTION: call physician at once; as first aid, induce vomiting and give milk and magnesium sulfate (Epsom salt); *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m³; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Impairs development of human fetal connective tissue cells; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Lithium Aluminum Hydride — (i) Chemical Designations — *Synonyms*: LAH; *Chemical Formula*:

$LiAlH_4$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White to gray; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 37.94; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.917 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubberized gloves; full face shield; *Symptoms Following Exposure*: Contact of solid with eyes and skin causes severe burns similar to those caused by caustic soda; *General Treatment for Exposure*: In case of accidental contact with the skin, wipe off excess with a dry paper towel. Wash the affected area with a large volume of water to prevent localized heating of the skin; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Moisture of skin causes caustic burns; *Odor Threshold*: Not pertinent.

Lithium Hydride — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: LiH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Gray-blue crystalline mass; finely ground material ranges in color from white to gray; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 7.95; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.78 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubberized gloves; flame proof outer clothing; respirator; high boots or shoes; *Symptoms Following Exposure*: Inhalation of dust causes coughing, sneezing, and burning of nose and throat. Ingestion causes severe burns of mouth and stomach; symptoms of central nervous system damage may occur. Contact with eyes causes severe caustic burns; *General Treatment for Exposure*: Lithium hydride burns of the eyes, skin, or respiratory tract appear to be worse than those caused by an equivalent amount of sodium hydroxide. INHALATION: remove victim to fresh air; if irritation persists get medical attention at once. INGESTION: give large volumes of water and milk; gastric lavage may be indicated. EYES: flush with copious quantities of running water for at least 15 min; get medical attention. SKIN: flush with water; treat as a caustic burn; *Toxicity by Inhalation (Threshold Limit Value)*: 0.025 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Lithium, Metallic — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: Li; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; light silvery; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 6.939; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.53 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,470, -10,260, -429.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber or plastic gloves; face shield; respirator; fire-retardant clothing; *Symptoms Following Exposure*: Contact with eyes causes caustic irritation or burn. In contact with skin lithium react with body moisture to cause chemical burns; foil, ribbon, and wire react relatively slowly; *General Treatment for Exposure*: EYES or SKIN: flush with water and treat with boric acid; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

M

Magnesium — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*:

Mg; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Silvery; looks like aluminum; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 24.3; *Boiling Point at 1 atm.*: 2,012, 1,100, 1,373; *Freezing Point*: 1,202, 650, 923; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.74 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11,950, -6,650, -278; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Eye protection; *Symptoms Following Exposure*: Dust irritates eyes in same way as any foreign material. Penetration of skin by fragments of metal is likely to produce local irritation, blisters, and ulcers which may become infected; *General Treatment for Exposure*: EYES: flush with water to remove dust. SKIN: treat as any puncture; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Oral LDL_0 (lowest lethal dose) = 230 mg/kg (dog); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Magnesium Perchlorate — **(i) Chemical Designations** — *Synonyms*: Anhydrone; Dehydrite; Magnesium perchlorate, anhydrous; Magnesium perchlorate, hexahydrate; *Chemical Formula*: $Mg(ClO_4)_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 223.2; *Boiling Point at 1 atm.*: Decomposes above 250°C; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.21 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: U.S. Bu. Mines approved respirator; chemical safety goggles; face shield; *Symptoms Following Exposure*: Inhalation of dust irritation of mucous membrane. Ingestion of large amounts may be fatal; immediate symptoms include abdominal pains, nausea and vomiting, diarrhea, pallor, blueness, shortness of breath, unconsciousness. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention if irritation persists. INGESTION: give large amounts of water; induce vomiting; call a physician. EYES: flush with copious quantities of water for 15 min.; call a physician. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Malathion — **(i) Chemical Designations** — *Synonyms*: CYTHION Insecticide; S-[1,2-Bis(ethoxycarbonyl) ethyl]; 0,0-dimethyl phosphorodithioate; *Chemical Formula*: $C_{10}H_{19}O_6PS_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow to dark brown; *Odor*: Characteristic skunk-like mercaptan; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 330.36; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 37, 2.9, 276; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.234 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Wear self-contained breathing apparatus (or respirator for organophosphate pesticides) and rubber clothing while fighting fires of malathion with chlorine bleach solution. All clothing contaminated by fumes and vapors must be decontaminated; *Symptoms Following Exposure*: Exposure to fumes from a fire or to liquid causes headache, blurred vision, constricted pupils of the eyes, weakness, nausea, cramps, diarrhea, and tightness in the chest. Muscles twitch and convulsions may follow. The symptoms may develop over a period of 8 hours; *General Treatment for Exposure*: Speed is essential. INHALATION: in the non-breathing victim immediately institute artificial respiration, using the mouth-to-mouth, the mouth-to-nose, or the mouth-to-oropharyngeal method. Call physician! INGESTION: administer milk, water or salt-water and induce vomiting repeatedly. SKIN OR EYE CONTACT: flood and wash exposed skin areas thoroughly with water. Remove contaminated

clothing under a shower. Administer atropine, 2 mg (1/30 gr) intramuscularly or intravenously as soon as any local or systemic signs or symptoms of an intoxication are noted; repeat the administration of atropine every 3-8 min. until signs of atropinization (mydriasis, dry mouth, rapid pulse, hot and dry skin) occur; initiate treatment in children with 1 mg of atropine. Watch respiration, and remove bronchial secretion if they appear to be obstructing the airway; incubate if necessary. Give 2-PAM (Pralidoxime; Protopan), 2.5 gm in 100 ml of sterile water or in 5% dextrose and water, intravenously, slowly, in 15-30 min.; if sufficient fluid is not available, give 1 gm of 2-PAM in 3 ml of distilled water by deep intramuscular injection; repeat this every half hour if respiration weakens or if muscle fasciculation or convulsions recur; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None likely; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Maleic Acid — (i) Chemical Designations — *Synonyms*: cis-Butenedioic acid; cis-1,2-Ethylenedicarboxylic acid; Maleinic acid; Malenic acid; Toxilic acid; *Chemical Formula*: HOOC-CH=CH-COOH; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 116.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.59 at 20°C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -5,000, -2,800, -117; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: immediately flush with plenty of water for at least 15 min.; get medical attention if irritation persist. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 708 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Maleic Anhydride — (i) Chemical Designations — *Synonyms*: cis-Butenedioic anhydride; 2,5-Furanedione; Toxilic anhydride; *Chemical Formula*: OCOCH=CHCO; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid or liquid; *Color*: Colorless; *Odor*: Acrid; choking; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 98.06; *Boiling Point at 1 atm.*: 392, 200, 473; *Freezing Point*: 127, 53, 326; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.43 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -5936, -3298, -138.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Approved organic vapor-acid gas canister; chemical goggles and face shield; rubber gloves and boots; coveralls or rubber apron; *Symptoms Following Exposure*: Inhalation causes coughing, sneezing, throat irritation. Skin contact causes irritation and redness. Vapors cause severe eye irritation; photophobia and double vision may occur; *General Treatment for Exposure*: INHALATION: give oxygen. EYE OR SKIN CONTACT: flush with lots of water for at least 15 min.; for eyes, call a physician. For molten maleic burns, remove crust and treat as chemical and thermal burn; *Toxicity by Inhalation (Threshold Limit Value)*: 0.25 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 1.3-2.0 mg/m^3.

Maleic Hydrazide — (i) Chemical Designations — *Synonyms*: 1,2-Dihydro-3,6-pyridazinedione; 6-Hydroxy-3-(2H)-pyridazinone; Maleic acid hydrazide; Malazide; MH; Regulox; *Chemical Formula*: $C_4H_4N_2O_2$; **(ii) Observable Characteristics —** *Physical State (as*

shipped): Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 112.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 558, 292, 565; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.60 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -8,200, -4,500, -190; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust mask; *Symptoms Following Exposure*: Inhalation of dust may causes irritation of nose and throat. Contact with eyes or skin causes irritation. Ingestion has been observed to cause tremors and muscle spasms in test animals; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: flush with water for at least 15 min. SKIN: flush with water; wash with soap and water. INGESTION: get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 3,800 mg/kg (rat); *Late Toxicity*: Causes cancer in rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Mercuric Acetate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $(CH_3COO)_2Hg$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Slight acetic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 318.7; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.27 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, dust mask, goggles; *Symptoms Following Exposure*: The general symptoms are those of mercury poisoning, developing rapidly after ingestion but more slowly after low repeated exposures. Contact with eyes causes irritation and ulceration. Skin contact may cause dermatitis. Ingestion causes pain, vomiting, ulceration of mouth and stomach, kidney failure, metallic taste, pallor, and rapid, weak pulse; *General Treatment for Exposure*: Have physician treat for mercury poisoning. EYES or SKIN: flush with water. INGESTION: call physician; poison should be removed from stomach as soon as possible; give milk or white of eggs beaten with water, than tablespoon of salt in a glass of warm water and repeat until vomit fluid is clear; repeat milk or white of eggs beaten with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 76 mg/kg (rat); *Late Toxicity*: Intestinal bleeding and kidney damage may develop; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Mercuric Ammonium Chloride — (i) Chemical Designations — *Synonyms*: Albus; Aminomercuric chloride; Ammoniated mercury; Mercuric chloride, ammoniated; Mercury ammonium chloride; Mercury (II) chloride ammonobasic; *Chemical Formula*: $HgNH_2Cl$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 252.1; *Boiling Point at 1 atm.*: Not pertinent (sublimes at red heat); *Freezing Point*: Not pertinent (infusible); *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.7 at 20 C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Gloves, goggles, respirator; *Symptoms Following Exposure*: The general symptoms are those of mercury poisoning, developing rapidly after ingestion but more slowly after low repeated exposures. Contact with eyes causes irritation and ulceration. Skin contact may cause dermatitis. Ingestion causes pain, vomiting, ulceration of mouth and stomach, kidney failure, metallic taste, pallor, and rapid, weak pulse; *General Treatment for Exposure*: Have physician treat for mercury poisoning. EYES or SKIN: flush with water. INGESTION: call physician; poison should be removed from stomach as soon as possible; give milk or white of eggs beaten with water, than tablespoon of salt in a glass of warm water and repeat until vomit fluid is clear; repeat milk or white of eggs; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mer-

cury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 76 mg/kg (rat); *Late Toxicity*: Intestinal bleeding and kidney damage may develop; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Mercuric Chloride — (i) Chemical Designations — *Synonyms*: Calochlor; Corrosive mercury chloride; Corrosive sublimate; Mercury bichloride; Mercury (II) chloride; Mercury perchloride; *Chemical Formula*: $HgCl_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 271.50; *Boiling Point at 1 atm.*: 576, 302, 575; *Freezing Point*: 531, 277, 550; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.4 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Bu. Mines approved airline respirator; impervious suit; appropriate eye protection; *Symptoms Following Exposure*: All forms of exposure to this compound are hazardous; acute systemic mercurialism may be fatal within a few minutes, but death by uremic poisoning is usually delayed 5-12 days. Acute poisoning has resulted from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. Ingestion causes necrosis, pain, vomiting, and severe purging; as little as 0.5 gm cam be fatal. Contact with eyes causes ulceration of conjunctiva and cornea. Contact with skin causes irritation and possible dermatitis; systemic poisoning can occur by absorption through skin; *General Treatment for Exposure*: Act promptly! Alimentary absorption is very rapid, and first 10-15 minutes determine the prognosis. INHALATION: remove victim to fresh air; get medical attention. INGESTION: give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES or SKIN: wash with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 1 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Mercuric Cyanide — (i) Chemical Designations — *Synonyms*: Cianurina; Mercury cyanide; Mercury (II) cyanide; *Chemical Formula*: $Hg(CN)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White or colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 252.63; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.0 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Symptoms of both cyanide and mercury intoxication can occur. Acute poisoning has resulted from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing; cyanide poisoning can cause anxiety, confusion, dizziness, and shortness of breath, with possible unconsciousness, convulsions, and paralysis; breath may smell like bitter almonds. Ingestion causes necrosis, pain, vomiting, and severe purging, plus the above symptoms. Contact with eyes causes ulceration of conjunctiva and cornea. Contact with skin causes irritation and possible dermatitis; systemic poisoning can occur by absorption through skin; *General Treatment for Exposure*: Act quickly; call physician. INHALATION: if victim has stopped breathing, start artificial respiration immediately; using amyl nitrite pearls, adniinister amyl nitrite by inhalation for 15-30 seconds of every minute while sodium nitrite solution is being prepared; discontinue amyl nitrite and immediately inject intravenously 10 ml of a 3% solution of sodium nitrite (nonsterile if necessary) over a period of 2-4 min.; without removing needle, infuse intravenously 50 ml of a 25% aqueous solution of sodium thiosulphate; injection should take about 10 min. (concentrations of 5-50% may be used, but keep total dose approx. 12 gm). Oxygen therapy may be helpful in combination with the above. INGESTION: Alimentary absorption is very rapid, and first 10-15 minutes determine the prognosis. Give egg whites, milk, or activated charcoal; induce vomiting; treat for cyanide poisoning as above. EYES or SKIN: wash with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available;

Toxicity by Ingestion: Grade 4, oral LD_{50} = 25 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Mercuric Iodide — (i) Chemical Designations — *Synonyms*: Mercuric iodide, red; Mercury biniodide; *Chemical Formula*: HgI_2; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Red; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 454.90; *Boiling Point at 1 atm.*: 669, 354, 627; *Freezing Point*: 495, 257, 530; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 6.3 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: All forms of exposure to this compound are hazardous; acute systemic mercurialism may be fatal within a few minutes, but death by uremic poisoning is usually delayed 5-12 days. Acute poisoning has resulted from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. Ingestion causes necrosis, pain, vomiting, and severe purging. Contact with eyes causes ulceration of conjunctiva and cornea. Contact with skin causes irritation and possible dermatitis; systemic poisoning can occur by absorption through skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention. INGESTION: Alimentary absorption is very rapid, and first 10-15 minutes determine the prognosis. Give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES: wash with water for at least 15 min. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 40 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Mercuric Nitrate — (i) Chemical Designations — *Synonyms*: Mercuric nitrate monohydrate; Mercury (II) nitrate; Mercury pernitrate; *Chemical Formula*: $Hg(NO_3)_2 \cdot H_2O$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; colorless; *Odor*: Sharp odor of nitric acid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 342.6; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.3 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: All forms of exposure to this compound are hazardous; acute systemic mercurialism may be fatal within a few minutes, but death by uremic poisoning is usually delayed 5-12 days. Acute poisoning has resulted from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. Ingestion causes necrosis, pain, vomiting, and severe purging. Contact with eyes causes ulceration of conjunctiva and cornea. Contact with skin causes irritation and possible dermatitis; systemic poisoning can occur by absorption through skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention. INGESTION: Alimentary absorption is very rapid, and first 10-15 minutes determine the prognosis. Give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Mercuric Oxide — (i) Chemical Designations — *Synonyms*: Mercuric oxide, red ("Red precipitate"); Mercuric oxide, yellow ("Yellow precipitate"); Mercury oxide; *Chemical Formula*: HgO; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Red; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 216.61; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent;

Critical Temperature: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 11.1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Acute poisoning may be fatal within a few minutes; death by uremic poisoning is usually delayed 5-12 days. Acute poisoning has resulted from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. Ingestion causes necrosis, pain, vomiting, and severe purging. Contact with eyes causes ulceration of conjunctiva and cornea. Contact with skin causes irritation and possible dermatitis; systemic poisoning can occur by absorption through skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention. INGESTION: Alimentary absorption is very rapid; action during first 10-15 minutes determine the prognosis. Give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES: wash with water for at least 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 18 mg/kg (rat); *Late Toxicity*: Causes birth defects in rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Mercuric Sulfide — (i) Chemical Designations — *Synonyms*: Mercuric sulfide, black (Ethiops mineral); Mercuric sulfide, red (Vermilon; Artificial cinnabar; Chinese red); *Chemical Formula*: HgS; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Red or black; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 232.7; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 8 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Acute poisoning has result from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. If ingested, toxicity depends on release Hg^{++} ion; chronic mercury poisoning can cause kidney, mental, and nervous disturbances. Dust irritates eyes and frequently causes allergic dermatitis; absorption through skin can cause systemic poisoning; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give artificial respiration if breathing has stopped. INGESTION: Give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES: flush with water. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Central nervous system affects, tremors, psychological disturbances in humans; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Mercurous Chloride — (i) Chemical Designations — *Synonyms*: Calomel; Mercury monochloride; Mercury protochloride; Mercury subchloride; Mild mercury chloride; *Chemical Formula*: HgCl or Hg_2Cl_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 236.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 7.15 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Acute poisoning has result from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. Compound is an irritant, cathartic, or purgative; rarely, "calomel sickness", a benign reaction with fever and rash, appears after about 1 week; seldom causes systemic poisoning but may be fatal if retained to 30-40 mg/kg. Contact with eyes causes mild irritation;

General Treatment for Exposure: INHALATION: remove victim to fresh air; give artificial respiration if breathing has stopped. INGESTION: Give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES: flush with water. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 210 mg/kg (rat); *Late Toxicity*: Central nervous system affects, tremors, psychological disturbances in humans; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Mercuric Nitrate — (i) Chemical Designations — *Synonyms*: Mercurous nitrate monohydrate; Mercury protonitrate; *Chemical Formula*: $HgNO_3 \cdot H_2O$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Slight odor of nitric acid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 280.6; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.78 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Acute systemic poisoning may be fatal within a few minutes; death by uremic poisoning is usually delayed 5-12 days. Acute poisoning has result from inhaling dust concentrations of 1.2-8.5 mg/m^3 of air; symptoms include tightness and pain in chest, coughing, and difficulty in breathing. Ingestion causes necrosis, pain, vomiting, and severe purging. Contact with eyes causes ulceration of conjunctiva and cornea. Contact with skin causes irritation and possible dermatitis; systemic poisoning can occur by absorption through skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; get medical attention. INGESTION: Give egg whites, milk, or activated charcoal; induce vomiting; consult physician. EYES: flush with water for at least 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3 (as mercury); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 297 mg/kg (rat); *Late Toxicity*: Central nervous system affects, tremors, psychological disturbances in humans; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Mercury — (i) Chemical Designations — *Synonyms*: Quicksilver; *Chemical Formula*: Hg; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Silvery; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 200.59; *Boiling Point at 1 atm.*: 675, 357, 630; *Freezing Point*: -38.0, -38.9, 234.3; *Critical Temperature*: 2664, 1462, 1735; *Critical Pressure*: 23,300, 1587, 160.8; *Specific Gravity*: 13.55 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Avoid contact of liquid with skin. For vapor use chemical cartridge (Hopcalite) respirator; *Symptoms Following Exposure*: No immediate symptoms. As poisoning becomes established, slight muscular tremor, loss of appetite, nausea, and diarrhea are observed. Psychic, kidney, and cardiovascular disturbances may occur; *General Treatment for Exposure*: Consult a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: No immediate toxicity; *Late Toxicity*: Development of mercury poisoning; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Mesityl Oxide — (i) Chemical Designations — *Synonyms*: Isobutenyl methyl ketone; Isopropylideneacetone; Methyl isobutenyl ketone; 4-Methyl -3-pentene-2-one; *Chemical Formula*: $CH_3COCH{=}C(CH_3)_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless to slightly yellow; *Odor*: Strong; peppermint; honeylike; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.2; *Boiling Point at 1 atm.*: 266, 130, 403; *Freezing Point*: -51, -46, 227; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.853 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 157, 87, 3.7; *Heat of Combustion*: -14,400, -8,000, -330; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Pro-*

tective Equipment: Air pack or organic canister mask; rubber gloves; goggles; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat, dizziness, headache, difficult breathing. Contact with liquid or concentrated vapor causes severe eye irritation. Liquid irritates skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and restore breathing; call physician. EYES: immediately flush with plenty of water for at least 15 min. SKIN: wash with water. INGESTION: give large amount of water; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Inhalation Limits*: 1,000 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 1,120 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 12 ppm.

Methallyl Chloride — (i) Chemical Designations — *Synonyms*: gamma-Chloroisobutylene; 3-Chloro-2-methylpropene; beta-Methallyl chloride; beta-Methylallyl chloride; *Chemical Formula*: $CH_2=C(CH_3)CH_2Cl$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless to straw; *Odor*: Pungent; penetrating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 90.55; *Boiling Point at 1 atm.*: 162.0, 72.2, 345.4; *Freezing Point*: <-112, <-80, <193; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.928 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.12; *Ratio of Specific Heats of Vapor (Gas)*: 1.0893; *Latent Heat of Vaporization*: 160, 89, 3.7; *Heat of Combustion*: (est.) -11,600, -6,500, -270; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic canister mask; goggles; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Contact with vapor or liquid causes irritates eyes. Liquid irritates skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give oxygen if breathing stops; give artificial respiration and oxygen; subsequent treatment is symptomatic and supportive. EYES: flush with water for at least 15 min.; get medical attention if exposure has been to liquid. SKIN: flush with water; get medical attention if skin is burned. INGESTION: induce vomiting and follow with gastric lavage, demulcents, and saline cathartics; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Methane — (i) Chemical Designations — *Synonyms*: Marsh gas; *Chemical Formula*: CH_4; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Mild; sweet; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 16.04; *Boiling Point at 1 atm.*: -258.7, -161.5, 111.7; *Freezing Point*: -296.5, -182.5, 90.7; *Critical Temperature*: -116.5, -82.5, 190.7; *Critical Pressure*: 668, 45.44, 4.60; *Specific Gravity*: 0.422 at =160 °C (liquid); *Vapor (Gas) Specific Gravity*: 0.55 1.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.306; *Latent Heat of Vaporization*: 219.4, 121.9, 5.100; *Heat of Combustion*: -21,517, -11,954, -500.2; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high concentrations; protective clothing if exposed to liquid; *Symptoms Following Exposure*: High concentrations may cause asphyxiation. No systemic effects, even at 5% concentration in air; *General Treatment for Exposure*: Remove to fresh air. Support respiration; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent(methane is an asphyxiant, and limiting factor is available oxygen); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly, but may cause some frostbite; *Odor Threshold*: 200 ppm.

Metanearsonic Acid, Sodium Salts — (i) Chemical Designations — *Synonyms*: Disodium methanearsonate; Disodium methyl arsonate; DSMA; Monosodium methanearsonate; Monosodium methyl arsonate; MSMA; *Chemical Formula*: $CH_3AsO(OH)(ONa)$; $CH_3AsO(ONa)_2 \cdot 6H_2O$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Colorless; solutions may contain red or green dyes; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid or water solution; *Mo-*

lecular Weight: 162 (MSMA); 292 (DSMA hexahydrate); *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: (MSMA) 243, 117, 390; (DSMA) 137, 58, 332; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (DSMA) 1.0 at 20 °C (solid); (MSMA solutions) 1.4 - 1.6 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing to prevent contact with skin; chemical goggles; *Symptoms Following Exposure*: Subacute poisoning by arsenicals causes salty taste, burning in throat and stomach, and intestinal pain. Acute toxicity indicated by headache, vomiting, stupor, convulsions, paralysis. About 1 ounce to 1 pound must be taken to cause these symptoms; *General Treatment for Exposure*: INGESTION: cause vomiting; give water and repeat; give a saline cathartic such as sodium sulfate. SKIN: wash with soap and water. EYES: wash with water; consult physician if irritation remains; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Repeated contact may cause skin sensitivity; *Odor Threshold*: Not pertinent.

Methoxychlor — (i) Chemical Designations — *Synonyms*: 2,2-Bis(p-methoxyphenyl)-1,1,1-trichloroethane; 2,2-Di-(p-anisyl)-1,1,1- trichloroethane; DMDT; Marlate 50; Methoxy-DDT; *Chemical Formula*: $C_{16}H_{15}Cl_3O_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Light cream; white to light yellow; *Odor*: Slightly fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 345.7; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 171 - 192, 77 - 89, 350 - 362; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.41 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator if needed; gloves and goggles; *Symptoms Following Exposure*: Toxicity is relatively low. Inhalation or ingestion causes generalized depression; *General Treatment for Exposure*: EYES: flush with water if irritated. SKIN: wash well with soap and water. INGESTION: consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Methyl Acetate — (i) Chemical Designations — *Synonyms*: Acetic acid, methyl ester; *Chemical Formula*: CH_3COOCH_3; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Slightly acrid, sweet; fragrant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 74.1; *Boiling Point at 1 atm.*: 134.6, 57.0, 330.2; *Freezing Point*: -145.3, -98.5, 174.7; *Critical Temperature*: 452.7, 233.7, 506.9; *Critical Pressure*: 666, 45.3, 4.60; *Specific Gravity*: 0.927 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.8; *Ratio of Specific Heats of Vapor (Gas)*: 1.1192; *Latent Heat of Vaporization*: 174, 97, 4.1; *Heat of Combustion*: 9,260, 5,150, 215; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air mask or organic canister mask; goggles or face shield; *Symptoms Following Exposure*: (Very similar to those of methyl alcohol, which constitutes 20% of commercial grade.) Inhalation causes headache, fatigue, and drowsiness; high concentrations can produce central nervous system depression and optic nerve damage. Liquid irritates eyes and may cause defatting and cracking of skin. Ingestion causes headache, dizziness, drowsiness, fatigue; may cause severe eye damage; *General Treatment for Exposure*: INHALATION: remove victim from affected area; if breathing has ceased, apply artificial respiration; call doctor. EYES: irrigate thoroughly with clear water for 15 min. and call doctor. SKIN: wash affected area with water. INGESTION: get medical attention for methyl alcohol poisoning; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*: 400 ppm for 5 min.; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 3,700 mg/kg (rabbit); *Late Toxicity*: Optic nerve may be damaged following overexposure to vapor or liquid; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Methyl Acetylene-Propadiene Mixture — (i) Chemical Designations — *Synonyms*: Allene-methylacetylene mixture; MAPP gas; Methylacetylene-allene mixture; Propadiene-methylacetylene mixture; *Chemical Formula*: $CH_3C{=}CH{+}CH_2{=}C{=}CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Offensive, like acetylene; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 40.1; *Boiling Point at 1 atm.*: -36 to -4, -38 to -20, 235 to 253; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.576 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.48; *Ratio of Specific Heats of Vapor (Gas)*: 1.1686; *Latent Heat of Vaporization*: 227, 126, 5.28; *Heat of Combustion*: -19,800, -11,000, -460; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high concentrations; safety goggles; protective gloves; *Symptoms Following Exposure*: Simple asphyxiant. Toxicology of propadiene component not fully established. Contact with liquid may burn eyes and cause frosbite of skin; *General Treatment for Exposure*: INHALATION: remove to fresh air; give artificial respiration if necessary. EYES or SKIN: treat burns caused by cold liquid; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Lung irritation in rats and dogs; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 100 ppm.

Methyl Acrylate — (i) Chemical Designations — *Synonyms*: Acrylic acid, methyl ester; Methyl 2-propenoate; *Chemical Formula*: $CH_2{=}CHCOOCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic acrylic; sweet, sharp; sharp, fragrant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 86.09; *Boiling Point at 1 atm.*: 177, 80.6, 353.8; *Freezing Point*: -105.7, -76.5, 196.7; *Critical Temperature*: 505, 263, 536; *Critical Pressure*: 630, 43, 4.3; *Specific Gravity*: 0.956 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.102; *Latent Heat of Vaporization*: 160, 90, 3.8; *Heat of Combustion*: (est.) -9900, -5500, -230; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister for high vapor concentrations; rubber gloves; chemical goggles or face shield; *Symptoms Following Exposure*: May irritate skin, eyes, respiratory system, and gastrointestinal tract. Fumes cause tears; *General Treatment for Exposure*: INHALATION: remove to fresh air; lay patient down; keep him warm; administer artificial respiration if breathing has stopped; administer oxygen. SKIN OR EYES: flush with plenty water for 15 min.; consult physician for eye exposure; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Inhalation Limits*: 25 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg (rabbit); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Methyl Alcohol — (i) Chemical Designations — *Synonyms*: Colonial spirit; Wood alcohol; Columbian spirit; Wood naphtha; Methanol; Wood spirit; *Chemical Formula*: CH_3OH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Faint alcohol; like ethyl alcohol; faintly sweet; characteristic pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 32.04; *Boiling Point at 1 atm.*: 148.1, 64.5, 337.7; *Freezing Point*: -144.0, -97.8, 175.4; *Critical Temperature*: 464, 240, 513; *Critical Pressure*: 1142.0, 77.7, 7.87; *Specific Gravity*: 0.792 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.254; *Latent Heat of Vaporization*: 473.0, 262.8, 11.00; *Heat of Combustion*: -8419, -4677, -195.8; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister mask for high vapor concentrations; safety goggles; rubber gloves; *Symptoms Following Exposure*: Exposure to excessive vapor causes eye irritation, headache, fatigue and drowsiness. High concentrations can produce central nervous system depression and optic nerve damage. 50,000 ppm will probably cause death in 1 to 2 hrs. Can be absorbed trough skin. Swallowing may cause death or eye damage; *General Treatment for Exposure*: Remove victim from exposure and apply artificial respiration if breathing has ceased. INGESTION: induce vomiting, then give 2 teaspoons of baking soda in glass of water; call a physician. EYES or SKIN: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*:

260 mg/m³ for 60 min.; *Toxicity by Ingestion*: Grade 1; 5 to 15 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 100 ppm.

Methylamine — (i) Chemical Designations — *Synonyms*: Aminomethane; Mercurialin; Monomethylamine, anhydrous; *Chemical Formula*: CH_3NH_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied; *Color*: Colorless; *Odor*: Like ammonia, pungent, fishy, suffocating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 31.1; *Boiling Point at 1 atm.*: 20.3, -6.5, 266.7; *Freezing Point*: -134.5, -92.5, 180.7; *Critical Temperature*: 318, 159, 432; *Critical Pressure*: 1,080, 73.6, 7.47; *Specific Gravity*: 0.693 at -6.5 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.1946; *Latent Heat of Vaporization*: 358, 199, 8.33; *Heat of Combustion*: -15,000, -8,340, -34.9; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face mask; rubber suit, apron, sleeves, and/or gloves; rubber or leather safety shoes; air-line mask, positive-pressure hose mask, self-contaminated breathing apparatus, or industrial canister-type gas mask; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat, followed by violent sneezing, burning sensation in throat, coughing, constriction of larynx and difficulty in breathing, pulmonary congestion, edema of the lung, and conjunctivitis. Contact with liquid burn eyes and skin. (Severe exposure may cause blindness.) Vapors may cause dermatitis. Ingestion causes burns of the mouth, throat, and esophagus; *General Treatment for Exposure*: Get medical attention for anyone overcome or injured by exposure to this compound. INHALATION: remove victim to fresh air at once; apply artificial respiration if breathing has stopped; administer oxygen. EYES: flush with water for at least 15 min. SKIN: flush with water; if skin is burned do not use ointments or cover for 24 hours. INGESTION: do NOT induce vomiting; give large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: 0.021 ppm.

Methyl Amyl Acetate — (i) Chemical Designations — *Synonyms*: Hexyl acetate; MAAc; Methylisobutylcarbinyl acetate; 4-Methyl-2-pentanol, acetate; 4-Methyl-2-pentyl acetate; *Chemical Formula*: $CH_3COOCH(CH_3)CH_2CH(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Fruity; mild, pleasant; mild and nonresidual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 144.22; *Boiling Point at 1 atm.*: 295.2, 146.2, 419.4; *Freezing Point*: -82.8, -63.8, 209.4; *Critical Temperature*: 606, 319, 592; *Critical Pressure*: 382, 26, 2.6; *Specific Gravity*: 0.860 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.046; *Latent Heat of Vaporization*: 225, 125, 5.23; *Heat of Combustion*: (est.) -14,400, -8000, -335; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister or air pack; rubber gloves; goggles; *Symptoms Following Exposure*: Headache, dizziness, nausea, irritation to respiratory passages. Irritates eyes; *General Treatment for Exposure*: INHALATION: remove from exposure immediately; call a physician; if breathing is irregular or has stopped, start resuscitation and administer oxygen. EYE CONTACT: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Methyl Amyl Alcohol — (i) Chemical Designations — *Synonyms*: Isobutylmethyl carbinol; Isobutyl methylmethanol; MAOH; Methylisobutyl carbinol; 4-Methyl-2-pentanol; MIC; *Chemical Formula*: $(CH_3)_2CHCH_2CH(OH)CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp; mild and nonresidual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.18; *Boiling*

Point at 1 atm.: 269.2, 131.8, 405; *Freezing Point*: <-130, <-90, <183; *Critical Temperature*: 556, 291, 564; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.807 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.053; *Latent Heat of Vaporization*: 162, 90.1, 3.77; *Heat of Combustion*: -16,640, -9240, -387; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister mask; rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Vapor irritates eyes and nose. May cause anesthesia. Prolonged contact with liquid causes irritation and cracking of skin, and irritates eyes; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give artificial respiration if needed; call a doctor. SKIN: flush with water. EYES: flood with water for at least 15 min.; consult a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

N-Methylaniline — (i) Chemical Designations — *Synonyms*: Anilinomethane; N-Methylaminobenzene; Methylaniline (mono); Methylphenylamine; *Chemical Formula*: $C_6H_5NHCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow to light brown; *Odor*: Moderate aniline-type; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 107.2; *Boiling Point at 1 atm.*: 384.6, 195.9, 469.1; *Freezing Point*: -71, -57, 216; *Critical Temperature*: 802, 428, 701; *Critical Pressure*: 754, 51.3, 5.20; *Specific Gravity*: 0.989 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.70; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 180, 100, 4.20; *Heat of Combustion*: -16,350, -9,085, -380.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved respirator; rubber gloves; splash proof goggles; *Symptoms Following Exposure*: Inhalation causes dizziness and headache. Ingestion causes bluish discoloration (cyanosis) of lips, ear lobes, and fingernail beds. Liquid irritates eyes. Absorption through skin produces same symptoms as for ingestion; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and call a physician at once; administer oxygen until physician arrives. INGESTION: give large amount of water; get medical attention at once. EYES or SKIN: flush with plenty of water for at least 15 min.; if cyanosis is present, shower with soap and warm water, with special attention to scalp and finger nails; remove any contaminated clothing; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Methyl Bromide — (i) Chemical Designations — *Synonyms*: Bromomethane; Embafume; M-B-C Fumigant; Monobromomethane; *Chemical Formula*: CH_3Br; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Relatively odorless; sweet, chloroform-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 94.95; *Boiling Point at 1 atm.*: 38.5, 3.6, 276.8; *Freezing Point*: -135, -93, 180; *Critical Temperature*: 376, 191, 464; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.68 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.3; *Ratio of Specific Heats of Vapor (Gas)*: 1.247; *Latent Heat of Vaporization*: 108, 59.7, 2.50; *Heat of Combustion*: -3188, -1771, -74.15; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles; *Symptoms Following Exposure*: Inhalation of vapor causes lung congestion and pulmonary edema. Higher concentrations cause rapid narcosis and death. Contact with liquid irritates eyes and burns skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give artificial respiration if needed. SKIN OR EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 15 ppm; *Short-Term Inhalation Limits*: 20 ppm for 5 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: Data not available.

Methyl n-Butyl Ketone — (i) Chemical Designations — *Synonyms*: n-Butyl methyl ketone; 2-Hexanone;

Chemical Formula: $CH_3(CH_2)_3COCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Clear; *Odor*: Characteristic; strong, disagreeable odor resembling acetone; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.16; *Boiling Point at 1 atm.*: 261, 127, 400; *Freezing Point*: -70.4, -56.9, 216.3; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.812 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 148, 82, 3.4; *Heat of Combustion*: -16,100, -8,940, -374; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; approved respirator (for major spills); *Symptoms Following Exposure*: Inhalation of high concentrations of vapor may result in narcosis; peripheral neuropathy may develop. Ingestion of large amounts may cause some systemic injury. Contact with eyes causes mild to moderate irritation. Liquid irritates skin; prolonged or repeated contact may cause defatting of the skin with resultant dermatitis; *General Treatment for Exposure*: INHALATION: move to uncontaminated atmosphere and treat symptomatically; alert physician to possible development of peripheral neuropathy. INGESTION: give large amount of water and induce vomiting. EYES: irrigate immediately and thoroughly with water for 15 min. and get medical attention. SKIN: flush exposed areas thoroughly with water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 2,590 mg/kg (rat); *Late Toxicity*: Peripheral neuropathy in experimental animals and man (disease of motor and/or sensor nerves); *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Methyl Chloride — (i) Chemical Designations — *Synonyms*: Artic; Chloromethane; *Chemical Formula*: CH_3Cl; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Faint, sweet, non-irritating; faint ether-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 50.49; *Boiling Point at 1 atm.*: -11.6, -24.2, 249; *Freezing Point*: -143.9, 97.7, 175.5; *Critical Temperature*: 290.5, 143.6, 416.8; *Critical Pressure*: 969, 65.9, 6.68; *Specific Gravity*: 0.997 at -24 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.7; *Ratio of Specific Heats of Vapor (Gas)*: 1.259; *Latent Heat of Vaporization*: 182.3, 101.3, 4.241; *Heat of Combustion*: -5290, -2939, -123.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister mask; leather or vinyl gloves; goggles or face shield; *Symptoms Following Exposure*: Inhalation causes nausea, vomiting, weakness, headache, emotional disturbances; high concentrations cause mental confusion, eye disturbances, muscular tremors, cyanosis, convulsions. Contact of liquid with skin may cause frostbite; *General Treatment for Exposure*: Remove to fresh air. Call a doctor and have patient hospitalized for observation of slowly developing symptoms; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: 100 ppm for 5 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin because it is very volatile and evaporates quickly. May cause frostbite; *Odor Threshold*: Data not available.

Methyl Chloroformate — (i) Chemical Designations — *Synonyms*: Chlorocarbonic acid, methyl ester; Chloroformic acid, methyl ester; Methyl chlorocarbonate; *Chemical Formula*: $ClCOOCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 94.5; *Boiling Point at 1 atm.*: 160, 71, 344; *Freezing Point*: <-114, <-81, <192; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.25; *Ratio of Specific Heats of Vapor (Gas)*: 1.1544; *Latent Heat of Vaporization*: (est.) 153, 85, 3.6; *Heat of Combustion*: -4,690, -2,600, -109; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid- or organic-canister mask or self-contained breathing apparatus; goggles or face shield; plastic gloves; *Symptoms Following Exposure*: Inhalation of vapor irritates nose and throat and can cause delayed pulmonary edema. Liquid irritates eyes and causes severe skin burns if allowed to remain. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from exposure; if breathing has stopped, administer artificial respiration; call physician. EYES: irrigate with copious amounts of water for at least 15 min.; call a physician if needed. SKIN: flush with water for 15 min.; get medical attention for

burns. INGESTION: give large amount of water; do NOT induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} <50 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Methylcyclopentadienylmanganese Tricarbonyl — (i) Chemical Designations — *Synonyms*: Combustion Improver C12; *Chemical Formula*: $C_9H_7O_3Mn$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Straw to dark orange; *Odor*: Faint, pleasant, herbaceous; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 218.1; *Boiling Point at 1 atm.*: 451, 233, 506; *Freezing Point*: 34, 1, 274; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.39 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -9,900, -5,500, -230; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic vapor canister mask; rubber gloves and apron; protective goggles or face shield; *Symptoms Following Exposure*: Inhalation, ingestion, or skin contact affect central nervous system, causing convulsions, respiratory depression, cyanosis, and coma. Liquid irritates eyes; *General Treatment for Exposure*: Get medical attention following all exposures to this compound. INHALATION: remove victim from exposure; give artificial respiration if necessary. EYES: flush with plenty of water for at least 15 min. SKIN: wash well with soap and water. INGESTION: induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm (as manganese); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 23 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Methyl Cyclopentane — (i) Chemical Designations — *Synonyms*: Cyclopentane, methyl; *Chemical Formula*: C_6H_{12}; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 84.2; *Boiling Point at 1 atm.*: 161.3, 71.8, 345.0; *Freezing Point*: -224, -142, 131; *Critical Temperature*: 499.3, 259.6, 532.8; *Critical Pressure*: 550, 37.4, 3.79; *Specific Gravity*: 0.749 at 20 C (liquid); *Vapor (Gas) Specific Gravity*: 2.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.0834; *Latent Heat of Vaporization*: 162, 90, 3.8; *Heat of Combustion*: (liquid) -18,900, -10,500, -440; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes dizziness, nausea, and vomiting; concentrated vapor may cause unconsciousness and collapse. Liquid causes irritation of eyes and mild irritation of skin if allowed to remain. Ingestion causes irritation of stomach. Aspiration causes severe lung irritation, rapidly developing pulmonary edema, and central nervous system excitement followed by depression; *General Treatment for Exposure*: INHALATION: remove victim from exposure; if breathing has stopped, administer artificial respiration; call physician. EYES: flush with water for 15 min.; call physician. SKIN: flush well with water, than wash with soap and water. INGESTION: do NOT induce vomiting; guard against aspiration into lungs. ASPIRATION: enforce bed rest; give oxygen; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: 300 ppm for 60 min.; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Methyldichlorosilane — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: CH_3SiHCl_2; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid; sharp, hydrochloric acid-like; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 115; *Boiling Point at 1 atm.*: 106.7, 41.5, 314.7; *Freezing Point*: -135, -93, 180; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.11 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: 4; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 106, 59, 2.5; *Heat of Combustion*: (est.) -4,700, -2,600, -110; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recom-*

mended Personal Protective Equipment: Full protective clothing; acid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation causes irritation of respiratory tract; heavy exposure can cause pulmonary edema. Contact of liquid with skin or eyes causes severe burns. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure*: Get medical attention following all exposure to this compound. INHALATION: remove victim from exposure; if breathing has stopped, begin artificial respiration. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Methyl Ethyl Ketone — (i) Chemical Designations — *Synonyms*: 2-Butanone; Ethyl methyl ketone; MEK; *Chemical Formula*: $CH_3COCH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like acetone; pleasant; pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72.11; *Boiling Point at 1 atm.*: 175.3, 79.6, 352.8; *Freezing Point*: -123.3, -86.3, 186.9; *Critical Temperature*: 504.5, 262.5, 535.7; *Critical Pressure*: 603, 41.0, 4.15; *Specific Gravity*: 0.806 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.075; *Latent Heat of Vaporization*: 191, 106, 4.44; *Heat of Combustion*: -13,480, -7491, -313.6; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister or air pack; plastic gloves; goggles or face shield; *Symptoms Following Exposure*: Liquid causes eye burn. Vapor irritates eye, nose, and throat; can cause headache, dizziness, nausea, weakness, and loss of consciousness; *General Treatment for Exposure*: INHALATION: remove victim from exposure; if breathing has stopped, start resuscitation and administer oxygen. EYES: wash with plenty of water for at least 15 min. and call physician; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*: 290 mg/m^3 for 60 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 10 ppm.

Methylethylpyridine — (i) Chemical Designations — *Synonyms*: Aldehyde-collidine; Aldehydine; 5-Ethyl-2-Methylpyridine; 5-Ethyl-2-picoline; MEP; *Chemical Formula*: $C_8H_{11}N$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, penetrating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 121.18; *Boiling Point at 1 atm.*: 252, 178, 451; *Freezing Point*: -94.5, -70.3, 202.9; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.922 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask for high vapor concentrations; plastic gloves; goggles or face shield; *Symptoms Following Exposure*: Breathing of vapors will cause vomiting and chest discomfort. Contact with liquid causes skin and eye burns; *General Treatment for Exposure*: INHALATION: remove victim from exposure; give oxygen if breathing is difficult; call a physician. EYES OR SKIN: immediately flush with plenty of water for at least 15 min.; get medical care for eyes; *Toxicity by Inhalation (Threshold Limit Value)*: 1700 ppm/3.7 hr/lethal (rat); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Methyl Formal — (i) Chemical Designations — *Synonyms*: Dimethoxymethane; Dimethylformal; Formaldehyde dimethylacetat; Methylal; Methylene dimethyl

ether; *Chemical Formula*: $CH_2(OCH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, ethereal; chloroform-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 76.1; *Boiling Point at 1 atm.*: 108, 42, 315; *Freezing Point*: -157, -105, 168; *Critical Temperature*: 419, 215, 488; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.861 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.0888; *Latent Heat of Vaporization*: 161.5, 89.8, 3.76; *Heat of Combustion*: -10,970, -6,100, -255; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus or all-purpose canister mask; gloves; rubber gloves; chemical safety goggles; impervious apron and boots; *Symptoms Following Exposure*: Inhalation causes irritation of respiratory system and depression of central nervous system. Liquid causes irritation of eyes and will irritate skin if allowed to remain. Ingestion causes depression of central nervous system; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area and administer artificial respiration and oxygen if necessary. EYES: flush with plenty of water; get medical attention. SKIN: flush with plenty of water. INGESTION: induce vomiting, then give gastric lavage and saline cathartics; subsequent treatment is symptomatic and supportive; *Toxicity by Inhalation (Threshold Limit Value)*: 1,000 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Liver and kidney injury may follow high exposures; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Methyl Formate — (i) Chemical Designations — *Synonyms*: Formic acid, methyl ester; *Chemical Formula*: $HCOOH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant; agreeable; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 60.1; *Boiling Point at 1 atm.*: 89.2, 31.8, 305; *Freezing Point*: -147.6, -99.8, 173.4; *Critical Temperature*: 417, 214, 487; *Critical Pressure*: 870, 59.2, 6.00; *Specific Gravity*: 0.977 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.07; *Ratio of Specific Heats of Vapor (Gas)*: 1.1446; *Latent Heat of Vaporization*: 202, 112, 4.696; *Heat of Combustion*: -6,980, -3,880, -162; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or safety glasses; self-contained breathing apparatus; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membranes. Prolonged inhalation can produce narcosis and central nervous symptoms, including some temporary visual disturbance. Contact with liquid irritates eyes and may irritate skin if allowed to remain. Ingestion causes irritation of mouth and stomach and central nervous system depression, including visual disturbances; *General Treatment for Exposure*: INHALATION: remove to fresh air and rest; if pulmonary edema develops, administer oxygen; call physician. EYES: irrigate with water for 15 min SKIN: wash thoroughly with soap and water. INGESTION: do NOT induce vomiting; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Methylhydrazine — (i) Chemical Designations — *Synonyms*: Monomethylhydrazine; MMH; *Chemical Formula*: CH_3NHNH_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 46.1; *Boiling Point at 1 atm.*: 189.5, 87.5, 360.7; *Freezing Point*: -62.3, -52.4, 220.8; *Critical Temperature*: 594, 312, 585; *Critical Pressure*: 1,195, 81.3, 8.25; *Specific Gravity*: 0.878 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.59; *Ratio of Specific Heats of Vapor (Gas)*: 1.1326; *Latent Heat of Vaporization*: 376, 209, 8.75; *Heat of Combustion*: -12,178, -6,766, -283.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister mask or self-contained breathing apparatus; goggles or face shield; rubber gloves; protective clothing; *Symptoms Following Exposure*: Tremors and convulsions follow absorption by any route. Inhalation causes local irritation of respiratory tract, respiratory distress, and systemic

effects. Contact of liquid with eyes or skin causes irritation and burns. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: Get medical attention at once following all exposures to this compound. INHALATION: move victim to fresh air and keep him quiet; give artificial respiration if breathing stops. EYES: flush with large quantities of water for at least 15 minutes. SKIN: immediately flush with large quantities of water and treat as for alkali burn. INGESTION: give egg whites or other emollient, followed by a 5% salt solution or other mild emetic. Keep patient as quiet as possible. To control convulsions, short-acting barbiturates may be administered parenterally by a physician with due regard for depression of respiration; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 ppm; *Short-Term Inhalation Limits*: 90 ppm for 10 min.; 30 ppm for 30 min.; 15 ppm for 60 min.; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 33 mg/kg (rat); *Late Toxicity*: Hemolytic anemia may result from large doses by any route; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: 1-3 ppm.

Methyl Isobutyl Carbinol — (i) Chemical Designations — *Synonyms*: Isobutyl methyl carbinol; Methyl Alcohol; MAOH; 4-Methyl-2-pentanol; MIBC; MIC; *Chemical Formula*: $(CH_3)_2CHCH_2CH(OH)CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, sharp, non-residual; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 102.18; *Boiling Point at 1 atm.*: 269.2, 131.8, 405; *Freezing Point*: <-130, <-90, <183; *Critical Temperature*: 556, 291, 564; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.807 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.053; *Latent Heat of Vaporization*: 162, 90.1, 3.77; *Heat of Combustion*: (est.) -16,600, -9,300, -387; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister mask; rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Vapor irritates eyes and nose; may cause anesthesia. Prolonged contact with liquid causes irritation and cracking of skin; also irritates eyes; *General Treatment for Exposure*: INHALATION: remove to fresh air; give artificial respiration if needed; call a doctor. SKIN: flush with water. EYES: flush with water for at least 15 min.; consult a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Methyl Isobutyl Ketone — (i) Chemical Designations — *Synonyms*: Hexone; Isobutyl methyl ketone; Isopropylacetone; 4-Methyl-2-pentanone; MIBK; MIK; *Chemical Formula*: $(CH_3)_2CHCH_2COCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pleasant; mild, characteristic; sharp; non-residual; ketonic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.16; *Boiling Point at 1 atm.*: 241.2, 116.2, 389.4; *Freezing Point*: -119, -84, 189; *Critical Temperature*: 568.9, 298.3, 571.5; *Critical Pressure*: 475, 32.3, 3.27; *Specific Gravity*: 0.802 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.061; *Latent Heat of Vaporization*: 149, 82.5, 3.45; *Heat of Combustion*: (est.) -10,400, -5,800, -242; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air pack or organic canister mask; rubber gloves; goggles or face shield; *Symptoms Following Exposure*: Vapor irritates eyes and nose; high concentrations cause anesthesia and depression. Liquid dries out skin and may cause dermatitis; irritates eyes but does not injure them; *General Treatment for Exposure*: INHALATION: remove to fresh air; give artificial respiration if needed; call a doctor. SKIN OR EYES: flush eyes thoroughly with water; wash skin with water until irritation stops; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: 100 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 0.47 ppm.

Methyl Isopropenyl Ketone, Inhibited — (i) Chemical Designations — *Synonyms*: Isopropenyl methyl ketone; 2-Methyl-1-butene-3-one; *Chemical Formula*:

$CH_3COC(CH_3)=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Very pungent; pleasant; sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 84.1; *Boiling Point at 1 atm.*: 208, 98, 371; *Freezing Point*: -65, -54, 219; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.85 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.0796 at 20 °C (68°F); *Latent Heat of Vaporization*: (est.) 182, 101, 4.23; *Heat of Combustion*: (est.) -15,500, -8,600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Liquid may cause severe damage to eyes, resulting possibly in some permanent impairment of vision; vapor produces tears. If not removed promptly from skin, liquid may cause delayed pain and blistering. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from exposure; give artificial respiration if needed; call physician. EYES: immediately irrigate with copious amounts of water for 15 min.; call physician if burn has occurred. INGESTION: induce vomiting; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; oral LD_{50} = 180 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Methyl Mercaptan — (i) Chemical Designations — *Synonyms*: Mercaptomethane; Methanethiol; Methyl sulfidrate; Thiomethyl alcohol; *Chemical Formula*: CH_3SH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Garlic; foul; strong offensive; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 48.1; *Boiling Point at 1 atm.*: 43.2, 6.2, 279.4; *Freezing Point*: -189, -123, 150; *Critical Temperature*: 386.2, 196.8, 470.0; *Critical Pressure*: 1,050, 71.4, 7.25; *Specific Gravity*: 0.892 at 6 C (liquid); *Vapor (Gas) Specific Gravity*: 1.66; *Ratio of Specific Heats of Vapor (Gas)*: 1.1988; *Latent Heat of Vaporization*: 220, 122, 5.10; *Heat of Combustion*: -11,054, -6,141, -257.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus or air-line mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes irritation of respiratory system, tremors, paralysis, unconsciousness; death may follow respiratory paralysis. Contact with liquid irritates eyes and skin. Ingestion causes irritation of mouth and stomach plus symptoms described for inhalation; *General Treatment for Exposure*: INHALATION: remove patient immediately from the contaminated area; keep him warm and at complete rest; if necessary give artificial respiration until medical assistance can be obtained; oxygen or oxygen-CO_2 inhalation is recommended, continuing after spontaneous breathing has returned. EYES: for exposure to vapor, apply hot and cold compresses to reduce pain of conjunctivitis; for exposure to liquid, wash with water and obtain medical assistance. SKIN: wash with water. INGESTION: induce vomiting and follow with gastric lavage; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 ppm; *Short-Term Inhalation Limits*: 20 ppm for 5 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.0021 ppm.

Methyl Methacrylate — (i) Chemical Designations — *Synonyms*: Methacrylate monomer; Methacrylic acid, methyl ester; Methyl alpha-methylacrylate; Methyl 2-methyl-2-propenoate; *Chemical Formula*: $CH_2=C(CH_3)COOCH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, fragrant; pleasant smelling; pungent ester; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.12; *Boiling Point at 1 atm.*: 214, 101, 374; *Freezing Point*: -54, -48, 225; *Critical Temperature*: 561, 294, 567; *Critical Pressure*: 485, 33, 3.3; *Specific Gravity*: 0.945 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.059; *Latent Heat of Vaporization*: 140, 77, 3.2; *Heat of Combustion*: (est.) -11,400, -6,310, -264; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air mask; plastic gloves; goggles; *Symptoms Following Exposure*: Irritation of eyes, nose, and throat. Nausea and vomiting. Liquid may cause skin irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air; apply artificial respiration and oxygen

if needed; refer to physician. SKIN OR EYES: flush with plenty of water for 15 min.; refer to physician for eye exposure; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Methyl Parathion — (i) Chemical Designations — *Synonyms*: MPT; O,O-Dimethyl O-(p-Nitrophenyl) Phosphorothiorate; O,O-Dimethyl O-p-Nitrophenyl thiophosphate; Parathion-methyl; *Chemical Formula*: $(CH_3O)_2PSOC_6H_4NO_2$-p; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid or liquid; *Color*: Colorless solid or brownish liquid; *Odor*: Characteristic; like rotten eggs or garlic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid or solid; *Molecular Weight*: 263.2; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 65, 18, 291; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.360 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Approved mask or respirator; natural rubber gloves, overshoes; protective clothing; goggles; *Symptoms Following Exposure*: Exposure to fumes from a fire, or to the liquid, causes headache, blurred vision, constricted pupils of the eyes, weakness, nausea, cramps, diarrhea, and tightness in the chest. Muscle twitch and convulsions may follow. Symptoms may develop over a period of 8 hrs; *General Treatment for Exposure*: Speed is essential. INGESTION: call a doctor! If victim is not breathing, immediately institute artificial respiration by mouth-to-mouth, mouth-to-nose, or mouth-to-oropharyngeal method; when victim is conscious, give milk, water, or salt-water and induce vomiting repeatedly. SKIN OR EYES: flood and wash exposed areas thoroughly with water; remove contaminated clothing under a shower; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (solid); 100 ppm (liquid); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4; LD_{50} below 50 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Poisonous when absorbed thorough skin; *Odor Threshold*: Data not available.

Methyl Phosphonothioic Dichloride (Anhydrous) — (i) Chemical Designations — *Synonyms*: MPTD; *Chemical Formula*: CH_3PSCl_2; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Clear; *Odor*: Acrid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 149; *Boiling Point at 1 atm.*: Data not available; *Freezing Point*: -14.1, -25.6, 247.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.42 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: (est.) 110, 60, 2.5; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber or neoprene gloves; respiratory protection; goggles; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat; effects are quite similar to those of phosgene. Ingestion causes irritation of mouth and stomach. Delayed, painful eye irritation may occur from exposure to vapor; liquid causes severe irritation. Contact with skin causes irritation and burns; *General Treatment for Exposure*: Get medical attention after all exposures to this compound. INHALATION: remove victim to fresh air; alert physician to delayed effects similar to those of phosgene. INGESTION: give large amount of water and induce vomiting. EYES: flush with water for at least 15 min. SKIN: flood with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

1-Methylpyrrolidone — (i) Chemical Designations — *Synonyms*: 1-Methyl-2-pyrrolidinone; N-Methylpyrrolidinone; N-Methyl-pyrrolidone; N-Methyl-alpha-pyrrolidone; *Chemical Formula*: C_5H_9NO; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild amine-like; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 99; *Boiling Point at 1 atm.*: 396, 202, 475; *Freezing Point*: 1, -17, 256; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific*

Gravity: 1.03 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: -13,000, -7,220, -302; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of hot vapors can irritate nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes causes irritation. Repeated and prolonged skin contact produces a mild, transient irritation; *General Treatment for Exposure*: INHALATION: remove to fresh air. INGESTION: give large amounts of water and induce vomiting. EYES: flush with water for at least 15 min. SKIN: remove from skin and eyes by flooding the affected tissues with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 3.5 mg/kg (rabbit); *Late Toxicity*: Causes blood abnormalities in rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

alpha-Methylstyrene — (i) Chemical Designations — *Synonyms*: Isopropenylbenzene; 1-Methyl-1-phenylethylene; Phenylpropylene; *Chemical Formula*: $C_6H_5C(CH_3)=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 118.17; *Boiling Point at 1 atm.*: 329, 165, 438; *Freezing Point*: -9.8, -23.2, 250.0; *Critical Temperature*: 719.1, 381.7, 654.9; *Critical Pressure*: 494, 33.6, 3.41; *Specific Gravity*: 0.91 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 4.08; *Ratio of Specific Heats of Vapor (Gas)*: 1.060 at 27 °C; *Latent Heat of Vaporization*: 140.4, 78.0, 3.26; *Heat of Combustion*: -17,690, -9,830, -411; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Neoprene gloves; splashproof goggles or face shield; *Symptoms Following Exposure*: Inhalation causes irritation of respiratory tract, headache, dizziness, light-heatedness, and breathlessness. Ingestion causes irritation of mouth and stomach. Contact with liquid irritates eyes. Prolonged skin contact can cause severe rashes, swelling, and blistering; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration; contact a physician; keep victim quiet and warm. INGESTION: do NOT induce vomiting; call a physician. EYES: flush with water for at least 15 min.; get medical attention. SKIN: wash area with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: 100 ppm, 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: < 10 ppm.

Methyltrichlorosilane — (i) Chemical Designations — *Synonyms*: Trichloromethylsilane; *Chemical Formula*: CH_3SiCl_3; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid; sharp, like hydrochloric acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 149.5; *Boiling Point at 1 atm.*: 151.5, 66.4, 339.6; *Freezing Point*: -130, -90, 183; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.27 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: 5.16; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 89.3, 49.6, 2.08; *Heat of Combustion*: (est.) -3,000, -1,700, -70; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full protective clothing; acrid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membrane. Contact with liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: Get medical attention at once following all exposures to this compound. INHALATION: remove victim from exposure; give artificial respiration if breathing has ceased. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Decomposes in moist air, creating HCl with odor threshold of 1 ppm.

Methyl Vinyl Ketone — (i) Chemical Designations — *Synonyms*: 3-Buten-2-one; *Chemical Formula*: $CH_3COCH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Powerfully irritating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 70.1; *Boiling Point at 1 atm.*: 178.5, 81.4, 354.6; *Freezing Point*: 20, -7, 266; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.864 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.1053; *Latent Heat of Vaporization*: (est.) 203, 113, 4.73; *Heat of Combustion*: (est.) -14,600, -8,100, -340; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus with full face piece; rubber gloves; chemical goggles or face piece of breathing apparatus; *Symptoms Following Exposure*: Inhalation causes irritation of nose and throat. Vapor causes tears; contact with liquid can burn eyes. Liquid irritates skin and will cause burn if not removed at once. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: Get medical attention for all exposures to this compound. INHALATION: remove victim to fresh air; administer artificial respiration if necessary. EYES or SKIN: flush with copious quantities of water for 15 min. INGESTION: do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} < 50 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: 0.5 mg/m^3.

Mineral Spirits — (i) Chemical Designations — *Synonyms*: Naphtha; Petroleum spirits; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 310-395, 154-202, 428-475; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.78 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.030; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves; goggles or face shield (as for gasoline); *Symptoms Following Exposure*: INHALATION: mild irritation of respiratory tract. ASPIRATION: severe lung irritation and rapidly developing pulmonary edema; central nervous system excitement followed by depression. INGESTION: irritation of stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. ASPIRATION: enforced bed rest; give oxygen; call a doctor. INGESTION: do NOT induce vomiting; guard against aspiration into lungs. EYES: wash with copious amounts of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*: 4000-7000 ppm for 60 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Molybdic Trioxide — (i) Chemical Designations — *Synonyms*: Molybdenum trioxide; Molybdic anhydride; *Chemical Formula*: MoO_3; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Colorless or white-yellow to yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 143.94; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.69 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved by U.S. Bu. Mines respirator; safety glasses or face shield; protective gloves; *Symptoms Following Exposure*: Compound is relatively nontoxic. Dust irritates eyes; *General Treatment for Exposure*: No treatment necessary except those applicable to any nontoxic dust. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant*

Characteristics: Data not available; *Odor Threshold*: Data not available.

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2-Nitrophenol — (i) Chemical Designations — *Synonyms*: 2-Hydroxynitrobenzene; o-Nitrophenol; ONP; *Chemical Formula*: 1,2-$HOC_6H_4NO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Yellow; *Odor*: Peculiar aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 139.1; *Boiling Point at 1 atm.*: 417, 214, 487; *Freezing Point*: 111, 44, 313; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.49 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,910, -4,950, -207; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for fumes; goggles; rubber gloves; *Symptoms Following Exposure*: Inhalation or ingestion causes headache, drowsiness, nausea, and blue color in lips, ears, and fingernails (cyanosis). Contact with eyes causes irritation. Can be absorbed through the intact skin to give same symptoms as for inhalation; *General Treatment for Exposure*: INHALATION or INGESTION: remove victim to fresh air; give artificial respiration; call a doctor if symptoms persist. EYES: flood with water for at least 15 min.; get medical attention. SKIN: cleanse thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; oral LD_{50} = 1,297 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

4-Nitrophenol — (i) Chemical Designations — *Synonyms*: 2-Hydroxynitrobenzene; p-Nitrophenol; PNP; *Chemical Formula*: 1,4-$HOC_6H_4NO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Yellow to brown; *Odor*: Slight characteristic, sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 139.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 235, 113, 386; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.48 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,870, -4,930, -206; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus or dust mask; butyl rubber gloves; side-shield safety glasses; *Symptoms Following Exposure*: Inhalation or ingestion causes headache, drowsiness, nausea, and blue color in lips, ears, and fingernails (cyanosis). Contact with eyes causes irritation; can be absorbed through the intact skin to give same symptoms as for inhalation; *General Treatment for Exposure*: INHALATION or INGESTION: remove victim to fresh air; give artificial respiration; call a doctor if symptoms persist. EYES: flood with water for at least 15 min.; get medical attention. SKIN: cleanse thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

2-Nitropropane — (i) Chemical Designations — *Synonyms*: Izonitropropane; sec-Nitropropane; 2-NP; *Chemical Formula*: $CH_3CH(NO_2)CH_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, fruity; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 89.09; *Boiling Point at 1 atm.*: 245.5, 120.3, 393.5; *Freezing Point*: -132,-91, 182; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.99 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.06 at 16 °C; *Ratio of Specific Heats of Vapor (Gas)*: 1.090 at 20 °C; *Latent Heat of Vaporization*: 178, 99, 4.1; *Heat of Combustion*: -9,650, -5,360, -224; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation causes respiratory tract irritation, headache, dizziness, nausea, and causes mild irritation of skin; *General Treatment for Exposure*: INHALATION: in case of pulmonary symptoms, enforce bed rest and give oxygen; get medical attention at once. INGESTION: give large amount of water and induce vomiting. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Inhalation Limits*: Data not available;

Toxicity by Ingestion: Grade 2; oral rat LD_{50}=720 g/kg; *Late Toxicity*: Causes liver cancer in rats; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 300 ppm.

Nitrosyl Chloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NOCl; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied gas; *Color*: Yellow to red; *Odor*: irritating, choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 65,46; *Boiling Point at 1 atm.*: 21.6, -5.8, 267.4; *Freezing Point*: -74, -59, 214; *Critical Temperature*: 334, 168, 441; *Critical Pressure*: 1300, 90, 9.1; *Specific Gravity*: 1.36 at -5.7 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.3; *Ratio of Specific Heats of Vapor (Gas)*: 1.229; *Latent Heat of Vaporization*: 164, 91.0, 3.81; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus (approved mask may be used for short exposures only); rubberized clothing; gloves; shoes; chemical goggles; *Symptoms Following Exposure*: Gas is highly toxic. Inhalation causes severe irritation of respiratory tract and damage to mucous membranes. Delayed effects, which include severe pulmonary edema, may not be apparent for several hours; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; call a doctor; enforce complete rest until doctor arrives; observe at least 24 hours for delayed effects. SKIN OR EYES: flush with water for at least 15 min.; consult physician; *Toxicity by Inhalation (Threshold Limit Value)*: 1 ppm (recommended); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe burns to eyes and skin; *Odor Threshold*: Data not available.

Nitrous Oxide — (i) Chemical Designations — *Synonyms*: Dinitrogen monoxide; *Chemical Formula*: N_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: None; slightly sweetish; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 44.0; *Boiling Point at 1 atm.*: -129.1, -89.5, 183.7; *Freezing Point*: -131.5, -90.8, 182.4; *Critical Temperature*: 97.7, 36.5, 309.7; *Critical Pressure*: 1.054, 71.7, 7.28; *Specific Gravity*: 1.266 at -89 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.53; *Ratio of Specific Heats of Vapor (Gas)*: 1.303 at 25 °C; *Latent Heat of Vaporization*: 161.7, 89.9, 3.76; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high vapor concentrations; *Symptoms Following Exposure*: Inhalation causes intense analgesia; concentrations of over 40-60% cause loss of consciousness preceded by hysteria. Contact of liquid with eyes or skin causes frostbite burn; *General Treatment for Exposure*: INHALATION: remove to fresh air. EYES: get medical attention for frostbite burn. SKIN: treat frostbite burn; soak in lukewarm water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: 56.000 ppm for 60 min.; *Toxicity by Ingestion*: Grade 0, LD_{50} 0.5 > 15 g/kg; *Late Toxicity*: Causes birth defects in rats; can cause lethal effects in chick eggs; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard; practically harmless to the skin; *Odor Threshold*: Data not available.

Nonane — (i) Chemical Designations — *Synonyms*: n-Nonane; *Chemical Formula*: C_9N_{20}; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 128.3; *Boiling Point at 1 atm.*: 304, 151, 424; *Freezing Point*: -64.3, -53.5, 219.7; *Critical Temperature*: 610.5, 321.4, 594.6; *Critical Pressure*: 335, 22.8, 2.31; *Specific Gravity*: 0.718 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 4.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.042 at 16 °C; *Latent Heat of Vaporization*: 127, 2.95; *Heat of Combustion*: -19,067, -10,593, -443.21; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for vapor concentrations; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of concentrated vapor causes depression, irritation of respiratory tract, and pulmonary edema. Liquid can irritate eyes and (on prolonged contact) skin. Ingestion causes irritation of mouth and stomach. Aspiration causes severe lung irritation, rapidly developing pulmonary edema, and central ner-

vous system excitement followed by depression; *General Treatment for Exposure*: INHALATION: remove victim from exposure; give artificial respiration if needed. EYES: irrigate with large amounts of water for 15 min. SKIN: flush with water; wash with soap and water. INGESTION: do NOT induce vomiting; call a physician. ASPIRATION: enforce bed rest; give oxygen; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0, LD_{50} 0.5 > 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Nonanol — (i) Chemical Designations — *Synonyms*: 1-Nonanol; Octylcarbinol; Nonilalcohol; Pelargonic alcohol; *Chemical Formula*: $CH_3(CH_2)_7CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Rose-citrus; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 144.26; *Boiling Point at 1 atm.*: 415, 213, 486; *Freezing Point*: 23, -5, 268; *Critical Temperature*: 759, 404, 677; *Critical Pressure*: 350, 24, 2.4; *Specific Gravity*: 0.827 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.039; *Latent Heat of Vaporization*: 131, 72.5, 3.04; *Heat of Combustion*: -17,800, -9860, -413; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Liquid irritates eyes; *General Treatment for Exposure*: Flush eyes and skin with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; 0.5 to 5 g/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Nonene — (i) Chemical Designations — *Synonyms*: Nonene (non-linear); Propylene trimer; Tripropylene; *Chemical Formula*: C_9H_{18}; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 126.2; *Boiling Point at 1 atm.*: 275-284, 135-140, 408-413; *Freezing Point*: Not pertinent; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 0.739 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.044; *Latent Heat of Vaporization*: (est.) 124, 68.9, 2.88; *Heat of Combustion*: -19,100, -10,600, -445; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory organic vapor canister or air-supplied mask; face splash shield; *Symptoms Following Exposure*: High vapor concentrations irritate eyes and respiratory tract and act as an anesthetic; *General Treatment for Exposure*: INHALATION: remove patient to fresh air; if breathing stops, apply artificial respiration and administer oxygen; call a physician. INGESTION: do NOT induce vomiting because of aspiration hazard; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present at high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

1-Nonene — (i) Chemical Designations — *Synonyms*: n-Heptylethylene; 1-Nonylene; *Chemical Formula*: $CH_3(CH_2)_6CH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Hydrocarbon odor; like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 126.2; *Boiling Point at 1 atm.*: 297, 147, 420; *Freezing Point*: -115, -81.7, 191.5; *Critical Temperature*: 622, 327.8, 601.0; *Critical Pressure*: 360, 24.5, 2.98; *Specific Gravity*: 0.733 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.044; *Latent Heat of Vaporization*: 124, 68.8, 2.88; *Heat of Combustion*: -18,979, -10,544, -441.46; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respiratory organic vapor canister or air-supplied mask; face splash shield; *Symptoms Following Exposure*: High vapor concentrations irritate eyes and respiratory tract and act as an anesthetic; *General Treatment for Exposure*: INHALATION: remove to fresh air; if breathing stops, apply artificial respiration; administer oxygen; call a physician. INGESTION: if swallowed, do

NOT induce vomiting because of aspiration hazard; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting pf the eyes or respiratory system if present at high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Nonylphenol — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: p-$HOC_6H_4(CH_2)_8CH_3$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Phenolic; like disinfectant; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 220.36; *Boiling Point at 1 atm.*: 579, 304, 577; *Freezing Point*: Not pertinent; *Critical Temperature*: 878, 470, 743; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.9494 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -17,500, -9730, -407; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber gloves and splash-proof goggles; *Symptoms Following Exposure*: Moderately toxic if swallowed. Severely irritating to skin and eyes; *General Treatment for Exposure*: EYES: wash with water for 15 min. and get medical attention. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2; LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

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Octane — (i) Chemical Designations — *Synonyms*: n-Octane; *Chemical Formula*: C_8H_{18}; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 114.2; *Boiling Point at 1 atm.*: 258.1, 125.6, 398.9; *Freezing Point*: -70.2, -56.8, 216.4; *Critical Temperature*: 563.7, 295.4, 568.6; *Critical Pressure*: 361, 24.5, 2.49; *Specific Gravity*: 0.703 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.9; *Ratio of Specific Heats of Vapor (Gas)*: 1.047 at 16 °C; *Latent Heat of Vaporization*: 130.4, 72.5, 3.03; *Heat of Combustion*: -19,112, -10,618, -442.26; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Self-contained breathing apparatus for high vapor concentrations; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation of concentrated vapor may cause irritation of respiratory tract, depression, and pulmonary edema. Liquid can cause irritation of eyes and (on prolonged contact) irritation and cracking of skin. Ingestion causes irritation of mouth and stomach. Aspiration causes severe lung irritation, rapidly developing pulmonary edema, and central nervous system excitement, followed by depression; *General Treatment for Exposure*: INHALATION: remove victim from exposure; apply artificial respiration if breathing has stopped; call physician if needed. EYES: irrigate with copious quantities of water for 15 min. SKIN: flush with water; wash with soap and water. INGESTION: do NOT induce vomiting; call a physician. ASPIRATION: enforce bed rest; give oxygen; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 440 ppm; *Short-Term Inhalation Limits*: 500 ppm for 30 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 4 ppm.

Octanol — (i) Chemical Designations — *Synonyms*: Alcohol C-8; Heptylcarbinol; 1-Octanol; Octyl alcohol; *Chemical Formula*: $CH_3(CH_2)_6CH_2OH$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: sweet; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 130.23; *Boiling Point at 1 atm.*: 383, 195, 468; *Freezing Point*: 5, -15, 258; *Critical Temperature*: 725, 385, 658; *Critical Pressure*: 400, 27, 2.7; *Specific Gravity*: 0.829 at 20 C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.044; *Latent Heat of Vaporization*: 176, 97.5, 4.08; *Heat of Combustion*: -16,130, -8,963, -375.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical gloves and chemical goggles; *Symptoms Following Exposure*:

Irritates skin and eyes; *General Treatment for Exposure*: Flush with copious amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; oral rat LD_{50} = 3.2 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: 0.49.

1-Octene — (i) Chemical Designations — *Synonyms*: Caprylene; alpha-Octylene; *Chemical Formula*: $CH_3(CH_2)_5CH=CH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 112.22; *Boiling Point at 1 atm.*: 250.3, 121.3, 194.5; *Freezing Point*: -151, -102, 172; *Critical Temperature*: 560.1, 293.4, 566.6; *Critical Pressure*: 400, 27.2, 2.76; *Specific Gravity*: 0.715 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.050; *Latent Heat of Vaporization*: 129, 71.9, 3.01; *Heat of Combustion*: -19,170, -10,650, -445.89; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic vapor canister; goggles or face shield; *Symptoms Following Exposure*: Generally low toxicity. Mildly anesthetic at high vapor concentrations. May irritate eyes; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration. INGESTION: do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present at high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Octyl Epoxy Tallate — (i) Chemical Designations — *Synonyms*: Epoxidized tall oil, octyl ester; *Chemical Formula*: Mixture; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Mild; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 420 (approx.); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 1.002 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical goggles; face shield; oil-resistant gloves; *Symptoms Following Exposure*: Contact with eyes causes mild inflammation. Contact with skin may produce allergic response; *General Treatment for Exposure*: EYES or SKIN: remove excess oil with cloth or absorbent paper; then wash with soapy water and flush with clear water; consult a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; $LD_{50} > 15$ g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils: Clarified — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Data not available; *Odor*: Data not available; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Data not available; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (etc.) 0.85 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: If liquid is ingested, an increased frequency of bowel movements will occur; *General Treatment for Exposure*: INGESTION: Do not induce vomiting: SKIN: Wipe off, wash with soap and water; EYES: Wash with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 50 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils: Crude — (i) Chemical Designations — *Synonyms*: Petroleum; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Dark; *Odor*: Offensive; tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 90->750, 32->400, 306->673; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.70 0.98 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 140-150, 76-86, 3.2-3.6; *Heat of Combustion*: -18,252, -10,140, -424.54; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves and boots; *Symptoms Following Exposure*: May irritate eyes and skin; *General Treatment for Exposure*: EYES: Flush with water for at least 15 min. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Oils: Diesel — (i) Chemical Designations — *Synonyms*: Fuel Oil 1-D; Fuel Oil 2-D; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light brown; *Odor*: Like fuel oil; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 550-640, 288-338, 561-612; *Freezing Point*: 0 to -30, -18 to -34, 255 to 239; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.841 at 16 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,400, -10,200, 429; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: If liquid is ingested, an increased frequency of bowel movements will occur; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting. SKIN: wipe off, wash with soap and water. EYES: wash with copious amounts of water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Oils, Edible: Castor — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light yellow to green; *Odor*: Characteristic; odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Varies, depending on composition; *Freezing Point*: 10, -12, 261; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.96 at 25 C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -15,950, -8,860, -371.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: If ingested causes severe diarrhea; *General Treatment for Exposure*: INGESTION: if more than 2 tablespoons, consult physician. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: None; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg (Fatal dose unknown but presumably large); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: None.

Oils, Edible: Coconut — (i) Chemical Designations — *Synonyms*: Coconut butter; Coconut oil; Copra oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid or solid; *Color*: Light yellow-orange; *Odor*: Weak acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid of liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (very high); *Freezing Point*: (approx.) 76, 24, 297; *Critical Temperature*: Not pertinent; *Critical Pressure*:

Not pertinent; *Specific Gravity*: 0.922 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -15,500, -8,600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Oil is essentially nontoxic, but can cause mild irritation of eyes on contact; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. INGESTION: do not induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Oils, Edible: Cottonseed — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 32, 0, 273; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.922 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,000, -8,870, -371; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None; is used as a food; *General Treatment for Exposure*: EYES: wash with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: None; *Short-Term Inhalation Limits*: Not pe; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Oils, Edible: Fish — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.93 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,000, -8,870, -371; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None — is a food; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Oils, Edible: Lard — (i) Chemical Designations — *Synonyms*: Kettle-rendered lard; Leaf lard; Prime steam lard; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid or liquid; *Color*: Colorless or pale yellow; *Odor*: Fatty; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 66 - 99, 19 - 37, 292 - 310; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.861 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -16,750, -9,320, -390; *Heat of Decomposition*; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Substance is essentially nontoxic. Prolonged contact with skin may cause dermatitis (oil acne). Hot liquid can burn eyes or skin; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; get medical attention for burn. SKIN: wipe off; get medical attention for burn. INGESTION: do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Oils, Edible: Olive — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*:

Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow-green; *Odor*: Weak, characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.915 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) = 16,000, -8,870, -371; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None — is a food; *General Treatment for Exposure*: No treatment necessary; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Oils, Edible — **(i) Chemical Designations** — *Synonyms*: Palm butter; Palm fruit oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Semi-solid to liquid; *Color*: Orange-red; *Odor*: Pleasant, characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid to liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (very high); *Freezing Point*: 70 - 80, 21 - 27, 294 - 300; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.906 at 38 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -15,500, -8,600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Oil is essentially nontoxic; may cause mild irritation of eyes; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. INGESTION: do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Oils, Edible: Peanut — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Characteristic slight nutty odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 28, -2, 271; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.919 at 20°C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,000, -8,870, -371; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None — is a food; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Oils, Edible: Safflower — **(i) Chemical Designations** — *Synonyms*: *Carthamus tinctorius* oil; Safflower seed oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Bland, fatty; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (very high); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.923 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -15,500, -8,600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Oil essentially nontoxic. Contact with eyes can cause mild vomiting; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. INGESTION: do not induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available;

Liquid or Solid Irritant Characteristics: Data not available; *Odor Threshold*: Not pertinent.

Oils, Edible: Soya Bean — (i) Chemical Designations — *Synonyms*: Soybean oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Weak; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: -4, -20, 253; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.22 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,000, -8,870, -371; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None — is a food; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Oils, Edible: Tucum — (i) Chemical Designations — *Synonyms*: American palm kernel oil; Aouara oil; Palm seed oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light yellow; *Odor*: Weak, acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (very high); *Freezing Point*: 86, 30, 303; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.908 at 60 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -15,500, -8,600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Oil essentially nontoxic. Contact with eyes cause mild irritation, and prolonged contact with skin may cause dermatitis; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. INGESTION: do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None known; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Oils, Edible: Vegetable — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Weak fatty; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.923 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,000, -8,870, -371; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None — is a food; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Data not available.

Oils, Fuel: 2 — (i) Chemical Designations — *Synonyms*: Home heating oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light brown; *Odor*: Like kerosine; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 540-640, 282-338, 555-611; *Freezing Point*: -20, -29, 244; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.879 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -19,440, -10,800, -452.17; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INHALATION: causes headache and slight giddiness. INGESTION: causes nausea, vomiting, and cramping; depression of central nervous system ranging

from mild headache to anesthesia, coma, and death; pulmonary irritation secondary to exhalation of solvent; signs of kidney and liver damage may be delayed. ASPIRATION: causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting. ASPIRATION: enforce bed rest; administer oxygen; seek medical attention. EYES: wash with copious quantity of water. SKIN: remove solvent by wiping and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single value applicable; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5-15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Slight smarting of eyes or respiratory system if present in high concentrations. The effects is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Fuel: 4 — (i) Chemical Designations — *Synonyms*: Residual fuel oil, No 4; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Brown; *Odor*: Like kerosine; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 214 to 1092, 101 to > 588, 374 to 861; *Freezing Point*: -20 to +15, -29 to -9, 244 to 264; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.904 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -17,460, -9,700, -406.17; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: Treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Fuel: 5 — (i) Chemical Designations — *Synonyms*: Residual fuel oil, No 5; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Brown; *Odor*: Like kerosine; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 426 ->1062, 218 ->570, 491 ->843; *Freezing Point*: 0, -18, 255; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.936 at 16 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,000, -10,000, -418.68; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: Treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays; consider prophylactic antibiotic regime if condition warrants. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Fuel: 1-D — (i) Chemical Designations — *Synonyms*: Diesel oil, light; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light brown; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 380-560, 193-293, 466-566; *Freezing Point*: -30, -34, 240; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.81-0.85 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 110, 60, 2.5; *Heat of Combustion*:

-18,540, -10,300, -431.24; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INHALATION: causes headache and slight giddiness. INGESTION: causes nausea, vomiting, and cramping; depression of central nervous system ranging from mild headache to anesthesia, coma, and death; pulmonary irritation secondary to exhalation of solvent; signs of kidney and liver damage may be delayed. ASPIRATION: causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting; seek medical attention. ASPIRATION: enforce bed rest; administer oxygen; EYES: wash with copious quantity of water. SKIN: remove solvent by wiping and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single value applicable; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5-15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Slight smarting of eyes or respiratory system if present in high concentrations. The effects is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Fuel: 2-D — (i) Chemical Designations — *Synonyms*: Diesel oil, medium; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light brown; *Odor*: Characteristic; like kerosine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 540-640, 282-338, 555-611; *Freezing Point*: -0, -18, 255; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.87-0.90 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -19,440, -10,800, -452.17; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: causes nausea, vomiting, and cramping; depression of central nervous system ranging from mild headache to anesthesia, coma, and death; pulmonary irritation secondary to exhalation of solvent; signs of kidney and liver damage may be delayed. ASPIRATION: causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis; acute onset of central nervous system excitement followed by depression; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting; seek medical attention. ASPIRATION: enforce bed rest; administer oxygen; EYES: wash with copious quantity of water. SKIN: remove solvent by wiping and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5-15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Slight smarting of eyes or respiratory system if present in high concentrations. The effects is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Fuel: No. 1 — (i) Chemical Designations — *Synonyms*: JP-1; Kerosene; Kerosine; Range oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light brown; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 380 - 560, 193 - 293, 466 - 566; *Freezing Point*: -45 to -55, -43 to -48, 230 to 225; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.81-0.85 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 110, 60, 2.5; *Heat of Combustion*: -18,540, -10,300, -421.24; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: causes irritation of gastrointestinal tract; pulmonary tract irritation secondary to exhalation of vapors. ASPIRATION: causes severe lung irritation with coughing, gagging, dyspnea, substernal distress, and rapidly developing pulmonary edema; later, signs of bronchopneumonia and pneumonitis appear later; minimal central nervous system depression; *General Treatment for Exposure*: INGESTION: do NOT lavage induce vomiting; call a physician. ASPIRATION: enforce bed rest; administer oxygen; call a physician. EYES: wash with plenty of water. SKIN: wipe off and wash with soap

and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm (suggested); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 1ppm.

Oils, Miscellaneous: Absorption — (i) Chemical Designations — *Synonyms*: Absorbent oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow to colorless; *Odor*: Like fuel oil; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >500, >200, >533; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.85 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: irritation of stomach. ASPIRATION: pulmonary irritation is normally minimal but may become more several hours after exposure. (Delayed development can be detected by serial chest x-rays.); *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. EYES: wash with copious amounts of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1; LD_{50} 5-15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Coal Tar — (i) Chemical Designations — *Synonyms*: Light oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Aromatic; like benzene; pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 233-333, 106-167, 379-440; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.90 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.071; *Latent Heat of Vaporization*: (est.) 107, 59.8, 2.5; *Heat of Combustion*: -17,440, -9,690, -405.7; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Vapor causes slight irritation of nose and throat, smarting of eyes. Liquid may irritate skin on prolonged contact; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. EYES: flush with water for at least 15 min. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Croton — (i) Chemical Designations — *Synonyms*: Crotonoel; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Dark; *Odor*: Unpleasant, acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (very high); *Freezing Point*: 0 to 18, -18 to -8, 255 to 265; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.946 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -16,800, -9,300, -390; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves and other protective clothing to prevent contact with skin; *Symptoms Following Exposure*: Contact of liquid with eyes causes severe irritation. May induce severe skin irritation, inflammation, swelling, and pustule formation. Absorption through the skin may cause purging. Inges-

tion causes burning of the mouth and stomach and drastic purging, possibly leading to collapse and death. Small doses have a strong laxative effect; *General Treatment for Exposure*: EYES: flush with water; a 2.5% hydroxycortisone ointment is recommended. SKIN: remove as much liquid as possible from skin by use of a good solvent such as acetone or alcohol; wash with soap and water. INGESTION: for gastrointestinal symptoms, use demulcents; further treatment is symptomatic; do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} <50 mg/kg; *Late Toxicity*: Has been used in cancer research as a promoter for other compounds that cause skin cancer; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Linseed — (i) Chemical Designations — *Synonyms*: Flaxseed oil; Raw linseed oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow to dark amber; *Odor*: Like oil-base paint; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (very high); *Freezing Point*: -2, -19, 254; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.932 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -16,800, -9,300, -390; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact of liquid with eyes causes mild irritation. Prolonged contact with skin can cause dermatitis. Ingestion of large doses (over 1 oz) has laxative effect; *General Treatment for Exposure*: EYES: flesh with water for at least 15 min. SKIN: wipe off; wash with soap and water. INGESTION: do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 0, LD_{50} > 15 g/kg; *Late Toxicity*: Liver damage in rats (from addition of oil to diet); *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Lubricating — (i) Chemical Designations — *Synonyms*: Crankcase oil; Motor oil; Transmission oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow fluorescent; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.902 at 20 C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,486, -19,270, -429.98; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: minimal gastrointestinal tract irritation; increased frequency of bowel passage may occur. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure; *General Treatment for Exposure*: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Mineral — (i) Chemical Designations — *Synonyms*: Liquid petrolatum; White oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Very faint; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.822 at 20 C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent;

Latent Heat of Vaporization: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Ingestion of liquid can cause very loose bowel movements; *General Treatment for Exposure*: EYES: wash with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Oils, Miscellaneous: Mineral Seal — (i) Chemical Designations — *Synonyms*: Long-time burning oil; Mineral colza oil; 300° oil; signal oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light brown; *Odor*: Like kerosene; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: >500, >260, >533; *Freezing Point*: 10.0, -12.2, 261; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.811-0.825 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Vapors cause slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs causes coughing, distress, and rapidly developing pulmonary edema; *General Treatment for Exposure*: ASPIRATION: enforced bed rest; administer oxygen; call a doctor. INGESTION: do NOT induce vomiting; have victim drink water or milk. EYES: wash with copious amounts of water. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Motor — (i) Chemical Designations — *Synonyms*: Crankcase oil; Lubricating oil; Transmission oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow fluorescent; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: -29.9, 034.4, 238.8; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.84 - 0.96 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,486, -19,270, -429.98; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: INGESTION: minimal gastrointestinal tract irritation; increased frequency of bowel passage may occur. ASPIRATION: pulmonary irritation is normally minimal but may become more severe several hours after exposure; *General Treatment for Exposure*: INGESTION: do NOT lavage or induce vomiting. ASPIRATION: treatment probably not required; delayed development of pulmonary irritation can be detected by serial chest x-rays. EYES: wash with copious quantity of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Neatsfoot — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow; *Odor*: Peculiar; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 32 to 14, 0 to -10, 273 to 263; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.915 at 16 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not perti-

nent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: May cause dermatitis in sensitive individuals (humans); *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0, LD_{50} above 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Penetrating — (i) Chemical Designations — *Synonyms*: Protective oil; Water displacing oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellowish; *Odor*: Like motor oil; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.8961 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Liquid may irritate stomach and increase frequency of bowel movements; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. ASPIRATION: check for delayed development of pulmonary irritation by serial x-rays. EYES: wash with copious amounts of water. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Range — (i) Chemical Designations — *Synonyms*: No.1; Fuel oil; JP-1; Kerosene; Kerosine; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like kerosene; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 392-500, 200-260, 473-533; *Freezing Point*: -45 to -55, -43 to -48, 230 to 225; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.80-0.85 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 108, 60, 2.51; *Heat of Combustion*: -18,540, -10,300, -421.24; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Vapors cause slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs causes coughing, distress, and rapidly developing pulmonary edema; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting; call a physician. ASPIRATION: enforce bed rest; administer oxygen; call a physician. EYES: wash with plenty of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm (suggested); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1; LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 1 ppm.

Oils, Miscellaneous: Resin — (i) Chemical Designations — *Synonyms*: Codoil; Retinol; Rosin oil; Rosinol; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light amber to red to black, depending on grade; *Odor*: Characteristic; like pinetree pitch; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 572-750, 300-400, 573-673; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.96 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not

pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available, but toxicity is probably low; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Road — (i) Chemical Designations — *Synonyms*: Liquid asphalt; Petroleum asphalt; Slow-curing asphalt; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Dark brown to black; *Odor*: Tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0-1.2 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing for hot asphalt; face and eye protection when hot; *Symptoms Following Exposure*: Contact with skin may cause dermatitis. Inhalation of vapors may cause moderate irritation of nose and throat. Hot liquid burns skin; *General Treatment for Exposure*: Severe burns may result from hot liquid. Cool the skin at once with water. Cover burn with sterile dressing and seek medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None observed; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Rosin — (i) Chemical Designations — *Synonyms*: Codoil; Retinol; Resin oil; Rosinol; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light amber to red to black, depending on grade; *Odor*: Characteristic; like pinetree pitch; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 572-750, 300-400, 573-673; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.96 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available, but toxicity is probably low; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Sperm — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.882 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -17,900, -9943, -416.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available, but toxicity is probably low; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Spindle — (i) Chemical Designations — *Synonyms*: Bearing oil; High-speed bearing oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Light brown; *Odor*: Weak, like kerosene; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.881 at 15 C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Vapors cause slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs causes coughing, distress, and rapidly developing pulmonary edema; *General Treatment for Exposure*: ASPIRATION: enforced bed rest; administer oxygen; call a doctor. INGESTION: do NOT induce vomiting; have victim drink water or milk. EYES: wash with copious amounts of water. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Spray — (i) Chemical Designations — *Synonyms*: Dormant oil; Foliage oil; Kerosene, heavy; Plant spray oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light brown; *Odor*: Like kerosene; like fuel oil; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 590 - 700, 310 - 371, 583 - 644; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.82 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18,540, -10,300, -431.24; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Vapors cause slight irritation of eyes and nose. Liquid irritates stomach; if taken into lungs causes coughing, distress, and rapidly developing pulmonary edema; *General Treatment for Exposure*: ASPIRATION: enforced bed rest; administer oxygen; call a doctor. INGESTION: do NOT induce vomiting; have victim drink water or milk. EYES: wash with copious amounts of water. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Tall — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Yellow; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.951 at 16 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Tanner's — (i) Chemical Designations — *Synonyms*: Sulfated neatsfoot oil, sodium

salt; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Data not available; *Color*: Data not available; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.85 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -420,; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Data not available; *Symptoms Following Exposure*: Data not available; *General Treatment for Exposure*: Data not available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Transformer — (i) Chemical Designations — *Synonyms*: Electrical insulating oil; Insulating oil; Petroleum insulating oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to light brown; *Odor*: Like motor oil. **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: -75, -59, 214; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.891 at 15°C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles or face shield; *Symptoms Following Exposure*: Ingestion of liquid bay irritate stomach and cause increased frequency of bowel movements. If taken into lungs, delayed pulmonary irritation may occur; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting. ASPIRATION: check for delayed irritation by serial X-rays. EYES: wash with copious amounts of water. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Oils, Miscellaneous: Turbine — (i) Chemical Designations — *Synonyms*: Steam turbine oil; Steam turbine lube oil; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to pale brown; *Odor*: Weak, like lube oil; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.87 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -17,600, -9,800, -410; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with liquid causes slight irritation of eyes and (on prolonged contact) skin. Ingestion causes slight irritation of stomach and bowel, increased frequency of bowel movement; *General Treatment for Exposure*: EYES: wash with copious quantity of water for least 15 min. SKIN: wipe off; wash with soap and water. INGESTION: do NOT induce vomiting; do NOT lavage; 2-4 oz. Olive and 1-2 oz. Activated charcoal may be given; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0, LD_{50} > 15 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oleic Acid — (i) Chemical Designations — *Synonyms*: *cis*-8-Heptadecylene-carboxylic acid; *cis*-9-Octadecenoic acid; *cis*-9-Octadecylenic acid; Red oil; *Chemical Formula*: $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale; *Odor*: Faint; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 277 (avg.);

Boiling Point at 1 atm.: 432, 222, 495; *Freezing Point*: 57, 14, 287; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.89 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 103, 57, 2.4,; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Impervious gloves; goggles or face shield; impervious apron; *Symptoms Following Exposure*: Industrial use of compound involves no known hazards. Ingestion causes mild irritation of mouth and stomach. Contact with eyes or skin causes mild irritation; *General Treatment for Exposure*: INGESTION: give large amount of water. EYES: if eye irritation occurs, flush with water and get medical attention. SKIN: wash thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} >15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oleic Acid, Potassium Salt — (i) Chemical Designations — *Synonyms*: Potassium oleate; *Chemical Formula*: $C_{17}H_{33}COOK$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid or liquid; *Color*: Brown; *Odor*: Faint soapy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 320 (solid only); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 455-464, 235-240, 508-513; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1.1 at 20 °C (solid or liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles and rubber gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat, coughing, and sneezing. Ingestion causes mild irritation of mouth. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water. EYES: flush with copious quantities of tap water. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oleic Acid, Sodium Salt — (i) Chemical Designations — *Synonyms*: Eunatrol; Sodium oleate; *Chemical Formula*: $C_{17}H_{33}COONa$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Light tan; *Odor*: Slight tallow-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 304 (approx.); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 450-455, 232-235, 505-508; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1.1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask and gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat, coughing, and sneezing. Ingestion causes mild irritation of mouth. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water. EYES: flush with copious quantities of tap water. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Oleum — (i) Chemical Designations — *Synonyms*: Fuming sulfuric acid; *Chemical Formula*: SO_3-H_2SO_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to cloudy; *Odor*: Sharp penetrating; choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.91-1.97 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recom-*

mended Personal Protective Equipment: Respirator approved by U.S. Bureau of Mines for acid mists; rubber gloves; splashproof goggles; eyewash fountain and safety shower; rubber footwear; face shield; *Symptoms Following Exposure*: Acid mist is irritating to eyes, nose and throat. Liquid causes severe burns of skin and eyes; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. EYES: flush with plenty of water for at least 15 min.; call a doctor. SKIN: flush with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3; *Short-Term Inhalation Limits*: 5 mg/m^3 for 5 min.; 3 mg/m^3 for 10 min.; 2 mg/m^3 for 30 min.; 1 mg/m^3 for 60 min.; *Toxicity by Ingestion*: Severe burns of mouth and stomach; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors causes a severe irritation of the eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact; very injurious to the eyes; *Odor Threshold*: 1 mg/m^3.

Oxalic Acid — (i) Chemical Designations — *Synonyms*: Ethanedioic acid; *Chemical Formula*: $C_2H_2O_4$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid *Molecular Weight*: 126.7; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 214.7, 101.5, 374.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.90 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Respirator for dust or mist protection; rubber, neoprene, or vinyl gloves; chemical safety glasses; rubbers, over leather or rubber safety shoes; apron or impervious clothing for splash protection; *Symptoms Following Exposure*: As dust or as a solution, can cause severe burns of eyes, skin, or mucous membranes. Ingestion of 5 grams has caused death with symptoms of nausea, shock, collapse, and convulsions coming on rapidly. Repeated or prolonged skin exposure can cause dermatitis and slow-healing ulcers; *General Treatment for Exposure*: Get medical attention for all eye exposure and any serious overexposures; treatment is symptomatic. INHALATION: rinse mouth and/or gargle repeatedly with cold water. INGESTION: dilute by drinking large amounts of water; repeat at least once and then administer milk or milk of magnesia as an emollient; do NOT induce vomiting. EYES and SKIN: flush thoroughly with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent.

Oxygen, Liquefied — (i) Chemical Designations — *Synonyms*: Liquid oxygen; LOX; *Chemical Formula*: O_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefies gas; *Color*: Light blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 32.0; *Boiling Point at 1 atm.*: -297.3, -182.9, 90.3; *Freezing Point*: -361, -218, 55; *Critical Temperature*: -180, -118, 155; *Critical Pressure*: 738, 50.1, 5.09; *Specific Gravity*: 1.14 at -183 °C (liquid); *Vapor (Gas) Specific Gravity*: 1.1; *Ratio of Specific Heats of Vapor (Gas)*: 1.3962; *Latent Heat of Vaporization*: 91.6, 50.9, 2.13; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety goggles or face shield; insulated gloves; long sleeves; trousers worn outside boots or over high-top shoes to shed spilled liquid; *Symptoms Following Exposure*: Inhalation of 100% oxygen can cause nausea, dizziness, irritation of lungs, pulmonary edema, pneumonia, and collapse. Liquid may cause frostbite of eyes and skin; *General Treatment for Exposure*: INHALATION: in all but the most severe cases (pneumonia), recovery is rapid after reduction of oxygen pressure; supportive treatment should include immediate sedation, anticonvulsive therapy if needed, and rest. EYES: treat frostbite burns. SKIN: treat frostbite; soak in lukewarm water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Not pertinent; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

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Paraformaldehyde — (i) Chemical Designations — *Synonyms*: Formaldehyde polymer; Polyformaldehyde; Polyfooxymethylene; Polyoxymethylene glycol; *Chemi-*

cal Formula: $HO(CH_2O)_nH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Pungent and irritating; like formaldehyde; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 600 (approx.); *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 311 - 342, 155 - 172, 428 - 455; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.46 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6682, -3712, -155.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; protective clothing; *Symptoms Following Exposure*: Vapor or dust irritates eyes, mucous membranes, and skin; may cause dermatitis. Ingestion of solid or of a solution in water irritates mouth, throat, and stomach and may cause death; *General Treatment for Exposure*: INGESTION: give milk or white of egg beaten with water; call a doctor. SKIN OR EYES: rinse with copious amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

Parathion, Liquid — **(i) Chemical Designations** — *Synonyms*: O,O-Diethyl O-(p-nitrophenyl) phoshorothioate; O,O-Diethyl O-(p-nitrophenyl) thiophosphate; Ethyl Parathion; Phosphorothioic acid; O,O-diethyl O-p-nitrophenyl ester; *Chemical Formula*: $(C_2H_5O)_2PSOC_6H_4NO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Deep brown to yellow; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 291.3; *Boiling Point at 1 atm.*: Very high; decomposes; *Freezing Point*: 43, 6, 279; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.269 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -9,240, -5,140, -215; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Neoprene-coated gloves; rubber work shoes or overshoes; latex rubber apron; goggles; respirator or mask approved for toxic dusts and organic vapors; *Symptoms Following Exposure*: Inhalation of mist, dust, or vapor (or ingestion, or absorption through the skin) cause dizziness, usually accompanied by constriction of the pupils, headache, and tightness of the chest. Nausea, vomiting, abdominal cramps, diarrhea, muscular twitchings, convulsions and possibly death may follow. An increase in salivary and bronchial secretions may result which simulate severe pulmonary edema. Contact with eyes causes irritation; *General Treatment for Exposure*: Call a doctor for all exposure to this compound. INHALATION: remove victim from exposure immediately; have physician treat with atropine injections until full atropinization; 2-PAM may also be administered by physician. EYES: flush with water immediately after contact for at least 15 min. SKIN: remove all clothing and shoes immediately; quickly wipe off the affected area with a clean cloth; follow immediately with a shower, using plenty of soap. If a complete shower is impossible, wash the affected skin repeatedly with soap and water. INGESTION: if victim is conscious, induce vomiting and repeat until vomit fluid is clear; make victim drink plenty of milk or water; have him lie down and keep warm; *Toxicity by Inhalation (Threshold Limit Value)*: 0.01 mg/m^3; *Short-Term Inhalation Limits*: 0.5 mg/m^3 for 30 min.; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 2 mg/kg (rat); *Late Toxicity*: Birth defects in chick embryos; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 4.04 ppm.

Pentaborane — **(i) Chemical Designations** — *Synonyms*: (9)-Pentaboron nooahydride; *Chemical Formula*: B_5H_9; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; strong, pungent; foul; sour milk; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 63.2; *Boiling Point at 1 atm.*: 137.1, 58.4, 33.15; *Freezing Point*: -52.2, -46.8, 224.6; *Critical Temperature*: 441, 227, 500; *Critical Pressure*: 570, 38, 3.9; *Specific Gravity*: 0.623 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.0399; *Latent Heat of Vaporization*: 219, 122, 5.10; *Heat of Combustion*: -29,100, -16,200, -677; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus or air-line mask; goggles or

face shield; rubber gloves and protective clothing; *Symptoms Following Exposure*: Inhalation of low concentrations causes dizziness, blurred vision, nausea, fatigue, light headedness or nervousness; higher concentrations also cause abnormal muscular contractions or twitching of any part of body, difficult breathing, poor muscular coordination, imperfect articulation of speech, convulsions, and (rarely) coma. Contact with liquid causes severe irritation of eyes and irritation of skin (acute local inflammation with the formation of small blisters, redness and swelling). Can be absorbed through the skin; *General Treatment for Exposure*: get medical attention following all exposures to this compound. INHALATION: remove victim to fresh air; watch for delayed symptoms for 1-2 days. EYES: wash with copious amounts of water for at least 30 min., holding eyelids apart to insure thorough flushing. SKIN: wash immediately with soap and water; rinse affected area with a 3% ammonia solution followed by additional flushing with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.005 ppm; *Short-Term Inhalation Limits*: 25 ppm for 5 min., 8 ppm for 15 min., 4 ppm for 30 min., 2 ppm for 60 min.; *Toxicity by Ingestion*: Grade 4, LD_{50} <50 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.8.

Pentachlorophenol — (i) Chemical Designations — *Synonyms*: Dowicide 7; Penta; Santophen 20; *Chemical Formula*: C_6Cl_5OH; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Colorless to light brown; *Odor*: Very weak; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 266.35; *Boiling Point at 1 atm.*: 590, 310, 583; *Freezing Point*: 370, 188, 461; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.98 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Respirator for dust; goggles; protective clothing; *Symptoms Following Exposure*: Dust or vapor irritates skin and mucous membranes, causing coughing and sneezing. Ingestion causes loss of appetite, respiratory difficulties, anesthesia, sweating coma. Overexposure can cause death; *General Treatment for Exposure*: Call a doctor! INGESTION: induce vomiting at once. EYES: flush with water for 15-30 min. SKIN: wash well with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Pentadecanol — (i) Chemical Designations — *Synonyms*: 1-Pentadecanol; Pentadecyl alcohol; *Chemical Formula*: $CH_3(CH_2)_{13}CH_2OH$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak alcoholic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 228.42; *Boiling Point at 1 atm.*: 572, 44, 317; *Freezing Point*: 111, 44, 317; *Critical Temperature*: 824, 440, 713; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.829 at 50 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.024; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Low toxicity. Excessive exposure produces some central nervous system depression. Prolonged contact produces skin irritation; *General Treatment for Exposure*: INHALATION: if necessary, support respiration. INGESTION: induce vomiting and call a doctor. SKIN AND EYES: wash with copious amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Pentaerythritol — (i) Chemical Designations — *Synonyms*: Mono PE; PE; Pentaerythrite; Pentek; Tetrahydroxymethylmethane; Tetrakis (Hydroxymethyl) methane; Tetramethylolmethane; *Chemical Formula*: $C(CH_2OH)_4$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical*

State at 15 °C and 1 atm.: Solid; *Molecular Weight*: 136.2; *Boiling Point at 1 atm.*: Not pertinent (sublimes); *Freezing Point*: 502, 261, 534; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.39 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -8,730, -4,850, -203; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles; *Symptoms Following Exposure*: Non-toxic; no symptoms likely; *General Treatment for Exposure*: None needed; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent ("Inert" particulate); *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 0, LD_{50} > 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Pentane — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: n-C_5H_{12}; **(ii) Observable Characteristics** -*Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like a gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 72.15; *Boiling Point at 1 atm.*: 97.0, 36.1, 309.3; *Freezing Point*: -201.0, -129.4, 143.8; *Critical Temperature*: 385.7, 196.5, 469.7; *Critical Pressure*: 490, 33.3, 3.37; *Specific Gravity*: 0.626 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.075; *Latent Heat of Vaporization*: 153.7, 85.38, 3.575; *Heat of Combustion*: -19,352, -10,751, -450; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield (as for gasoline); *Symptoms Following Exposure*: Low toxicity. Very high vapor concentrations produce narcosis. Aspiration into lungs can produce chemical pneumonitis and/or pulmonary edema; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration if needed. INGESTION: do NOT induce vomiting; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: 500 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: 10 ppm.

1-Pentene — **(i) Chemical Designations** — *Synonyms*: alfa-n-Amylene; Propylethylene; *Chemical Formula*: $CH_3(CH_2)_2CH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 70.13; *Boiling Point at 1 atm.*: 85.8, 29.9, 303.1; *Freezing Point*: -265, -165, 108; *Critical Temperature*: 376.9, 191.6, 464.8; *Critical Pressure*: 588, 40, 4.5; *Specific Gravity*: 0.641 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.083; *Latent Heat of Vaporization*: 154.6, 85.87, 3.595; *Heat of Combustion*: -19.359, -10.755, -450.29; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield (as for gasoline); *Symptoms Following Exposure*: Acts as a simple asphyxiant or weak anesthetic in high vapor concentrations. Similar to effects caused by gasoline vapors; *General Treatment for Exposure*: INHALATION: remove from exposure. SKIN: wash with soap and water. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available: *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not irritating; *Liquid or Solid Irritant Characteristics*: Not irritating; *Odor Threshold*: Data not available.

Peracetic Acid — **(i) Chemical Designations** — *Synonyms*: Acetyl hydroperoxide; Peroxyacetic acid; *Chemical Formula*: CH_3COOOH-CH_3COOH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; strong; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (mixture); *Freezing Point*: (approx.) -22, -30, 243; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 1.153 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; impervious gloves; full protective clothing (goggles, rubber gloves, etc.); *Symptoms Following Exposure*: inhalation causes severe irritation of mucous membrane. Contact with liquid causes severe irritation of eyes and skin. Ingestion causes severe distress, including

burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, apply artificial respiratory and oxygen; Call a doctor. EYES; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} 10 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Perchloric Acid — (i) Chemical Designations — *Synonyms*: Dioxonium perchlorate solution; Perchloric acid solution; *Chemical Formula*: $HClO_4$-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 100.46 (solute only); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: -170, -112, 161; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.6 - 1.7 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves, face shield or vapor-tight chemical-type safety goggles; rubber apron; rubber boots or shoes; *Symptoms Following Exposure*: Inhalation of vapors or mist causes burning sensation of nose and throat, and lung irritation with coughing; prolonged or excessive exposure could cause vomiting and severe coughing. Ingestion causes blistering and burns of mouth and stomach. Contact with eyes or skin causes blistering and burns; *General Treatment for Exposure*: *Get medical attention following all exposures to this compound.* INHALATION: move to fresh air; give oxygen if necessary. INGESTION: give large amounts of water. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Perchloromethyl mercaptan — (i) Chemical Designations — *Synonyms*: Trichlormethanesulfenyl chloride; Trichloromethane sulphurl chloride; Trichloromethyl sulfochloride; Trichloromethyl sulfur chloride; *Chemical Formula*: Cl_3CSCl; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Bright yellow; pale yellow; orange-red; *Odor*: Intensely unpleasant; strong, unbearable; strongly acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 185.9; *Boiling Point at 1 atm.*: 300, 148, 421; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.706 at 11 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: (est.) 94, 52, 2.2; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic- and acid-type canister mask or self-contained breathing apparatus; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation may cause severe irritation of upper respiratory tract; brief exposure to low concentrations may produce central nervous system depression and causes immediate eye irritation and severe conjunctivitis; if not promptly washed away, severe corneal damage may result. Liquid also causes severe local skin irritation; may be absorbed through skin in quantities sufficient to produce systemic poisoning. Ingestion may cause damage to the membranes of the mouth, throat, and gastrointestinal tract. Pain and burning of the mouth and throat, nausea, vomiting, cramps and diarrhea may occur. In severe cases, tissue ulceration and central nervous system depression may result; *General Treatment for Exposure*: Get medical attention at once following all exposures to this compound. INHALATION: remove victim to fresh air; give mouth-to-mouth resuscitation if needed. EYES: flush with water for 15 min.; if physician is not available, flush for another 15 min. SKIN: flush with water. INGESTION: give large amounts of water, then induce vomiting until vomitus is clear; give milk, eggs, or olive oil to soothe stomach; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, oral LD_{50} =83 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Petrolatum — (i) Chemical Designations — *Synonyms*: Petrolatum jelly; Petroleum jelly; Vaseline; Yellow petrolatum; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless, amber, green, dark

brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Grease; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 100-135, 38-57, 311-330; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.865 at 60 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 97-100, 54-63, 2.3-2.6; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: None; *General Treatment for Exposure*: EYES: wash with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Petroleum Naphtha — (i) Chemical Designations — *Synonyms*: Petroleum solvent; *Chemical Formula*: Not applicable; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Like gasoline and kerosene; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 207.0, 97.2, 370.4; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.74 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.030; *Latent Heat of Vaporization*: 130 - 150, 71 - 81, 3.0 - 3.4; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield (as for gasoline); *Symptoms Following Exposure*: Inhalation of concentrated vapor may cause intoxication. Liquid is not ver irritating to skin or eyes but may get into lungs by aspiration; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and treat symptoms. INGESTION: have victim drink water or milk; do NOT induce vomiting. EYES: flush with water for 15 min. SKIN: wipe off and wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: No single TLV applicable; *Short-Term Inhalation Limits*: 500 ppm. For 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are non-irrigating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Phenol — (i) Chemical Designations — *Synonyms*: Carbolic acid; Hydroxybenzene; Phenic acid Phenyl hydroxide; *Chemical Formula*: C_6H_5OH; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid or liquid; *Color*: Colorless to light pink; *Odor*: Characteristically sweet; sweet, tarry; pungent, distinctive; distinct, aromatic, somewhat sickening sweet and acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: 94.11; *Boiling Point at 1 atm.*: 359.2, 181.8, 455.0; *Freezing Point*: 105.6, 40.9, 314.1; *Critical Temperature*: 790.0, 421.1, 694.3; *Critical Pressure*: 889, 60.5, 6.13; *Specific Gravity*: 1.058 at 41 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.089; *Latent Heat of Vaporization*: 130, 72, 3.0; *Heat of Combustion*: -13.400, -7.445, -311.7; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Fresh-air mask for confined areas; rubber gloves; *Symptoms Following Exposure*: Will burn eyes and skin. The analgesic action may cause loss of pain sensation. Readily absorbed through skin, causing increase in heart rate, convulsions, and death; *General Treatment for Exposure*: INHALATION: if victim shows any ill effects, move him to fresh air, keep him quiet and warm, and call a doctor immediately; if breathing stops, give artificial respiration. INGESTION: do NOT induce vomiting; give milk, eggs whites, or large amounts of water and call a doctor immediately; no known antidote; treat the symptoms. EYES: immediately flush with plenty of water for at least 15 min.; continue for another 15 min. if doctor has not taken over. SKIN: immediately remove all clothing while in a shower and wash affected area with abundant flowing water or soap and water for at least 15 min.; clean clothing; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Carcinogenic in laboratory animals; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: 0.05 ppm.

Phenyldichloroarsine, Liquid — (i) Chemical Designations — *Synonyms*: Phenlarsenic dichloride; *Chemical*

Formula: $C_6H_5AsCl_2$ **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to yellow; *Odor*: Weak, but very unpleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 222.9; *Boiling Point at 1 atm.*: 495, 257, 530; *Freezing Point*: 3.9, -15.6, 257.6; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.657 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 99, 55, 2.3; *Heat of Combustion*: (est.) -6.450, -3.600, -150; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full protective clothing; gas mask or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation causes irritation of respiratory system, pulmonary edema, and systemic effects. Vapor irritates eyes. Liquid causes severe burns of eyes and severe irritation or burns of mouth and stomach; *General Treatment for Exposure*: *Get medical attention following all exposures to this compound.* INHALATION: remove victim from exposure; give artificial respiration if breathing has ceased. EYES: immediately wash with copious amounts of water for at least 15 min. SKIN: flush with water and wash well with soap and water; compound can be absorbed through skin and cause toxic systemic effects. INGESTION: give large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Phenylhydrazine hydrochloride — (i) Chemical Designations — *Synonyms*: Phenyldraziniun chloride; *Chemical Formula*: $C_6H_5NHNH_2 \cdot HCl$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White to tan; *Odor*: Weak aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 144.6; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 469, 243, 516; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator, rubber gloves; goggles; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat; fumes from hot material may cause same symptoms as ingestion. Phenylhydrazine is a chronic poison; ingestion can cause jaundice, anorexia, nausea, and vascular thrombosis; may also cause anemia and liver injury. Contact with eyes causes irritation. Contact with skin causes irritation and dermatitis; *General Treatment for Exposure*: INHALATION: move to fresh air; get medical attention. INGESTION: give large amounts of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min.; if exposure is prolonged or repeated, get medical attention. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Causes tumors in mice; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Phosgene — (i) Chemical Designations — *Synonyms*: Carbonyl chloride; Chloroformyl chloride; *Chemical Formula*: $COCl_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Compressed gas; *Color*: Colorless; *Odor*: Sharp, pungent odor in higher concentrations; like new-mown grass in low concentrations; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Gas; *Molecular Weight*: 98.92; *Boiling Point at 1 atm.*: 46.8, 8.2, 281.4; *Freezing Point*: -195, -126, 147; *Critical Temperature*: 360, 182, 455; *Critical Pressure*: 823, 56.0, 5.67; *Specific Gravity*: 1.38 at 20 C (liquid); *Vapor (Gas) Specific Gravity*: 3.4; *Ratio of Specific Heats of Vapor (Gas)*: 1.170; *Latent Heat of Vaporization*: 110, 59, 2.5; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved by U.S. Bureau of Mines respirator; protective clothing; *Symptoms Following Exposure*: Irrigates lungs, causing delayed pulmonary edema. Slight gassing produces dryness or burning sensation in the throat, numbers, pain in the chest, bronchitis, and shortness of breath; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area; enforce absolute rest; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 ppm; *Short-Term Inhalation Limits*: 1 ppm for 5 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Severe delayed pulmonary edema; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They can-

not be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe irritant to all tissues; *Odor Threshold*: 0.5 ppm.

Phosphoric Acid — (i) Chemical Designations — *Synonyms*: Orthophosphoric acid; *Chemical Formula*: H_3PO_4; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.00; *Boiling Point at 1 atm.*: >266, >130, >403; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.892 at 25 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves and protective clothing; *Symptoms Following Exposure*: Burns on mouth and lips, sour acrid taste, severe gastrointestinal irritation, nausea, vomiting, bloody diarrhea, difficult swallowing, severe abdominal pains, thirst, acidemia, difficult breathing, convulsion, collapse, shock, death; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting; give water, milk, or vegetable oil. SKIN OR CONTACT: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 1.0 mg/m^3; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Not volatile; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: Not pertinent.

Phosphorus Oxychloride — (i) Chemical Designations — *Synonyms*: Phosphoryl chloride; *Chemical Formula*: $POCl_3$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Pungent and musty; disagreeable and lingering; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 153.33; *Boiling Point at 1 atm.*: 255, 107, 380; *Freezing Point*: 34, 1, 274; *Critical Temperature*: 630, 332, 605; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.675 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.290; *Latent Heat of Vaporization*: 97, 54, 2.3; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical safety goggles; face shield; self-contained or air-line respirator; hard hat; foot protection; rubber gloves and clothing; *Symptoms Following Exposure*: Vapor burns eyes and respiratory tract. Liquid is very corrosive to body tissues because of reaction with water to form hydrochloric and phosphoric acids; *General Treatment for Exposure*: *CAUTION: persons doing treatment should protect themselves against exposure.* INHALATION: remove victim from contaminated area at once; if breathing has stopped, start artificial respiration; call a doctor. INGESTION: give water or milk; do NOT induce vomiting. SKIN: remove contaminated clothing and flood exposed skin surfaces with water. EYES: retract eyelids and wash with water for at least 15 min.; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, oral rat LD_{50} = 380 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Phosphorus Pentasulfide — (i) Chemical Designations — *Synonyms*: Phosphoric sulfide; Phosphorus persulfide; Thiophosphoric anhydride; *Chemical Formula*: P_2S_5-P_4S_{10}; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Light greenish yellow; greenish gray; *Odor*: Like rotten eggs. High (lethal) concentrations can paralyze the sense of smell; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 222.27; *Boiling Point at 1 atm.*: 957, 514, 787; *Freezing Point*: 527, 275, 548; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.03 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 184, 102, 4.27; *Heat of Combustion*: -10.890, -6.050, -253.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Chemical safety goggles; plastic face shielding; self-contained or air-line respirator; *Symptoms Following Exposure*: Hydrogen sulfide gas formed by reaction with moisture can cause death be respiratory failure. The gas also irritates eyes and respiratory system. The solid irritates skin

and eyes; the symptoms may be delayed several hours; *General Treatment for Exposure*: INHALATION: remove victim from contaminated area; if breathing has stopped, begin artificial respiration. INGESTION: induce vomiting; call a physician. SKIN: remove contaminated clothing and wash areas with copious large amounts of water. EYES: flush with large amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Inhalation Limits*: 20 ppm. for 5 min. (hydrogen sulfide); *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Hydrogen sulfide gas formed by reaction with moisture, cause severe irritation of eyes and throat and can cause eye and lung injury. It cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: 0.0047 ppm. (hydrogen sulfide). See also note par *Odor*.

Phosphorus, Red — (i) Chemical Designations — *Synonyms*: Amorphous phosphorus; *Chemical Formula*: P; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: Reddish brown; *Odor*: Odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 123.89; *Boiling Point at 1 atm.*: Catches fire; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.20 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; gloves of rubber or vinyl; chemical safety glasses; rubber shoes; *Symptoms Following Exposure*: Physically irritating to eyes, otherwise essentially harmless and nontoxic unless contaminated by highly toxic yellow phosphorus as an impurity; *General Treatment for Exposure*: EYES: flush with thoroughly with water and get medical attention. SKIN: flush with water and wash with soap and water. CAUTION: *Avoid brushing, as friction may ignite material on skin or clothing*; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Nonvolatile; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Phosphorus Tribromide — (i) Chemical Designations — *Synonyms*: Phosphorus bromide; *Chemical Formula*: PBr_3; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless or slightly yellow; *Odor*: Pungent; sharp, penetrating; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 270.73; *Boiling Point at 1 atm.*: 343, 173, 446; *Freezing Point*: -42.9, -40.5, 232.2; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.862 at 30 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 64.4, 35.8, 1.50; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Acid-gas canister-type mask (full face type emergencies); chemical safety goggles; apron, gloves, clothing, and safety shoes all made from rubber; *Symptoms Following Exposure*: Inhalation causes severe irritation of nose, throat, and lungs. Ingestion causes burns of mouth and stomach. Contact with eyes or skin causes severe burns; *General Treatment for Exposure*: INHALATION: remove victim to clear air; if necessary, apply artificial respiration and/or administer oxygen. INGESTION: dilute by drinking water. Then neutralize with milk of magnesia, egg white, etc; do not use sodium bicarbonate. EYES: immediately flush with large amounts of water for at least 15 min. SKIN: immediately flush with large amounts of water; remove contaminated clothing; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Phosphorus Trichloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: PCl_3; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent, irritating, like hydrochloric acid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 137.33; *Boiling Point at 1 atm.*: 169, 76, 349; *Freezing Point*: -170, -112, 161; *Critical Temperature*: 547, 286, 559; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.575 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 4.7; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.290; *Latent Heat of Vaporization*: 95, 53, 2.2; *Heat of Combus-*

tion: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles; plastic face shield; self-contained or air-line respirator; safety hat; rubber gloves and clothing; *Symptoms Following Exposure*: Vapors cause severe irritation of eyes and respiratory tract. Liquid burns eyes and skin; *General Treatment for Exposure*: CAUTION: *persons doing treatment should protect themselves against exposure*. INHALATION: remove victim from contaminated area at once; if breathing has stopped, start artificial respiration; call a doctor. INGESTION: if victim is conscious, give large quantities of water; do NOT induce vomiting. SKIN: remove contaminated clothing and flood exposed skin surfaces with water. EYES: retract eyelids and wash with water for at least 15 min.; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral rat LD_{50} 550 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Phosphorus White — (i) Chemical Designations — *Synonyms*: Yellow phosphorus; *Chemical Formula*: P; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Pale yellow to deep straw; *Odor*: Distinctive, disagreeable; pungent, sharp; like garlic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 123.89; *Boiling Point at 1 atm.*: 535.5, 279.7, 552.9; *Freezing Point*: 111.4, 44.1, 317.3; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.82 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Heavy rubber gloves and goggles or face shield; *Symptoms Following Exposure*: Solid or liquid causes severe burns of skin. If ingested, causes nausea, vomiting, jaundice, low blood pressure, depression, delirium, coma, death. Symptoms after ingestion may be delayed for from a few hours to 3 days; *General Treatment for Exposure*: INGESTION: if ingested, do NOT induce vomiting; call a doctor at once. SKIN OR EYE CONTACT: immediately flush with plenty of water for at least 15 min.; keep skin area wet until medical attention is obtained; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} below 55 mg/kg; *Late Toxicity*: Severe attack of liver and bones; *Vapor (Gas) Irritant Characteristics*: Nonvolatile; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Phthalic Anhydride — (i) Chemical Designations — *Synonyms*: 1,2-Benzenedicarboxylic acid anhydride; 1,3-Dioxophthalan; PAN; Phthalandione; Phthalic acid anhydride; *Chemical Formula*: $C_6H_4(CO)_2O$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid or liquid; *Color*: Colorless or pale yellow; *Odor*: Characteristic choking odor; choking, acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 148.12; *Boiling Point at 1 atm.*: 544.3, 284.6, 557.8; *Freezing Point*: 268, 131, 404; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.20 at 135 °C (liquid) 1.53 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.080; *Latent Heat of Vaporization*: 189, 105, 4.40; *Heat of Combustion*: -9473, -526.3, -220.4; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Coveralls and/or rubber apron; rubber shoes or boots; chemical goggles and/or face shield; Bureau of Mine organic vapor respiratory (Type AB); gauntlet-type leather or rubber gloves; *Symptoms Following Exposure*: Solid irritates skin and eyes, causing coughing and sneezing. Liquid causes severe thermal burns; *General Treatment for Exposure*: INHALATION: gargle with water and use a sedative cough mixture. INGESTION: induce vomiting and give water, milk, or vegetable oil. SKIN OR EYE CONTACT: Flush with water for at least 15 min.; if burned by molten material, remove as much solid as possible, soak off the remainder in cold water, and then treat the burn; *Toxicity by Inhalation (Threshold Limit Value)*: 2 ppm; *Short-Term Inhalation Limits*: 4 ppm for 5 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary

burns on long exposure; *Odor Threshold*: Data not available.

Piperazine — (i) Chemical Designations — *Synonyms*: Diethylenediamine; Hexahydro-1,4-diazine; Hexahydropyrazine; Lumbrical; Piperazidine; Pyrazine hexahydride; *Chemical Formula*: $NHCH_2CH_2NHCH_2CH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Mild, amine-like; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 86; *Boiling Point at 1 atm.*: 299, 148, 421; *Freezing Point*: 223, 106, 379; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -14.800, -8.200, -343; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Monogoggles or face shield; rubber gloves; dust mask; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of mouth and stomach; has been known to cause severe allergic reaction. Contact with eyes causes burns. Repeated contact with skin bay cause irritation and sensitization; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting; get medical attention. EYES: flush with plenty of water for at least 15 min.; get medical attention. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Polybutene — (i) Chemical Designations — *Synonyms*: Butene resins; Polyisobutylene plastics; Polyisobutylene resins; Polyisobutylene waxes; *Chemical Formula*: $C(CH_3)_2CH_2$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid; *Color*: Data not available; *Odor*: Data not available; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 225-230; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.81-0.91 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -20.000, -11.000, -470; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Low toxicity. Vapor may act as a simple asphyxiant in high concentrations; *General Treatment for Exposure*: INHALATION: remove victim from exposure; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0, LD_{50} above 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

Polychlorinated Biphenyl — (i) Chemical Designations — *Synonyms*: Aroclor; Chlorinated biphenyl; Halogenated waxes; PCB; Polychloropolyphenyls; *Chemical Formula*: $(C_{12}H_{10-X})Cl_X$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Liquid or solid; *Color*: Pale yellow (liquid); colorless (solid); *Odor*: Practically odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid or liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.3 - 1.8 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Gloves and protective garments; *Symptoms Following Exposure*: Acne from skin contact; *General Treatment for Exposure*: SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 to 1.0 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral rat LD_{50} = 3980 mg/kg; *Late Toxicity*: Causes chromosomal abnormalities in rats, birth defects in birds; *Vapor (Gas) Irritant Characteristics*: Vapors causes severe irritation of the eyes and throat and cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Contact with skin may cause irritation; *Odor Threshold*: Data not available.

Polymethylene Polyphenyl Isocyanate — (i) Chemical Designations — *Synonyms*: PAPI; *Chemical Formula*: $C_6H_4(NCO)CH_2C_6H_4(NCO)$-and polymer; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Dark brown; *Odor*: Very weak; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 400 (approx.); *Boiling Point at 1 atm.*: 392, 200, 473; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.20 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -13.000, -7.200, -300; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-line or organic canister mask; goggles or face shield; rubber gloves and other protective clothing to prevent contact with skin; *Symptoms Following Exposure*: Inhalation causes breathless, chest discomfort, and reduces pulmonary function; wheezing, cough, and sputum may also occur. Contact with liquid irritates eyes and skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: *Get medical attention at once following all exposures to this compound.* INHALATION: remove victim to fresh air; give artificial respiration if breathing has stopped; oxygen can be given by qualified personnel. EYES: immediately wash with large amounts of water for at least 15 min. SKIN: flush immediately with water, wipe off, treat with 30% isopropyl alcohol rubbing alcohol), and wash with soap and water. INGESTION: induce vomiting at least 3 times by giving warm salt water (one tablespoon of salt per cup); follow with a quart of milk and a mild cathartic such as milk of magnesia; *Toxicity by Inhalation (Threshold Limit Value)*: 0.02 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: Data not available.

Polyphosphoric Acid — (i) Chemical Designations — *Synonyms*: Condensed phosphoric acid; *Chemical Formula*: $(P_2O_5)(H_2O)_{<3}$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 1022, 550, 823; *Freezing Point*: 100, 38, 311; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.05 at 38 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves or protective clothing; *Symptoms Following Exposure*: Liquid burns skin and eyes unless washed off quickly. If injected will burn mouth and stomach unless diluted at once; *General Treatment for Exposure*: INGESTION: give victim water, milk, or vegetable oil; do NOT induce vomiting. SKIN OR EYES: flush with water for at least 15 min.; call doctor for eye exposure; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

Polypropylene — (i) Chemical Designations — *Synonyms*: Propene polymer; *Chemical Formula*: $CH(CH_3)$-CH_{2n}; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Tan or white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Mixture; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.90 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -19.600, -10.900, -456; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Filter respirator; *Symptoms Following Exposure*: No apparent toxicity; *General Treatment for Exposure*: None required; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Causes central; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Polypropylene Glycol — (i) Chemical Designations — *Synonyms*: Polyoxipropylene glycol; Polyoxpropylene ether, PPG; Pluracol polyol; Polyproplene glycols P400 to P4000; Thanol PPG; *Chemical Formula*: $HOCH(CH3)CH2O[CH2CH(CH3)O]_n$-H n averages 2-34; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; clear, lightly colored; *Odor*: None; slight sweet; faint ether-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Variable — 200 to 2000; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: -22 to -58, -30 to -50, -243 to 223; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.012 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -14.200, -7.900, -330; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety glasses or face shield; rubber gloves; *Symptoms Following Exposure*: The compound has a very low toxicity; few, if any, symptoms will be observed. Contact of liquid with eyes causes slight transient pain and irritation similar to that caused by a mild soap; *General Treatment for Exposure*: EYES: flush with water until mild irritation is gone; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: (depends on molecular wt.) Grade 2, oral LD_{50} = 2.150-5 mg/kg (rat); Grade 1, LD_{50} 5 to 15 g/kg; Grade 1, LD_{50} >15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Polypropylene Glycol Methyl Ether — (i) Chemical Designations — *Synonyms*: Polyoxipropylene glycol methyle ether; Poly(propylene glycol) methyl ether; *Chemical Formula*: $CH_3O(C_3H_6O)_nH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Data not available; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) 0.90 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.066; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -12,300, -6.860, -287; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Low toxicity. In high concentrations may be mildly anesthetic. Direct eye contact produces slight irritation; *General Treatment for Exposure*: Remove victim from exposure; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Hazard to skin considered minor; *Odor Threshold*: Data not available.

Potassium, Metallic — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: K; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Silvery white; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 39; *Boiling Point at 1 atm.*: 1,425, 774, 1,0047; *Freezing Point*: 145, 63, 336; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.86 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -2,003, -1.113, -46.57; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Contact with eyes or skin causes severe burns; *General Treatment for Exposure*: EYES OR SKIN: flush with water; treat caustic burns; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Potassium Arsenate — (i) Chemical Designations — *Synonyms*: Macquer's salt; *Chemical Formula*: KH_2AsO_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 180.0; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 550, 288, 561; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.8 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not

pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; rubber gloves; *Symptoms Following Exposure*: Dust may irritates eyes. Ingestion or severe exposure by inhalation can cause burning of throat and mouth, abdominal pain, vomiting, diarrhea with hemorrhage, dehydration, jaundice, and collapse; *General Treatment for Exposure*: EYES: flush with water to remove dust. INGESTION: immediately induce evacuation of intestinal tract by inducing vomiting, giving gastric lavage and saline cathartic; see physician at once; consider possible development of arsenic poisoning; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: May be carcinogenic; arsenic poisoning may develop; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Potassium Binoxalate — (i) Chemical Designations — *Synonyms*: Potassium acid oxalate; Salt acetosella; Salt of sorrel; *Chemical Formula*: KHC_2O_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 128.11; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.0 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion causes burning pain in throat, esophagus, and stomach; exposed areas of mucous membrane turn white; vomiting, severe purging, weak pulse, and cardiovascular collapse; if death is delayed, neuromuscular symptoms develop. Contact with dust irritates eyes and may cause mild irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air; if exposure to dust is severe, get medical attention. INGESTION: give immediately by mouth a dilute solution of any soluble calcium salt (calcium lactate, lime water, chalk solution; or even milk); large amounts of Ca are required; administer gastric lavage with dilute lime water consult physician; watch for edema of the glottis and delayed constriction of esophagus. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Potassium Chlorate — (i) Chemical Designations — *Synonyms*: Chlorate of potash; Chlorate of potassium; potcrate; *Chemical Formula*: $KClO_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 122.6; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 680, 360, 633; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.34 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: -176, -98, -4.1; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; rubber gloves; goggles; protective clothing to prevent contact with skin; *Symptoms Following Exposure*: Inhalation of dust can irritate nose and throat. Contact with eyes or skin causes irritation. Ingestion causes abdominal pain, nausea, vomiting, cyanosis; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wash with soap and water. INGESTION: dilute by drinking soapy or salty water to induce vomiting; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Potassium Chromate — (i) Chemical Designations — *Synonyms*: Neutral potassium chromate; Potassium chromate (VI); *Chemical Formula*: K_2CrO_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Bright yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 194,20; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing*

Point: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.73 at 18 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. of Mines approved filter-type respirator; close-fitting safety goggles; rubber boots and apron; safety hat; face shield; *Symptoms Following Exposure*: Inhalation causes local irritation of mucous membranes; continuing nose irritation can result in perforation of nasal septum. Ingestion may cause violent gastroenteritis, circulatory collapse, vertigo, coma, and toxic nephritis; ingestion of excessive quantities can be fatal. Contact with eyes causes severe irritation and conjunctivitis. Repeated or prolonged exposure to dust, mist, or solutions may cause dermatitis; contact with breaks in the skin may cause "chrome sores" appearing as slow-healing, hard-rimmed ulcers which leave the area vulnerable to infection; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amounts of water; induce vomiting; treat peripheral vascular shock vigorously; get medical attention. EYES: flush with water for at least 15 min.; get medical attention. SKIN: flush with water; if irritation persists, get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3 (as chromic acid); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Lung cancer may occur; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Potassium Cyanide — (i) Chemical Designations — *Synonyms*: Cyanide; *Chemical Formula*: KCN; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Like hydrogen cyanide; almond-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 65.12; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 1174, 634.5, 907.7; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.52 at 16 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Wear dry cotton gloves and U.S. Bureau of Mines approved dust respirator when handling solid potassium cyanide. Wear rubber gloves and approved Chemical safety goggles when handling solutions; *Symptoms Following Exposure*: Is rapidly fatal poison when taken into the digestive system. Dust may cause toxic symptoms when inhaled, and prolonged contact with the skin may cause irritation and possibly poisoning if skin is broken. Strong solutions are corrosive to skin and may cause deep ulcers that heal slowly; *General Treatment for Exposure*: INGESTION: call physician immediately; have victim lie down and keep him quiet and warm. If he is conscious, induce vomiting by having him drink warm salt water (1 tablespoon per cup of water); repeat until vomit fluid is clear; then give orally 1 pint of 1% solution of sodium thiosulfate, to be repeated in 15 min. Victim is not breathing, give artificial respiration until breathing starts. If victim is unconscious but breathing, give oxygen from an inhalator if he does not respond to treatment. In all cases, break an amyl nitrite pearl in a cloth and hold lightly under victim's nose for 15 sec., repeating 5 times at about 15-sec. intervals; if necessary, repeat procedure every 3 min. with fresh pearls until 3 or 4 have been used. *Amyl nitrite pearls must not be over 2 years old. Avoid breathing the vapor while administering it to the victim*; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} below 50 mg/kg (mice); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile, but moisture in air can liberate come lethal hydrogen cyanide gas; *Liquid or Solid Irritant Characteristics*: Moist solid can cause caustic-type irritation of skin and formation of ulcers; *Odor Threshold*: Not pertinent.

Potassium Dichloro-s-Triazinetrione — (i) Chemical Designations — *Synonyms*: Potassium; *Chemical Formula*: $KCl_2(NCO)_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Like chlorine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 236,1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.96 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask or chorine canister mask; goggles; rubber gloves and other

protective clothing to prevent contact with skin; *Symptoms Following Exposure*: Dust causes sneezing; is moderately irritating to the eyes and causes itching and redness of skin. Ingestion causes burn of mouth and stomach; *General Treatment for Exposure:* INHALATION: remove victim to fresh air. EYES: irrigate with running water fir 15 min.; call a physician. SKIN: flush with water. INGESTION: induce vomiting and call physician *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Inhalation Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 3;50 to 500 mg/kg (human); *Late Toxicity:* Some suggestion of lung cancer; *Vapor (Gas) Irritant Characteristics:* Dust or mists may severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations.; *Liquid or Solid Irritant Characteristics:* Severe skin irritant; causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold:* Not pertinent.

Potassium Dichromate — (i) Chemical Designations — *Synonyms*: Potassium bichromate, Bichromate; *Chemical Formula*: $K_2Cr_2O_7$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Orange-red; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 294,19; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 748, 398, 671; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.676 at 25 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust mask; protective gloves; goggles or face shield; *Symptoms Following Exposure*: Highly corrosive to skin and mucous membranes. If ingested, causes violent gastroenteritis, peripheral vascular collapse, vertigo, muscle cramps, coma, and (later) toxic nephritis with glycosuria. Allergic reaction may also occur; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting. SKIN: treat like acid burns; external lesions may be scrubbed with 2% solution of sodium thiosulfate; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3;50 to 500 mg/kg (human); *Late Toxicity*: Some suggestion of lung cancer; *Vapor (Gas) Irritant Characteristics*: Dust or mists may severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics:* Severe skin irritant; causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent.

Potassium Hydroxide — (i) Chemical Designations — *Synonyms:* Caustic potash; *Chemical Formula:* KOH; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Solid; *Color:* White; *Odor:* None; (iii)Physical and Chemical Properties — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 56,11; *Boiling Point at 1 atm:* Very high; *Freezing Point:* 716, 380, 653; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 2,04 at 15°C (solid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Wide brimmed hat and close-fitting safety goggles with rubber side; respirator for dust; long-sleeved cotton shirt or jacket with buttoned collar and buttoned sleeves; rubber or rubber-coated canvas gloves (shift sleeves should be buttoned over the gloves); rubber shoes or boots; cotton coveralls (with trouser cuffs worn over boots); rubber apron.; *Symptoms Following Exposure:* Causes severe burn of eyes, skin, and mucous membranes.; *General Treatment for Exposure:* (Act quickly!) Call a physician at once, even when injury seems to be slight. INGESTION: give water and milk; do NOT induce vomiting. EYES: flush with water at once for at least 15 min. SKIN: flush with water, then rinse with dilute vinegar; *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Exposure Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 3; oral rat LD_{50} = 364 mg/kg; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Not pertinent; *Liquid or Solid Irritant Characteristics:* Severe skin irritant; causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold:* Not pertinent.

Potassium Iodide — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* KI; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Solid; *Color:* White; *Odor:* Odorless; (iii)Physical and Chemical Properties — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 166,01; *Boiling Point at 1 atm:* Very high; *Freezing Point:* 1258, 681, 954; *Critical Temperature:* Not perti-

nent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 3,13 at 15°C (solid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Goggles or face shield; *Symptoms Following Exposure:* May irritate eyes or open cuts; *General Treatment for Exposure:* Flush all affected areas with water; *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Exposure Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 3; oral rat LD_{50} = 364 mg/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Non-volatile; *Liquid or Solid Irritant Characteristics:* None; *Odor Threshold:* Not pertinent.

Potassium Oxalate — (i) Chemical Designations — *Synonyms*: Potassium oxalate monohydrate; *Chemical Formula*: $K_2C_2O_4 \cdot H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Colorless; White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 184.24; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.13 at 18.5 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust respirator, chemical goggles: rubber or plastic-coated gloves; *Symptoms Following Exposure*: Inhalation of dust can cause systemic poisoning. Ingest ion causes burning pain in throat, esophagus, and stomach; exposed areas of mucous membrane turn white; vomiting, severe purging, weak pulse, and cardiovascular collapse may result; if death is delayed, neuromuscular symptoms develop. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: *Act promptly!* INHALATION: remove victim to fresh air; if exposure to dust is severe, get medical attention. INGESTION: call physician immediately: have victim drink dilute calcium lactate, lime water, chalk soln, or even milk; large amounts of calcium arc required; administer gastric lavage with dilute lime water; watch for edema of the glottis and delayed constriction of esophagus. EYES: flush with water and seek medical attention. SKIN: flush with; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Potassium Permanganate — (i) Chemical Designations — *Synonyms:* No common synonyms; *Chemical Formula:* $KMnO_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Solid; *Color:* Dark purple or bronze-like; *Odor:* Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 158,04; *Boiling Point at 1 atm:* Decomposes; *Freezing Point:* >464, >240, >513; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 2,70 at 15°C (solid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Goggles or face shield, rubber gloves; *Symptoms Following Exposure:* Burns and stains the dark brown. If ingested will cause severe distress of Castro-intestinal system. May be fatal if over 4 oz. Are consumed; *General Treatment for Exposure:* INGESTION: induce vomiting and with thorough gastric lavage, demulcent, glucose I.V., fluid therapy, and antibiotics. Tracheotomy may be lifesaving; *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Exposure Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 3; LD_{50} 50 to 500 mg/kg; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Non-volatile; *Liquid or Solid Irritant Characteristics:* Can burn skin if not flushed with water; *Odor Threshold:* Not pertinent.

Potassium Peroxide — (i) Chemical Designations — *Synonyms:* Potassium superoxide; *Chemical Formula:* K_2O_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Powder; *Color:* Yellow; *Odor:* None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Solid; *Molecular Weight:* 110; *Boiling Point at 1 atm:* Not pertinent (decomposes); *Freezing Point:* 914, 490, 763; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* > 1 at 20°C (solid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* Not pertinent; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards In-**

formation — *Recommended Personal Protective Equipment:* Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure:* Inhalation causes respiratory irritation. Ingest ion causes severe burn of mouth and stomach. Contact with eyes or skin causes irritation and caustic burns; *General Treatment for Exposure:* INHALATION: remove from exposure; support respiration. INGESTION: give large amount of water; do NOT induce vomiting; get medical attention EYES: irrigate with large quantities of water for at least 15 min.; get medical attention for caustic burn. SKIN: flush with water; treat caustic burns; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Data not available; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Data not available.

Propane — **(i) Chemical Designations** — *Synonyms:* Dimethylmethane; *Chemical Formula:* $CH_3CH_2CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Liquefied compressed gas; *Color:* Colorless; *Odor:* Faint gassy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 44.09; *Boiling Point at 1 atm:* -49, -42.1, 231.1; *Freezing Point:* -305.9, -108.7, 85.5; *Critical Temperature:* -142.01, -96.67, 176.53; *Critical Pressure:* 616.5, 41.94, 4.249; *Specific Gravity:* 0.590 at -50°C; *Vapor (Gas) Density:* 1.5; *Ratio of Specific Heats of Vapor (Gas):* 1.130; *Latent Heat of Vaporization:* 183.2, 101.8, 4.262; *Heat of Combustion:* -19.782, -10.990, -460.13; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Self-contained breathing apparatus for high concentrations of gas; *Symptoms Following Exposure:* Vaporizing liquid may cause frostbite. Concentrations in air greater than 10% cause dizziness in a few minutes. 1% concentrations give the effect in 10 min. High concentration cause asphyxiation; *General Treatment for Exposure:* Remove to open air. If victim is by gas apply artificial respiration. Guard against self-injury if confused; *Toxicity by Inhalation (Threshold Limit Value):* 1000 ppm; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Not pertinent; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin because it evaporates quickly; *Odor Threshold:* 5.000-20.000 ppm.

beta-Propiolactone — **(i) Chemical Designations** — *Synonyms:* Betaprone; Hydracrylic acid, beta-lactone; 2-Oxetanone; Propanolide; beta-Propionolactone; *Chemical Formula:* OCH_2CH_2CO; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Liquid; *Color:* Colorless; *Odor:* Pungent, acrylic; irrigating; **(iii) Physical and Chemical Properties** — *Molecular Weight:* 72.1; *Boiling Point at 1 atm:* Not pertinent; *Freezing Point:* -28.1, -33.4, 239.8; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1.148 at 20°C; *Vapor (Gas) Density:* 2.5; *Ratio of Specific Heats of Vapor (Gas):* 1.1089; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion:* -8.510, -4.730, -198; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Air mask or organic canister mask; goggles or face shield; rubber gloves; protective clothing to prevent all contact with skin; *Symptoms Following Exposure:* Inhalation causes irritation of nose, throat, and respiratory tract. Contact of liquid with eyes causes irritation and tears. Contact with skin causes irritation and blistering. Ingestion causes burn of mouth and stomach; *General Treatment for Exposure:* Get medical attention following all exposures to this compound. INHALATION: move victim to fresh air; if breathing has stopped, give artificial respiration. EYES: flush continuously with water for at least 15 min. SKIN: flush with water; if blistering occurs, alert physician to fact than fluid from blister will cause additional blistering of adjacent skin. INGESTION: give large amount of water and induce vomiting; *Toxicity by Inhalation (Threshold Limit Value):* 0.07 ppm. Because of the high incidence of cancer, either in man or animal, no exposure or contact by any route — respiratory, oral, or skin — should be permitted; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; oral LDL_o = 50 mg/kg (rat); *Late Toxicity:* Because of the high incidence of cancer, either in man or animal, no exposure or contact by any route — respiratory, oral, or skin — should be permitted; *Vapor (Gas) Irritant Characteristics:* Vapors are moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics:* Fairly severe skin irritant. May cause pain and second-degree burn after a few minutes' contact; *Odor Threshold:* Data not available.

Propionaldehyde — **(i) Chemical Designations** — *Synonyms:* Melhylacelaldehyde; Propaldehyde; Propanal; Propionic aldehyde; Propylaldehyde; *Chemical Formula:* CH_3CH_2CHO; **(ii) Observable Characteristics** —

Physical State (as normally shipped): Liquid; *Color:* Colorless; *Odor:* Pungent, unpleasant; suffocating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 58.08; *Boiling Point at 1 atm:* 118.4, 48.08, 321.2; *Freezing Point:* -112, -80, 193; *Critical Temperature:* 433, 223, 496; *Critical Pressure:* 690, 47, 4.8; *Specific Gravity:* 0.805 at 20°C; *Vapor (Gas) Density:* 2.0; *Ratio of Specific Heats of Vapor (Gas):* 1.120; *Latent Heat of Vaporization:* 211, 117, 4.90; *Heat of Combustion:* -12.470, -6.930, -290.1,; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Air-supplied mask for high vapor concentrations; plastic glove; goggles; *Symptoms Following Exposure:* Vapors will irritate nose and throat, and may cause nausea and vomiting. Liquid causes eye irritation; *General Treatment for Exposure:* INHALATION: remove victim to fresh air; give oxygen if breathing is difficult; call a physician. EYES: flush with plenty of water for at least 15 min., and call a physician. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; oral LDL_o = 50 mg/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors are moderate irritation, such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* 1 ppm.

Propionic Acid — (i) Chemical Designations — *Synonyms:* Ethanecarboxylic acid; Methylacetic acid; Propanoic acid; *Chemical Formula:* CH_3CH_2COOH; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Liquid; *Color:* Colorless; *Odor:* Sharp, irritating; slightly pungent, rancid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 74.08; *Boiling Point at 1 atm:* 285.4, 140.8, 414; *Freezing Point:* -5.3, -20.7, 252.5; *Critical Temperature:* 642, 339, 612; *Critical Pressure:* 779, 53, 5.37; *Specific Gravity:* 0.995 at 20°C; *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.103; *Latent Heat of Vaporization:* 248, 138, 5.78; *Heat of Combustion:* -8.883, -4.935, -206.6; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Air-supplied mask for high vapor concentrations; plastic gloves; goggles or face shield; *General Treatment for Exposure:* INHALATION: remove victim to fresh air. INGESTION: have victim drink water or milk; do NOT induce vomiting. SKIN OR EYES CONTACT: immediately flush with plenty of water for at least 15 min., get medical care for eyes; remove contaminated clothing; *Toxicity by Inhalation (Threshold Limit Value):* 10 ppm; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Grade 3; oral rat LD_{50} = 2.6 g/kg (rat); *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Fairly severe skin irritant; may cause pain and second-degree burn after a few minutes' contact; *Odor Threshold:* Data not available.

Propionic Anhydride — (i) Chemical Designations - *Synonyms:* Methylacetic anhydride; Propanoic anhydride; Propionyl oxide; *Chemical Formula:* $(CH_3CH_2CO)_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped):* Liquid; *Color:* Colorless; *Odor:* Pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 130.1; *Boiling Point at 1 atm:* 336, 169, 442; *Freezing Point:* -45, -43, 230; *Critical Temperature:* 660, 349, 622; *Critical Pressure:* 490, 33, 3.3; *Specific Gravity:* 1.01 at 20°C (liquid); *Vapor (Gas) Density:* 4.5; *Ratio of Specific Heats of Vapor (Gas):* 1.0543; *Latent Heat of Vaporization:* 149, 83, 3.5; *Heat of Combustion:* (at 15 °C) -10.320, -5.740, -240; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Organic canister mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure:* Inhalation causes irritation of eyes and respiratory tract. Contact with liquid causes burns of eyes and skin. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure:* INHALATION: move victim to fresh air; if breathing has stopped, give artificial respiration. EYES: immediately flush with plenty of water for at least 15 min.; get medical attention. SKIN: immediately flush with plenty of water for at least 15 min. INGESTION: give large amount of water; do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Grade 1; LD_{50} 5 to 15 g/kg; Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors are moderatory irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics:* Causes smarting of the skin and first-degree burns on short exposure; my cause second-degree

burns on long exposure; *Odor Threshold:* Data not available.

n-Propyl Acetate — (i) Chemical Designations — *Synonyms:* Acetic acid; Propyl ester; Methylacetic anhydride; Propanoic anhydride; Propionyl oxide *Chemical Formula:* $CH_3COOCH_2CH_2CH_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped):* Liquid; *Color:* Colorless; *Odor:* Mild fruity; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 102.13; *Boiling Point at 1 atm:* 214.9, 101.6, 374.8; *Freezing Point:* -139, -95.0, 178.2; *Critical Temperature:* 529, 276, 549; *Critical Pressure:* 485, 33, 3.3; *Specific Gravity:* 0.886 at 20°C (liquid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.071; *Latent Heat of Vaporization:* 145, 80.3, 3.36; *Heat of Combustion:* (at 15 °C) -10.320, -5.740, -240; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment:* Air-supplied mask or chemical canister; goggles or face shield; protective gloves; *Symptoms Following Exposure:* Contact with skin and eyes causes no serious injury. High vapor concentrations will be irritating and will cause nausea, vomiting, and dizziness, with final loss of consciousness; *General Treatment for Exposure:* INHALATION: remove victim to fresh air; give artificial respiration if breathing has stopped; give oxygen if will breathing is difficult. SKIN AND EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value):* 200 ppm; *Short-Term Exposure Limits:* 200 ppm for 60 min.; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg; *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold:* 70 mg/m^3.

n-Propyl Alcohol — (i) Chemical Designations — *Synonyms:* Ethylcarbinol; 1-Propanol; Propylalcohol; *Chemical Formula:* $CH_3CH_2CH_2OH$; **(ii) Observable Characteristics —** *Physical State (as normally shipped):* Liquid; *Color:* Colorless; *Odor:* Resembles that of ethyl alcohol; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 60.10; *Boiling Point at 1 atm:* 207.0, 97.2, 370.4; *Freezing Point:* -195.2, -126.2, 147.0; *Critical Temperature:* 506.5, 263.6, 536.8; *Critical Pressure:* 750, 51, 5.2; *Specific Gravity:* 0.803 at 20°C (liquid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 2.1; *Latent Heat of Vaporization:* 292.7, 162.6, 6.808; *Heat of Combustion:* -13.130, -7.296, -305.5; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment:* Air-supplied respirator for high concentrations; goggles or face shield; plastic gloves; *Symptoms Following Exposure:* Contact with eyes extremely irritating and may cause burns. Vapors irritate nose and throat. In high concentrations, may cause nausea, dizziness, headache, and stupor; *General Treatment for Exposure:* INHALATION: remove victim to fresh air; call a physician. SKIN: OR EYE CONTACT: flush at once with plenty of water; get medical care for eyes; *Toxicity by Inhalation (Threshold Limit Value):* 200 ppm; *Short-Term Exposure Limits:* 400 ppm for 30 min.; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors causes a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin; *Odor Threshold:* 30 ppm.

Propylene — (i) Chemical Designations — *Synonyms:* Methelethyene; Propene; *Chemical Formula:* $CH_3CH=CH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped):* Liquified gas; *Color:* Colorless; *Odor:* Weak gassy; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Gas; *Molecular Weight:* 42.08; *Boiling Point at 1 atm:* -53.9, -47.7, 225.5; *Freezing Point:* -301.4, -185.2, 88; *Critical Temperature:* 197.2, 91.8, 365.0; *Critical Pressure:* 670, 45.6, 4.62; *Specific Gravity:* 0.609 at -47°C; *Vapor (Gas) Density:* 1.4; *Ratio of Specific Heats of Vapor (Gas):* 1.152; *Latent Heat of Vaporization:* 187, 104, 435; *Heat of Combustion:* -19.692, -10.940, -458.04; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment:* Organic vapor canister or air-supplied mask; goggles or face shield (for liquid); protective clothing (for liquid); *Symptoms Following Exposure:* Moderate concentration in air causes dizziness, drowsiness, and unconsciousness. Contact with liquified propylene will cause "freezing burn"; *General Treatment for Exposure:* INHALATION: remove victim from exposure; if breathing is irregular or has stopped, start resuscitation; give oxygen; call a doctor; *Toxicity by Inhalation (Threshold Limit Value):* 4000 ppm; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Not pertinent; *Late Toxicity:* None; *Vapor (Gas) Irritant*

Characteristics: Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin because it evaporate quickly; *Odor Threshold:* Data not available.

Propylene Glycol — (i) Chemical Designations — *Synonyms:* 1,2-Dihidroxypropane; Methelethyene glycol; 1,2-Propanediol; *Chemical Formula:* $CH_3CH(OH)CH_2CH$; **(ii) Observable Characteristics —** *Physical State (as normally shipped):* Liquid; *Color:* Colorless; *Odor:* Odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 76.10; *Boiling Point at 1 atm:* 369.1, 183.3, 460.5; *Freezing Point:* <-76,<-60,<213; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* 1.04 at 20 °C; *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* 1.073; *Latent Heat of Vaporization:* 306, 170, 7.12; *Heat of Combustion:* -10.310, -5.728, -239.8; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment:* Goggles; *Symptoms Following Exposure:* Liquid may irritate eyes; *General Treatment for Exposure:* Flush eyes with plenty of water; *Toxicity by Inhalation (Threshold Limit Value):* Not pertinent; *Short-Term Exposure Limits:* Not pertinent; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (mouse); *Late Toxicity:* None; *Vapor (Gas) Irritant Characteristics:* Vapors are nonirritating to the eyes and throat; *Liquid or Solid Irritant Characteristics:* No appreciable hazard. Practically harmless to the skin; *Odor Threshold:* Not pertinent.

Propylene Oxide — (i) Chemical Designations — *Synonyms:* 1,2-Epoxypropane; Methyloxirane propene oxide; *Chemical Formula:* CH_3CHCH_2O; **(ii) Observable Characteristics —** Physical State (as normally shipped): Liquid; *Color:* Colorless; *Odor:* Ethereal; characteristic; sweet, alcoholyc; like natural gas; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 58.08; *Boiling Point at 1 atm:* 93.7, 34.3, 307.5; *Freezing Point:* -169.4, -11.9, 161.3; *Critical Temperature:* 408.4, 209.1 482.3; *Critical Pressure:* 714, 48.6, 4.92; *Specific Gravity:* 0.830 at 20°C; *Vapor (Gas) Density:* 2.0; *Ratio of Specific Heats of Vapor (Gas):* 1.133; *Latent Heat of Vaporization:* 205, 114, 4.77; *Heat of Combustion:* -13.000, -7.221, -302.3; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment:* Air-supplied mask; rubber or plastic gloves; vapor-proof goggles; *Symptoms Following Exposure:* Inhalation may introduce headache, nausea, vomiting, and unconsciousness; mild depression of central nervous system; lung irritation. Slightly irritating to skin, but covered contact may cause burn. Very irritating to eyes; *General Treatment for Exposure:* INHALATION: remove person to fresh air immediately, keep quit and warm; call a physician; if breathing stop, start artificial respiration. SKIN OR EYE CONTACT: immediately flush with plenty of water for at 15 min.; immediately remove contaminated clothing, watch bands, rings, etc. to prevent confiding product to skin; for eyes get medical attention; *Toxicity by Inhalation (Threshold Limit Value):* 100 ppm; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Grade 2; LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors is moderatory irritating such that personnel will not short exposure; may cause secondary burn on long exposure; *Liquid or Solid Irritant Characteristics:* Causes smarting on the skin and first-degree burns on short exposure; may causes secondary burns on long exposure; *Odor Threshold:* 200 ppm.

Propylene Tetramer — (i) Chemical Designations — *Synonyms:* Dodecene (nonelinear); Tetrapropylene; *Chemical Formula:* $CH_{12}H_{14}$; **(ii) Observable Characteristics —** Physical State (as normally shipped): Liquid; *Color:* Colorless; *Odor:* Data not available; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm:* Liquid; *Molecular Weight:* 168.3; *Boiling Point at 1 atm:* 365-368, 185-196, 458-469; *Freezing Point:* Not pertinent; *Critical Temperature:* Data not available; *Critical Pressure:* Not pertinent; *Specific Gravity:* 0.2937 at 20°C (liquid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* 205, 58.6, 2.45; *Heat of Combustion:* -19.100, -10.600, -444; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment:* Goggles or face shield; *Symptoms Following Exposure:* No inhalation hazard expected. Aspiration hazard if ingested; *General Treatment for Exposure:* INHALATION: remove victim to fresh air. INGESTION: do NOT lavage or induce vomiting; give vegetable oil demulcent; call physician. EYES: flush with water for 15 min. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value):* 200 ppm; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Grade 0; LD_{50} above 15 g/kg; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors causes a slight smarting of the eyes or respiratory

system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics:* Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold:* Data not available.

n-Propyl Mercaptan — (i) Chemical Designations — *Synonyms*: 1-Propanethiol; Propane-1-thiol; *Chemical Formula*: $CH_3CH_2CH_2SH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Skunky; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 76.2; *Boiling Point at 1 atm.*: 153, 67, 340; *Freezing Point*:-171, -113, 160; *Critical Temperature*: 495, 257, 530; *Critical Pressure*: 667, 45.3, 4.60; *Specific Gravity*: at 20 °C (solid): 0.841 at 20°C; *Vapor (Gas) Density*: 2.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.0984; *Latent Heat of Vaporization*: 179, 99, 4.16; *Heat of Combustion*: -15.990, -8.890, -372; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; self-contained breathing apparatus or organic canister mask; *Symptoms Following Exposure*: Inhalation causes muscular weakness, convulsion, and respiratory paralysis; high concentrations may cause pulmonary irritation. Contact with liquid causes irritation of eyes and skin. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from contaminated atmosphere; give artificial respiratory paralysis; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} = 1.790 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.00075 ppm.

Propyleneimine, Inhibited — (i) Chemical Designations — *Synonyms*: 2-Methylaziridine; 2-Methylethynimine; Propylenimine; *Chemical Formula*: CH_3CHCH_2NH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Strong, ammonia-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 57.1; *Boiling Point at 1 atm.*: 151, 66, 339; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.802 at 25 °C (Liquid); *Vapor (Gas) Density*: 2; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 250, 139, 5.82; *Heat of Combustion*: (est.) -15.500, -8.600, -360; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles or face shield; *Symptoms Following Exposure*: Inhalation causes vomiting, breathing difficulty, and irritation of eyes, nose, and throat; on prolonged exposure, vapors tend to redden the whites of the eyes. Contact with liquid causes eye irritation, like that caused by strong ammonia. Liquid causes skin burns, which are slow lo heal. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: move victim to fresh air; if he is not breathing, apply artificial respiration, oxygen; if breathing is difficult, administer oxygen; call physician. EYES: flush with plenty of water for at least 30 min. and obtain prompt medical attention. SKIN: remove all contaminated clothing and flush with water; rinse with vinegar and water. INGESTION: drink large amounts of milk or water; get prompt medical attention; *Toxicity by Inhalation (Threshold Limit Value)*:2 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 19 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Pyridine — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: C_5H_5N; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Yellow or colorless; *Odor*: Disagreeable: strong unpleasant, characteristic unpleasant: sharp penetrating, unpleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 79.1; *Boiling Point at 1 atm.*: 239.5, 115.3, 388.5; *Freezing Point*: -44, -42, 231; *Critical Temperature*: 656.2, 346.8, 620; *Critical Pressure*: 817.3, 55.6, 5.63; *Specific Gravity*: 0.983 at 20 °C (solid); *Vapor (Gas) Density*: 2.73; *Ratio of Specific Heats of Vapor (Gas)*: 1.123; *Latent Heat of Vaporization*: 193, 107, 4.48; *Heat of Combustion*: -14.390, -7992, -334.6; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** —*Recommended Personal Protective Equipment*: Air-supplied mask or organic canister; vapor-proof goggles; rubber gloves and protective clothing; *Symptoms Following Exposure*: Vapor irritates eyes and nose. Liquid irritates skin and is absorbed through the skin. Overexposure causes nausea, headache, nervous symptoms, increased urinary frequency; *General Treatment for Exposure*: IN-

HALATION: remove individual promptly from contaminated area: give artificial respiration and oxygen if necessary: treat symptomatically. INGESTION: induce vomiting and follow with gastric lavage. SKIN: wash thoroughly with large amounts of water. EYES: irrigate with water for at least 15 min. *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Liver and kidney damage after ingestion; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will Find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure: may cause secondary burns on long exposure; *Odor Threshold*: 0.021 ppm.

Pyrogallic Acid — (i) Chemical Designations — *Synonyms*: 1,2,3-Benzenetriol; Pyrogallol; 1,2,3-Trihydroxybenzene; *Chemical Formula*: 1,2,3-$C_6H_3(OH)_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*:Solid; *Color*: White to gray; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 126; *Boiling Point at 1 atm.*: 588, 309, 582; *Freezing Point*: 268, 309, 582; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.45 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -9.130, -5.070, -212; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber gloves: safety goggles, dust mask; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion may cause severe gastrointestinal irritation, convulsions, circulatory collapse, and death. Contact with eyes causes irritation. Skin contact can cause local discoloration, irritation. eczema, and death: repeated contact can cause sensitization; *General Treatment for Exposure*: INHALATION: remove victim lo fresh air. INGESTION: give large amount of water: induce vomiting immediately: consult a physician. EYES: flush with water for at least 15 min.: consult a physician. SKIN: wash immediately with soap and water: consult a physician if exposure has been severe; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} =719 mg/kg (rat); *Late Toxicity*: Depresses growth in chicks; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Q

Quinoline — (i) Chemical Designations — *Synonyms*: 1-Azanapthalene; 1-Benzazine; Benzo(b)pyridine; Chinoline; Leucol; *Chemical Formula*: C_9H_7N; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to brown; *Odor*: Strong, unpleasant; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 129; *Boiling Point at 1 atm.*: 459, 237, 510; *Freezing Point*: 5, -15, 258; *Critical Temperature*: 948, 509, 782; *Critical Pressure*: Data not available; *Specific Gravity*: 1.095 at 20 °C (liquid); *Vapor (Gas) Density*: 4.5; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: (est.) 155, 86, 3.6; *Heat of Combustion*: -15.700, -8.710, -365; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: U. S. Bu. Mines approved respirator: rubber gloves; safety glasses with side shields or chemical goggles: coveralls or rubber apron; *Symptoms Following Exposure*: Inhalation of vapors or dust causes irritation of respiratory tract, ingestion causes burns of mucous membranes, severe diarrhea, pallor, sweating, weakness, headache, dizziness, tinnitus, shock, and severe convulsions: may also cause siderosis of the spleen and tubular injury to the kidney. Contact with eyes causes irritation. Can be absorbed from wounds or through unbroken skin, producing severe dermatitis, methemoglobinemia, cyanosis, convulsions, tachycardia, dyspnea, and death; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration, preferably mouth-to-mouth; if breathing is difficult, give oxygen, call a physician. INGESTION: give activated charcoal; administer gastric lavage with water; consult physician. EYES: flush with water for IS min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, oral LD_{50} =460 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 71 ppm.

R

Resorciol - (i) Chemical Designations — *Synonyms*: 1,3-Benzenediol; m-Dihydroxybenzene; 1,3-Dihydroxybenzene; Dihydrobenzol; Resorcin; *Chemical Formula*: $1,3\text{-}C_6H_4(OH)_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White or nearly white; *Odor*: Faint, characteristic aromatic; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 110.11; *Boiling Point at 1 atm.*: 531, 277, 550; *Freezing Point*: 228, 109, 382; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.2 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -11.200, -6.200, -259; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: D. S. Bu. Mines approved respirator, rubber gloves; safety glasses with side shields or chemical goggles; coveralls or rubber apron; *Symptoms Following Exposure*: Inhalation of vapors or dust causes irritation of respiratory tract. Ingestion causes burns of mucous membranes, severe diarrhea, pallor, sweating, weakness, headache, dizziness, tinnitus, shock, and severe convulsions; may also cause siderosis of the spleen and tubular injury to the kidney. Contact with eyes causes irritation. Can be absorbed from wounds or through unbroken skin, producing severe dermatitis, methemoglobincmia, cyanosis, convulsions, tachycardia, dyspnea, and death; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if he is not breathing, give artificial respiration, preferably mouth-to-mouth; if breathing is difficult, give oxygen; call a physician. INGESTION: give activated charcoal; administer gastric lavage with water; consult physician. EYES: Hush with water for 15 min. SKIN: Hush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Produces goiters in rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

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Salicylic Acid — (i) Chemical Designations — *Synonyms*: o-Hydroxybenzoic acid; Retarder W; *Chemical Formula*: $1,2\text{-}HOC_6H_4COOH$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White to very light; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 138.13; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 315, 157, 430; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.44 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -9.420, -5.230, -219; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Gloves: goggles: respirator For dust: clean body-covering clothing; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Vomiting may occur spontaneously if large amounts are swallowed. Contact with eyes causes irritation, marked pain, and corneal injury which should heal. Prolonged or repeated skin contact may cause marked irritation or even a mild burn; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: induce vomiting and get medical attention promptly. EYES: promptly flush with water for 15 min. and get medical attention. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Selenium Dioxide — (i) Chemical Designations — *Synonyms*: Selenious anhydride; Selenium oxide; *Chemical Formula*: SeO_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Pungent; sour; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 111; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.95 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; rubber gloves; protective clothing; *Symptoms Following Exposure*: Absorption of selenium may be

demonstrated by presence of the element in the urine and by a garlic-like odor of the breath, inhalation of dust can cause bronchial spasms, symptoms of asphyxiation, and pneumonitis. Acute symptoms of ingestion include sternal pain, cough, nausea, pallor, coated tongue, gastrointestinal disorders, nervousness and conjunctivitis. Contact with eyes causes irritation; *General Treatment for Exposure*: Consult physician after all exposures or his compound. INHALATION remove victim to fresh air: give oxygen if needed. INGESTION: induce vomiting; follow with gastric lavage and saline cathartics. EYES: flush immediately and thoroughly with water. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as selenium); *Short-Term Exposure Limits*: 0.3 mg/m^3, 30 min. (as selenium); *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 0.0002 mg/m^3.

Selenium Trioxide — (i) Chemical Designations — *Synonyms*: Selenic anhydride; *Chemical Formula*: SeO_3; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 126.9; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 244, 118, 391; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.6 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask: goggles or Face shield: rubber gloves; *Symptoms Following Exposure*: Absorption of selenium may be demonstrated by presence of the element in the urine and by a garlic-like odor of breath, inhalation can cause bronchial spasms symptoms of asphyxiation, and pneumonitis. Acute symptoms of ingestion include sternal pain, cough, nausea, pallor, coated tongue, gastrointestinal disorders, nervousness and conjunctivitis. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give oxygen if necessary. INGESTION: induce vomiting: follow with gastric lavage and saline cathartics. EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3, (as selenium); *Short-Term Exposure Limits*: 0.3 mg/m^3, 30 min. (as selenium); *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Silicon Tetrachloride — (i) Chemical Designations — *Synonyms*: Silicon chloride; *Chemical Formula*: $SiCl_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Suffocating; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Liquid; *Molecular Weight*: 169.9; *Boiling Point at 1 atm.*: 135.7, 57.6, 330.8; *Freezing Point*: -94, -70, 203; *Critical Temperature*: 472.5, 233.6, 506.8; *Critical Pressure*: 542, 36.8, 3.74; *Specific Gravity*: 1.48 at 20 °C (liquid); *Vapor (Gas) Density*: 5.86; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 74.2, 41.2, 1.73; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Add-canister-type gas mask or self-contained breathing apparatus; goggles or face shield, rubber gloves, other protective clothing to prevent contact with skin; *Symptoms Following Exposure*: Inhalation causes severe irritation of upper respiratory tract resulting in coughing, choking, and a feeling of suffocation; continued inhalation may produce ulceration of the nose, throat, and larynx; if inhaled deeply, edema of the lungs may occur. Contact of liquid with eyes causes severe irritation and painful burns; may cause permanent visual impairment. Liquid may cause severe burns of skin. Repeated skin contact with dilute solutions or exposure to concentrated vapors may cause dermatitis, ingestion causes severe internal injury with pain in the throat and stomach, intense thirst, difficulty in swallowing. nausea, vomiting, and diarrhea; in severe cases, collapse and unconsciousness may result; *General Treatment for Exposure: Get medical attention at once following any exposure to this compound,* INHALATION: remove victim from contaminated atmosphere; if breathing has ceased, start mouth-to-mouth resuscitation; oxygen should only be administered by an experienced person when authorized by a physician; keep patient warm and comfortable. EYES: immediately flush with large quantities of running water for a minimum of 15 min.; continue irrigation for an additional 15 min. if physician is not available. SKIN: immediately flush affected area with water; severe or extensive burns may be caused by silicon tetrachloride, producing shock symptoms (rapid pulse, sweating and collapse); keep patient comfortably warm. INGESTION:

if patient is conscious give large amounts of lime water or milk of magnesia; plain water should be given if neither of these is available; do NOT give sodium bicarbonate or make any attempt to induce vomiting, if patient is unconscious, do not give anything but ensure there is no obstruction to breathing (tongue should be kept forward and false teeth removed); he will be less likely to aspirate vomitus if placed in a face-downward position; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} < 50 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Silver Acetate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: CH_3COOAg; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White to gray; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 166.9; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.26 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Contact with eyes or skin causes irritation. If continued for a long period, ingestion or inhalation of silver compounds can cause permanent discoloration of skin (argyria); *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting. EYES: flush with water for at least 15 min. SKIN: flood with water; *Toxicity by Inhalation (Threshold Limit Value)*:0.01 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Silver Carbonate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Ag_2CO_3; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Yellow to brown; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 275.75; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 6.1 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, rubber gloves; *Symptoms Following Exposure*: Contact with eyes causes irritation. If continued for a long period, ingestion or inhalation of silver compounds can cause permanent discoloration of the skin (argyria); *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water, induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.01 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Silver Fluoride — (i) Chemical Designations — *Synonyms*: Argentous fluoride; Silver monofluoride; *Chemical Formula*: AgF; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Yellow to gray; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 126.9; *Boiling Point at 1 atm.*: 2.118, 1.159, 1.432; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.82 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: inhalation of dust causes irritation of nose and throat. Ingestion may cause

vomiting, salty taste, abdominal pain, diarrhea, convulsions, collapse, thirst, disturbed color vision, and acute toxic nephritis. Contact with eyes causes irritation. Skin may be blackened on prolonged exposure; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: get medical attention at once: give large amount of water and induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.01 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Silver Iodate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $AgIO_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 282.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.53 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask: goggles or face shield, protective gloves; *Symptoms Following Exposure*: Contact with eyes causes irritation, if continued for a long period, ingestion or inhalation of silver compounds can cause permanent discoloration of the skin (argyria); *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water: induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.01 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Silver Nitrate — (i) Chemical Designations — *Synonyms*: Lunar caustic; *Chemical Formula*: $AgNO_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 169.87; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 414, 212, 485; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.35 at 19 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Concentrated solution will produce irritation, ulceration, and discoloration of the skin; also causes severe irritation of the eyes. Ingestion will produce violent abdominal pain and other gastroenteric symptoms; *General Treatment for Exposure*: INGESTION: gastric lavage with dilute solution of chloride, followed by cathartics and demulcents. Other treatment is symptomatic. SKIN: wash promptly; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Burns skin on prolonged contact; *Odor Threshold*: Not pertinent

Silver Oxide — (i) Chemical Designations — *Synonyms*: Argentous oxide; *Chemical Formula*: Ag_2O; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Brown-black; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 231.8; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 7.14 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Contact with eyes causes mild irritation. If continued for a long period, ingestion or inhalation of silver compounds can cause permanent discoloration of the skin (argyria); *General Treatment for Exposure*: EYES: flush with water. SKIN: flush with water; wash soap and water;

Toxicity by Inhalation (Threshold Limit Value): 0.01 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Silver Sulfate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Ag_2SO_4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to gray; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 311.80; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 5.45 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Contact with eyes causes irritation. If continued for long period, ingestion or inhalation of silver compounds can cause permanent discoloration of the skin (argyria); *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting; EYES flush with water for at least 15 min. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.01 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Na; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Soft solid or liquid; *Color*: Silvery white, changing to gray on exposure to air; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 22.49; *Boiling Point at 1 atm.*: 1621, 883, 1156; *Freezing Point*: 207.5, 97.5, 370.7; *Critical Temperature*: 3632, 2000, 2273; *Critical Pressure*: 5040, 343, 34.8; *Specific Gravity*: 0.971 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Maximum protective clothing; goggles and face shield; *Symptoms Following Exposure*: Severe burns caused by burning metal or by caustic soda formed by reaction with moisture on skin; *General Treatment for Exposure*: SKIN: brush off any metal, then flood with water for at least 15 min.; treat as heat or caustic burn; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Cause second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent

Sodium Alkylbenzenesulfonates — (i) Chemical Designations — *Synonyms*: Alkylbenzenesulfonic acid, sodium salt; Sulfonated alkylbenzene; *Chemical Formula*: $C_nH_{2n+1}C_6H_4SO_3Na$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Powder or thick liquid; *Color*: Pale yellow; *Odor*: Faint detergent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid or solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.0 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: In general, these chemical have a moderate order of toxicity. Repeated skin contact with concentrated solutions may cause dermatitis. Ingestion may cause gastrointestinal, vomiting, and diarrhea; *General Treatment for Exposure*: INGESTION: induce vomiting and call a doctor. EYES OR SKIN: flush with copious amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant*

Characteristics: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Not pertinent.

Sodium Alkyl Sulfates — (i) Chemical Designations — *Synonyms*: Sodium hydrogen alkyl sulfate; *Chemical Formula*: $C_nH_{2n+1}OSO_2ONa$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to pale yellow; *Odor*: Weak Detergent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid or solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: Data not available; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: In general, these chemical have a moderate order of toxicity. Repeated skin contact with concentrated solutions may cause dermatitis. Ingestion may cause gastrointestinal, vomiting, and diarrhea; *General Treatment for Exposure*: INGESTION: induce vomiting and follow with gastric lavage. SKIN: wash off with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Sodium Amide — (i) Chemical Designations — *Synonyms*: Sodamite; *Chemical Formula*: $NaNH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Gray; *Odor*: Like a ammonia; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 39.01; *Boiling Point at 1 atm.*: 752, 400, 673; *Freezing Point*: 410, 210, 483; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.39 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield, dust respirator; rubber gloves and shoes; *Symptoms Following Exposure*: Ammonia gas formed by reaction of solid with moisture irritates eyes and skin. Solid causes caustic burns of eyes and skin. Ingestion burns mouth and stomach in same way as caustic soda and may cause perforation of tissue; *General Treatment for Exposure*: INGESTION: give water or milk followed by dilute vinegar or fruit juice; do NOT induce vomiting; call a doctor. SKIN OR EYES: flood all affect areas with copious amounts of water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Only that of ammonia formed by reaction of solid with moisture in air; *Liquid or Solid Irritant Characteristics*: Burns skin and eyes just like caustic soda; *Odor Threshold*: Not pertinent.

Sodium Arsenate — (i) Chemical Designations — *Synonyms*: Disodium arsenate heptahydrate; Sodium arsenate, dibasic; *Chemical Formula*: $Na_2HasO_4 \cdot 7H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 312; *Boiling Point at 1 atm.*: (decomposes) 356, 180, 453; *Freezing Point*: 135, 57, 330; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.87 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of massive doses can cause laryngitis, bronchitis. Ingestion cause concentration in throat and difficulty in swallowing; also causes burning and pain, vomiting, profuse diarrhea. Cyanosis, coma, convulsion, and death. Contact with eyes causes irritation. Contact with skin causes various skin eruptions, more after as a late manifestation, or chronic poisoning; *General Treatment for Exposure*: INHALATION: remove victim from exposure; support respiration; INGESTION: gastric lavage with water, followed by 1 glass of milk; consult physician. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-*

Term Exposure Limits: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} < 50 mg/kg; *Late Toxicity*: Possible carcinogenic effects on skin and lungs; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Arsenite — (i) Chemical Designations — *Synonyms*: Sodium metaarsenite; *Chemical Formula*: Na_3AsO_3-$NaAsO_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White to gray; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 1.139, 615, 888; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.87 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; rubber gloves, goggles or face shield; *Symptoms Following Exposure*: Dust may irritate eyes. Ingestion or excessive inhalation of dust causes irritation of stomach and intestines with nausea, vomiting, and diarrhea: bloody stools, shock, rapid pulse, coma; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wash with large amounts of water. INGESTION: immediately induce evacuation of intestinal tract by gastric lavage and saline cathartic, see physician immediately, consider possible development of arsenic poisoning; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3 (as arsenic); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} = 42 mg/kg; *Late Toxicity*: May be carcinogenic. Arsenic poisoning may develop; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Sodium Azide — (i) Chemical Designations — *Synonyms*: Hydrazoic acid, sodium salt; *Chemical Formula*: NaN_3; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 65; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.85 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, protective clothing, goggles; *Symptoms Following Exposure*: Inhalation or ingestion causes dizziness, weakness, blurred vision, slight shortness of breath, and reeling of going to faint; moderate reduction of blood pressure and bardycardia. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: Give oxygen if weakness, pallor, or low blood pressure is observed. INHALATION: remove victim lo fresh air, enforce rest; call a doctor. EYES: flush with water for at least 15 min. SKIN: flush with water, wash with soap and water. INGESTION: give large amount of water and induce vomiting at once, get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral rat LD_{50} = 27 mg/kg (technical); *Late Toxicity*: Potent mutagen of salmon-sperm DNA; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Sodium Bisulfite — (i) Chemical Designations — *Synonyms*: Sodium acid sulfite; Sodium metebisulfite; Sodium pyrosulfite; *Chemical Formula*: $NaHSO_4$-$Na_2S_2O_5$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Pungent odor of sulfur dioxide when moist; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 104.06; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.48 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; *Symptoms Following Exposure*: Powder is irritating to eyes, nose, and throat and can irritate skin. Ingestion may cause irritation of stomach. Very large doses cause violent colic, diarrhea, depression, and death; *General Treatment for Exposure*: INHALATION OR INGESTION: get medical attention

at once. SKIN: wash with plenty of water. EYES: flush with plenty of water for at least 15 min., and get medical attention at once; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Irritates skin and mucous membranes; *Odor Threshold*: Not pertinent.

Sodium Borate — (i) Chemical Designations — *Synonyms*: Borax, anhydrous; Sodium biborate; Sodium pyroborate; Sodium tetraborate,anhydrous; *Chemical Formula*: $Na_2B_4O_7$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 201.26; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.367 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask and goggles or face shield; *Symptoms Following Exposure*: No adverse effects from inhaling borax have been reported. Ingestion may cause acute or chronic effects: initial symptoms are nausea, vomiting, and diarrhea: these may be followed by weakness, depression, headaches, skin rashes, drying skin, cracked lips, and loss of hair; shock may follow ingestion of large doses and may interfere with breathing. Eye contact with powder or solutions may cause irritation; no chronic effects have been recognized, but continued contact should be avoided. Local skin irritation may result from contact with powder or strong solutions: the latter may cause chronic dermatitis on prolonged contact, and if skin is broken. enough boron may be absorbed lo cause boron poisoning (symptoms are similar to those for ingestion); *General Treatment for Exposure*: INHALATION: move to fresh air: call physician immediately; give mouth-to-mouth resuscitation if breathing has ceased: give oxygen if authorized by physician: keep victim warm. INGESTION: get medical attention quickly: if victim is conscious, give warm salty or soapy water to induce vomiting: repeat until vomitus is clear: additional water may be given lo wash out stomach. EYES: get medical attention quickly: Hush with copious amounts of water for at least 15 min. (30 min. if physician is not available), holding eyelids apart. SKIN: Hush with water: remove contaminated clothing under shower: do not use chemical neulralizers: get medical attention unless burn is minor; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Borohydride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $NaBH_4$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid or solution in caustic; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 37.83; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.074 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles, rubber gloves, and protective clothing; *Symptoms Following Exposure*: Solid irritates skin If ingested can form large volume of gas and lead to a gas embolism; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting: give dilute vinegar, lemon juice, milk. or olive oil: call a doctor. SKIN AND EYES: flood with large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Violent reaction with acid in stomach. Considered toxic because of boron content; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Irritates skin; *Odor Threshold*: Not pertinent.

Sodium Cacodylate — (i) Chemical Designations — *Synonyms*: Arsecodile; Arsicodile; Arsycodile; Phytar 160; Phytar 560; Sodium dimethylarsonate; *Chemical Formula*: $(CH_3)_2AsOONa$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid or water solution; *Color*: Colorless to light yellow; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid;

Molecular Weight: 160.0; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity:* (est.) >1 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield: dust mask: rubber gloves; *Symptoms Following Exposure*: Dust may irritate eyes. Ingestion or excessive inhalation causes irritation of stomach and intestines with nausea, vomiting, diarrhea, shock, rapid pulse, coma; *General Treatment for Exposure*: INHALATION: remove victim from exposure: call physician. EYES: flush with water. SKIN: flush with water and wash well with soap and water. INGESTION: call physician: induce evacuation of intestinal tract by inducing vomiting, giving gastric lavage and a saline cathartic. Do NOT use BAL as an antidote; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} = 2,600 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Sodium Chlorate — (i) Chemical Designations — *Synonyms*:Chlorate of soda; *Chemical Formula*: $NaClO_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Pale yellow to white; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 106.45; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 478, 248, 521; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.49 at 15 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Clean work clothing (must be washed well with water after each exposure): rubber gloves and shoes: where dusty, goggles and an approved dust respirator. Do NOT use oils, greases, or protective creams on skin; *Symptoms Following Exposure*: ingestion of a toxic dose (at least ½ oz.) leads to severe gastroenteric pain, vomiting, and diarrhea. Possible respiratory difficulties, including failure of respiration. Kidney and liver injury may also be produced. The lethal oral dose For an adult is approximately 15 gm. Contact with eyes causes irritation; *General Treatment for Exposure*: INGESTION: induce vomiting and follow with gastric lavage, saline cathartics. Fluid therapy, and oxygen. EYES: wash thoroughly with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Prolonged exposure to solid or dust may irritate skin; *Odor Threshold*: Not pertinent.

Sodium Chromate — (i) Chemical Designations — *Synonyms*: Neutral sodium chromate, anhydrous; Sodium chromate (VI); *Chemical Formula*: Na_2CrO_4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 162; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.723 at 25 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: U. S. Bu. Mines approved respirator, rubber gloves; chemical safely goggles; rubber apron and sleeves, face shield, rubber shoes, protective clothing; *Symptoms Following Exposure*: Inhalation causes irritation and may ulcerate mucous membranes: continued irritation of the nose may lead to perforation of the septum, ingestion causes severe circulatory collapse and toxic nephritis, may be fatal. Contact with eyes causes severe irritation and possible conjunctivitis. Irritates skin and can cause ulcers: if skin is broken, prolonged contact may cause "chrome sores" (slow-healing, hard-rimmed ulcers), which leave the area vulnerable lo infection as a secondary effect; *General Treatment for Exposure*: INHALATION: remove victim to fresh air: get medical attention. INGESTION: get immediate medical help: if vomiting is not spontaneous, give an emetic such as soapy water followed by copious water in lake. EYES: immediately flush with plenty of water for at least 15 min.; consult physician promptly. SKIN: immediately flush with plenty of water for at least

15 min.; persistent dermatitis should be referred to a physician: wash contaminated skin or clothing until chromate color disappears; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Possible lung cancer; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Cyanide — (i) Chemical Designations — *Synonyms*: Hydrocyanic acid; *Chemical Formula*: NaCN; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Odorless when dry. When moist it has a slight odor of hydrocyanic acid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 49.01; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 1047, 564, 837; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.60 at 25 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Protective gloves when handling solid sodium cyanide; rubber gloves when handling cyanide solutions (wash hands and rubber gloves thoroughly with running water after handling cyanides); U. S. Bureau of Mines approved dust respirator; approved chemical safety goggles; *Symptoms Following Exposure*: As little as 180 milligrams is a rapidly fatal poison if ingested non-lethal doses may cause toxic symptoms. Strong water solutions, or the solid itself, can be absorbed by the skin and cause deep ulcers which heal slowly; *General Treatment for Exposure*: INGESTION: start treatment immediately; call a physician; carry victim to fresh air; have him lie down; keep him quiet and warm until physician arrives. If victim is conscious and breathing: induce vomiting by giving emetic of warm salt water (1 tablespoon salt/cup water) repeat until vomit fluid is clear; then have victim drink one pint of 1% solution of sodium thiosulfate, to be repealed in 15 min. If victim has stopped breathing: give artificial respiration until breathing starts. If victim is unconscious but breathing: give oxygen from an inhalator. For all of above conditions, have victim breathe amyl nitrite. Break nitrite pearl in a cloth and hold lightly under victim's nose for 15 sec., repeating 5 times at about 15-sec. intervals, If necessary repeat this procedure every 3 min. with fresh pearls until 3 or 4 have been given. (Pearls must not be over 2 years old. Avoid breathing amyl nitrite while administering it to victim.); *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 4, bellow 50 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile, but moisture in air liberate some lethal hydrogen cyanide gas; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant; may cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: Not pertinent.

Sodium Dichromate — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $Na_2Cr_2O_7$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Bright orange red; *Odor*: Odorless; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 262.01; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 675, 357, 630; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.35 at 25 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Approved dust mask, protective gloves; goggles or face shield; *Symptoms Following Exposure*: Inhalation of dust or mist causes respiratory irritation sometimes resembling asthma, nasal septal perforation may occur. Ingestion causes vomiting, diarrhea, and (rarely) stomach and kidney complications. Contact with eyes or skin produces local irritation: repeated skin exposure causes dermatitis; *General Treatment for Exposure*: INGESTION: have victim drink water or milk; do NOT induce vomiting; call a doctor. SKIN OR EYE CONTACT: treat like acid burns; flush eyes with water for at least 15 min.; external lesions can be scrubbed with a 2% solution of sodium thiosulfate; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Some suggestion of lung cancer; *Vapor (Gas) Irritant Characteristics*: Dusts or mists may cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and

third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Odorless.

Sodium Ferrocyanide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $Na_4Fe_4(CN)_6$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 484.04; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.458 at 25 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: U. S. Bureau of Mines respirator for excessive dustiness; safety goggles; *Symptoms Following Exposure*: None recorded; *General Treatment for Exposure*: None is required except for ingestion of a huge dose, in which case the stomach should be emptied by inducing vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Sodium Fluoride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NaF; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 41.99; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.79 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Ingestion may cause vomiting, abdominal pain, diarrhea, convulsion, collapse, thirst, disturbed color vision, acute toxic nephritis; *General Treatment for Exposure*: INGESTION: promptly administer gastric lavage with lime water or 1% calcium chloride solution; support respiration; call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg (rabbit, rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Sodium Hydride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: NaH; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Gray; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: Not applicable; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: Data not available; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Face shield; rubber gloves; *Symptoms Following Exposure*: Moisture of body converts compound to caustic soda, which irritates all tissues; *General Treatment for Exposure*: INGESTION: do NOT induce vomiting; neutralize alkali in stomach by drinking dilute vinegar, lemon juice, or orange juice; call a physician. SKIN CONTACT: brush off all particles at once and flood the affected area with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious ti the EYES; *Odor Threshold*: Not pertinent.

Sodium Hydrosulfide Solution — (i) Chemical Designations — *Synonyms*: Sodium bisulfide; Sodium hydrogen sulfide; Sodium sulfhydrate; *Chemical Formula*: To be developed; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Light lemon; pale yellow; amber to dark red; *Odor*: Rotten eggs; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Liquid; *Molecular Weight*: Not pertinent; *Boiling*

Point at 1 atm.: (approx.) 212, 100, 373; *Freezing Point:* (approx.) 63, 17, 290; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.3 at 15 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber protective equipment, such as apron, boots, splash-proof goggles, gloves; canister-type respirator or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation of mist causes irritation of respiratory tract and possible systemic poisoning, hydrogen sulfide gas, which may be given off when acid is present, causes headache, dizziness, nausea, vomiting: continued exposure can lead to loss of consciousness, respiratory failure, and death. Liquid causes marked eye irritation, itching, lachrymation, swelling, and corneal injury causing blurring of vision are the most common effects exposure to light may increase the painful effects. Contact of liquid with skin causes irritation and corrosion of tissue, continued exposure may cause dermatitis. Ingestion causes severe burning and corrosion of all portions of the gastro-intestinal tract, pain in the throat and abdomen, nausea, and vomiting, followed by diarrhea, in severe cases, collapse, unconsciousness, and paralysis of respiration may be expected; *General Treatment for Exposure*: INHALATION: move victim from contaminated atmosphere, call physician, if breathing has ceased, start mouth-to-mouth resuscitation. EYES: immediately flush with large quantities of running water for a minimum of 15 min., obtain medical attention as soon as possible; while awaiting instructions from physician, patient may be kept in a dark room and ice compresses applied to the eyes and forehead. SKIN: immediately flush affected areas with water: obtain medical attention if irritation persists. INGESTION: obtain medical attention as soon as possible; if patient is conscious, induce vomiting by giving large amounts of water or warm salty water (2 tablespoons of table sail to a pint of water), if this measure is unsuccessful, vomiting may be induced by tickling back of patient's throat with a finger. Vomiting should be encouraged until the vomitus is clear. if patient is unconscious, do not give anything but ensure there is no obstruction to breathing (his tongue should be kept forward and false teeth removed). He will be less likely to aspirate vomitus if he is placed in a face-down position; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes contact; *Odor Threshold*: 0.0047 ppm.

Sodium Hydroxide — (i) Chemical Designations — *Synonyms*: Caustic soda; *Chemical Formula*: NaON; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 40.00; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 604, 318, 591; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.13 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safely goggles, lace shield: tiller or dust-type respirator: rubber boots: rubber gloves; *Symptoms Following Exposure*: Strong corrosive, destroys tissues. INHALATION: dust may cause damage to upper respiratory tract and lung itself, producing from mild nose irritation to pneumonitis. INGESTION: severe damage to mucous membranes; severe scar formation or perforation may occur. EYE CONTACT: produces severe damage; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; call physician. INGESTION: give water or milk followed by dilute vinegar or fruit juice: do NOT induce vomiting. SKIN: wash immediately with large quantities of water under emergency safety shower while removing clothing: continue washing until medical help arrives, call physician. EYES: irrigate immediately with copious amounts of water for at least 15 min.; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: (10% solution) oral Grade 2, LDL_0 = 500 mg/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second-and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent.

Sodium Hypochlorite — (i) Chemical Designations — *Synonyms*: Clorox; *Chemical Formula*: $NaOCl\text{-}H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Green-yellow; *Odor*: Like bleach solution; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not applicable; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.06 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves: goggles; *Symptoms Following Exposure*: Liquid can be irritating to skin and eyes; *General Treatment for Exposure*: INGESTION: induce vomiting, give water, and repeat. SKIN: wash off contacted skin area. EYES: flush with plenty of water for 15 min. and consult a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Sodium Methylate — (i) Chemical Designations — *Synonyms*: Sodium methoxide; *Chemical Formula*: CH_3ONa; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 54.0; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point:* Not pertinent; *Critical Temperature:* Not pertinent; *Critical Pressure:* Not pertinent; *Specific Gravity:* > 1 at 20°C (solid); *Vapor (Gas) Density:* Not pertinent; *Ratio of Specific Heats of Vapor (Gas):* Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition:* Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment:* Self-contained breathing apparatus, rubber gloves and apron; goggles or face shield; *Symptoms Following Exposure:* Inhalation of dust causes severe irritation of nose and throat. Contact with eyes or skin causes severe irritation and burns. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure:* Get medical attention at once following all exposures to this compound. INHALATION: remove victim from contamination and keep him quiet and warm. Rest is essential. Hot tea or coffee may be given as a stimulant if patient is conscious, if breathing has apparently ceased, give artificial respiration, if available, oxygen should be administered by experienced personnel. EYES: wash well with water, then with 3% boric acid solution and additional water washes. SKIN: wash well with water, then with dilute vinegar. INGESTION: if victim is conscious, induce vomiting by administering a glassful of warm water containing a teaspoon full of salt; repeat until vomit is clear, then give two teaspoons of baking soda every 15 min.; keep victim's eyes covered until all visual and retinal changes have disappeared, alert physician to possibility of methyl alcohol poisoning; *Toxicity by Inhalation (Threshold Limit Value):* Data not available; *Short-Term Exposure Limits:* Data not available; *Toxicity by Ingestion:* Data not available; *Late Toxicity:* Data not available; *Vapor (Gas) Irritant Characteristics:* Not pertinent; *Liquid or Solid Irritant Characteristics:* Data not available; *Odor Threshold:* Not pertinent.

Sodium Nitrite — (i) Chemical Designations — *Synonyms*: Erinitrit; Filmerine; *Chemical Formula*: $NaNO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 69; *Boiling Point at 1 atm.*: (decomposes) >608, >320, >593; *Freezing Point*: 520, 271, 544; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.17 at 20°C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Ingestion (or inhalation of excessive amounts of dust) causes rapid drop in blood pressure, persistent and throbbing headache, vertigo, palpitations, and visual disturbances; skin becomes flushed and sweaty, later cold and cyanotic; other symptoms include nausea, vomiting, diarrhea (sometimes), fainting, methemoglobinemia. Contact with eyes causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; if exposure is severe, get medical attention. INGESTION: keep patient recumbent in a shock position and comfortably warm; administer gastric lavage; consult a

physician. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Oxalate — (i) Chemical Designations — *Synonyms*: Ethanedioic acid; disodium salt; *Chemical Formula*: $Na_2C_2O_4$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 134.0; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.27 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Inhalation or ingestion causes pain in throat, esophagus, and stomach; mucous membranes turn white; other symptoms include vomiting, severe purging, weak pulse, cardiovascular collapse, neuromuscular symptoms, and kidney damage. Contact with eyes or skin causes irritation; *General Treatment for Exposure: Act promptly!* INHALATION: move to fresh air; if exposure to dust is severe, get medical attention. INGESTION: give dilute calcium lactate, lime water, or milk; administer gastric lavage; consult physician; watch for edema of the glottis and delayed constriction of esophagus. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Phosphate — (i) Chemical Designations — *Synonyms*: "Sodium phosphate" is generic term and includes the following: (1) monosodium phosphate (MSP; sodium phosphate, monobasic), (2) disodium phosphate (DSP; sodium phosphate dibasic), (3) trisodium phosphate (TSP; sodium phosphate, tribasic), (4) sodium acid pyrophosphate (ASPP; SAPP; disodium pyrophosphate (TSPP), (6) sodium metaphosphate (insoluble sodium metaphosphate), (7) sodium trimetaphosphate, and (9) sodium tripolyphosphate (STPP; TPP); *Chemical Formula*: (1) NaH_2PO_4; (2) Na_2HPO_4; (3) Na_3PO_4; (4) $Na_2H_2P_2O_7$; (5) $Na_4P_2O_7$; (6) $(NaPO_3)_n$; (7) $(NaPO_3)_3$; (8) $(NaPO_3)_n$ NaO; (9) $Na_5P_3O_{10}$; **(ii) Observable Characteristics —** *Physical State (as shipped)*: Granular or powdered solid; some may appear glassy; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Values for anhydrous salt run from 120 to high polymer values; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.8-2.5 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: U.S. Bu. Mines toxic dust mask; protective gloves; chemical-type goggles; full-cover clothing; *Symptoms Following Exposure*: Inhalation of heavy dust may irritate nose and throat. Ingestion may injure mouth, throat, and gastrointestinal tract, resulting in nausea, vomiting, cramps and diarrhea; pain and burning in moth may occur. Contact with eyes produces local irritation; can lead to chronic damage. Contact with skin produces local irritation; repeated or prolonged contact can lead to dermatitis; *General Treatment for Exposure*: If the following measures do not eliminate the symptoms, see a physician. INHALATION: give large amounts of water or warm salty water to induce vomiting; repeat until vomitus is clear; milk, eggs, or olive oil may then be given to soothe stomach. EYES: immediately flush with large amounts of water for at least 15 min., holding eyelids to ensure flushing or entire surface; avoid chemical neutralizers. SKIN: flush with water; avoid chemical neutralizers; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Silicate — (i) Chemical Designations — *Synonyms*: Water glass; Soluble glass; *Chemical Formula*: Na_2SiO_3-$NaSiO_4$-H_2O; **(ii) Observable**

Characteristics — *Physical State (as shipped)*: High-viscosity liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not applicable; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.1 - 1.7 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: If large doses are ingested, some irritation of mucous membranes may occur, similar to that caused by caustic solution; *General Treatment for Exposure*: INGESTION (large doses): give water or milk; do NOT induce vomiting; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (human); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Sodium Silicofluoride — **(i) Chemical Designations** — *Synonyms*: Salufer; Sodium fluosilicate; Sodium hexafluorosilicate; *Chemical Formula*: Na_2SiF_6; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 188; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.68 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust respirator; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Ingestion causes symptoms similar to fluoride poisoning; compound is highly toxic; initial symptoms include nausea, cramps, vomiting, diarrhea, and dehydration; in severe cases, convulsions, shock, and cyanosis are followed by death in 2-4 hr. Contact with eyes causes irritation. Contact with skin causes rash, redness, and burning, sometimes followed by ulcer formation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: seek medical attention; administer gastric lavage with lime water, then give lime water or milk at frequent intervals. EYES: flush with water for at least 15 min. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 2.5 mg/m^3 (as fluoride); *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3; LD_{50} 50-500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sodium Sulfide — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: Na_2S; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Yellow or light buff; *Odor*: Like rotten eggs; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 78.4; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.856 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Caustic action on skin and eyes. If ingested may liberate hydrogen sulfide in stomach; *General Treatment for Exposure*: INGESTION: give water; induce vomiting; call a doctor. SKIN OR EYE CONTACT: wash with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3; LD_{50} 50 - 500 mg/kg (human); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Irritates skin and mucous membranes; *Odor Threshold*: Not pertinent.

Sodium Sulfite — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: Na_2SO_3; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 126.04; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: Not pertinent; *Critical Temperature*: Not

pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.633 at 15 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; *Symptoms Following Exposure*: When ingested, solutions cause gastric irritation by the liberation of sulfurous acid. Because of rapid oxidation to sulfate, sulfites are well tolerated until large doses are reached; than violent colic and diarrhea, circulatory disturbances, central nervous depression, and death can occur; *General Treatment for Exposure*: INGESTION: treatment is symptomatic and supportive; call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Not very irritating; *Odor Threshold*: Not pertinent.

Sodium Thiocyanate — (i) Chemical Designations — *Synonyms*: Rhodanate; Sodium rhodanide; Sodium sulfocyanate; *Chemical Formula*: NaSCN; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 81.08; Boiling Point at 1 atm.: Not pertinent (decomposes); *Freezing Point*: 572, 300, 573; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: >1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber or plastic gloves; standard goggles; rubber or plastic apron; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion of large doses causes vomiting, extreme cerebral excitement, convulsions, and death in 10-48 hrs.; chronic poisoning can cause flu-like symptoms, skin rashes, weakness, fatigue, vertigo, nausea, vomiting, diarrhea, confusion. Contact with eyes causes irritation. Prolonged contact with skin may produce various skin eruptions, dizziness, cramps, nausea, and mild to severe disturbance of the nervous system; *General Treatment for Exposure*: INHALATION: move to fresh air; if exposure has been great, get medical attention. INGESTION: consult physician; hemodialysis is recommended as the treatment of choice. EYES or SKIN: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Causes birth defects in chick embryos; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Sorbitol — (i) Chemical Designations — *Synonyms*: D-Glucitol; Hexahydric alcohol; 1,2,3,4,5,6-Hexanehexol; Sorbit; Sorbo; Sorbol; *Chemical Formula*: $CH_2OH(CHOH)_4CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 182.17; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 230, 110, 383; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.49 at 15 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -6,750, -3,750, -157; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; protective clothing for hot liquid; *Symptoms Following Exposure*: Hot liquid will burn skin; *General Treatment for Exposure*: Only for burns caused by hot liquid; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: None; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Stearic Acid — (i) Chemical Designations — *Synonyms*: 1-Heptadecancecarboxylic acid; Octadecanoic acid; n-Octadecylic acid; Stearophanic acid; *Chemical Formula*: $CH_3(CH_2)_{16}CO_2H$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Fatty; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: (avg.) 282; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 157, 70, 343; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.86 at 20°C

(solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -17,310, -9,616, -402.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: For prolonged exposure to vapors, use air-supplied mask of chemical cartridge respirator; impervious gloves; goggles; impervious apron; *Symptoms Following Exposure*: Compound is generally considered nontoxic. Inhalation of dust irritates nose and throat. Dust causes mild irritation of eyes; *General Treatment for Exposure*: INGESTION: drink large volume of water; induce vomiting; call a physician. EYES: flush with water; if irritation persists, get medical attention. SKIN: wash thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; LD_{50} >15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 20 ppm.

Styrene — (i) Chemical Designations — *Synonyms*: Phenethylene; Phenylethylene; Styrol; Styrolene; Vinylbenzene; *Chemical Formula*: $C_6H_5CH{=}CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet at low concentrations; characteristic pungent; sharp; disagreeable; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 104.15; *Boiling Point at 1 atm.*: 293.4, 145.2, 418.4; *Freezing Point*: -23.1, -30.6, 242.6; *Critical Temperature*: 703, 373, 646; *Critical Pressure*: 580, 39.46, 4.00; *Specific Gravity*: 0.906 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.074; *Latent Heat of Vaporization*: 156, 86.8, 3.63; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask or approved canister; rubber or plastic gloves; boots; goggles or face shield; *Symptoms Following Exposure*: Moderate irritation of eyes and skin. High vapor concentrations cause dizziness, drunkenness, and anesthesia; *General Treatment for Exposure*: INHALATION: remove to fresh air; keep warm and quiet; use artificial respiration if needed. INGESTION: do NOT induce vomiting; call physician; no known antidote. SKIN OR EYE CONTACT: flush with plenty of water; for eyes get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: 100 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause second-degree burns on long exposure; *Odor Threshold*: 0.148 ppm.

Sucrose — (i) Chemical Designations — *Synonyms*: Beet sugar; Cane sugar; Saccharose; Saccharum; Sugar; *Chemical Formula*: $C_{12}H_{22}O_{11}$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 342.3; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: (decomposes) 320-367, 160-186,433-459; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.59 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6,400, -3,600, -150; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask and goggles or face shield; *Symptoms Following Exposure*: None; *General Treatment for Exposure*: EYES: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 0; oral LD_{50} (100 days) = 28,500 mg/kg (rat); *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Sulfolane — (i) Chemical Designations — *Synonyms*: Sulfolane-W; Tetrahydrothiophene-1,1-dioxide; Tetramethylene sulfone; *Chemical Formula*: $CH_2CH_2CH_2CH_2SO_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak oily; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 120.17; *Boiling Point at 1 atm.*: 545, 285, 558; *Freezing Point*: 79, 26, 299; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.26 at 20 °C (liquid); *Vapor*

(Gas) Specific Gravity: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -9,500, -5,300, -220; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Very mildly irritating to the eyes; *General Treatment for Exposure*: INGESTION: induce vomiting. SKIN OR EYE CONTACT: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat, mouse); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to eyes and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Sulfur Dioxide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: SO_2; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Sharp, pungent; characteristic; like burning sulfur; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 64.06; *Boiling Point at 1 atm.*: 14, -10, 263.2; *Freezing Point*: -103.9, -75.5, 197.7; *Critical Temperature*: 315, 157, 430; *Critical Pressure*: 1142, 77.69, 7.870; *Specific Gravity*: 1.45 at -10 °C (liquid); *Vapor (Gas) Specific Gravity*: 2.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.265; *Latent Heat of Vaporization*: 171, 94.8, 3.97; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask or approved canister; goggles or face shield; rubber gloves; rubber clothing where contact with liquid is possible; *Symptoms Following Exposure*: Vapors cause irritation of eyes and lungs, with severe choking; *General Treatment for Exposure*: INHALATION: remove from exposure; support respiration; administer oxygen; call a doctor. SKIN: flush with water after exposure to liquid. EYES: wash promptly for at least 15 min.; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Inhalation Limits*: 20 ppm for 5 min.; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eye and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Liquid can cause frostbite; *Odor Threshold*: 3 ppm.

Sulfuric Acid — (i) Chemical Designations — *Synonyms*: Battery acid; Chamber acid; Fertilizer acid; Oil of vitriol; *Chemical Formula*: H_2SO_4; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless (pure) to dark brown; *Odor*: Odorless unless hot, then choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 98.08; *Boiling Point at 1 atm.*: 644, 340, 613; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.84 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Safety shower; eyewash fountain; safety goggles; face shield; approved respirator (self-contained or air-line); rubber safety shoes; rubber apron; *Symptoms Following Exposure*: Inhalation of vapor from hot, concentrated acid may injure lungs. Swallowing may cause severe injury or death. Contact with skin or eyes causes severe burns; *General Treatment for Exposure*: Call a doctor. INHALATION: observe victim for delayed pulmonary reaction. INGESTION: have victim drink water if possible; do NOT induce vomiting. EYES AND SKIN: wash with large amounts of water for at least 15 min.; do not use oils or ointments in eyes; treat skin burns; *Toxicity by Inhalation (Threshold Limit Value)*: 1 mg/m^3; *Short-Term Inhalation Limits*: 10 mg/m^3 for 5 min.; 5 mg/m^3 for 10 min.; 2 mg/m^3 for 30 min.; 1 mg/m^3 for 60 min.; *Toxicity by Ingestion*: No effects except those secondary to tissue damage; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapors from hot acid (77-98%) cause moderate irritation of eyes and respiratory system. The effect is temporary; *Liquid or Solid Irritant Characteristics*: 77-98% acid causes severe second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Greater than 1 mg/m^3.

Sulfuric Acid, Spent — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: H_2SO_4-H_2O; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless to dark brown; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling*

Point at 1 atm.: 212, 100, 373; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.39 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical safety goggles and face shield; rubber gloves, boots, and apron; *Symptoms Following Exposure*: Contact with eyes or skin causes severe burns, the severity depending on the strength of the acid. Ingestion can cause severe irritation of mouth and stomach; *General Treatment for Exposure*: Call a doctor. INGESTION: do NOT induce vomiting. SKIN OR EYES: flush affected parts with large amounts of water for at least 15 min.; do NOT use oils or ointments in eyes; treat burns; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: No effects except those stemming from tissue damage; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent.

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Titanium Tetrachloride — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*: $TiCl_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Acrid; choking; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 189.71; *Boiling Point at 1 atm.*: 277, 136, 249; *Freezing Point*: -11, -24, 249; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.726 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.221; *Latent Heat of Vaporization*: 79.7, 44.3, 1.86; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and face shield; air-supplied mask or approved canister; rubber gloves; protective clothing; *Symptoms Following Exposure*: Vapors can cause severe irritation and damage to eyes, coughing, headache, dizziness, lung damage, bronchial pneumonia. Liquid causes thermal and acid burns of eyes, skin, throat, and stomach. If ingested, causes nausea, vomiting, cramps, diarrhea, and possible tissue ulceration; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if symptoms persist, call a doctor. INGESTION: give large amounts of water, then induce vomiting; give milk, eggs ir olive oil; call a doctor. EYES: immediately flush with copious amounts of water for at least 15 min.; call a doctor. SKIN: flush with water; obtain medical attention if irritation persists; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm in moist air; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Disturbances of upper respiratory and nervous system in man; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not tolerate moderate or high vapor concentrations; *Liquid or Solid Irritant Characteristics*: Fairly Severe skin irritant; may cause pain and second- degree burns after a few minutes' contact; *Odor Threshold*: Data not available.

Toluene — **(i) Chemical Designations** — *Synonyms*: Methylbenzen, Methylbenzol, Toluol; *Chemical Formula*: $C_6H_6CH_3$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Pungent; aromatic, benzene-like; distinct, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 92.14; *Boiling Point at 1 atm.*: 231.1, 110.6, 383.8; *Freezing Point*: -139, -95.0, 178.2; *Critical Temperature*: 605.4, 318.6, 591.8; *Critical Pressure*: 596.1, 40.55, 4.108; *Specific Gravity*: 0.867 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.089; *Latent Heat of Vaporization*: 155, 86.1, 3.61; *Heat of Combustion*: -17,430, -9686, -405.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask; goggles and face shield; plastic gloves; *Symptoms Following Exposure*: Vapors irritate eyes and upper respiratory tract; cause dizziness, headache, anesthesia, respiratory arrest. Liquid irritates eyes and causes coughing, gagging distress, and rapidly developing pulmonary edema. If ingested causes vomiting, griping, diarrhea, depressed respiration; *General Treatment for Exposure*: INHALATION: remove victim to fresh air, give artificial respiration and oxygen if needed; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*:

100 ppm; *Short-Term Exposure Limits*: 600 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Kidney and liver damage may follow ingestion; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.17 ppm.

Toluene 2,4-Diisocyanate — (i) Chemical Designations — *Synonyms*: Hylene T; Mondur TDS; Nacconate 100; 2,4-Tolylene diisocyanate; TDE; *Chemical Formula*: 1-$CH_3C_6H_3(NCO)_2$-2,4; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless to light yellow; *Odor*: Sweet, fruity, pungent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 174.16; *Boiling Point at 1 atm.*: 482, 250, 523; *Freezing Point*: 68 - 72, 20 - 22, 293 - 295; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.22 at 25 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -10,300, -5720, -239; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor canister; goggles and face shield; rubber gloves; boots and apron; *Symptoms Following Exposure*: Irritates eyes and skin. Potent sensitizer and lung irritant if inhaled. May produce bronhospasm (asthma), pneumonitis, bronchitis, and pulmonary edema. Nocturnal cough and shortness of breath are common. Repeated low-level exposure may produce chronic lung disease. Oral toxicity is low; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; administer artificial respiration and oxygen if needed; call a doctor. EYES: flush with water; wipe off; with rubbing alcohol; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.02 ppm; *Short-Term Exposure Limits*: 0.02 ppm for 5 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors is moderately irritating such that personnel will not usually tolerate moderate or high vapor concentration; *Liquid or Solid Irritant Characteristics*: Fairly Severe skin irritant; may cause pain and second-degree burns after a few minutes' contact; *Odor Threshold*: 0.4-2.14 ppm.

p-Toluenesulfonic Acid — (i) Chemical Designations — *Synonyms*: Methylbenzenesulfonic acid; Tosic acid; p-TSA; *Chemical Formula*: $CH_3C_6H_4SO_3H$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White to brown to black; yellow to amber; *Odor*: None when pure; technical grade has slight aromatic odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 172.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 219 - 221, 104 - 105, 377 - 378; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.45 at 25 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles and face shield; rubber gloves; *Symptoms Following Exposure*: Contact with eyes or skin causes severe irritation. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: EYES: wash thoroughly with copious amounts of water for at least 15 min.; call physician if irritation persists. SKIN: wash thoroughly with large amounts of water for at least 15 min. INGESTION: give large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, oral LD_{50} =400 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

o-Toluidine — (i) Chemical Designations — *Synonyms*: 2-Amino-1-methyl-benzene; 2-Aminotoluene; 2-Methylaniline; o- Methylaniline; *Chemical Formula*: 1,2-$CH_3C_6H_4NH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Clear to light yellow; turns yellow, brown or deep red on exposure to air and light; *Odor*: Aromatic, aniline-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Liquid; *Molecular Weight*: 107.2; *Boiling Point at 1 atm.*: 392, 200, 473; *Freezing Point*: -11, -24, 249; *Critical Temperature*: 790, 421, 694; *Critical Pressure*: 544, 37.0, 3.75; *Specific Gravity*: 0.998 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 179.1, 99.5, 4.16; *Heat of Combustion*: -16,180, -8,990, -376; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards**

Information — *Recommended Personal Protective Equipment*: Chemical safety goggles; face shield; Bu. Mines approved respirator; leather or rubber safety shoes; butyl rubber gloves; *Symptoms Following Exposure*: Absorption of toxic quantities by any route causes cyanosis (blue discoloration of lips, nails, skin); nausea, vomiting, and coma may follow. Repeated inhalation of low concentration may cause pallor, low-grade secondary anemia, and loss of appetite. Contact with eyes causes irritation; *General Treatment for Exposure*: Get medical attention following all exposured to this compound. INHALATION: move to fresh air. INGESTION: if victim is conscious, promptly induce vomiting by giving lukewarm soapy water or mustard and water. EYES: flush with copious amounts of water for at least 15 min., holding lids apart. SKIN: remove all contaminated clothing; wash affected areas immediately and thoroughly with plenty of warm water and soap; *Toxicity by Inhalation (Threshold Limit Value)*: 5 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50}=900 mg/kg (rat); *Late Toxicity*: Causes tumors in urinary bladder of rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Toxaphene — **(i) Chemical Designations** — *Synonyms*: Octachlorocamphene; *Chemical Formula*: $C_{10}H_8Cl_8$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Waxy solid; *Color*: Amber; *Odor*: Mild turpentine odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Waxy solid; *Molecular Weight*: 414 (avg.); *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 149-194, 65-90, 338-363; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.6 at 15 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical-type respirator; rubber gloves; chemical Goggles and face shield; *Symptoms Following Exposure*: May be absorbed through skin, lungs, or intestinal tract. Symptoms include salivation, leg and back muscle spasms, nausea, vomiting, hyper excitability, tremors, shivering, clonic convulsions, then titanic contraction of all skeletal muscles. Lethal doses cause respiratory failure. Respiration, affected as a result of the exertion from vomiting or convulsions, is first arrested because of titanic muscular contraction, then increased in both amplitude and rate as the muscles relax; *General Treatment for Exposure*: If symptoms of poisoning appear, promptly remove the unabsorbed pesticide from the stomach by inducing vomiting with warm salty or soapy water (if the patient is conscious) or from the skin with soap and water. Keep patient warm and quiet. Call a physician; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 4, LD_{50} below 50 mg/kg (dot); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: The solid is non-volatile. For solutions, see meta-xylene; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Not pertinent.

Trichloroethylene — **(I) Chemical Designations** - *Synonyms*: Algylen; Clorilen; Gemalgene; Threthylene; Trethylene; Tri; Trihloran; Trihloroethelene; TriClene; Trielene; Triline; Trimar; *Chemical Formula*: $CHCl=CCl_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Chloroform-like; ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 131.39; *Boiling Point at 1 atm.*: 189, 87, 360; *Freezing Point*: -123.5, -86.4, 186.8; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: Not pertinent; *Vapor (Gas) Specific Gravity*: 4.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.116; *Latent Heat of Vaporization*: 103, 57.2, 2.40; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic vapor-acid gas canister; self-contained breathing apparatus for emergencies; neoprene or vinyl gloves; chemical safety goggles; face-shield; neoprene safety shoes; neoprene suit or apron for splash protection; *Symptoms Following Exposure*: INHALATION: symptoms range from irritation of the nose and throat to nausea, an attitude of irresponsibility, blurred vision, and finally disturbance of central nervous system resulting in cardiac failure. Chronic exposure may cause organic injury. INGESTION: symptoms similar to inhalation. SKIN: defatting action can cause dermatitis. EYES: slightly irritating sensation and lachrymation; *General Treatment for Exposure*: Do NOT administer adrenaline or epinephrine; get medical attention for all cases of overexposure. INHALATION: remove victim to fresh air; if necessary, apply artificial respiration and/or

administer oxygen. INGESTION: have victim drink water and induce vomiting; repeat three times; then give 1 tablespoon Epsom salts in water. EYES: flush thoroughly with water. SKIN: wash thoroughly with soap and warm water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Inhalation Limits*: 200 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor cause slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 50 ppm.

Trichlorofluoromethane — (i) Chemical Designations — *Synonyms*: Arcton 9; Freon 11; Isceon 11; Eskimon 11; Frigen 11; Isotron 11;F-11; Genetron 11; Ucon 11; *Chemical Formula*: $CFCl_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Liquid; *Color*: Colorless; *Odor*: Odorless; weak chlorinated solvent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 137.4; *Boiling Point at 1 atm.*: 4.8, 23.8, 297.0; *Freezing Point*: -168, -111, 162; *Critical Temperature*: 388, 198, 471; *Critical Pressure*: 639.4, 43.5, 4.41; *Specific Gravity*: 1.49 at 20°C (liquid); *Vapor (Gas) Specific Gravity*: 4.7; *Ratio of Specific Heats of Vapor (Gas)*:(est.) 1.128; *Latent Heat of Vaporization*: 78.3, 43.5, 1.82; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air line respirator; rubber gloves; monogoggles; *Symptoms Following Exposure*: Breathing concentration approaching 10% in air will cause dizziness and drowsiness. Contact with tissues may cause frostbite; *General Treatment for Exposure*: INHALATION: remove victim to not-contaminated area and apply artificial respiration if breathing has stopped; call a physician immediately; oxygen inhalation may be utilized. SKIN: if frostbite has occurred, flush areas with warm water; *Toxicity by Inhalation (Threshold Limit Value)*: 1000 ppm; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-irritating; *Liquid or Solid Irritant Characteristics*: May cause frostbite; *Odor Threshold*: Data not available.

Trichlorophenol — (i) Chemical Designations — *Synonyms*: Dowicide-2; Omal; Phenachlor; 2,4,5-Trichlorophenol; *Chemical Formula*: 1-$HOC_6H_2Cl_3$-2,4,5; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: Colorless to gray; *Odor*: Strong disinfectant; **(iii) Physical and Chemical Properties** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 197.5; *Boiling Point at 1 atm.*: 485, 252, 525; *Freezing Point*: 135, 57, 330; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.7 at 25 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust respirator for toxic dust; goggles; protective clothing to prevent contact with skin. *Symptoms Following Exposure*: INHALATION: Dust may cause swelling of eyes and eye injury, irritation of nose and throat. Solid irritates skin on prolonged contact; *General Treatment for Exposure*: INHALATION: remove to fresh air; get medical attention; EYES: flush with water for at least 15 min.; get medical attention. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: 20% solution in fuel oil: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Essentially non-volatile at ordinary temperatures; *Liquid or Solid Irritant Characteristics*: May cause injury to eye. Prolonged contact with skin causes a slight burn. Dust irritates nose and throat; *Odor Threshold*: Data not available.

2,4,5-Trichlorophenoxy Acetic Acid — (i) Chemical Designations — *Synonyms*: 2,4,5-T; *Chemical Formula*: 2,4,5-$Cl_3C_6H_2OCH_2COOH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 255.5; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: 316, 158, 431; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.803 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -6,500, -3,600, -150; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask and rubber gloves. *Symptoms Following Exposure*: INHALATION: Overexposure to

dust by inhalation or ingestion may cause fatigue, nausea, vomiting, lowered blood pressure, convulsions, coma. Dust may irritate eyes and skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; if required, give artificial respiration. EYES: flush with water until irritating dust is removed. SKIN: wash with soap and water. INGESTION: call physician at once; induce vomiting and administer gastric lavage; *Toxicity by Inhalation (Threshold Limit Value)*: 10 mg/m^3; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, oral LD_{50} 500 mg/kg (rat); *Late Toxicity*: Birth defects in rats and mice. Causes an acne-like skin eruption among human workers; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Trichlorosilane — (i) Chemical Designations — *Synonyms*: Silicochloroform, Trichloromonosilane; *Chemical Formula*: $SiHCl_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Sharp, choking, like hydrochloric acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 135.5; *Boiling Point at 1 atm.*: 90, 32, 305; *Freezing Point*: -197, -127, 146; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.344 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 4.9; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 85, 47, 2.0; *Heat of Combustion*: -6,500, -3,600, -150; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation causes severe irritation of respiratory system. Liquid causes severe burns of eyes and skin. Ingestion causes severe burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from exposure; if breathing is difficult or stopped, give artificial respiration; call physician. EYES or SKIN: flush with plenty of water immediately for at least 15 min., and get medical attention. INGESTION: do NOT induce vomiting; give large amount of water; get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} = 1,000 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injure. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritation. Causes second-and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Trichloro-s-Triazinetrione — (i) Chemical Designations — *Synonyms*: Trichloroiminoisocyanuris acid; Trichloroisocyanuric acid; Trichloro-s-Triazine-2,4,6-(1H,3H,5H)-trion; Trichlorotriazinetrion; 1,3,5-Trichloro- 2,4,6-trioxo-1,3,5-triazine; *Chemical Formula*: $Cl_3(NCO)_3$; **(ii) Observable Characteristics** — *Physical State (as shipped)*: Solid; *Color*: White; *Odor*: Like chlorine; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: solid; *Molecular Weight*: 232.5; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) > 1 at 20 °C (solid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization:* Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask or chlorine canister mask, goggles; rubber gloves; *Symptoms Following Exposure*: Inhalation causes sneezing and coughing. Contact with dust causes moderate irritation of eyes and itching and redness of skin. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. EYES: irrigate with running water for 15 min.; call physician. SKIN: flush with water INGESTION: induce vomiting and call physician. *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} = 750 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Tricresyl Phosphate — (i) Chemical Designations — *Synonyms*: TCP; Tri-p-tolil phosphate; Tri-p-cresyl phosphate; *Chemical Formula*: $(p\text{-}CH_3C_6H_4O)_3PO$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 368; *Boiling Point at 1 atm.*: 770, 410, 683; *Freezing Point*:

-27, -33, 240; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.16 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: (est.) 80.0, 44.5, 1.86; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; *Symptoms Following Exposure*: Vapors may irritate eyes, but only at high temperatures. Ingestion of liquid may cause severe damage to central nervous system and death if significant amounts of the toxic ortho-isomer are present. *General Treatment for Exposure*: INGESTION: induce vomiting and call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (chicken LD_{50} > 2 g/kg); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary. The compound is not-volatile for all practical purposes; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Tridecanol — **(i) Chemical Designations** — *Synonyms*: Isotridecanol; Isotridecyl alcohol; 1-tridecanol; *Chemical Formula*: $C_{12}H_{25}CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Mild alcoholic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 200.37; *Boiling Point at 1 atm.*: 525, 274, 547; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.846 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.027; *Latent Heat of Vaporization*: 120, 64, 2.7; *Heat of Combustion*:: -12,200, -6,790, -284; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Synthetic rubber gloves; chemical goggles. *Symptoms Following Exposure*: Inhalator hazard slight. Skin contact results in moderate irritation. Liquid contact with eyes causes severe irritation and possible eye damage. *General Treatment for Exposure*: EYES: promptly flush with clean water for at least 15 min. and see a physician. SKIN: wash exposed area with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors are nonirritating to the eye and throat; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Data not available.

1-Tridecene — **(i) Chemical Designations** — *Synonyms*: Undecylethylene; *Chemical Formula*: $CH_3(CH_2)_{10}CH=CH_2$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 182.35; *Boiling Point at 1 atm.*: *451, 233, 506*; *Freezing Point*: -11, -24, 249; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.765 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.029; *Latent Heat of Vaporization*: 110, 59, 2.5; *Heat of Combustion*:: -19,048, -10,582, -443.05; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles of face shield. *Symptoms Following Exposure*: Liquid may irritate eyes. *General Treatment for Exposure*: EYES: flush with water for 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics: Non-volatile*; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Triethanolamine — **(i) Chemical Designations** — *Synonyms*: 2,2'2''-Nitrilotriethanol; Triethilolamine; Trihydroxytriethylamine; Tris(hydroxyethy)amine; *Chemical Formula*: $(HOCH_2CH_2)_3N$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Mild ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 149.19; *Boiling Point at 1 atm.*: decomposes; *Freezing Point*: 70.9, 21.6, 294.8; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.13 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 176, 97.8, 4.10; *Heat of Combustion*:: -11,050, -6140, -257; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards**

Information — *Recommended Personal Protective Equipment*: Goggles of face shield; rubber gloves and boots; *Symptoms Following Exposure*: Liquid may irritate eyes and skin; *General Treatment for Exposure*: EYES: flush with water for 15 min.; call a doctor. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics: Non-volatile*; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Triethylaluminum — (i) Chemical Designations — *Synonyms*: ATE; Aluminum triethyl; TEA; *Chemical Formula*: $(C_2H_5)_3Al$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Not pertinent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 114.2; *Boiling Point at 1 atm.*: 367.9, 186.6, 459.8; *Freezing Point*: -51, -46, 227; *Critical Temperature*: 761, 405, 678; *Critical Pressure*: 1,970, 134, 13.6; *Specific Gravity*: 0.836 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 216, 120, 5.02; *Heat of Combustion*:: -18,364, -10,202, -426.85; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full protection clothing, preferably of aluminized glass cloth; goggles; face shield; gloves. In case of fire, all purpose canister or self-contained breathing apparatus; *Symptoms Following Exposure*: Exposure to smoke from fire causes metal-fume (flu-like symptoms). Since liquid ignites spontaneously, contact with eyes or skin causes several burns; *General Treatment for Exposure*: INHALATION: only fumes from fire need be considered; metal-fume fever is not critical, lasting less then 36 hrs. EYES: flush gently with copious quantities of water for 15 min. with lids held open; treat burns if fire occurred; get medical attention. SKIN: wash with water; treat burns if fire occurred; get medical attention. *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics:* Not pertinent; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and very injurious to the see; *Odor Threshold*: Not pertinent.

Triethylamine — (i) Chemical Designations — *Synonyms*: TEN; *Chemical Formula*: $(C_2H_5)_3N$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Fishy; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 101.19; *Boiling Point at 1 atm.*: 193.1, 89.5, 362.7; *Freezing Point*: -174.5, -114.7, 158.5; *Critical Temperature*: 504, 262, 535; *Critical Pressure*: 440, 30, 3.0; *Specific Gravity*: 0.729 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: 3.5; *Ratio of Specific Heats of Vapor (Gas)*: 1.055; *Latent Heat of Vaporization*: 140, 80, 3.3; *Heat of Combustion*:: -17,040, -9,466, -369.3; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Air-supplied mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Vapors irritate nose, throat, and lungs, causing coughing, choking and difficult breathing. Contact with eyes causes several burns. Clothing wet with chemical causes burns; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give artificial respiration in needed; call a doctor. INGESTION: induce vomiting if patient is conscious. EYES: flush with water for at least 30 min.; call a doctor. SKIN: flush with water for at least 30 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm; *Short-Term Inhalation Limits*: 100 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg (rat - LD_{50} 460 mg/kg); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause moderate irritation, such that personnel will find high concentration unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Triethylbenzene — (i) Chemical Designations — *Synonyms*: 1,3,5-Triethylbenzene; sym Triethylbenzene; *Chemical Formula*: $C_6H_3(C_2H_5)_3$-1,3,5; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Weak aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 162.27; *Boiling Point at 1 atm.*: 421, 216, 489; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.861 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.039; *Latent Heat of Vaporization*: 120, 65, 2.7; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not

pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Eye irritation by vapors or liquid. Central nervous system depression. Prolonged skin contact with liquid can cause dermatitis; *General Treatment for Exposure*: EYES: flush with water for at least 15 min.; call a doctor. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Inhalation Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors cause a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may be cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

Triethylene Glycol — (i)Chemical Designations — *Synonyms*: Di-beta-hydroxyethoxy-ethan; 2,2'-Ethylenedioxydiethanol; Ethylene glycol dihydroxydiethyl ether; TEG; Triglycol; *Chemical Formula*: $HO(CH_2CH_2O)_3CH$; **(ii) Observable Characteristics** — *Physical State (as shipped)*:Liquid; *Color*: Colorless; *Odor*: Very mild, sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: liquid; *Molecular Weight*: 150.17; *Boiling Point at 1 atm.*: 550, 288, 561; *Freezing Point*: 24.3, -4.3, 268.9; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.125 at 20 °C (liquid); *Vapor (Gas) Specific Gravity*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.039; *Latent Heat of Vaporization*: 180, 99, 4.1; *Heat of Combustion*:: -10,190, -5,660, -237.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: goggles; plastic gloves; *Symptoms Following Exposure*: Vapors and liquid are unlikely to cause harm; *General Treatment for Exposure*: flush eyes and skin with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Inhalation Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg (guinea pig); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics:* Vapors are non-irritation to the eyes and skin; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

Triethylenetetramine — (i) Chemical Designations — *Synonyms*: N,N'-Bis(2-aminoethyl)-ethylenediamine; TETA; Trien; *Chemical Formula*: $NH_2(CH_2)_2NH(CH_2)_2$-$NH(CH_2)_2NH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Light straw; amber; *Odor*: Ammoniacal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 146.24; *Boiling Point at 1 atm.*: 531.3, 277.4, 550.6; *Freezing Point*: -31, -35, 238; *Critical Temperature*: 860, 460, 733; *Critical Pressure*: 470, 32, 3.2; *Specific Gravity*: 0.982 at 20 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.037; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -13,500, -7,530, -315.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Amine-type canister; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Vapors from hot liquid can irritate eyes and upper respiratory system. Liquid burns eyes and skin. May cause sensitization of skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; INGESTION: do NOT induce vomiting; give large quantities of water; give at least one ounce of vinegar in equal amount of water; get medical attention. SKIN: flush with plenty of water. EYES: flush with plenty of water for at least 15 min. and get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: May cause dermatitis, asthma and other allergic reaction in man; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentration unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Trifluorochloroethylene — (i) Chemical Designations — *Synonyms*: Chlorotrifluoroethylene; Kel F monomer; Plascon monomer; Trifluoromonochloroethylene; Trifluoroevinil chloride; *Chemical Formula*: $F_2C{=}CFCl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*:Compressed liquefied gas; *Color*: Colorless; *Odor*: None faint ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 116.5; *Boiling Point at 1 atm.*: -18, -28, 245; *Freezing Point*: Not pertinent; *Critical Temperature*: (est.) 223.2, 106.2, 379.4; *Critical*

Pressure: 592, 40.2, 4.08; *Specific Gravity*: 1.307 at 20 °C (liquid); *Vapor (Gas) Density*: 4.02; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 83, 46, 1.92; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Self-contained breathing apparatus; goggles; rubber gloves; *Symptoms Following Exposure*: Inhalation causing dizziness, nausea, vomiting; liver and kidney injury may develop after several hours and cause jaundice and necrosis of the kidney; *General Treatment for Exposure*: Call a physician after all exposures to this compound; it is more toxic then most oh the closely related propellant gases. INHALATION: remove victim to fresh air; enforce bed rest; administer oxygen for 30 min. of very hour oh 6 hours, even if no symptoms appear. SKIN: if frostbite has occurred, apply warm and tread burn; *Toxicity by Inhalation (Threshold Limit Value)*: 20 ppm (suggested); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent (TFC is a gas at normal temperatures); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Trifluralin — **(i) Chemical Designations** — *Synonyms*: 2,6-Dinitro-N,N-dipropyl-4-trifluoromethylaniline; 2,6-Dinitro-N,N-dipropyl-alpha, alpha-trifluoro-p-toluidine; N,N-Dipropyl-2,6-dinitro-4-trifluoro-methylaniline; Treflan; alpha, alpha-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine; *Chemical Formula*: $C_{13}H_{16}F_3N_3O_4$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow-orange; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 335.3; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 108, 42, 315; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.294 at 20 °C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -9,040, -5,020, -210; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; goggles; dust mask; *Symptoms Following Exposure*: Dust may irritate eyes. No toxic symptoms have been observed during the manufacture and use of this compound; *General Treatment for Exposure*: INHALATION: move to fresh air. EYES: wash with running water; call physician if irritation persist. SKIN: wash with soap and running water. INGESTION: induce vomiting; call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, oral LD_{50} = 500 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Triisobutylaluminum — **(i) Chemical Designations** — *Synonyms*: Aluminium triisobutyl; TIBA; TIBAL; *Chemical Formula*: $(iso\text{-}C_4H_9)_3Al$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Not pertinent; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 198.3; *Boiling Point at 1 atm.*: 414, 212, 485; *Freezing Point*: 33.8, 1.0, 274.2; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.788 at 20 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 101, 56, 2.3; *Heat of Combustion*: -18,423, -10,235, -428.23; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Full protective clothing, preferably of aluminized glass cloth; goggles; face shield; gloves. In case of fire, all-purpose canister or self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation of smoke from fire causes metal-fume fever (flu-like symptoms). Contact with liquid can cause severe burns of eyes and skin because of spontaneous ignition; *General Treatment for Exposure*: INHALATION: only fumes from fire need be considered; methal-fume fever lasts less than 36 hrs. and is not critical. EYES: flush gently with copious quantities of water for 15 min. with lids open; treat burns, if fire occurred; get medical attention. SKIN: wash with water; treat burns caused by fire; get medical attention. INGESTION: Not pertinent; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Not pertinent; *Late Toxicity*: Metal fume fever may develop following exposure to smoke from fire; *Vapor (Gas) Irritant Characteristics*: Not pertinent; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Not pertinent.

Trimethylamine — **(i) Chemical Designations** — *Synonyms*: No common synonyms; *Chemical Formula*:

$(CH_3)_3N$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Ammonical; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 59.11; *Boiling Point at 1 atm.*: 37.2, 2.9, 276.1; *Freezing Point*: -178.8, -117.1, -156.1; *Critical Temperature*: 320.2, 160.1, 433.3; *Critical Pressure*: 591, 40.2, 4.07; *Specific Gravity*: 0.633 at 20 °C (liquid); *Vapor (Gas) Density*: 2.0; *Ratio of Specific Heats of Vapor (Gas)*: 1.139; *Latent Heat of Vaporization*: 174, 96.5, 4.04; *Heat of Combustion*: -17,660, -9,810, -410.7; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Vapor-proof goggles and face shield; rubber gloves; air-supplied mask; *Symptoms Following Exposure*: Vapor irritates eyes, nose, and throat; high concentrations can cause pulmonary edema. Liquid burns eyes and skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air and call a doctor; give artificial respiration and oxygen if needed. EYES: flush with water for at least 15 min.; consult an eye doctor. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapor is moderately irritating such that personnel will not usually tolerate moderate or high concentrations; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure; *Odor Threshold*: less than 100 ppm.

Trimethylchlorosilane — (i) Chemical Designations — *Synonyms*: Chlorotrimethylsilane; Trimethylsilyl chloride; *Chemical Formula*: $(CH_3)_3SiCl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sharp, hydrochloric acid-like; acrid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 108.7; *Boiling Point at 1 atm.*: 135, 57, 330; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.846 at 20 °C (liquid); *Vapor (Gas) Density*: 3.7; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.0683; *Latent Heat of Vaporization*: 126, 70, 2.9; *Heat of Combustion*: (est.) -10,300, -5,700, -240; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection; rubber gloves; chemical worker's goggles; other protective equipment as necessary to protect skin and eyes; *Symptoms Following Exposure*: Inhalation of vapor irritates mucous membranes. Contact of liquid with eyes or skin causes severe burns of mouth and stomach; *General Treatment for Exposure*: Get medical attention all exposures to this compound. INHALATION: remove victim from exposure; if breathing is difficult or stopped, give artificial respiration. EYES: flush with water for 15 min. SKIN: flush with water. INGESTION: do NOT induce vomiting; give large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

Tripropylene Glycol — (i) Chemical Designations — *Synonyms*: Now common synonyms; *Chemical Formula*: $HO(C_3H_6)_2C_3H_6OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 192.26; *Boiling Point at 1 atm.*: Not pertinent (decomposes) 523, 273, 546; *Freezing Point*: (sets to glass) -49, -45, 228; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.022 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: (est.) -13,700, -7,6610, -318; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Plastic gloves; safety glasses of face shield; *Symptoms Following Exposure*: Non-irritation; no symptoms observed by any exposure route; *General Treatment for Exposure*: INGESTION: if large amounts are swallowed, induce vomiting; treat symptomatically. EYES: or SKIN: flush with water, get medical attention if ill effects develop; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50}=3,000 mg/kg (rat); *Late Toxicity*: Vapors are nonirritating to eyes and throat; *Vapor (Gas) Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Tris(Aziridinyl)Phosphine Oxide — (i) Chemical Designations — *Synonyms*: APO; Phosphoric acid triethileneimide; Triethylenephosphoramide; Tris (1-aziridinyl) phosphin oxide; *Chemical Formula*: $(CH_2CH_2N)_3PO$ or $C_6H_{12}N_3PO$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Data not available; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 173.16; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 106, 41, 314; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: (est.) >1 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective clothing and gloves to prevent contact with skin; goggles; *Symptoms Following Exposure*: Inhalation (unlikely unless a heave mist is formed) causes symptoms similar to the those observed after ingestion. Contact with liquid or powder causes irritation of eyes and (on prolonged contact) irritation and burns of skin. Burns are slow to develop and slow to heal. May sensitize on repeated contact. Ingestion causes depression, anorexia and diarrhea, appearing 2-3 days before death, followed by terminal dyspnea, incoordination, epistaxis, salivation and cyanosis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. EYES: flush with water at once for at least 15 min.; get medical attention. SKIN: flush with water at once, followed by vinegar and dilute hydrogen peroxide. INGESTION: only symptomatic and supportive measured are available; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral rat LD_{50}=37 mg/kg; *Late Toxicity*: None observed; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Turpentine — (i) Chemical Designations — *Synonyms*: D.D. turpentine, Gum turpentine, Spirits of turpentine, Sulfate turpentine, Turps, Wood turpentine; *Chemical Formula*: $C_{10}H_{16}$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Aromatic, rather unpleasant, penetrating; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: 302-320, 150-160, 423-433; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.86 at 15 C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Data not available; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister or air-supplied mask; goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Vapors cause headache, confusion, respiratory distress. Liquid irritates skin. If ingested, can irritate the entire digestive system and may injure kidneys. If liquid is taken into lungs, causes several pneumonitis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; call a doctor; administer artificial respiration and oxygen if required. INGESTION: give water and induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 200 ppm for 30 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Vapor causes a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may be cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

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Undecanol — (i) Chemical Designations — *Synonyms*: Hendecanoic alcohol; 1-Hendecanol; n-Hendecylenic alcohol; 1-Undecanol; Undecyl alcohol; Undecylic alcohol; *Chemical Formula*: $CH_3(CH_2)_9CH_2OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Faint alcohol; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 172.30; *Boiling Point at 1 atm.*: 473, 245, 518; *Freezing Point*: 60.6, 15.9, 289.1; *Critical Temperature*: 739, 393, 666; *Critical Pressure*: 308, 21, 2.1; *Specific Gravity*: 0.835 at 20 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.032; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: (est.) -18,000, -10,000, -419; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and face shield; *Symptoms Following Exposure*: Liquid can irritate eyes;

General Treatment for Exposure: Wash eyes with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: None; *Liquid or Solid Irritant Characteristics*: No appreciable hazard. Practically harmless to the skin; *Odor Threshold*: Not pertinent.

1-Undecene — (i) Chemical Designations — *Synonyms*: n-Nonylethylene; *Chemical Formula*: $CH_3(CH_2)_8CH=CH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild, pleasant; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 154.2; *Boiling Point at 1 atm.*: 378.9, 192.7, 465.9; *Freezing Point*: -56, 49, 224; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.750 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.035; *Latent Heat of Vaporization*: 154, 85.8, 3.59; *Heat of Combustion*: -19.084, -10.602, -443.89; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Aspiration hazard if ingested. Slight skin and eye irritation. No inhalation hazard expected; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. INGESTION: do NOT lavage or induce vomiting; give vegetable oil and demulcents; call a doctor. EYES: flush with water for 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Slight smarting of eyes and respiratory system at high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: Data not available.

n-Undecylbenzene — (i) Chemical Designations — *Synonyms*: 1-Phenylundecane; *Chemical Formula*: $C_6H_5(CH_2)_{10}CH_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Mild; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 232.4; *Boiling Point at 1 atm.*: 601, 316, 589; *Freezing Point*: 23, -5, 268; *Critical Temperature*: 918.1, 492.3, 765.5; *Critical Pressure*: 234, 15.9, 1.61; *Specific Gravity*: 0.855 at 20 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 101.27, 56.26, 2.354; *Heat of Combustion*: -19.490, -10.830, -453.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves; *Symptoms Following Exposure*: Ingestion may cause intestinal disturbances. Contact with eyes causes mild irritation; *General Treatment for Exposure*: INGESTION: induce vomiting if large amount has been swallowed. EYES: flush with water. SKIN: remove spills on skin or clothing by washing with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Uranyl Acetate — (i) Chemical Designations — *Synonyms*: Bis(acetato)dixouranium; Uranium acetate; Uranium acetate dihydrate; Uranium oxyacetate dihydrate; Uranyl acetate dihydrate; *Chemical Formula*: $UO_2(C_2H_3O_2)_2 \cdot 2H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: Slight vinegar; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 424.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.89 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Approved dust respirator; goggles or face shield; protective clothing; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Contact with eyes causes irritation; *General Treatment for Exposure*: *Get medical attention after all exposures to this compound.* INHALATION: move to fresh air. INGESTION: give large amount of water; induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as uranium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Tox-*

icity: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Uranyl Nitrate — (i) Chemical Designations — *Synonyms*: Uranium nitrate; *Chemical Formula*: $UO_2(NO_3)_2 \cdot 6H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Pale yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 502.13; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 140.4, 60.2, 333.4; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.81 at 13 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, gloves, goggles; *Symptoms Following Exposure*: Excessive inhalation of dust may cause irritation of lungs and delayed symptoms similar to those observed after ingestion. Dust irritates eyes and skin and may be absorbed through skin on prolonged exposure, ingestion causes irritation of mouth and stomach; inflammation of kidney and liver develops 1 to 4 days after exposure; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. EYES: Hush with water for at least 15 min.: see physician if irritation persists. SKIN: wash thoroughly with soap and water. INGESTION: administer large doses of sodium bicarbonate.(This will convert the uranium salt lo the bicarbonate, which is much less toxic.) Additional treatment is symptomatic get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: 0.05 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Delayed inflammation of kidneys. Airborne radioactive particles have apparent been responsible for a significantly increased death rate from lung cancer among long-term uranium miners; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Uranyl Sulfate — (i) Chemical Designations — *Synonyms*: Uranium sulfate; Uranium sulfate trihydrate; Uranyl sulfate trihydrate; *Chemical Formula*: $UO_2SO_4 \cdot 3H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 420.2; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.28 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved dust respirator; goggles or face shield; protective clothing; *Symptoms Following Exposure*: irritates eyes and skin, stomach; *General Treatment for Exposure*: *Get medical attention after all exposure to this compound.* INGESTION: give large amounts of water; induce vomiting. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.2 mg/m^3 (as uranium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5-15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Urea — (i) Chemical Designations — *Synonyms*: Carbamide, Carbonyldiamide; *Chemical Formula*: NH_2CONH_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Odorless, or slight ammonia odor; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 60.06; *Boiling Point at 1 atm.*: Decomposes; *Freezing Point*: 271, 133, 406; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.34 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -3913, -2174, -91.02; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; dust mask; *Symptoms Following Exposure*: May irritate eyes; *General Treatment for Exposure*: Wash eyes with water; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

Urea Peroxide — (i) Chemical Designations — *Synonyms*: Carbamide peroxide, Carbonyldiamine, Hydrogen peroxide carbamide, Percarbamide, Perhydrol-Urea, Urea hydrogen peroxide; *Chemical Formula*: $CO(NH_2)_2 \cdot H_2O_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 94.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.8 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: -540, -300, -12.5; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber gloves and protective goggles; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose From hydrogen peroxide formed when heated. Contact with eyes causes severe damage. Contact with moist skin causes temporary itching or burning sensation. Ingestion causes irritation of mouth and stomach; *General Treatment for Exposure*: INHALATION: remove victim from exposure; call physician. EYES: wash thoroughly with large quantities of water for at least 15 min., call physician; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Valeraldehyde — (i) Chemical Designations — *Synonyms*: Amyl aldehyde, Pentanal, Valeral Valeric aldehyde; *Chemical Formula*: $CH_3(CH_2)_3CHO$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Fruity; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 86.13; *Boiling Point at 1 atm.*: 217.4, 103.0, 376.2; *Freezing Point*: -132, -91, 182; *Critical Temperature*: 538, 281, 554; *Critical Pressure*: 514, 35, 3.5; *Specific Gravity*: 0.811 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.072; *Latent Heat of Vaporization*: 170, 93, 3.9; *Heat of Combustion*: -15.500, -8.610, -360.5; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Goggles or face shield; rubber gloves and boots; *Symptoms Following Exposure*: Vapor may irritate eyes. Liquid irritates eyes and skin; *General Treatment for Exposure*: EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg (mouse); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin; *Odor Threshold*: Data not available.

V

Vanadium Oxytrichloride — (i) Chemical Designations — *Synonyms*: Trichloroxo vanadium; Vanadyl chloride; Vanadyl trichloride; *Chemical Formula*: $VOCl_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Lemon yellow; *Odor*: Acrid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 173.3; *Boiling Point at 1 atm.*: 259, 126, 399; *Freezing Point*: -107, -77, 196; *Critical Temperature*: Data not available; *Critical Pressure*: Data not available; *Specific Gravity*: 1.83 at 20 °C (liquid); *Vapor (Gas) Density*: 5.98; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: Data not available; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Acid vapor mask, rubber gloves: face shield: acid-resistant clothing; *Symptoms Following Exposure*: Inhalation of vapor causes irritation of nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes or skin causes severe irritation; *General Treatment for Exposure*: *Consult a physician after all exposures to this compound.* INHALATION: move to fresh air: give artificial respiration if necessary. INGESTION: give large amount of water. EYES: flush with water for 15 min. SKIN: wipe exposed areas free of the chemical with a dry cloth, then flush thoroughly with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: 5 ppm (HCl) ceiling level, based on fact that compound decomposes in moist air into vanadic acid and HCl; *Toxicity by Ingestion*: Grade 3, LD_{50} = 140 mg/kg; *Late Toxicity*: Repeated exposures may cause discoloration of tongue, loss

of appetite, anemia, kidney disorders, and blindness; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: 10 ppm HCl, based on decomposition of compound in moist air.

Vanadium Pentoxide — (i) Chemical Designations — *Synonyms*: Vanadic anhydride, Vanadium pentaoxide; *Chemical Formula*: V_2O_5; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow-orange (powder), dark gray (flakes), yellow brown; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 181.88; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.36 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator: rubber gloves: goggles for prolonged exposure; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion causes irritation of mouth and stomach. Contact with eyes or skin causes irritation: eczema may develop; *General Treatment for Exposure*: INHALATION: move to fresh air: if exposure to dust has been severe, get medical attention. INGESTION: induce vomiting: get medical attention. EYES: flush w water for at least 15 min. SKIN: flush with water; wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, LD_{50} = 23 mg/kg (mouse); *Late Toxicity*: Repeated exposures may cause discoloration of tongue, loss of appetite, kidney disorders, and blindness; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Vanadyl Sulfate — (i) Chemical Designations — *Synonyms*: Vanadium oxysulfate, Vanadyl sulfate dihydrate; *Chemical Formula*: $VOSO_4 \cdot 2H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Pale blue; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 199.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.5 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask, goggles or face shield: protective gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat, ingestion is irritation of mouth and stomach. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air; if exposure to dust has been severe, medical attention. INGESTION: give large amount of water; induce vomiting; get medical attention. EYES: flush with water for at least 15 min. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, LD_{50} 500-500 mg/kg; *Late Toxicity*: Repeated exposures may cause discoloration of tongue, loss of appetite, anemia, and blindness; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Vinyl Acetate — (i) Chemical Designations — *Synonyms*: VAM, Vinyl A monomer, Vy Ac; *Chemical Formula*: $CH_3COOCH{=}CH_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Not unpleasant, sweet smell in small quantities; pleasant fruity; characteristic; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Liquid; *Molecular Weight*: 86.09; *Boiling Point at 1 atm.*: 163.2, 72.9, 346.1; *Freezing Point*: -135.0, -92.8, 180.4; *Critical Temperature*: 486, 252, 525; *Critical Pressure*: 617, 42, 4.25; *Specific Gravity*: 0.934 at 20 C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: 1.103; *Latent Heat of Vaporization*: 163, 90.6, 3.79; *Heat of Combustion*: -9754, -5419, -226.9; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister or air-supplied mask; goggles or face shield; rubber or plastic gloves; *Symptoms Following Exposure*: High vapor concentrations cause narcosis. Liquid irritates eyes and may irritate skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; give artificial respiration if required. EYES: flush with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*: 10 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*:

Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 0.12 ppm.

Vinyl Chloride — (i) Chemical Designations — *Synonyms*: Chloroethene, Chloroethylene, Vinyl C Monomer, VCL,VCM; *Chemical Formula*: CH_2=CHCl; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquefied gas; *Color*: Colorless; *Odor*: Pleasant, sweet; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 62.50; *Boiling Point at 1 atm.*: 7.2, -13.8, 259.4; *Freezing Point*: -244.8, -153.8, 259.4; *Critical Temperature*: 317.1, 158.4, 431.6; *Critical Pressure*: 775, 52.7, 5.34; *Specific Gravity*: 0.969 at-13 °C (liquid); *Vapor (Gas) Density*: 2.2; *Ratio of Specific Heats of Vapor (Gas)*: 1.186; *Latent Heat of Vaporization*: 160, 88, 3.7; *Heat of Combustion*: -8136, -4520,-189.1; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves and shoes; gas-tight goggles, organic vapor canister or self-contained breathing apparatus; *Symptoms Following Exposure*: INHALATION: high concentrations cause dizziness, anesthetic lung irritation. SKIN: may cause frostbite; phenol inhibitor may be absorbed through skin if large amounts of liquid evaporate; *General Treatment for Exposure*: INHALATION: remove patient lo fresh air arid keep him quiet and warm, call a doctor; give artificial respiration if breathing stops. EYES AND SKIN: flush with plenty of water for at least 15 min.; for eyes, get medical attention; remove contaminated clothing; *Toxicity by Inhalation (Threshold Limit Value)*: 200 ppm; *Short-Term Exposure Limits*: 500 ppm for 5 min.; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Chronic exposure may cause liver damage; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin. May cause frostbite; *Odor Threshold*: 260 ppm.

Vinyl Fluoride, Inhibited — (i) Chemical Designations — *Synonyms*: Fluoroethylene, Monofluoro ethylene; *Chemical Formula*: CH_2=CHF; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Faint ethereal; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*:Gas; *Molecular Weight*: 46.1; *Boiling Point at 1 atm.*: -98, -72, 201; *Freezing Point*: -258, -161, 112; *Critical Temperature*: 130.5, 54.7, 327.9; *Critical Pressure*: 760, 51.6, 5.24; *Specific Gravity*: 0.707 at 0°C (liquid); *Vapor (Gas) Density*: 1.6; *Ratio of Specific Heats of Vapor (Gas)*: 1.2097; *Latent Heat of Vaporization*: 156, 86.5, 3.62; *Heat of Combustion*: (est.) -6.500, -3.600, -150; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Protective gloves; safety glasses; self-contained breathing apparatus; *Symptoms Following Exposure*: Inhalation of vapor causes slight intoxication, some shortness of breath. Liquid may cause frostbite of eyes or skin; *General Treatment for Exposure*: INHALATION: remove victim to fresh air. SKIN: if frostbite has occurred, immerse in warm water, treat burn; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Not pertinent (gas at normal temperatures); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Vinylidene Chloride, Inhibited — (i) Chemical Designations — *Synonyms*: 1,1-Dichloroethylene, unsym-Dichloroethylene; *Chemical Formula*: CH_2=CCl_2; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Sweet, like carbon tetrachloride or chloroform; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 96.95; *Boiling Point at 1 atm.*: 88.9, 31.6, 304.8; *Freezing Point*: -187.6, -122.0, 151.2; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.21 at 20 C (liquid); *Vapor (Gas) Density*: 3.3; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 130, 72, 3.0; *Heat of Combustion*: -4860, -2700, -113.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister or air-supplied mask: goggles or face shield, rubber gloves and boots; *Symptoms Following Exposure*: Vapor can cause dizziness and drunkenness: high levels cause anesthesia. Liquid irritates eyes and skin; *General Treatment for Exposure*: INHALATION: if any illness develops, remove person to fresh air pr keep warm and

quiet, and get medical attention; if breathing stops, start artificial respiration. INGESTION: not likely a problem, no known antidote, treat symptomatically. EYES OR SK flush with plenty of water for at least 15 min.; get medical attention for eyes; remove contaminated clothing and wash before reuse; *Toxicity by Inhalation (Threshold Limit Value)*: 25 ppm (suggested); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 3, Oral LD_{50} 24 hr = 84 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Causes smarting of the skin and first-degree burns oi short exposure, may cause secondary burns on long exposure; *Odor Threshold*: Data not available.

Vinyl Methyl Ether, Inhibited — (i) Chemical Designations — *Synonyms*: Methoxyethylene, Methyl vinyl ether; *Chemical Formula*: $CH_2=CH\text{-}O\text{-}CH_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquefied compressed gas; *Color*: Colorless; *Odor*: Sweet, pleasant; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Gas; *Molecular Weight*: 58.1; *Boiling Point at 1 atm.*: Not pertinent (decomposes) 41.9, 5.5, 278.7; *Freezing Point*: -188, -122, 151; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.777 at 0 °C (liquid); *Vapor (Gas) Density*: 2.0; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.1473; *Latent Heat of Vaporization*: (est.) 180, 100, 4.2; *Heat of Combustion*: (est.) -14.200, -7.900, -330; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Organic-vapor musk: plastic or rubber gloves, safety glasses; *Symptoms Following Exposure*: Inhalation causes intoxication, blurring of vision, headache, dizziness, excitation, loss of consciousness. Liquid or concentrated vapor irritates eyes and causes frostbite of skin. Aspiration of the liquid will cause chemical pneumonitis; *General Treatment for Exposure*: INHALATION: remove victim to fresh air if breathing is difficult, administer oxygen; call physician. EYES: wash with copious quantities of water; consult an eye specialist. SKIN: wash with copious quantities of water; treat frostbite by use of warm water or blankets. INGESTION: do NOT induce vomiting: get medical attention; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Vinyltoluene — (i) Chemical Designations — *Synonyms*: Methylystyrene; *Chemical Formula*: $CH_3C_6H_4CH=CH_2$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Disagreeable; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*:Liquid; *Molecular Weight*: 118.18; *Boiling Point at 1 atm.*: 333.9, 167.7, 440.9; *Freezing Point*: -106.6, -77.0, 196; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.897 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: (est.) 1.060; *Latent Heat of Vaporization*: 150, 83.5, 3.50; *Heat of Combustion*: -17.710, -9840, -412.0; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Air-supplied mask, goggles or lace shield, plastic gloves; *Symptoms Following Exposure*: Vapors irritate eyes and nose, high levels cause dizziness drunkenness, and anesthesia. Liquid irritation eyes and may irritate skin; *General Treatment for Exposure*: INHALATION: remove person to fresh air, give artificial respiration and oxygen if needed; call a doctor. INGESTION: do NOT induce vomiting; no known antidote. Call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 400 ppm for 5 min.; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 to 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin; *Odor Threshold*: 50 ppm.

Vinyltrichlorosilane — (i) Chemical Designations — *Synonyms*: Trichlorovinylsilane, Trichlorovinylsilicane, Vinylsilicon trichloride; *Chemical Formula*: $CH_2=CHSiCl_3$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless or pale yellow; *Odor*: Sharp, choking, like hydrochloric acid; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 161.5; *Boiling Point at 1 atm.*: 195.1, 90.6, 363.8; *Freezing Point*: -139, -95, 178; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.26 at 20 °C (liquid); *Vapor (Gas)*

Density: 5.61; *Ratio of Specific Heats of Vapor (Gas)*: Data not available; *Latent Heat of Vaporization*: 88, 49, 2.0; *Heat of Combustion*: (est.) -4.300, -2.400, -100; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Acid-vapor-type respiratory protection, rubber gloves, chemical worker's goggles; other protective equipment as necessary lo protect skin and eyes; *Symptoms Following Exposure*: Inhalation causes irritation of mucous membranes. Vapor irritates eyes. Contact with liquid causes severe burns of eyes and skin. Ingestion causes burns of mouth and stomach; *General Treatment for Exposure*: *Get medical attention following all exposures to this compound.* INHALATION: remove victim from exposure; give artificial respiration if required. EYES: flush with water for 15 min. SKIN: Hush with water. INGESTION: do NOT induce vomiting: give large amount of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} = 1.280 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Vapors cause severe irritation of eyes and throat and can cause eye and lung injury. They cannot be tolerated even at low concentrations; *Liquid or Solid Irritant Characteristics*: Severe skin irritant. Causes second- and third-degree burns on short contact and is very injurious to the eyes; *Odor Threshold*: Data not available.

W

Waxes: Carnauba — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Yellow to dark brownish green; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 176-187, 80-86, 353-359; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.998 at 20°C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Data not available; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; protective gloves and clothing for hot liquid wax; *Symptoms Following Exposure*: Hot wax can burn skin and eyes; *General Treatment for Exposure*: SKIN OR EYE CONTACT: remove solidified wax from skin, wash with soap and water; if in eyes, or if skin is burned, call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Hot wax can burn skin and eyes; *Odor Threshold*: Not pertinent.

Waxes: Paraffin — (i) Chemical Designations — *Synonyms*: Petroleum wax; *Chemical Formula*: Not pertinent; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid to hard solid; *Color*: Yellow to white; *Odor*: Very weak; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: Not pertinent; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 118 - 149, 48 - 65, 321 - 338; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 0.78-0.79 at 20°C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -18.000, -10.000, -430; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles or face shield; protective gloves and clothing for hot liquid wax; *Symptoms Following Exposure*: Hot wax can burn skin and eyes; *General Treatment for Exposure*: SKIN OR EYE CONTACT: remove solidified wax, wash with soap and water; if in eyes, call a doctor; *Toxicity by Inhalation (Threshold Limit Value)*: Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 1, LD_{50} 5 to 15 g/kg; *Late Toxicity*: None; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: None; *Odor Threshold*: Not pertinent.

X

m-Xylene — (i) Chemical Designations — *Synonyms*: 1,3-Dimethilbenzene, Xylol; *Chemical Formula*: m-$C_6H_4(CH_3)_2$; (ii) **Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like benzene; characteristic aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 106,16; *Boiling Point at 1 atm.*: 269.4, 131.9, 405.1; *Freezing Point*: -54.2, -47.9, 225.3; *Critical Temperature*: 680.5, 343.8, 617.0; *Critical Pressure*: 34.95, 513.8, 3.540;

Specific Gravity: 0.864 at 20 °C; *Vapor (Gas) Density*: 36.4 dynes/cm =0.0364 n/m at 30 °C; *Ratio of Specific Heats of Vapor (Gas)*: 1.071; *Latent Heat of Vaporization*: 147, 81.9, 3.43; *Heat of Combustion*: -17,554, -9752, -408.31; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister or Air-supplied mask; goggles and face shield; plastic gloves and boots; *Symptoms Following Exposure*: Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and coma; can be fatal. Kidney and liver damage can occur; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 300 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 g/kg; *Late Toxicity*: Kidney and liver damage; *Vapor (Gas) Irritant Characteristics*: Vapor causes a slight smarting of the eyes or respiratory system if present in high concentration; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may be cause smarting and reddening of the skin; *Odor Threshold*: 0.05 ppm.

o-Xylene — *Synonyms*: 1,2-Dimethilbenzene; *Chemical Formula*: o-$C_6H_4(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Benzene-like; characteristic aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Liquid; *Molecular Weight*: 106,16; *Boiling Point at 1 atm.*: 291.9, 144.4, 417.6; *Freezing Point*: -13.3, -25.2, 248.0; *Critical Temperature*: 674.8, 357.1, 630.3; *Critical Pressure*: 36.84, 541.5, 3.732; *Specific Gravity*: 0.880 at 20 C; *Vapor (Gas) Density*: 30.53 dynes/cm = 0.03053 N/m at 15.5 C; *Ratio of Specific Heats of Vapor (Gas)*: 1.068; *Latent Heat of Vaporization*: 149, 82.9, 3.47; *Heat of Combustion*: -17,558, -9754, -408.41; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister or air-supplied mask; goggles and face shield; plastic gloves and boots; *Symptoms Following Exposure*: Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and coma; can be fatal. Kidney and liver damage can occur; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 300 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Kidney and liver damage; *Vapor (Gas) Irritant Characteristics*: Vapor causes a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may be cause smarting and reddening of the skin; *Odor Threshold*: 0.05 ppm.

p-Xylene — *Synonyms*: 1,4-Dimethilbenzene; *Chemical Formula*: p-$C_6H_4(CH_3)_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Like benzene; characteristic aromatic; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 106,16; *Boiling Point at 1 atm.*: 280.9, 138.3, 411.5; *Freezing Point*: 55.9, 13.3, 286.5; *Critical Temperature*: 649.4, 343.0, 616.2; *Critical Pressure*: 34.65, 509.4, 3.510; *Specific Gravity*: 0.861 at 20 °C; *Vapor (Gas) Density*: 28.3 dynes/cm = 0.0283 N/m at 20°C; *Ratio of Specific Heats of Vapor (Gas)*: 1.071; *Latent Heat of Vaporization*: 150, 81, 3.4; *Heat of Combustion*: -17,559, -9754.7, -408.41; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Approved canister or air-supplied mask; goggles and face shield; plastic gloves and boots; *Symptoms Following Exposure*: Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and coma; can be fatal. Kidney and liver damage can occur; *General Treatment for Exposure*: INHALATION: remove victim to fresh air; administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 100 ppm; *Short-Term Exposure Limits*: 300 ppm for 30 min.; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Kidney and liver damage; *Vapor (Gas) Irritant Characteristics*: Vapor causes a slight smarting of the eyes or respiratory system if present in high concentration. The effect is temporary; *Liquid or Solid Irritant Characteristics*: Minimum hazard. If spilled on clothing and allowed to remain, may be cause smarting and reddening of the skin; *Odor Threshold*: 0.05 ppm.

Xylenol — (i) Chemical Designations — *Synonyms*: Cresylic acid; 2,6-Dimetuylphenol; 2-Hydroxy-m-xylene; 2,6-Xylenol; vic-m-Xylenol; *Chemical Formula*: $2,6\text{-}(CH_3)_2C_6H_3OH$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or liquid; *Color*: Light yellow-brown; *Odor*: Sweet tarry; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid or liquid; *Molecular Weight*: 122.2; *Boiling Point at 1 atm.*: 413, 212, 485; *Freezing Point*: -40 to +106, -40 to +45, 233 to 318; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.01 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: 212.74, 118.19, 4.9451 at 25 °C; *Heat of Combustion*: -15,310, -8,500, -356 at 25 °C; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Organic canister mask; goggles and face shield; rubber gloves; other protective clothing to prevent contact with skin; *Symptoms Following Exposure*: Vapor irritates eyes, nose, and throat and readily absorbed through mucous membranes and lungs; producing general toxic symptoms (weakness, dizziness, headache, difficult breathing, twitching). Contact with skin causes temporary prickling and intense burning, then local anesthesia. Affected areas initially show white discoloration, wrinkling, and softening, then become red, then brown or black (sings of gangrene). Extensive burns may permit absorption of chemical to produce toxic symptoms described above. Ingestion causes irritation of mouth and stomach, nausea, abdominal pain, weakness, dizziness, headache, difficult breathing, and twitching; *General Treatment for Exposure*: Get medical attention at once following exposure to this compound. INHALATION: remove patient immediately to fresh air; irritation of nose or throat may be somewhat relieved by spraying or gargling with water until all odor is gone; 100% oxygen inhalation is indicated for cyanosis or respiratory distress; keep patient warm, but not hot. EYES: flood with running water for 15 min.; if physician is not immediately available, continue irritation for another 15 min.; do not use oils or oily ointments unless ordered by physician. SKIN: wash affected areas with large quantities of water or soapy water until all odor is gone; then wash with alcohol or 20% glycerin solution and more water; keep patient warm, but not hot; cover chemical burns continuously with compresses wet with saturated solution of sodium thiosulphate; apply no salves or ointments for 24 hrs after injury. INGESTION: give large quantities of liquid (salt water, weak sodium bicarbonate solution, milk, or gruel) followed by demulcent such as raw egg white or corn starch paste; if profuse vomiting does not follow immediately, give a mild emetic (such as 1 tbsp. mustard in glass of water), or tickle back of throat. Repeat procedure until vomitus is free of the odor. Some demulcent should be left in stomach after vomiting. Keep patient comfortably warm; *Toxicity by Inhalation (Threshold Limit Value)*: 45 ppm; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50}=1,070 mg/kg (mouse); *Late Toxicity*: Damage to heart muscle, and changes in liver, kidney in rats; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

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Zinc Acetate — (i) Chemical Designations — *Synonyms*: Acetic acid, zinc salt; Dicarbomethoxyzine; Zinc acetate dehydrat; Zinc diacetate; *Chemical Formula*: $Zn(C^2H^3O^2)^2$ or $Zn(C^2H^3O^2)^22H^2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Faint acetic acid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 219.49; *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.74 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respiration; rubber gloves; Chemical goggles; *Symptoms Following Exposure*: Inhalator causes mild irritation of nose and throat, coughing, and sneezing. Ingestion can cause irritation or corrosion of the alimentary tract, resulting in vomiting. Contact with dust causes irritation of eyes and mild irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air; if exposure is severe, get medical attention. INGESTION: induce vomiting; followed by prompt and complete gastric lavage, cathartics, and demulcents. EYES: flush with water for at least 10 min.; consult physician if irritation persists. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant*

Characteristics: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Ammonium Chloride — (i) Chemical Designations — *Synonyms*: Ammonium pentachlorozincate; Ammonium zinc zhloride; *Chemical Formula*: $ZnCl_2 3NH_4Cl$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 296.8; *Boiling Point at 1 atm.*: (sublimes) 644, 340, 613; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.81 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Dust mask; Goggles and face shield; protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat. Ingestion can cause irritation or corrosion of the alimentary tract. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: remove dust. INGESTION: immediately induce evacuation of intestinal tract by inducing vomiting and giving gastric lavage and saline cathartic; see physician at once; consider development of arsenic poisoning; *Toxicity by Inhalation (Threshold Limit Value)*: 0.5 mg/m_3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Data not available; *Late Toxicity*: May be carcinogenic. Arsenic poisoning may develop; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Not pertinent.

Zinc Acetate — (i) Chemical Designations — *Synonyms*: Acetic acid, zinc salt; Dicarbomethoxyzic; Zinc acetate dihydrate; Zinc dicetate; *Chemical Formula*: $Zn(C_2H_3O_2)2$ or $Zn(C_2H_3O_2)_2 \cdot 2H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Faint acetic aid; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 219.49; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.47 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; Heat of Decomposition: (approx.) -0.5, -0.3, -0.01; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Bu. Mines approved respirator; rubber gloves; chemical goggles; *Symptoms Following Exposure*: Inhalation causes mild irritation of nose and throat, coughing, and sneezing. Ingestion can cause irritation or corrosion of the alimentary tract, resulting in vomiting. Contact with dust causes irritation of eyes and mild irritation of skin; *General Treatment for Exposure*: INHALATION: move to fresh air; if exposure is severe, get medical attention. INGESTION: induce vomiting, followed by prompt and complete gastric lavage, cathartic, and demulcents. EYES: flush with water for at least 10 min.; consult physician if irritation persists. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Bromide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $ZnBr_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 C and 1 atm.*: Solid; *Molecular Weight*: 225.18; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.22 at 20 °C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Chemical goggles and face shield; dust mask; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Ingestion can cause irritation or corrosion of the alimentary tract; if large amount is swallowed and not thrown up, drowsiness and other symptoms of bromide poisoning may occur. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount off water; induce vomiting, followed by prompt and complete gastric lavage, catharsis, and demulcents. EYES or SKIN: wash immediately with large volumes of water; *Toxicity by Inhalation (Threshold Limit Value)*:

Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 15 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Chloride — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: $ZnCl_2$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Odorless; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 136.28; *Boiling Point at 1 atm.*: Very high; *Freezing Point*: 541, 283, 556; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.91 at 25 °C; *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Goggles and face shield; *Symptoms Following Exposure*: Solid or water solution is astringent and can irritate the eyes. When ingested, can cause intoxication, several irritation of stomach, nausea, vomiting, and diarrhea; *General Treatment for Exposure*: INGESTION: give large volumes of water and induce vomiting; repeat process; call a doctor. EYES: wash with water for at least 15 min.; *Toxicity by Inhalation (Threshold Limit Value)*:Not pertinent; *Short-Term Exposure Limits*: Not pertinent; *Toxicity by Ingestion*: Grade 3, LD_{50} 50 to 500 mg/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Non-volatile; *Liquid or Solid Irritant Characteristics*: Solid irritates skin on prolonged contact; *Odor Threshold*: Not pertinent.

Zinc Chromate — (i) Chemical Designations — *Synonyms*: Buttercup yellow; Zinc chromate (VI) hydroxide; Zinc yellow; *Chemical Formula*: $4ZnO{\bullet}K_2O{\bullet}4CrO{\bullet}3H_2O$; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid; *Color*: Yellow; *Odor*: None; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 874 (approx.); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 3.43 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Suitable respirator (For dust): rubber gloves: chemical goggles or face shield; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion can cause irritation or corrosion of the alimentary tract, circulatory collapse, and toxic nephritis. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air: if exposure has been severe, gel medical attention. INGESTION: induce vomiting, followed by prompt and complete gastric lavage. catharsis, and demulcents. EYES: flush with water. SKIN: wash thoroughly with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 0.1 mg/m^3; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Possible lung cancer; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Dialkyldithiophosphate — (i) Chemical Designations — *Synonyms*: ZincO.O-di-n-butylphos: phorodithioale; Zinc dihexyldithio-phosphalc; Zinc dihexylphosphoro-dithioate; *Chemical Formula*: $[(RO)_2PSS]_2Zn$ where $R=C_4H_9$ etc.; **(ii) Observable Characteristics** — *Physical State (as normally shipped)*: Solid or liquid; *Color*: Straw yellow; yellow-green; *Odor*: Sweet, alcohol-like; **(iii) Physical and Chemical Properties** — *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 548 (approx.); *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.12-1.26 at 20 °C (liquid) 1.6 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information** — *Recommended Personal Protective Equipment*: Rubber gloves: safety glasses or face shield: dust respirator for solid form; *Symptoms Following Exposure*: (All commercially available members of this class have about the same health hazards.) Inhalation of dust can cause respiratory discomfort. Ingestion causes irritation of mouth and stomach. Contact with eyes causes moderately severe irritation. Contact with skin causes mild irritation; *General Treatment for Exposure*: INHALATION: move from exposure. INGESTION: if large amounts have been ingested, induce vomiting. EYES: flush with copious

amounts of water, if irritation persists, consult a physician. SKIN: wash affected areas with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Fluoroborate — (i) Chemical Designations — *Synonyms*: Zinc fluoborate solution; *Chemical Formula*: $Zn(SF_4)_2$-H_2O; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Liquid; *Molecular Weight*: 238.98 (solute only); *Boiling Point at 1 atm.*: (approx.) 212, 100, 373; *Freezing Point*: Data not available; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.45 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber gloves; safely glasses or face shield; *Symptoms Following Exposure*: Ingestion may cause irritation or corrosion tract. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INGESTION: give gastric lavage, cathartics, and demulcents. EYES: flush with plenty of water: get medical attention. SKIN: flush with plenty of water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Nitrate — (i) Chemical Designations — *Synonyms*: Zinc nitrate hexahydrate; *Chemical Formula*: $Zn(NO_3)_2 \cdot 6H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*:Solid; *Molecular Weight*: 297.47; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: 97, 36, 309; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.07 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield: protective gloves; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Ingestion can cause irritation or corrosion of the alimentary tract. Contact with eyes causes irritation, which may be delayed. Contact with skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: induce vomiting, followed by prompt and complete gastric lavage, cathartics, and demulcents. EYES: flush with water; consult a physician. SKIN: wash with soap and water.; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, oral LD_{50} = 2.500 mg/kg; *Late Toxicity*: Causes enlarged liver, spleen, and bone marrow in rabbits; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Zinc Phenolsulfonate — (i) Chemical Designations — *Synonyms*: p-Hydroxybenzenesulfonic acid, zinc salt; Zinc p-phenolsulfonate: Zinc phenolsulfonate octahydrate: Zinc sulfocarbolate; Zinc sulfophenate; *Chemical Formula*: $(1,4\text{-}HOC_6H_4SO_3)_2Zn \cdot 8H20$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 C and 1 atm.*: Solid; *Molecular Weight*: 555.8; *Boiling Point at 1 atm.*: (decomposes) 248, 120, 393; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask: goggles or Face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust may irritate nose and throat. Ingestion of large doses has emetic and astringent effects, can cause irritation or corrosion of the alimentary tract. Contact with eyes causes irritation. Contact with skin causes mild irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: if large amount has been swallowed, induce vomiting, followed by prompt and complete gastric lavage, cathartics, and demulcents. EYES or SKIN: flush with water; *Tox-*

icity by Inhalation (Threshold Limit Value): Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Odorless.

Zinc Phosphide — (i) Chemical Designations — *Synonyms*: No common synonyms; *Chemical Formula*: Zn_3P_2; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Gray or gray-black; *Odor*: Faint phosphorus; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 258.10; *Boiling Point at 1 atm.*: 2.012, 1.110, 1.373; *Freezing Point*: (sublimes) 788, 420, 693; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 4.55 at 13 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: -4.100, -2.270, -95; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask or self-contained breathing apparatus; goggles or face shield: protective gloves; *Symptoms Following Exposure*: When inhaled or ingested, compound releases phosphine, which causes faintness, weakness, nausea, vomiting, dyspnea, fall in blood pressure, change in pulse rate, diarrhea, intense thirst, convulsions, paralysis, and coma. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move lo fresh air; give artificial respiration if required; get medical attention for phosphine poisoning. INGESTION: give one tablespoonful of mustard in a glass of warm water; repeat until vomit fluid is clear; avoid use of all oils; call a physician immediately; have patient lie down and keep warm. EYES: flush with water for at least 15 min. SKIN: flush with water, wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 4, oral LD_{50} = 40 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Silicofluoride — (i) Chemical Designations — *Synonyms*: Zinc fluosilicate; Zinc hexafluorosilicate; Zinc silicofluoride hexahydrate; *Chemical Formula*: $ZnSiF_6 \cdot 6H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; transparent; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 315.5; *Boiling Point at 1 atm.*: 122 - 158, 50 - 70, 232 - 343; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 2.10 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust respirator: chemical goggles or face shield: protective gloves; *Symptoms Following Exposure*: Inhalation of dust irritates nose and throat, excessive inhalation may cause severe pulmonary inflammation. Ingestion causes nausea, cramps, vomiting, shock, convulsions, cyanosis, and other symptoms of fluoride poisoning. Contact with eyes or skin causes irritation: skin ulcers may develop; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: cause vomiting by giving soapy water or mustard water: have patient drink large quantities of lime water: if necessary, give stimulant such as strong coffee. EYES: flush with water: call physician as necessary. SKIN: wash with soap and water; *Toxicity by Inhalation (Threshold Limit Value)*: 2.5 mg/m^3 (as fluoride); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: LD_{LO} = 100 mg/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zinc Sulfate — (i) Chemical Designations — *Synonyms*: White vitroil; Zinc sulfate heptahydrate; Zinc vitriol; *Chemical Formula*: $ZnSO_4 \cdot 7H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: Colorless; *Odor*: None; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 287.54; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: (decomposes) 122 -212, 50 -100, 323 - 373; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.96 at 20 °C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask, gog-

gles or face shield, protective gloves; *Symptoms Following Exposure*: Inhalation of dust causes irritation of nose and throat. Ingestion can cause irritation or corrosion of the alimentary tract. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: induce vomiting, followed by prompt and complete gastric lavage, cathartics, and demulcents. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: Data not available; *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5-5 g/kg; *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zirconium Acetate — (i) Chemical Designations — *Synonyms*: Zirconium acetate solution; *Chemical Formula*: $Zr(C_2H_3O_2)_4$-H_2O; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Liquid; *Color*: Colorless; *Odor*: Weak vinegar; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*:Liquid; *Molecular Weight*: 327 (solute only); *Boiling Point at 1 atm.*: Not pertinent; *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: 1.37 at 20 °C (liquid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Rubber gloves; chemical goggles or face shield; *Symptoms Following Exposure*: Has only a mild pharmacological action. Contact with eyes or skin may cause irritation; *General Treatment for Exposure*: INGESTION: give large amount of water. EYES: flush with water for at least 15 min.; consult a physician if irritation persist. SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m_3 (as zirconium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} 0.5 - 5 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

Zirconium Nitrate — (i) Chemical Designations — *Synonyms*: Zirconium nitrate; *Chemical Formula*: $Zr(NO_3)\cdot 5H_2O$; **(ii) Observable Characteristics —** *Physical State (as normally shipped)*: Solid; *Color*: White; *Odor*: Nine; **(iii) Physical and Chemical Properties —** *Physical State at 15 °C and 1 atm.*: Solid; *Molecular Weight*: 429.3; *Boiling Point at 1 atm.*: Not pertinent (decomposes); *Freezing Point*: Not pertinent; *Critical Temperature*: Not pertinent; *Critical Pressure*: Not pertinent; *Specific Gravity*: > 1 at 20 C (solid); *Vapor (Gas) Density*: Not pertinent; *Ratio of Specific Heats of Vapor (Gas)*: Not pertinent; *Latent Heat of Vaporization*: Not pertinent; *Heat of Combustion*: Not pertinent; *Heat of Decomposition*: Not pertinent; **(iv) Health Hazards Information —** *Recommended Personal Protective Equipment*: Dust mask; goggles or face shield; protective gloves; *Symptoms Following Exposure*: Has only a mild pharmacological action. Inhalation of dust may irritate nose and throat. Contact with eyes or skin causes irritation; *General Treatment for Exposure*: INHALATION: move to fresh air. INGESTION: give large amount of water. EYES or SKIN: flush with water; *Toxicity by Inhalation (Threshold Limit Value)*: 5 mg/m_3 (as zirconium); *Short-Term Exposure Limits*: Data not available; *Toxicity by Ingestion*: Grade 2, LD_{50} = 25 g/kg (rat); *Late Toxicity*: Data not available; *Vapor (Gas) Irritant Characteristics*: Data not available; *Liquid or Solid Irritant Characteristics*: Data not available; *Odor Threshold*: Data not available.

6

EMERGENCY RESPONSE FACT SHEETS

I. INTRODUCTION

This chapter comes directly from the U.S. Department of Transportation's Emergency Response Guidebook, and is therefore most beneficial to first responders or the On-the-Scene (OSC) coordinator of a hazardous materials incident. There are three sections to the chapter. The first section provides an alphabetical listing of chemicals that are regulated by the DOT, along with the 4-digit shipping number designation, and a reference number referring the reader to an Emergency Response Guide or fact sheet. The second section contains the same list of chemicals, but they are listed chronologically, in accordance with their 4-digit shipping number designation. Hence, from either the shipping number designation, or the common shipping name, the chemical's emergency response fact sheet can be identified. The last section, containing the Emergency Response Fact Sheets, contains descriptive information on emergency response actions for spills or fires involving the chemical. Many of the recommendations are general, and the reader should cross reference the chemical specific information provided in Chapters 4 and 5 for properties and more detailed responses under emergency situations, as well as health effects from overexposure to a particular chemical. The present chapter should also be used in conjunction with Chapter 7, which is also extracted from the U.S. Department of Transportation's Emergency Response Guidebook. Chapter 7 contains recommended initial isolation distances for chemicals involved in spills. Those chemicals listed in the tables of this chapter that are highlighted by boldface print, denote chemicals that should be approached with special caution, and have isolation distances that can be found in Chapter 7. A detailed explanation of the isolation distance can be found in the next chapter. Note that in some of the chemical shipping name designations provided in this chapter, the abbreviation n.o.s. is used. This stands for *not otherwise specified*, which refers to the fact that this material is not assigned a hazard class according to the U.S. Department of Transportation shipping regulations. The reader may refer to the author's book for a detailed explanation of the hazardous materials transportation laws in the United States (Cheremisinoff, N.P., *Transportation of Hazardous Materials: A Guide to Compliance*, Noyes Publications, Westwood, New Jersey, 1994).

The information in this chapter is designed primarily for use by firefighters and hazardous materials specialists that are trained as Level II emergency responders. Transporters, in particular the carrier, should be well versed with the placarding requirements and should understand all information included on shipping papers. Although it is not the role of the carrier to respond to a hazardous materials incident, it is his responsibility to have the necessary information available for the OSC and emergency responders. This should include Packing Group designations for the chemicals in transport. The definitions for Packing Groups (PGs) are provided in Chapter 1.

II. ALPHABETICAL LISTING OF CHEMICALS

From the Fact Sheet Guide number, the reader can obtain fire hazard and emergency response information on a specific chemical by matching the number with fact sheets at the end of this chapter. Those chemicals in the table which are boldfaced represent materials that require an initial isolation distance when involved in a spill or leak. Information and guidelines on isolation distances can be found in Chapter 7.

Table 1. Alphabetical Listing of Regulated Chemicals

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Acetal	1088	26
Acetaldehyde	1089	26
Acetaldehyde Ammonia	1841	31
Acetaldehyde Oxime	2332	26
Acetic Acid, Glacial	2789	29
Acetic Acid Solution, more than 10% but no more than 80% acid	2790	60
Acetic Acid Solution, more than 80% acid	2789	29
Acetic Anhydride	1715	39
Acetone, and solutions	1090	26
Acetone Cyanohydrin, stabilized	**1541**	**55**
Acetone Oils	1091	26
Acetonitrile	1648	28
Acetyl Acetone Peroxide	2080	48
Acetyl Benzoyl Peroxide	2081	48
Acetyl Bromide	1716	60
Acetyl Chloride	1717	29
Acetyl Cyclohexane Sulfonyl Peroxide	2082	52
Acetylene	1001	17
Acetylene, dissolved	1001	17
Acetylene Tetrabromide	2504	58
Acetyl Iodide	1898	60
Acetyl Methyl Carbinol	2621	26
Acetyl Peroxide	2084	49
Acid, liquid, n.o.s.	1760	60
Acid, Sludge	1906	60
Acid Butyl Phosphate	1718	60
Acid Mixture, hydrofluoric and sulfuric acids	1786	59
Acid mixture, nitrating	1796	73
Acid mixture, spent, nitrating	1826	60
Acridine	2713	32
Acrolein, inhibited	**1092**	**30**
Acrolein dimer, stabilized	2607	26
Acrylamide	2074	55
Acrylic acid, inhibited	2218	29
Acrylonitrile, inhibited	1093	30
Activated carbon	1362	32
Adhesive	1133	2
Aerosols	1950	12
Air, compressed	1002	12
Air, refrigerated liquid (cryogenic liquid)	1003	23
Air bag inflators	3268	31
Air bag inflators	1325	32
Air Bag Modules	3268	31
Air Bag Modules	1325	32
Aircraft Hydraulic Power Unit Fuel Tank	3165	28
Alcohol (beverage)	1170	26
Alcohol, denatured	1987	26
Alcohol, denatured (toxic)	1986	28
Alcohol (ethyl)	1170	26
Alcohol, nontoxic, n.o.s.	1987	26
Alcoholates Solution, n.o.s., in alcohol	3274	26
Alcoholic beverage	1170	26
Alcoholic beverages	3065	26
Alcohols, n.o.s.	1987	26
Alcohols, toxic, n.o.s.	1986	28
Aldehydes, n.o.s.	1989	26
Aldehydes, toxic, n.o.s.	1988	28
Aldol	2839	55
Aldrin and its mixtures	2761	55
Alkali Metal Alcoholates, n.o.s.	3206	38
Alkali metal Alcoholates, self-heating, corrosive, n.o.s.	3206	38
Alkali Metal Alloys, liquid, n.o.s.	1421	40
Alkali Metal Amalgams	1389	40
Alkali Metal Amides	1390	40
Alkali Metal Dispersions	1391	40
Alkaline Corrosive Liquid, n.o.s.	1719	60
Alkaline Earth Metal Alcoholates, n.o.s.	3205	37
Alkaline Earth Metal Alloys, n.o.s.	1393	40
Alkaline Earth Metal Amalgams	1392	40
Alkaline Earth Metal Dispersions	1391	40

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Alkaloid Salts, liquid, n.o.s., poisonous	3140	53
Alkaloid Salts, solid, n.o.s., poisonous	1544	55
Alkaloids, liquid, n.o.s., poisonous	3140	53
Alkaloids, solid, n.o.s., poisonous	1544	55
Alkyl Phenols, liquid, n.o.s.	3145	55
Alkylamines, n.o.s.	2733	29
Alkylamines, n.o.s.	2734	29
Alkylamines, n.o.s.	2735	60
Alkylphenols, solid, n.o.s.	2430	55
Alkylsulfonic Acids, liquid with more than 5% free sulfuric acid	2584	60
Alkylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2586	60
Alkylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2583	60
Alkylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2585	60
Alkylsulfuric Acids	2571	60
Allethrin	2902	55
Allyl Acetate	2333	28
Allyl Alcohol	**1098**	**57**
Allylamine	**2334**	**28**
Allyl Chlorocarbonate	**1722**	**57**
Allyl Chloroformate	**1722**	**57**
Allyl Ethyl Ether	2335	28
Allyl Formate	2336	28
Allyl Glycidil Ether	2219	29
Allyl Iodide	1723	29
Allyl Isothiocyanate, inhibited	**1545**	**57**
Allyl Isothiocyanate, stabilized	**1545**	**57**
Allyltrichlorosilane, stabilized	1724	29
Aluminum, molten	9260	77
Aluminum Alkyl	2845	40
Aluminum Alkyl Halides	3052	40
Aluminum Alkyl Hydrides	3076	40
Aluminum Alkyls	3051	40
Aluminum Borohydride	2870	37
Aluminum Boro-hydride in Devices	2870	37
Aluminum Bromide, anhydrous	1725	39
Aluminum Bromide, Solution	2580	60
Aluminum Carbide	1394	40
Aluminum Chloride, anhydrous	1726	39
Aluminum Chloride, Solution	2581	60
Aluminum Dross	3170	40
Aluminum Ferro-silicon, powder	1395	41
Aluminum Hydride	2463	40
Aluminum Nitrate	1438	35
Aluminum Phosphate Solution	1760	60
Aluminum Phosphide	1397	41
Aluminum Phosphide Pesticides	3048	53
Aluminum Powder, coated	1309	32
Aluminum Powder, uncoated	1396	40
Aluminum Processing By-Products	3170	40
Aluminum Resinate	2715	32
Aluminum Silicon Powder uncoated	1398	40
Aluminum Sulfate Solution	1760	60
Amines, flammable, corrosive, n.o.s.	2733	29
Amines, liquid, corrosive, flammable, n.o.s.	2734	29
Amines, liquid, corrosive, n.o.s.	2735	60
Amines, solid, corrosive, n.o.s.	3259	60
2-amino-4-chloro-phenol	2673	53
2-amino-5-diethyl-aminopentane	2946	31
Aminoethoxyethanol	1760	60
2-(2-aminoethoxy) ethanol	3055	60
N-Aminoethyl-piperazine	2815	60
Aminophenols (o-, m-,p-)	2512	55
Aminopropyl-diethanolamine	1760	60
N-Aminopropyl-morpholine	1760	60
N-Aminopropyl-piperazine	1760	60
Aminopyridines (o-, m-, p-)	2671	55
Ammonia	**1005**	**15**
Ammonia Anhydrous, liquefied	**1005**	**15**
Ammonia Solutions with more than 10% but no more than 35% ammonia	2672	60
Ammonia Solutions with more than 35% but no more than 50% ammonia	2073	15

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ammonia Solutions with more than 50% ammonia	1005	15
Ammonium Arsenate	1546	53
Ammonium Bifluoride, solid	1727	60
Ammonium Bifluoride, solution	2817	60
Ammonium Bisulfite, solid	2693	60
Ammonium Bisulfite Solution	2693	60
Ammonium Carbamate	9083	31
Ammonium Carbonate	9084	31
Ammonium Dichromate	1439	35
Ammonium Dinitro-o-Cresolate	1843	42
Ammonium Fluoborate	9088	31
Ammonium Fluoride	2505	54
Ammonium Fluorosilicate	2854	53
Ammonium Hydrogendifluoride, solid	1727	60
Ammonium Hydrogendifluoride Solution	2817	60
Ammonium Hydrogendifluoride, solid	1727	60
Ammonium Hydrogendifluoride Solution	2817	60
Ammonium Hydrogen Sulfate	2506	60
Ammonium Hydrosulfide Solution	2683	28
Ammonium Hydroxide	2672	60
Ammonium Metavanadate	2859	53
Ammonium Nitrate, Liquid (hot concentrated solution)	2426	35
Ammonium Nitrate with more than 0.2 % combustible material	0222	46
Ammonium Nitrate with not more than 0.2 % combustible material	1942	43
Ammonium Nitrate, with organic coating	1942	43
Ammonium Nitrate Fertilizer	2067	43
Ammonium Nitrate Fertilizer, which is more liable to explode than ammonium nitrate with 0.2% combustible material	0223	46
Ammonium Nitrate Fertilizer with ammonium sulfate	2069	43
Ammonium Nitrate Fertilizer, with calcium carbonate	2068	43
Ammonium Nitrate Fertilizer, with not more than 0.4% of combustible material	2071	35
Ammonium Nitrate Fertilizer, with phosphate or potash	2070	43
Ammonium Nitrate Fertilizers	2071	35
Ammonium Nitrate Fertilizers	2072	43
Ammonium Nitrate Fertilizer, n.o.s.	2072	43
Ammonium Nitrate - Fuel Oil Mixture (containing only prilled ammonium nitrate and fuel oil)	0331	46
Ammonium Nitrate - Fuel Oil Mixtures	--	46
Ammonium Nitrate Mixed Fertilizers	2069	43
Ammonium Nitrate Solution, with not less than 15% water	2426	35
Ammonium Nitrate -Sulfate Mixture	2069	43
Ammonium Oxalate	2449	54
Ammonium Perchlorate	0402	46
Ammonium Perchlorate	1442	43
Ammonium Permanganate	9190	43
Ammonium Persulfate	1444	35
Ammonium Picrate, dry or wetted with less than 10% water	0004	46
Ammonium Picrate, wetted with less than 10% water	1310	33
Ammonium Poly-sulfide Solution	2818	60
Ammonium Polyvanadate	2861	55
Ammonium Silico-fluoride, solid	2854	53
Ammonium Sulfide Solution	2863	28
Ammunition, tear-producing, non-explosive	2017	58
Ammunition, toxic, non-explosive	2016	15
Amyl Acetates	1104	26
Amyl Acid Phosphate	2819	60
Amyl Alcohols	1105	26
Amylamines	1106	68
Amyl Butyrates	2620	27
Amyl Chlorides	1107	26
n-Amylene	1108	26
Amyl Formates	1109	26
Amyl Mercaptans	1111	27

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Amyl Methyl Ketone	1110	26
Amyl Nitrate	1112	26
Amyl Nitrites	1113	26
tert-Amyl Peroxy-2-Ethylhexanoate	2898	52
tert-Amyl Peroxy-Neodecanoate	2891	52
Amyltrichlorosilane	1728	29
Anhydrous Ammonia	**1005**	**15**
Aniline	1547	57
Aniline Hydrochloride	1548	53
Ansidines	2431	55
Anisole	2222	26
Anisoyl Chloride	1729	60
Anti-Freeze	1142	26
Anti-Knock Compound	1649	56
Antimony, powder	2871	53
Antimony Chloride	1733	60
Antimony Compound, inorganic, n.o.s.	1549	60
Antimony Compounds, inorganic, liquid, n.o.s.	3141	53
Antimony Compounds, inorganic, n.o.s.	1549	60
Antimony Lactate	1550	43
Antimony Penta-chloride, liquid	1730	60
Antimony Penta-chloride Solution	1731	60
Antimony Penta-fluoride	1732	59
Antimony Potassium Tartate	1551	53
Antimony Powder	2871	53
Antimony Tribromide	1549	60
Antimony Tribromide Solution	1549	60
Antimony Trichloride	1733	60
Antimony Trichloride Solution	1733	60
Antimony Trifluoride	1549	60
Antimony Trifluoride Solution	1549	60
Argon, compressed	1006	12
Argon, refrigerated liquid (cryogenic liquid)	1951	21
Arsenic	1558	53
Arsenic, white, solid	1561	53
Arsenic Acid, liquid	1553	55
Arsenic Acid, solid	1554	53
Arsenic Bromide	1555	53
Arsenic Chloride	**1560**	**55**
Arsenic Compounds, liquid, n.o.s.	1556	55
Arsenic Compounds, solid, n.o.s.	1557	53
Arsenic Disulfide	1557	53
Arsenic Iodide, solid	1557	53
Arsenic Pentoxide	1559	53
Arsenic Sulfide	1557	53
Arsenic Trichloride	**1560**	**55**
Arsenic Trioxide	1561	53
Arsenic Trisulfide	1557	53
Arsenical Dust	1562	53
Arsenical Pesticides, liquid, flammable, toxic, n.o.s.	2760	28
Arsenical Pesticides, liquid, toxic, flammable, n.o.s	2993	28
Arsenical Pesticides, liquid, toxic, n.o.s	2994	55
Arsenical Pesticides, solid, toxic, n.o.s	2759	55
Arsine	**2188**	**18**
Articles, pressurized pneumatic or hydraulic (containing non-flammable gas)	3164	12
Arylsulfonic Acids, liquid with more than 5% free sulfuric acid	2584	60
Arylsulfonic Acids, liquid with not more than 5% free sulfuric acid	2586	60
Arylsulfonic Acids, solid, with ore than 5% free sulfuric acid	2583	60
Arylsulfonic Acids, solid with not more than 5% free sulfuric acid	2585	60
Asbestos	2212	31
Asbestos, blue or brown	2212	31
Asbestos, white	2590	31
Asphalt	1999	27
Asphalt, Cut Back	1999	27
Azinphos Methyl (Guthion)	2783	55
1-Aziridinyl Phosphine Oxide (This)	2501	55
Azodicarbonamide	3242	32
2,2-Azodi-(2,4-Dimethyl-4-Methoxyvaleronitrile)	2955	70

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
2,2-Azodi-(2,4-Dimethyl-Valeronitrile)	2953	70
1,1'-Azodi-(Hexa-hydrobenzonitrile)	2954	72
Azodiisobutyronitrile	2952	70
2,2'-Azodi-(2-methyl-butyronitrile)	3030	70
Barium	1400	40
Barium Alloys, pyrophoric	1854	37
Barium Azide, wetted with not less than 50% water	1571	36
Barium Bromate	2719	42
Barium Chlorate	1445	42
Barium Compounds, n.o.s.	1564	55
Barium Cyanide	1565	53
Barium Hypochlorite	2741	45
Barium Nitrate	1446	42
Barium Oxide	1884	53
Barium Perchlorate	1447	42
Barium Permanganate	1448	42
Barium Peroxide	1449	42
Batteries, containing Sodium	3292	40
Batteries, dry, containing Potassium Hydroxide solid (electric storage)	2800	60
Batteries, electric storage, dry, containing Potassium Hydroxide	3028	60
Batteries, electric storage, wet, filled with acid	2794	60
Batteries, electric storage, wet, filled with alkali	2795	60
Batteries, electric storage, wet, non-spillable	2800	60
Batteries, wet, filled with acid (electric storage)	2794	60
Batteries, electric storage, wet, filled with acid wet, filled with alkali (electric storage)	2795	60
Batteries, wet, non-spillable (electric storage)	2800	60
Batteries, electric storage, dry, containing Potassium Hydroxide	1813	60
Battery Fluid, acid	2796	39
Battery Fluid, alkali	2797	60
Battery Fluid, alkali, with battery	2797	60
Battery Fluid, alkali, with electronic equipment or actuating device	2797	60
Battery-Powered Equipment (wet battery)	3171	60
Battery-Powered Vehicle (wet battery)	3171	60
Benzaldehyde	1989	26
Benzaldehyde	1990	26
Benzene	1114	27
Benzene-1,3- Disulfohydrazide	2971	72
Benzene Phosphorous Dichloride	2798	39
Benzene Phosphorous Thiodichloride	2799	39
Benzene Sulfo-hydrazide	2970	72
Benzene Sulfonyl Chloride	2225	59
Benzidine	1885	53
Benzine	1115	26
Benzoic Derivative Pesticides, liquid, flammable toxic, n.o.s.	2770	28
Benzoic Derivative Pesticides, liquid, toxic, flammable, n.o.s	3003	28
Benzoic Derivative Pesticides, liquid, toxic, n.o.s	3004	55
Benzoic Derivative Pesticides, solid, toxic, n.o.s	2769	55
Benzonitrile	2224	55
Benzoquinone	2587	55
Benzotrichloride	2226	60
Benzotrifluoride	2338	28
Benzoyl Chloride	1736	39
Benzoyl Peroxide	2085	49
Benzoyl Peroxide	2087	49
Benzoyl Peroxide	2088	49
Benzoyl Peroxide	2089	49
Benzoyl Peroxide	2090	49
Benzyl Bromide	1737	59
Benzyl Chloride	1738	59
Benzyl Chloroformate	1739	39
Benzyldimethylamine	2619	68
4-(Benzyl(ethyl) amino)-3-ethoxy-benzene-diazonium zinc Chloride	3037	70
Benzylidene Chloride	1886	55
Benzyl Iodide	2653	53
4-(benzyl(methyl) amino)-3-Ethoxy-benzene-diazonium Zinc Chloride	3038	70

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Beryllium, powder	1567	32
Beryllium Chloride	1566	53
Beryllium Compounds, n.o.s.	1566	53
Beryllium Fluoride	1566	53
Beryllium Nitrate	2464	42
Bifluorides, n.o.s.	1740	60
Biomedical Waste, n.o.s.	3291	24
Bipyridilium Pesticides, liquid, flamm-able, toxic, n.o.s.	2782	28
Bipyridilium Pesticides, liquid, toxic, flammable, n.o.s.	3015	28
Bipyridilium Pesticides, liquid, toxic, n.o.s.	3016	55
Bipyridilium Pesticides, solid, toxic, n.o.s.	2781	55
Bisulfates, aqueous solution	2837	60
Bisulfites, aqueous solution, n.o.s.	2693	60
Bisulfites, inorganic, aqueous solution, n.o.s.	2693	60
Blasting Agent, n.o.s.	--	46
Bleaching Powder	2208	35
Blue Asbestos	2212	31
Bombs, Smoke, Non-explosive, with cor-rosive liquid, without initiating device	2028	60
Borate and Chlorate Mixture	1458	35
Bordeaux Arsenite, liquid or solid	2759	55
Borneol	1312	32
Boron Tribromide	**2692**	**59**
Boron Trichloride	**1741**	**15**
Boron Trifluoride	**1008**	**15**
Boron Trifluoride Acetic Acid Complex	1742	59
Boron Trifluoride Diethyl Etherate	2604	29
Boron Trifluoride Dihydrate	2851	59
Boron Trifluoride Dimethyl Etherate	2965	29
Boron Trifluoride Propionic Acid Complex	1743	59
Brake Fluid, hydraulic	1118	27
Bromates, inorganic, aqueous solution, n.o.s.	3213	35
Bromates, inorganic, n.o.s.	1450	42
Bromine	**1744**	**59**
Bromine Chloride	**2901**	**20**
Bromine Pentafluoride	**1745**	**44**
Bromine Solutions	**1744**	**59**
Bromine Trifluoride	**1746**	**44**
Bromoacetic Acid, solid	1938	60
Bromoacetic Acid, solution	1938	60
Bromoacetone	**1569**	**55**
Bromoacetyl Bromide	2513	60
Bromobenzene	2514	26
Bromobenzyl Cyanides	1694	58
1-Bromobutane	1226	29
2-Bromobutane	2339	27
Bromochloro-methane	1887	58
2-Bromoethyl Ethyl Ether	2340	27
Bromoform	2515	58
1-Bromo-3-Methyl-butane	2341	27
Bromomethyl-propanes	2342	27
2-Bromo-2-Nitro-propane-1,3-Diol	3241	53
2-Bromopentane	2343	27
2-Bromopropane	2344	29
3-Bromopropyne	2345	29
Bromotrifluoro-ethylene	2419	17
Bromotrifluoro-methane	1009	12
Brown Asbestos	2212	31
Brucine	1570	53
Butadienes, inhibited	1010	17
Butane or Butane Mixtures	1011	22
Butanedione	2346	26
Butanols	1120	26
Butoxyl	2708	26
Butyl Acetates	1123	26
Butyl Acid Phosphate	1718	60
Butyl Acrylate	2348	26
Butyl Alcohol	1120	26
n-Butylamine	1125	68
N-Butylaniline	2738	55
Butyl Benzenes	2709	27
n-Butyl Bromide	1126	29

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Butyl Chloride	1127	27
n-Butyl Chloroformate	**2743**	**57**
sec-Butyl Chloroformate	**2742**	**57**
tert-Butyl Cumene Peroxide	2091	48
tert-Butyl Cumyl Peroxide	2091	48
tert-Butylcyclohexyl Chloroformate	2747	55
n-Butyl-4,4 Di (tert-Butyl-Peroxy) Valerate	2140	48
n-Butyl-4,4 Di (tert-Butyl-Peroxy) Valerate	2141	48
Butylene	1012	22
1,2-Butylene Oxide, stabilized	3022	26
Butyl Ether	1149	26
n-Butyl Formate	1128	26
tert-Butyl Hydroperoxide	2093	51
tert-Butyl Hydroperoxide	2094	51
tert-Butyl Hydroperoxide, not more than 80% in Di-tert Butyl Peroxide and/or solvent	2092	48
tert-Butyl Hypochlorite	3255	37
N-n Butyl Imidazole	2690	55
n-Butyl Isocyanate	**2485**	**57**
tert-Butyl Isocyanate	**2484**	**57**
tert-Butyl Isopropyl Benzene Hydroperoxide	2091	48
Butyl Mercaptans	2347	27
n-Butyl Methacrylate	2227	26
Butyl Methyl Ether	2350	26
tert-Butyl Monoperoxymaleate, technical pure	2099	49
Butyl Nitrites	2351	26
tert-Butyl Peroxyacetate	2095	49
tert-Butyl Peroxyacetate	2096	48
tert-Butyl Peroxybenzoate	2097	48
tert-Butyl Peroxybenzoate	2098	48
tert-Butyl Peroxybenzoate	2890	48
tert-Butyl Peroxycrotonate	2183	48
Butyl Peroxycarbonate	2169	52
Butyl Peroxycarbonate	2170	52
tert-Butyl Peroxydiethylacetate	2144	52
tert-Butyl Peroxydiethylacetate with tert-Butyl Peroxybenzoate	2551	48
tert-Butyl Peroxy-2-Ethylhexanoate, not more than 50% with phlegmatizer	2888	52
tert-Butyl Peroxy-2-Ethylhexanoate, technical pure	2143	52
tert-Butyl Peroxy-2-Ethylhexanoate, with 2,2-Di(tert-Butyl-peroxy) Butane	2887	48
tert-Butyl Peroxy-2-Ethylhexanoate, with 2,2-Di(tert-Butyl-peroxy) Butane	2886	48
tert-Butyl Peroxyisobutyrate	2562	52
tert-Butyl Peroxyisobutyrate	2142	52
tert-Butyl Peroxyisononanoate	2104	48
tert-Butyl Peroxyisopropyl Carbonate, technical pure	2103	49
tert-Butyl Peroxymaleate	2101	48
tert-Butyl Peroxymaleate, solution or paste	2100	48
tert-Butyl Peroxymaleate, technical pure	2099	49
tert-Butyl Peroxyneodecanoate	2177	52
tert-Butyl Peroxyneodecanoate	2594	52
tert-Butyl Peroxy-3-Phenylphthalide	2596	48
tert-Butyl Peroxyphthalate	2105	48
tert-Butyl Peroxypivalate	2110	52
tert-Butyl Peroxy-3,5,5-Trimethyl-hexanoate	2104	48
Butyl Phenols, liquid	2228	55
Butyl Phenols, solid	2229	53
Butyl Phosphoric Acid	1718	60
Butyl Propionate	1914	27
Butyltoluenes	2667	27
Butyltrichlorosilane	1747	29
5-tert Butyl-2,4,6-Trinitro-m-Xylene	2956	32
Butyl Vinyl Ether, inhibited	2352	26
1,4-Butynediol	2716	55
Butyraldehyde	1129	26
Butyraldoxime	2840	26
Butyric Acid	2820	60
Butyric Anhydride	2739	6
Butyronitrile	2411	28
Butyril Chloride	2353	29

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Cacodylic Acid	1572	53
Cadmium Compounds	2570	53
Caesium	1407	40
Caesium Hydroxide	2682	60
Caesium Hydroxide Solution	2681	60
Caesium Nitrate	1451	35
Calcium	1401	40
Calcium, metal and alloys, pyrophoric	1855	37
Calcium, Pyrophoric	1855	37
Calcium Alloy, Pyrophoric	1855	37
Calcium Arsenate	1573	53
Calcium Arsenate and Calcium Arsenite Mixtures, solid	1574	53
Calcium Arsenite	1574	53
Calcium Bisulfite Solution	2693	60
Calcium Carbide	1402	40
Calcium Chlorate	1452	35
Calcium Chlorate, aqueous solution	2429	35
Calcium Chlorite	1453	35
Calcium Cyanamide, with more than 0.1% calcium carbide	1403	40
Calcium Cyanide	1575	55
Calcium Dithionite	1923	37
Calcium Hydride	1404	40
Calcium Hydrogen Sulfite Solution	2693	60
Calcium Hydrosulfite	1923	37
Calcium Hypochlorite, dry, including mixtures, with more than 39% available chlorine (8.8% available oxygen)	1748	45
Calcium Hypochlorite, hydrated, including mixtures with not less than 5.5% but not more than 10% water	2880	45
Calcium Hypochlorite Mixture, dry, with more than 10% but not more than 39% available chlorine	2208	35
Calcium Manganese Silicon	2844	40
Calcium Nitrate	1454	35
Calcium Oxide	1910	60
Calcium Perchlorate	1455	35
Calcium Permanganate	1456	35
Calcium Peroxide	1457	35
Calcium Phosphide	1360	41
Calcium Resinate	1313	32
Calcium Resinate, fused	1314	32
Calcium Silicide	1405	40
Calcium Silicon	1406	40
Camphene	9011	58
Camphor	2717	32
Camphor, synthetic	2717	32
Camphor Oil	1130	27
Caproic Acid	2829	60
Caproic Acid (Hexanoic Acid)	1760	60
Caprylyl Peroxide	2199	52
Carbamate Pesticides, liquid, flammable, toxic, n.o.s.	2758	28
Carbamate Pesticides, liquid, toxic, flammable, n.o.s.	2991	28
Carbamate Pesticides, liquid, toxic, n.o.s.	2992	55
Carbamate Pesticides, solid, toxic, n.o.s.	2757	55
Carbaryl	2757	55
Carbofuran	2757	55
Carbolic Acid	1671	55
Carbon, activated	1362	32
Carbon, animal or vegetable origin	1361	32
Carbon Bisulfide	1131	28
Carbon Dioxide	1013	21
Carbon Dioxide, refrigerated liquid (cryogenic liquid)	2187	21
Carbon Dioxide, solid	1845	21
Carbon Dioxide and Ethylene Oxide Mixture, with more than 6% ethylene oxide	1041	17
Carbon Dioxide and Ethylene Oxide Mixture, with not more than 6% ethylene oxide	1952	12
Carbon Dioxide and Ethylene Oxide Mixture, with not more than 9% ethylene oxide	1952	12
Carbon Dioxide and Nitrous Oxide Mixtures	1015	12
Carbon Dioxide and Oxygen Mixtures	1014	14

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Carbon Disulfide	1131	28
Carbon Monoxide	**1016**	**18**
Carbon Monoxide, refrigerated liquid (cryogenic liquid)	**9202**	**67**
Carbon Monoxide and Hydrogen Mixture	**2600**	**18**
Carbon Tetrabromide	2516	53
Carbon Tetrachloride	1846	55
Carbonyl Fluoride	**2417**	**15**
Carbonyl Sulfide	**2204**	**18**
Castor Beans, Meal, Pomace or Flake	2969	31
Caustic Alkali Liquids, n.o.s.	1719	60
Caustic Potash, dry, solid	1813	60
Caustic Potash, liquid or solution	1814	60
Caustic Soda, dry, solid	1823	60
Caustic Soda, solution	1824	60
Cells, containing Sodium	3292	40
Celluloid, in blocks, rods, rolls, sheets, tubes, etc. except celluloid scrap	2000	32
Celluloid scrap	2002	32
Cement, containing flammable liquid	1133	26
Cement, liquid, n.o.s.	1133	26
Cerium, slabs, ingots or rods	1333	32
Cerium, turnings or gritty powder	3078	40
Cesium	1407	40
Cesium Hydroxide	2682	60
Cesium Hydroxide Solution	2681	60
Cesium Nitrate	1451	35
Charcoal	1361	32
Chemical Ammunition, nonexplosive, with irritant	2017	58
Chemical Ammunition, nonexplosive, with poisonous material	2016	15
Chemical Kit	1760	60
Chloral, anhydrous, inhibited	2075	55
Chlorate and Borate Mixtures	1458	35
Chlorate and Magnesium Chloride Mixtures	1459	35
Chlorate of Potash	1485	35
Chlorate of Soda	1495	35
Chlorates, inorganic, aqueous solution, n.o.s.	3210	35
Chlorates, inorganic, n.o.s.	1461	35
Chlorates, flammable liquid	2762	28
Chloric Acid, aqueous solution	2626	35
Chloride of Phosphorus	**1809**	**39**
Chloride of Sulfur	**1828**	**39**
Chlorine	**1017**	**20**
Chlorine Dioxide Hydrate, frozen	9191	47
Chlorine Pentafluoride	**2548**	**44**
Chlorine Trifluoride	**1749**	**44**
Chlorite Solution with more than 5% available chlorine	1908	60
Chlorites, inorganic, n.o.s.	1462	43
Chloroacetaldehyde	**2232**	**55**
Chloroacetic Acid, liquid	1750	59
Chloroacetic Acid, molten	3250	59
Chloroacetic Acid, solid	1751	60
Chloroacetone, stabilized	**1695**	**59**
Chloroacetonitrile	**2668**	**57**
Chloroacetophenole	1697	55
Chloroacetyl Chloride	**1752**	**59**
Chlorounilines, liquid	2019	55
Chloroanilines, solid	2018	53
Chloroanisidines	2233	53
Chlorobenzene	1134	57
Chlorobenzotrifluorides	2234	27
p-Chlorobenzol Peroxide	2113	48
p-Chlorobenzol Peroxide	2114	48
p-Chlorobenzol Peroxide	2115	48
Chlorobenzyl-chlorides	2235	55
1-Chloro-3-Bromopropane	2688	58
Chlorobutanes	1127	27
3-Chloro-4-diethyl-aminobenzenediazonium zinc chloride	3033	72
Chlorodifluoro-bromomethane	1974	12
1-Chloro-1,1-difluroethane	2517	22
Chlorodifluroethanes	2517	22
Chlorodifluromethane	1018	12

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Chlorodifluromethane and Chloro-pentafluoroethane Mixture	1973	12
Chlorodifluromethane and Chloro-pentafluoroethane Mixture	1078	12
Chlorodinitrobenzenes	1577	56
2-Chloroethanal	**2232**	**55**
Chloroform	1888	55
Chloroformates, n.o.s.	2742	57
Chloroformates, toxic, corrosive, flammable, n.o.s.	2742	57
Chloroformates, toxic, corrosive, n.o.s.	3277	59
Chloromethyl Chloroformate	2745	55
Chloromethyl Ethyl Ether	2354	28
3-Chloro-4-methyl-phenylisocyanate	2236	55
Chloronitroanilines	2237	53
Chloronitrobenzenes	1578	55
Chloronitrotoluenes	2433	53
Chloropentafluoroethane	1020	12
3-Chloroperoxybenzoic Acid	2755	49
Chlorophenates, liquid	2904	55
Chlorophenates, solid	2905	53
Chlorophenolates, liquid	2904	55
Chlorophenolates, solid	2905	43
Chlorophenols, liquid	2021	55
Chlorophenols, solid	2021	55
Chlorophenyl Trichlorosilane	1753	60
Chloropicrin	**1580**	**56**
Chloropicrin and Methyl Chloride Mixtures	**1581**	**55**
Chloropicrin and Methyl Chloride Mixtures	**1582**	**18**
Chloropicrin and Non-Flammable Compressed Gas Mixtures	**1955**	**15**
Chloropicrin Mixture, Flammable	2929	57
Chloropicrin Mixtures, n.o.s.	**1583**	**56**
Chloropivaloyl Chloride	**9263**	**59**
Chloroplatinic Acid, solid	2507	60
Chloroprene, inhibited	1991	30
1-Chloropropane	1278	26
2-Chloropropane	2356	26
3-Chloropropanol-1	2849	53
2- Chloropropene	2456	27
alpha-Chloro-propionic Acid	2511	60
2-Chloropropionic Acid	2511	60
2-Chloropyridine	2822	54
Chlorosilanes, corrosive, flamm-able, n.o.s.	2986	29
Chlorosilanes, corrosive, n.o.s.	2987	60
Chlorosilanes, flammable, corrosive, n.o.s.	2985	29
Chlorosilanes, n.o.s. (corrosive)	2987	60
Chlorosilanes, n.o.s. (flammable, corrosive)	2985	29
Chlorosilanes, n.o.s. (flammable, corrosive)	2986	29
Chlorosilanes, n.o.s. (emits flammable gas when wet)	2988	40
Chlorosilanes, water-reactive, flammable, corrosive, n.o.s.	2988	40
Chlorosulfonic Acid	**1754**	**39**
Chlorosulfonic Acid and Sulfur Trioxide Mixture	**1754**	**39**
Chlorotetrafluoroethane	1021	12
Chlorotoluenes	2238	27
4-Chloro-o-Toludine Hydrochloride	1579	53
Chlorotrifluoroethane	1983	12
Chlorotrifluoromethane	1022	12
Chlorotrifluoroethane and trifluoromethane Mixture	1078	12
Chlorpyrifos	2783	55
Chromic Acid, solid	1463	42
Chromic Acid Solution	1755	60
Chromic Anhydride	1463	42
Chromic Fluoride, solid	1756	60
Chromic Fluoride Solution	1757	60
Chromium Nitrate	2720	35
Chromium Oxychloride	1758	39
Chromium Trioxide, anhydrous	1463	42
Chromosulfuric Acid	2240	39
Cigarette, self-lighting	1867	32
Cigarette Lighter, with flammable gas	1057	17

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Cigarette Lighter, with flammable liquid	1226	26
Cleaning Compound	1142	26
Cleaning Compound, liquid, corrosive	1760	60
Clinical Waste, unspecified, n.o.s.	3291	24
Coal, ground bituminous, sea coal, etc	1361	32
Coal Facings	1361	32
Coal Gas	**1023**	**18**
Coal Tar Distillate	1137	27
Coal Tar Distillates, flammable	1136	27
Coal Tar Naphtha	2553	27
Coal Tar Oil	1136	27
Coal Tar Oil	1137	27
Coating Solution	1139	26
Cobalt Naphthenates, powder	2001	32
Cobalt Resinate, precipitated	1318	32
Coculus	1584	53
Collodion	2059	26
Combustible Liquid, n.o.s.	1993	27
Compounds, cleaning liquid (corrosive)	1760	60
Compounds, cleaning liquid (flammable)	1993	27
Compounds, Polishing, liquid, etc. (flammable)	1142	26
Compounds, Tree or Weed Killing, liquid (corrosive)	1760	60
Compounds, Tree or Weed Killing, liquid (flammable)	1993	27
Compounds, Tree or Weed Killing, liquid (poisonous)	2810	55
Compressed Gas, oxidizing, n.o.s.	3156	14
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone A)	**1953**	**18**
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone B)	**1953**	**18**
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone C)	**1953**	**18**
Compressed Gas, toxic, flammable, n.o.s. (Inhalation Hazard Zone D)	**1953**	**18**
Compressed Gases, flammable, n.o.s.	**1954**	**22**
Compressed Gases, flammable, poisonous, n.o.s.	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	**1953**	**18**
Compressed Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	**1953**	**18**
Compressed Gases, n.o.s.	**1956**	**12**
Compressed Gases, poisonous, n.o.s.	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone A)	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone B)	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone C)	**1955**	**15**
Compressed Gases, toxic, n.o.s. (Inhalation Hazard Zone D)	**1955**	**15**
Copper Acetoarsenite	1585	53
Copper Arsenite	1586	53
Copper-Based Pesticides, solid, toxic, n.o.s.	2775	53
Copper-Based Pesticides, liquid, flammable, toxic, n.o.s.	2776	28
Copper-Based Pesticides, liquid, toxic, flammable, n.o.s.	3009	28
Copper-Based Pesticides, liquid, toxic, n.o.s.	3010	55
Copper Chlorate	2721	35
Copper Chloride	2802	60
Copper Cyanide	1587	53
Copra	1363	37
Corrosive Liquid, acidic, inorganic, n.o.s.	3264	60

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Corrosive Liquid, acidic, organic, n.o.s.	3265	60
Corrosive Liquid, basic, inorganic, n.o.s.	3266	60
Corrosive Liquid, self-heating, n.o.s.	3301	37
Corrosive Liquid, toxic, n.o.s.	2922	59
Corrosive Liquids, flammable, n.o.s.	2920	29
Corrosive Liquids, n.o.s.	1760	60
Corrosive Liquids, oxidizing, n.o.s.	3093	45
Corrosive Liquids, poisonous, n.o.s.	2922	59
Corrosive Liquids, water-reactive, n.o.s.	3094	39
Corrosive Liquids, which in contact with water emit Flammable Gases, n.o.s.	3094	39
Corrosive Solid, acidic, inorganic, n.o.s.	3260	60
Corrosive Solid, acidic, organic, n.o.s.	3261	60
Corrosive Solid, basic, inorganic, n.o.s.	3262	60
Corrosive Solid, basic, organic, n.o.s.	3263	60
Corrosive Solid, toxic, n.o.s.	2923	59
Corrosive Solids, flammable, n.o.s.	2921	34
Corrosive Solids, n.o.s.	1759	60
Corrosive Solids, oxidizing, n.o.s.	3084	35
Corrosive Solids, poisonous, n.o.s.	2923	59
Corrosive Solids, self-heating, n.o.s.	3095	37
Corrosive Solids, water-reactive, n.o.s.	3096	40
Corrosive Solids, which in contact with water emit Flammable Gases, n.o.s.	3096	40
Cosmetics, corrosive liquid, n.o.s.	1760	60
Cosmetics, corrosive solid, n.o.s.	1759	60
Cosmetics, flammable liquid, n.o.s.	1993	27
Cosmetics, flammable solid, n.o.s.	1325	32
Cosmetics, oxidizer, n.o.s.	1479	35
Cotton, wet	1365	32
Cotton Waste, oily	1364	32
Coumaphos	2783	55
Coumarin Derivative Pesticides, liquid, flammable, n.o.s.	3024	28
Coumarin Derivative Pesticides, liquid, toxic, flammable, n.o.s.	3025	28
Coumarin Derivative Pesticides, liquid, toxic, n.o.s.	3026	55
Coumarin Derivative Pesticides, solid, toxic, n.o.s.	3027	55
Creosote, coal tar	1993	27
Creosote Salts	1334	32
Cresol (o-, m-, and p-)	2076	55
Creosols	2076	55
Cresylic Acid	2022	55
Crotonaldehyde, inhibited	**1143**	**28**
Crotonaldehyde, stabilized	**1143**	**28**
Crotonic Acid	2823	60
Crotonylene	1144	27
Cumene	1918	28
Cumene Hydroperoxide, technical pure	2126	51
Cupric Nitrate	1479	35
Cupriethylenediamine Solution	1761	59
Cyanide or Cyanide Mixture, dry	1588	55
Cyanide Solution, n.o.s.	1935	55
Cyanide Solutions	1935	55
Cyanides, inorganic, n.o.s.	1588	55
Cyanides, inorganic, solid, n.o.s.	1588	55
Cyanogen	**1026**	**18**
Cyanogen, liquefied	**1026**	**18**
Cyanogen Bromide	1889	55
Cyanogen Chloride, inhibited	**1589**	**55**
Cyanogen Gas	**1026**	**18**
Cyanuric Chloride	2670	60
Cyclobutane	2601	22
Cyclobutylchloroformate	2744	57
1,5,9-Cyclododecatriene	2518	59
Cycloheptane	2241	27
Cycloheptatriene	2603	28
Cycloheptene	2242	27
Cyclohexane	1145	26

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Cyclohexanone	1915	26
Cyclohexanone Peroxide, not more than 72% in solution	2896	51
Cyclohexanone Peroxide, not more than 90% with not less than 10% water	2119	51
Cyclohexene	2256	29
Cyclohexenyltrichlorosilane	1762	29
Cyclohexyl Acetate	2243	27
Cyclohexylamine	2357	68
Cyclohexyl Isocyanate	**2488**	**57**
Cyclohexyl Mercaptan	3054	28
Cyclohexyltrichlorosilane	1763	60
Cyclooctadiene Phosphines	2940	37
Cyclooctadienes	2520	27
Cyclooctatetraene	2358	27
Cyclopentane	1146	27
Cyclopentanol	2244	26
Cyclopentanone	2245	26
Cyclopentene	2246	27
Cyclopropane	1027	22
Cyclopropane, liquefied	1027	22
Cymenes	2046	27
2,4-D	2765	55
DDT	2761	55
Decarbonate	1868	34
Decahydro-naphthalene	1147	27
n-Decane	2247	27
Decanoyl peroxide, technical pure	2120	52
Denatured Alcohol	1987	26
Denatured Alcohol (toxic)	1986	28
Deuterium	1957	22
Devices, small, Hydrocarbon Gas powered, with release device	3150	22
Diacetone Alcohol	1148	26
Diacetone Alcohol Peroxide	2163	52
Diacetyl	2346	26
Diallylamine	2359	29
Diallyl Ether	2360	28
4,4-Diaminodiphenyl Methane	2651	53
Di-N-Amylamine	2841	68
Diazinon	2783	55
2-Diazo-1-Naphthol-4-Sulfochloride	3042	71
2-Diazo-1-Naphthol-5-Sulfochloride	3043	71
Dibenzyldichlorosilane	2434	60
Dibenzyl Peroxydicarbonate	2149	52
Diborane	**1911**	**18**
Diborane Mixtures	1911	18
Dibromobenzene	2711	26
1,2- Dibromobutan-3-One	2648	55
Dibromochloropropanes	2872	58
Dibromidofluoromethane	1941	58
1,2-Dibromoethane	**1605**	**55**
Dibromomethane	2664	74
Di-n-Butylamine	2248	68
Dibutylaminoethanol	2873	55
Di(4-tert-Butylcyclo-hexyl)Peroxydi-carbonate	2154	52
Di(4-tert-Butylcyclo-hexyl) Peroxy-dicarbonate	2894	52
Dibutyl Ethers	1149	26
Di-tert-Butyl Peroxide, technical pure	2102	48
2,2-Di(tert-Butyl-peroxy)Butane	2111	48
1,1-Di(tert-Butyl-peroxy) Cyclohexane	2179	49
1,1-Di(tert-Butyl-peroxy) Cyclohexane	2180	49
1,2-Di(tert-Butyl-peroxy) Cyclohexane	2181	48
1,1-Di(tert-Butyl-peroxy) Cyclohexane	2885	48
1,1-Di(tert-Butyl-peroxy) Cyclohexane	2897	48
Di-sec-Butyl-Peroxy-Dicarbonate	2150	52
Di-sec-Butyl-Peroxy-Dicarbonate	2151	52
Di-(2-tert-Butyl-peroxyisopropyl) Benzene	2112	48
1,4 Di-(2-tert-Butyl-peroxyisopropyl) Benzene and 1,3-Di(2-tert-Butyl-peroxyisopropyl) Benzene	2112	48
Di-tert-Butylperoxyphthalate	2106	48
Di-tert-Butylperoxyphthalate	2107	48
Di-tert-Butylperoxyphthalate	2108	48

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
2,2-Di(tert-Butyl-peroxy) Propane	2883	48
2,2-Di(tert-Butyl-peroxy) Propane	2884	48
1,1-Di(tert-Butyl-peroxy)-3,3,5-Trimethylcyclohexane	2145	48
1,1-Di(tert-Butyl-peroxy)-3,3,5-Trimethylcyclohexane	2146	48
1,1-Di(tert-Butyl-peroxy)-3,3,5-Trimethylcyclohexane	2147	48
Dicetyl Peroxydicarbonate, not more than 42%	2895	42
Dicetyl Peroxydicarbonate, technical pure	2164	52
Dichloroacetic Acid	1764	60
1,3-Dichloroacetone	2649	55
Dichloroacetyl Chloride	1765	60
Dichloroanilines, solid or liquid	1590	55
0-Dichlorobenzene	1591	58
p-Dichlorobenzene	1592	58
2,4-Dichlorbenzoyl Peroxide	2137	48
2,4-Dichlorbenzoyl Peroxide	2138	48
2,4-Dichlorbenzoyl Peroxide	2139	48
Dichlorobutene	2920	29
Dichlorobutene	2924	29
2,2'-Dichlordiethyl Ether	1916	55
Dichlorodifluoroethylene	9018	74
Dichlorodifluoromethane	1028	12
Dichlorodifluoromethane and Dichlorotetrafluoroethane Mixture	1078	12
Dichlorodifluoromethane and Difluoroethane Azeotropic Mixture	2602	12
Dichlorodifluoromethane and Dichlorodifluoroethane Mixture	1078	12
Dichlorodifluoromethane and Ethylene Oxide Mixture with not more than 12% Ethylene Oxide	3070	12
Dichlorodifluoromethane and Trichlorofluoromethane Mixture	1078	12
Dichlorofluoromethane, Trichlorofluoromethane and Chlorodifluoromethane Mixture	1078	12
Dichlorodifluoromethane and Trichlorotrifluoroethane Mixture	1078	12
Dichlorodifluoromethane and Chlorodifluoromethane Mixture	1078	12
Dichlorodimethyl Ether, symmetrical	2249	55
Dichlorodiphenyl-trichloroethane, DDT	2761	55
1,1-Dichloroethane	2362	27
Dichloroethylene	1150	29
1,2-Dichloroethylene	1150	29
Dichloroethyl Ether	1916	55
1,1-Dichloro-1-Fluoroethane	9274	74
Dichlorofluoro-methane	1029	12
Dichloroisocyanuric Acid, and its salts, dry	2465	45
Dichloroisopropyl Ether	2490	59
Dichloromethane	1593	74
Dichloromonofluoromethane	1029	12
1,1-Dichloro-1-Nitro-Ethane	2650	57
Dichloropentanes	1152	27
2,4-Dichlorphenoxyacetic Acid	2765	55
Dichlorophenylisocyanates	2250	53
Dichlorophenyltrichlorosilane	1766	60
Dichloropropanes	1279	27
1,3-Dichloro-propanol-2	2750	55
Dichloropropene	2047	29
Dichloropropene and Propylene Dichloride Mixture	2047	29
Dichloropropenes	2047	29
Dichloropropionic Acid	1760	60
2,2-Dichloro-propionic Acid	1760	60
Dichlorosilane	**2189**	**19**
Dichlorotetrafluoroethane	1958	12
Dichloro-S-Triazinetrione and its salts dry	2465	45
3,5-Dichloro-2,4,6-trifluoropyridine	**9264**	**55**
Dichlorvos	2783	55
Dicumyl Peroxide	2121	48
Dicycloheptadiene	2251	26
Dicyclohexylamine	2565	60
Dicyclohexylammonium Nitrite	2687	53
Dicyclohexyl Peroxydicarbonate	2152	52
Dicyclohexyl Peroxydicarbonate	2153	52
Dicyclopentadiene	2048	26
2,2-Di(4,4-Di-tert-Butylperoxycyclohexyl) Propane	2168	48

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Didymium Nitrate	1465	35
Dieldrin	2761	55
Diesel Fuel	1202	27
Diesel Fuel	1993	27
Diethoxyethane	1153	26
Diethoxymethane	2373	26
2,5-Diethoxy-4-Morpholinobenzene-diazonium Zinc Chloride	3036	72
Diethoxypropene	2374	26
Diethylamine	1154	68
Diethylaminoethanol	2686	29
Diethylaminopropylamine	2684	29
N,N-Diethyl Aniline	2432	57
Diethylbenzene	2049	29
Diethyl Carbonate	2366	26
Diethyl Cellosolve	1153	26
Diethyldichlorosilane	1767	29
Diethylenetriamine	2079	29
Diethyl Ether	1155	26
N,N-Diethylethylenediamine	2685	29
Di-(2-Ethylhexyl) Peroxydicarbonate	2122	52
Di-(2-Ethylhexyl)-Peroxydicarbonate	2123	52
Di-(2-Ethylhexyl) Phosphoric Acid	1902	60
Diethyl Ketone	1156	26
Diethyl Peroxydicarbonate	2175	52
Diethyl Sulfate	1594	55
Diethyl Sulfide	2375	28
Diethylthiophosphoryl Chloride	2751	59
Diethylzinc	1366	40
1,1-Difluoroethane	1030	22
Difluorochloroethanes	2517	22
Difluoroethane	1030	22
Difluoroethylene	1959	22
1,1-Difluoroethylene	1959	22
Difluoromethane	3252	22
Difluorophosphoric Acid, anhydrous	1768	59
2,2-Dihydroperoxy-propane	2178	49
2,3-Dihydropyran	2376	26
Di(1-Hydroxycyclo-hexyl) Peroxide	2148	48
Diisobutylamine	2361	68
Diisobutylene, Isomeric Compounds	2050	26
Diisobutyl Ketone	1157	26
Diisobutyryl Peroxide	2182	52
Diisooctyl Acid Phosphate	1902	60
Diisopropylamine	1158	68
Diisopropylbenzene Hydroperoxide	2171	48
Diisopropyl Ether	1159	26
Diisotridecylperoxydicarbonate	2889	52
Diketene	**2521**	**57**
1,1-Dimethoxyethane	2377	27
1,2-Dimethoxyethane	2252	27
Dimethylamine, anhydrous	1032	19
Dimethylamine Solution	1160	26
2-Dimethylaminoacetonitrile	2378	28
4-Dimethylamino-6-(2-Di-Methylamino-ethoxy)Toluene-2-Diazonium Zinc Chloride	3039	70
1,2-Di-(Dimethyl-amino)Ethane	2372	26
Dimethylamino-ethanol	2051	29
2-Dimethylamino-ethanol	2051	29
Dimethylaminoethyl Methacryalate	2522	55
N,N-Dimethylaniline	2253	57
Di(2-Methylbenzoyl) Peroxide	2593	52
2,3-Dimethylbutane	2457	27
1,3-Dimethylbutyl-amine	2379	68
Dimethylcarbamoyl Chloride	2262	60
Dimethyl Carbonate	1161	26
Dimethyl Chlorothiophosphate	2267	59
Dimethylcyclohexanes	2263	27
Dimethylcyclohexylamine	2264	60
2,5-Dimethyl-2,5-Di-(Benzoylperoxy) Hexane	2173	49
2,5-Dimethyl-2,5-Di-(Benzoylperoxy) Hexane, technical pure	2172	49
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexane	2156	48
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexane, technical pure	2155	48
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexyne-3, technical pure	2158	49

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
2,5-Dimethyl-2,5-Di(tert-Butylperoxy) Hexyne-3, with not more than 52% in inert solid	2159	48
Dimethyldichloro-silane	1162	29
Dimethyldiethoxy-silane	2380	26
2,5-Dimethyl-2,5-Di(2-Ethyl-hexanoyl-peroxy) Hexane, technical pure	2157	52
2,5-Dimethyl-2,5-Dihydroperoxy hexane	2174	49
Dimethyldioxanes	2707	27
Dimethyl Disulfide	2381	27
Dimethylethanol-amine	2051	29
Dimethyl Ether	1033	22
N,N-Dimethyl-formamide	2265	26
Dimethylhydrazine, symmetrical	**2382**	**57**
Dimethylhydrazine, unsymmetrical	**1163**	**57**
Dimethyl Phosphorochloridothioate	2267	59
2,2-Dimethylpropane	2044	22
Dimethyl-N-Propyl-amine	2266	29
Dimethyl Sulfate	1595	57
Dimethyl Sulfide	1164	27
Dimethyl Thiophosphoryl Chloride	2267	59
Dimethylzinc	1370	40
Dimyristyl Peroxy Dicarbonate	2595	52
Dimyristyl Peroxy Dicarbonate, not more than 42%, in water	2892	52
Dinitroanilines	1596	56
Dinitrobenzene Solution	1597	56
Dinitrobenzenes	1597	56
Dinitrochlorobenzene	1577	56
Dinitro-o-Cresol	1598	53
Dinitrocyclohexyl Phenol	9026	53
Dinitrogen Tetroxide, liquefied	**1067**	**20**
Dinitrophenol, wetted with not less than 15% water	1320	36
Dinitrophenol Solutions	1599	57
Dinitrophenolate, wetted with not less than 15% water	1321	36
Dinitroresorcinol, wetted with not less than 15% water	1322	36
N,N'-Dinitroso-N,N'-Dimethyl Terephthalamide	2973	71
N,N'-Dinitrosopentamethylene Tetramine	2972	71
Dinitrotoluenes	2038	56
Dinitrotoluenes, molten	1600	56
Dioxane	1165	26
Dioxolane	1166	26
Dipentene	2052	27
Diphenylamine Chloroarsine	1698	55
Diphenylchloroarsine, solid or liquid	1699	55
Diphenyldichlorosilane	1769	29
Diphenylmethane-4,4'-Diisocyanate (MDI)	2489	54
Diphenylmethyl Bromide	1770	60
Diphenyloxide-4,4'-Disulfohydrazide	2951	72
Dipicryl Sulfide, wetted with not less than 10% water	2852	33
Dipropylamine	2383	68
4-Dipropylaminobenzenediazonium Zinc Chloride	3034	72
Dipropyl Ether	2384	26
Dipropyl Ketone	2710	26
Di-n-Propyl Peroxydicarbonate, technical pure	2176	52
Disinfectant, liquid, corrosive, n.o.s.	1903	60
Disinfectant, solid, toxic, n.o.s.	1601	55
Disinfectants, liquid, n.o.s., poisonous	3142	55
Disinfectants, liquid, toxic, n.o.s.	3142	55
Disinfectants, solid, n.o.s., poisonous	1601	55
Disinfectants, corrosive, liquid, n.o.s.	1903	60
Disodium Trioxosilicate, pentahydrate	3253	60
Dispersant Gas, flammable, n.o.s.	1954	22
Dispersant Gas, n.o.s.	1078	12
Distearyl Peroxydicarbonate	2592	48
Disulfoton	2783	55
Dithiocarbamate Pesticides, liquid, flammable, toxic, n.o.s.	2772	28

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Dithiocarbamate Pesticides, liquid, toxic, flammable, n.o.s.	3005	28
Dithiocarbamate Pesticides, liquid, toxic, n.o.s.	3006	55
Dithiocarbamate Pesticides, solid, toxic, n.o.s.	2771	55
Di(3,5,5-Trimethyl-1,2-Dioxolanyl-3) Peroxide	2597	52
Divinyl Ether, inhibited	1167	30
Dodecylbenzene-sulfonic Acid	2584	60
Drier, paint or varnish, liquid, n.o.s.	1168	26
Dry Ice	1845	21
Dye, liquid, corrosive, n.o.s.	2801	60
Dye, liquid, n.o.s. (corrosive)	2801	60
Dye, liquid, toxic, n.o.s.	1602	55
Dye, solid, corrosive, n.o.s.	3147	60
Dye, solid, n.o.s. or Dye Intermediate, solid, n.o.s., corrosive	3147	60
Dye, solid, n.o.s. or Dye Intermediate, solid, n.o.s., poisonous	3143	55
Dye, solid, toxic, n.o.s.	3143	55
Dye Intermediate, liquid, corrosive, n.o.s.	2801	60
Dye Intermediate, liquid n.o.s. (corrosive)	2801	60
Dye Intermediate, liquid, toxic, n.o.s.	1602	55
Dye Intermediate, solid, corrosive, n.o.s.	3147	60
Dye Intermediate, solid, toxic, n.o.s.	3143	55
Dye Intermediate, liquid, n.o.s. (poisonous)	1602	55
Dye Intermediate, liquid n.o.s. (poisonous)	1602	55
Electrolyte, Battery Fluid, acid	2796	39
Elevated Temperature Liquid, flammable, n.o.s., with flash point above 60.5°C, at or above its flash point	3256	27
Elevated Temperature Liquid, n.o.s., at or above 100°C and below its flash point	3257	27
Elevated Temperature Material, liquid n.o.s. (at or above 100°C (212°F) and below its flash point)	9259	27
Elevated Temperature Solid, n.o.s., at or above 240°C	3258	31
Enamel	1263	26
Endosulfan	2761	55
Endrin Mixture, dry or liquid	2761	55
Engine Starting Fluid	1960	22
Engines, internal combustion, including when fitted in machinery or vehicles	3166	27
Environmentally Hazardous Substance, liquid, n.o.s.	3082	31
Environmentally Hazardous Substance, solid, n.o.s.	3077	31
Epibromohydrin	2558	57
Epichlorohydrin	2023	30
1,2-Epoxy-3-Ethoxypropane	2752	26
Esters, n.o.s.	3272	26
Etching Acid, liquid, n.o.s.	1790	59
Ethane, compressed	1035	22
Ethane, refrigerated liquid (cryogenic liquid)	1961	22
Ethane-Propane Mixture, refrigerated liquid (cryogenic liquid)	1961	22
Ethanol, and solutions	1170	26
Ethanolamine, and solutions	2491	60
Ether	1155	26
Ethers, n.o.s.	3271	26
Ethion	2783	55
Ethoxyethanol	1171	26
Ethoxyethyl Acetate	1172	26
Ethyl Acetate	1173	26
Ethyl Acetylene, inhibited	2452	17
Ethyl Acrylate, inhibited	1917	26
Ethyl Alcohol, and solutions	1170	26
Ethylamine	1036	68
Ethylamine, aqueous solution with not less than 50% but not more than 70% ethylamine	2270	29
Ethyl Amyl Ketone	2271	26
2-Ethylaniline	2273	55
N-Ethylaniline	2272	55
Ethylbenzene	1175	26

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
N-Ethyl-N-Benzylaniline	2274	53
N-EthylBenzyltoludines	2753	53
Ethyl Borate	1176	26
Ethyl Bromide	1891	58
Ethyl Bromoacetate	1603	55
2-Ethylbutanol	2275	26
2-Ethylbutyl Acetate	1177	26
Ethyl Butyl Ether	1179	26
2-Ethylbutyraldehyde	1178	26
Ethyl Butyrate	1180	26
Ethyl Chloride	1037	27
Ethyl Chloroacetate	1181	55
Ethyl Chloroformate	**1182**	**28**
Ethyl-2-Chloropropionate	2935	29
Ethyl Chlorothioformate	**2826**	**59**
Ethyl Crotonate	1862	26
Ethyl Cyanoacetate	2666	55
Ethyl-3,3-Di(tert-Butylperoxy) Butyrate	2184	49
Ethyl-3,3-Di(tert-Butylperoxy) Butyrate	2598	48
Ethyl-3,3-Di(tert-Butylperoxy) Butyrate, not more than 77%	2185	48
Ethyldichloroarsine	**1892**	**55**
Ethyldichlorosilane	1183	29
Ethylene, compressed	1962	22
Ethylene, refrigerated liquid (cryogenic liquid)	1038	22
Ethylene, Acetylene and Propylene Mixture, refrigerated liquid (cryogenic liquid), containing at least 71.5% Ethylene with not more than 22.5% Acetylene and not more than 6% Propylene	3138	17
Ethylene Chlorohydrin	**1135**	**55**
Ethylene Dibromide	**1605**	**55**
Ethylene Dichloride	1184	26
Ethylene Glycol Diethyl Ether	1153	26
Ethylene Glycol Monobutyl Ether	2369	26
Ethylene Glycol Monoethyl Ether	1171	26
Ethylene Glycol Monomethyl Ether	1188	26
Ethylene Glycol Monoethyl Ether Acetate	1172	26
Ethylene Glycol Monomethyl Ether Acetate	1189	26
Ethylene Oxide	**1040**	**69**
Ethylene Oxide and Carbon Dioxide Mix-ture, with more than 6% ethylene oxide	1041	17
Ethylene Oxide and Carbon Dioxide Mixture, with more than 9% but not more than 87% ethylene oxide	1041	17
Ethylene Oxide and Carbon Dioxide Mixture, with more than 87% ethylene oxide	**3300**	**18**
Ethylene Oxide and Carbon Dioxide Mixture, with not more than 6% ethylene oxide	1952	12
Ethylene Oxide and Carbon Dioxide Mixture, with not more than 9% ethylene oxide	1952	12
Ethylene Oxide and Chlorotetrafluoroethane Mixtures, with not more than 8.8% ethylene oxide	3297	12
Ethylene Oxide and Dichlorodifluoromethane Mixture, with not more than 12% ethylene oxide	3070	12
Ethylene Oxide and Dichlorodifluoromethane Mixture, with not more than 12.5% ethylene oxide	3070	12
Ethylene Oxide and Pentafluoroethane Mixtures, with not more than 7.9% ethylene oxide	3298	12
Ethylene Oxide and Propylene Oxide Mixtures	2983	26
Ethylene Oxide and Tetrafluoroethane Mixtures, with not more than 5.6% ethylene oxide	3299	12
Ethylene Oxide with nitrogen	**1040**	**69**
Ethylenediamine	1604	29
Ethyleneimine, inhibited	**1185**	**30**
Ethyl Ether	1155	26
Ethyl Fluid	1649	56
Ethyl Fluoride	2453	12
Ethyl Formate	1190	26

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Ethylhexaldehydes	1191	26
2-Ethyl Hexylamine	2276	29
2-Ethylhexyl Chloroformate	2748	55
Ethyl Isobutyrate	2385	26
Ethyl Isocyanate	**2481**	**28**
Ethyl Lactate	1192	26
Ethyl Mercaptan	2363	27
Ethyl Methacrylate	2277	26
Ethyl Methyl Ether	1039	26
Ethyl Methyl Ketone	1193	26
Ethyl Methyl Ketone Peroxide	2550	51
Ethyl Nitrate	1993	27
Ethyl Nitrite, and solutions	1194	30
Ethyl Orthoformate	2524	26
Ethyl Oxalate	2525	54
Ethyl Phenyl Dichlorosilane	2435	39
Ethyl Phosphonothioic Dichloride, anhydrous	1760	60
Ethyl Phosphonothioic Dichloride, anhydrous	**2927**	**59**
Ethyl Phosphonous Dichloride, anhydrous	**2845**	**40**
Ethyl Phosphorodichloridate	1760	60
Ethyl Phosphorodichloridate	**2927**	**59**
Ethyl Piperidine	2386	68
1-Ethylpiperidine	2386	68
Ethyl Propionate	1195	26
Ethyl Propyl Ether	2615	26
Ethyl Silicate	1292	29
Ethyl Sulfate	1594	55
Ethylsulfuric Acid	2571	60
N-Ethyltoludines	2754	55
Ethyltrichlorosilane	1196	29
Etiologic Agent, n.o.s.	2814	24
Explosive A	--	46
Explosive B	--	46
Explosive C	--	50
Explosives, division 1.1, 1.2, 1.3, 1.5 or 1.6	--	46
Explosives, division 1.4	--	50

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Extracts, aromatic, liquid	1169	26
Extracts, flavouring, liquid	1197	26
Fabric, animal or vegetable or synthetic, with oil, n.o.s.	1373	32
Fabrics, impregnated with weakly nitrated nitrocellulose, n.o.s.	1353	32
Ferric Arsenate	1606	53
Ferric Arsenite	1607	53
Ferric Chloride, anhydrous	1773	60
Ferric Chloride Solution	2582	60
Ferric Nitrate	1466	35
Ferrocerium	1323	32
Ferrosilicon	1408	41
Ferrous Arsenate	1608	53
Ferrous Chloride, solid	1759	60
Ferrous Chloride Solution	1760	60
Ferrous Metal, borings, cuttings, shavings, or turnings	2793	32
Fertilizer Ammoniating Solution, with more than 35% free ammonia	1043	16
Fiber, animal or vegetable, burnt, wet or damp, n.o.s.	1372	32
Fiber, animal or vegetable or synthetic, with oil, n.o.s.	1373	32
Fibers, impregnated with weakly nitrated nitrocellulose, n.o.s.	1353	32
Film, Motion Picture, nitro-cellulose base	1324	32
Film, Nitrocellulose Base	1324	32
Fire Extinguisher Charges, corrosive liquid	1774	60
Fire Extinguishers, with compressed or liquefied gas	1044	12
Fire Lighters, solid with flammable liquid	2623	32
Fish Meal or Scrap, unstabilized	1374	32
Fish Meal or Scrap, stabilized	2216	31
Flammable Gas in Lighter for cigars, cigarettes, etc.	1057	17
Flammable Gas, n.o.s.	1954	22
Flammable Liquid, toxic, corrosive, n.o.s.	3286	28
Flammable Liquid, toxic, n.o.s.	1992	28

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Flammable Liquid Preparations, n.o.s.	1142	26
Flammable Liquids, corrosive, n.o.s.	2924	29
Flammable Liquids, elevated temperature material, n.o.s.	9276	27
Flammable Liquids, n.o.s.	1993	27
Flammable Liquids, poisonous, n.o.s.	1992	28
Flammable Solid, corrosive, inorganic, n.o.s.	3180	34
Flammable Solid, corrosive, n.o.s.	2925	34
Flammable Solid, corrosive, organic, n.o.s.	2925	34
Flammable Solid, inorganic, corrosive, n.o.s.	3180	34
Flammable Solid, inorganic, n.o.s.	3178	32
Flammable Solid, inorganic, poisonous, n.o.s.	3179	34
Flammable Solid, n.o.s.	1325	32
Flammable Solid, organic, molten, n.o.s.	3176	32
Flammable Solid, oxidizing, n.o.s.	3097	32
Flammable Solid, poisonous, n.o.s.	2926	34
Flammable Solid, toxic, inoprganic, n.o.s.	3179	34
Flammable Solid, toxic, organic, n.o.s.	2926	34
Flue Dust, poisonous	2811	53
Fluoboric Acid	1775	60
Fluoric Acid	1790	59
Fluorine, compressed	**1045**	**20**
Fluorine, refrigerated liquid (cryogenic liquid)	**9192**	**25**
Fluoroacetic Acid	2642	59
Fluoroanilines	2941	55
Fluorobenzene	2387	27
Fluoroboric Acid	1775	60
Flurophosphoric Acid, anhydrous	1776	59
Fluorosilicates, n.o.s.	2856	53
Fluorosilicic Acid	1778	60
Fluorosulfonic Acid	1777	39
Fluorotoluenes	2388	27
Fluorosilicic Acid	1778	60
Formaldehyde Solutions (Formalin)	2209	29
Formaldehyde Solutions (Formalin)	1198	29
Formic Acid	1779	60
Fuel, Aviation, turbine engine	1863	27
Fuel Oil	1993	27
Fumaryl Chloride	1780	60
Fungicide, corrosive, n.o.s.	1759	60
Fungicide, poisonous, n.o.s.	2902	55
Furan	2389	26
Furfural	1199	29
Furfuryl Alcohol	2874	55
Furfurylamine	2526	28
Fusee (rail or highway)	1325	32
Fusel Oil	1201	26
Gallium	2803	60
Gallium, metal	2803	60
Gas, refrigerated liquid, n.o.s.	3158	21
Gas Drips, hydrocarbon	1864	27
Gas Identification Set	9035	15
Gasohol	1203	27
Gas Oil	1202	27
Gasoline	1203	27
Gas Sample, non-pressurized, flammable, n.o.s., not refrigerated liquid	3167	22
Gas Sample, non-pressurized, toxic, flammable, n.o.s., not refrigerated liquid	3168	18
Gas Sample, non-pressurized, toxic, n.o.s., not refrigerated liquid	3169	15
Gas Sample, non-pressurized, flammable, n.o.s., not deeply refrigerated	3167	22
Gas Sample, non-pressurized, toxic, flammable, n.o.s., not deeply refrigerated	3168	18
Gas Sample, non-pressurized, toxic, n.o.s., not deeply refrigerated	3169	15
Genetically Modified Microorganisms	3245	31
Genetically Modified Organisms	9278	31
Germane (germanium hydride)	**2192**	**18**

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Glycerol-alpha-Monochlorohydrin	2869	55
Glyceril Trinitrate Solution	1204	26
Glicidaldehyde	2622	28
Grenade, tear gas	2017	58
Grenade, without bursting charge, with poisonous gas	2016	15
Guanidine Nitrate	1467	43
Guthion	2783	55
Hafnium powder, dry	2545	40
Hafnium powder, wetted with not less than 25% water	1326	32
Halogenated Irritating Liquids, n.o.s.	1610	58
Hay, Straw or Bhusa, wet damp or contaminated with oil	1327	32
Hazardous Substance, liquid or solid, n.o.s.	9188	31
Hazardous Waste, liquid or solid, n.o.s.	9189	31
Hazardous Waste, liquid, n.o.s.	3082	31
Hazardous Waste, solid, n.o.s.	3077	31
Heating Oil, light	1202	27
Helium, compressed	1046	12
Helium, refrigerated liquid (cryogenic liquid)	1963	21
Helium-Oxygen Mixture	1980	14
Heptafluoropropane	3296	12
n-Heptaldehyde	3056	26
Heptanes	1206	27
n-Heptene	278	27
Hexachloroacetone	2661	54
Hexachlorobenzene	2729	53
Hexachlorobutadiene	2279	55
Hexachlorocyclo-pentadiene	**2646**	**55**
Hexachloroethane	9037	53
Hexachlorophene	2875	53
Hexadecyltrichlorosilane	1781	60
Hexadienes	2458	29
Hexaethyl Tetraphosphate	1611	55
Hexaethyl Tetraphosphate and Compressed Gas Mixtures	***1612***	***15***
Hexaethyl Tetraphosphate Mixture	2783	55
Hexafluoroacetone	**2420**	**15**
Hexafluoroacetone Hydrate	2552	55
Hexafluoroethane	2193	12
Hexafluoro-phosphoric Acid	1782	59
Hexafluoropropylene	1858	12
Hexafluoropropylene Oxide	1956	12
Hexaldehyde	1207	26
Hexamethylene-diamine, solid	2280	60
Hexamethylene-diamine Solution	1783	60
Hexamethylene Diisocyanate	2281	53
Hexamethyleneimine	2493	29
Hexamethylene-tetramine	1328	32
3,3,6,6,9,9-Hexa-methyl-1,2,4,5-Tetraoxocyclononane	2166	48
3,3,6,6,9,9-Hexa-methyl-1,2,4,5-Tetra-oxocyclononane	2167	48
3,3,6,6,9,9-Hexa-methyl-1,2,4,5-Tetra-oxocyclononane, technical pure	2165	49
Hexamine	1328	32
Hexanes	1208	27
Hexanoic Acid	1760	60
Hexanols	2282	26
1-Hexene	2370	27
Hexyltrichlorosilane	1784	29
Hydrazine, Anhydrous	2029	28
Hydrazine Aqueous Solution with not less than 37% but not more than 64% hydrazine	2030	59
Hydrazine Aqueous Solution with not more than 64% hydrazine	2030	59
Hydrazine Aqueous Solutions, with more than 64% hydrazine	2029	28
Hydrazine Aqueous Solutions, with not more than 37% hydrazine	3293	53
Hydrazine Hydrate	2030	59
Hydrazine Hydrate with not less than 37% but not more than 64% hydrazine	2030	59
Hydrazine Solution, with not more than 64% hydrazine	2030	59
Hydrides , metal, n.o.s.	1409	40
Hydriodic Acid, and Solutions	1787	60

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Hydrobromic Acid and Solutions	1788	60
Hydrocarbon Gas Mixtures, compressed, n.o.s.	1964	22
Hydrocarbon Gas Mixtures, liquefied, n.o.s.	1965	22
Hydrocarbon Gas Refills for small devices, with release device	3150	22
Hydrocarbon Gases, compressed, n.o.s.	1964	22
Hydrocarbon Gases, liquefied, n.o.s.	1965	22
Hydrochloric Acid, anhydrous	**1050**	**15**
Hydrochloric Acid Solution	1789	60
Hydrocyanic Acid	**1051**	**13**
Hydrocyanic Acid, aqueous solution, with less than 5% hydrocyanic acid	1613	55
Hydrocyanic Acid, aqueous solution, with not less than 5% hydrocyanic acid	1613	55
Hydrocyanic Acid, aqueous solution, with not more than 20% hydrogen cyanide	**1613**	**55**
Hydrofluoric Acid, anhydrous	**1052**	**15**
Hydrofluoric Acid Solution	1790	59
Hydrofluoric and Sulfuric Acid Mixtures	1786	59
Hydrofluosilicic Acid	1778	60
Hydrogen, compressed	1049	22
Hydrogen, refrigerated liquid (cryogenic liquid)	1966	22
Hydrogen and Methane Mixtures, compressed	2034	22
Hydrogen Bromide, anhydrous	**1048**	**15**
Hydrogen Bromide Solution	1788	60
Hydrogen Chloride, anhydrous	**1050**	**15**
Hydrogen Chloride, refrigerated liquid (cryogenic liquid)	**2186**	**15**
Hydrogen Chloride Solution	1789	60
Hydrogen Cyanide, anhydrous, stabilized	**1051**	**13**
Hydrogen Cyanide, anhydrous, stabilized (absorbed)	**1614**	**57**
Hydrogen Cyanide, aqueous solution, with not more than 20% hydrogen cyanide	**1613**	**55**
Hydrogen Cyanide, solution in alcohol with not more than 45% hydrogen cyanide	**3294**	**28**
Hydrogen Cyanide, stabilized, containing less than 3% water	**1051**	**13**
Hydrogen Cyanide, stabilized, containing less than 3% water (absorbed in porous inert material)	**1614**	**57**
Hydrogendifluorides, n.o.s., solid or solution	1740	60
Hydrogen Fluoride, anhydrous	**1052**	**15**
Hydrogen Fluoride Solution	1790	59
Hydrogen Iodide, anhydrous	**2197**	**15**
Hydrogen Iodide Solution	1787	60
Hydrogen Peroxide, stabilized	2015	47
Hydrogen Peroxide Aqueous Solutions, stabilized with more than 60% hydrogen peroxide	2015	47
Hydrogen Peroxide Aqueous Solutions with not less than 8% but less than 20% peroxide	2984	45
Hydrogen Peroxide Aqueous Solutions, with not less than 20% but not more than 60% peroxide	2014	45
Hydrogen Peroxide-Peroxyacetic Acid Mixtures, with acid(s), water and not more than 5% Peroxyacetic acid, stabilized	3149	45
Hydrogen Sulfide	**1053**	**13**
Hydrogen Selenide, anhydrous	**2202**	**13**
Hydrogen Sulfide, liquefied	**1053**	**13**
Hydroquinone	2662	53
Hydrosilicofluoric Acid	1778	60
3-(2-Hydroxy-ethoxy)-4-Pyrrolidin-1-Yl benzene Diazonium Zinc Chloride	3035	70
Hydroxylamine Sulfate	2865	60
Hypochlorite Solution with more than 5% available chlorine	1791	60
Hypochlorites, inorganic, n.o.s.	3212	35
Hyrocarbons, Liquid, n.o.s.	3295	27
Iminobispropylamine	2269	60
3,3'-Iminodipropyl-amine	2269	60

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Infectious Substances, affecting animal only	2900	24
Infectious Substances, affecting humans	2814	24
Ink, printer's, flammable	1210	26
Insecticide, dry, n.o.s.	2588	55
Insecticide, liquid, n.o.s.	1993	27
Insecticide, liquid, poisonous, n.o.s.	2902	55
Insecticide Gases, n.o.s.	1968	12
Insecticide Gases, toxic, n.o.s.	**1967**	**15**
Iodine Monochloride	1792	59
Iodine Pentafluoride	2495	44
2-Iodobutane	2390	26
IPDI	2290	53
Iron Chloride, solid	1773	60
Iron Chloride Solution	2582	60
Iron Oxide, spent	1376	37
Iron Pentacarbonyl	**1994**	**57**
Iron Sponge, spent	1376	37
Irritating Agent	1693	58
Isoamyl Alcohol	1105	26
Isobutane or Isobutane Mixtures	1969	22
Isobutanol	1212	26
Isobutyl Acetate	1213	26
Isobutyl Acrylate	2527	27
Isobutyl Alcohol	1212	26
Isobutyl Aldehyde	2045	26
Isobutylamine	1214	68
Isobutyl Chloroformate	**2742**	**57**
Isobutylene	1055	22
Isobutyl Formate	2393	29
Isobutyl Isobutyrate	2528	26
Isobutyl Isocyanate	**2486**	**57**
Isobutyl Methacrylate	2283	27
Isobutyl Propionate	2394	26
Isobutyraldehyde	2045	26
Isobutyric Acid	2529	29
Isobutyric Anhydride	2530	29
Isobutyronitrile	2284	28
Isobutyryl Chloride	2395	29

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Isocyanate Solution, flammable, toxic, n.o.s.	2478	28
Isocyanate Solution, toxic, n.o.s.	2206	55
Isocyanate Solutions, n.o.s.	3080	28
Isocyanate Solutions, toxic, flammable, n.o.s.	3080	28
Isocyanates and solutions, n.o.s., b.p. less than 300°C	2206	55
Isocyanates and solutions, n.o.s., b.p. not less than 300°C	2207	55
Isocyanates and solutions, n.o.s., (flammable)	2478	28
Isocyanates, flammable, toxic, n.o.s.	2478	28
Isocyanates, n.o.s.	3080	28
Isocyanates, toxic, flammable, n.o.s.	3080	28
Isocyanates, toxic, n.o.s.	2206	55
Isocyanatobenzotrifluorides	2285	55
Isoheptenes	2287	27
Isohexenes	2288	28
Isononanoyl Peroxide, technical pure or in solution	2128	52
Isooctane	1262	27
Isooctenes	1216	27
Isopentane	1265	27
Isopentanoic Acid	1760	60
Isopentenes	2371	27
Isophoronediamine	2289	60
Isophorone Diisocyanate	2290	53
Isoprene, inhibited	1218	27
Isopropanol	1219	26
Isopropenyl Acetate	2403	26
Isopropenylbenzene	2303	27
Isopropyl Acetate	1220	26
Isopropyl Acid Phosphate	1793	60
Isopropyl Alcohol	1219	26
Isopropylamine	1221	68
Isopropylbenzene	1918	28
Isopropyl Butyrate	2405	26
Isopropyl Chloroacetate	2947	29
Isopropyl Chloroformate	**2407**	**57**

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Isopropyl 2-Chloropropionate	2934	29
Isopropyl Ether	1159	26
Isopropyl Formate	2408	27
Isopropyl Isobutyrate	2406	28
Isopropyl Isocyanate	**2483**	**28**
Isopropyl Mercaptan	2402	27
Isopropyl Nitrate	1222	27
Isopropyl Peroxy-dicarbonate	2133	52
Isopropyl propionate	2409	27
Isosorbide Dinitrate Mixture	2907	32
Isosorbide-5-Mono-nitrate	3251	32
Kerosene	1223	27
Ketones, liquid, n.o.s.	1224	26
Krypton, compressed	1056	12
Krypton, refrigerated liquid (cryogenic liquid)	1970	21
Lacquer	1263	26
Lacquer Base, dry	2557	32
Lacquer Base, liquid	1263	26
Lauroyl Peroxide, not more than 42%	2893	48
Lauroyl Peroxide, technical pure	2124	48
Lead Acetate	1616	53
Lead Arsenates	1617	53
Lead Arsenites	1618	53
Lead Chloride	2291	53
Lead Compounds, soluble, n.o.s.	2291	53
Lead Cyanide	1620	53
Lead Dioxide	1872	42
Lead Fluoborate	2291	53
Lead Fluoride	2811	53
Lead Nitrate	1469	42
Lead Percholate, solid or solution	1470	42
Lead Peroxide	1872	42
Lead Phosphite, dibasic	2989	32
Lead Sulfate, with more than 3% free acid	1794	60
Life-Saving Appliances Not Self-Inflating	3072	31
Lighter, for cigars, cigarettes, etc. with flammable liquid	1226	26
Lighter Fluid	1226	26
Lighter Refills, cigarettes, containing flammable gas	1057	17
Lighters, cigarettes, containing flammable gas	1057	17
Lindane	2761	55
Liquefied Gas, flammable, n.o.s.	1954	22
Liquefied Gas, flammable, n.o.s.	3161	22
Liquefied Gas, non-flammable, charged with nitrogen, carbon dioxide or air	1058	12
Liquefied Gas, n.o.s.	1956	12
Liquefied Gas, n.o.s.	3163	12
Liquefied Gas, oxidizing, n.o.s.	3157	14
Liquefied Gas, toxic, flammable, n.o.s.	**3160**	**18**
Liquefied Gas, toxic, n.o.s.	**3162**	**15**
Liquefied Gases, flammable, poisonous, n.o.s.	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	**1953**	**18**
Liquefied Gases, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	**1953**	**18**
Liquefied Gases, poisonous, n.o.s.	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone A)	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone B)	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone C)	**1955**	**15**
Liquefied Gases, toxic, n.o.s. (Inhalation Hazard Zone D)	**1955**	**15**
Liquefied Natural Gas	1972	22
Liquefied Non-flammable Gas charged with nitrogen, carbon dioxide or air	1058	12
Liquefied Petroleum Gas	1075	22
Lithium	1415	40
Lithium Acetylide-Ethylenediamine Complex	2813	40

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Lithium Alkyls	2445	40
Lithium Alluminium Hydride	1410	40
Lithium Alluminium Hydride, ethereal	1411	40
Lithium Amide	1412	40
Lithium Batteries, contained in equipment	3091	40
Lithium Batteries, packed with equipment	3091	40
Lithium Battery	3090	40
Lithium Borohydride	1413	40
Lithium Ferrosilicon	2830	41
Lithium Hydride	1414	40
Lithium Hydride, fused, solid	2805	40
Lithium Hydroxide, solid	2680	60
Lithium Hydroxide Monohydrate	2680	60
Lithium Hydroxide Solution	2679	60
Lithium Hypo-chlorite, dry, including mixtures with more than 39% available chlorine	1471	45
Lithium Metal	1415	40
Lithium Nitrate	2722	35
Lithium Nitride	2806	37
Lithium Peroxide	1472	47
Lithium Silicon	1417	40
LNG, liquefied natural gas	1972	22
London Purple	1621	53
LPG, liquefied petroleum gas	1075	22
Magnesium, pellets, turnings or ribbon	1869	76
Magnesium, powder	1418	76
Magnesium Alkyls	3053	40
Magnesium Alloy, with more than 50% magnesium, pellets, turnings or ribbon	1869	76
Magnesium Alloy, with more than 50% magnesium, powder	1418	76
Magnesium Aluminum Phosphide	1419	41
Magnesium Arsenate	1622	53
Magnesium Bromate	1473	35
Magnesium Chlorate	2723	35
Magnesium Diamide	2004	37
Magnesium Diphenyl	2005	40
Magnesium Fluorosilicate	2853	53
Magnesium Granules, coated	2950	40
Magnesium Hydride	2010	40
Magnesium Nitrate	1474	35
Magnesium Perchlorate	1475	35
Magnesium Peroxide	1476	35
Magnesium Phosphide	2011	41
Magnesium Silicide	2624	40
Magnetized Material	2807	31
Malathion	2783	55
Maleic Acid	2215	60
Maleic Anhydride	2215	60
Malononitrile	2647	53
Maneb, or Maneb Preparation(s), stabilized against self-heating	2968	37
Maneb, or Maneb Preparation(s) with 50% or more Maneb	2210	37
Manganese Nitrate	2724	35
Manganese Resinate	1330	32
Matches, fusee	2254	32
Matches, safety	1944	32
Matches, strike anywhere	1331	32
Matches, wax (Vesta)	1945	32
Medical Waste, n.o.s.	3291	24
Medicines, corrosive, liquid, n.o.s.	1760	60
Medicines, corrosive, solid, n.o.s.	1759	60
Medicines, flammable, liquid, n.o.s.	1993	27
Medicines, flammable, solid, n.o.s.	1325	32
Medicines, liquid, flammable, poisonous, n.o.s.	3248	28
Medicines, liquid, flammable, toxic, n.o.s.	3248	28
Medicines, liquid, poisonous, n.o.s.	1851	55
Medicines, liquid, toxic, n.o.s.	1851	55
Medicines, oxidizing substance, solid, n.o.s.	1479	35
Medicines, poisonous, liquid, n.o.s.	2810	55
Medicines, poisonous, solid, n.o.s.	2811	53
Medicines, solid, poisonous, n.o.s.	3249	55
Medicines, solid, toxic, n.o.s.	3249	55

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Menthane Hydroperoxide, para, technical pure	2125	51
Mercaptan Mixture, aliphatic	1228	28
Mercaptan Mixture, liquid, flammable, toxic, n.o.s.	1228	28
Mercaptan Mixture, liquid, toxic, flamm-able, n.o.s.	3071	28
Mercaptan Mixtures, liquid, n.o.s.	3071	28
Mercaptans, liquid, flammable, toxic, n.o.s.	1228	28
Mercaptans, liquid, n.o.s.	3071	28
Mercaptans, liquid, toxic, flammable, n.o.s.	3071	28
Mercaptans and Mixtures, liquid, n.o.s.	1228	28
Mercuric Acetate	1629	53
Mercuric Arsenate	1623	53
Mercuric Bromide	1634	53
Mercuric Chloride	1624	53
Mercuric Cyanide	1636	53
Mercuric Nitrate	1625	42
Mercuric Oxycyanide	1642	53
Mercuric Potassium Cyanide	1626	53
Mercuric Sulfate	1645	53
Mercurol	1639	53
Mercurous Acetate	1629	53
Mercurous Bromide	1634	53
Mercurous Nitrate	1627	42
Mercurous Sulfate	1628	53
Mercury	2809	60
Mercury Acetate	1629	53
Mercury Ammonium Chloride	1630	53
Mercury-based Pesticides, liquid, flammable, toxic, n.o.s.	2778	28
Mercury-based Pesticides, liquid, toxic, flammable, n.o.s.	3011	28
Mercury-based Pesticides, liquid, toxic, n.o.s.	3012	55
Mercury-based Pesticides, solid, toxic, n.o.s.	2777	55
Mercury Benzoate	1631	53
Mercury Bisulfate	1633	53
Mercury Bromides	1634	53
Mercury Compounds, liquid, n.o.s.	2024	53
Mercury Compounds, solid, n.o.s.	2025	53
Mercury Cyanide	1636	53
Mercury Gluconate	1637	53
Mercury Iodide	1638	53
Mercury Metal	2809	60
Mercury Nucleate	1639	53
Mercury Oleate	1640	53
Mercury Oxide	1641	53
Mercury Oxycyanide, desensitized	1642	53
Mercury Potassium Iodide	1643	53
Mercury Salicylate	1644	53
Mercury Sulfate	1645	53
Mercury Thiocyanate	1646	53
Mesityl Oxide	1229	26
Metal Alkyl Halides, n.o.s.	3049	40
Metal Alkyl Hydrides, n.o.s.	3050	40
Metal Alkyl Solution, n.o.s.	9195	40
Metal Alkyls, n.o.s.	2003	40
Metal Carbonyls, toxic, n.o.s.	3281	55
Metal Catalyst, dry	2881	37
Metal Catalyst, finely divided, activated or spent, wet with not less than 40% water or other suitable liquid	1378	32
Metaldehyde	1332	32
Metal Hydrides, flammable, n.o.s.	3182	32
Metal Hydrides, water-reactive, n.o.s.	1409	40
Metallic Substance, water-reactive, n.o.s.	3208	40
Metallic Substance, water-reactive, self-heating, n.o.s.	3209	40
Metal Powder, flammable, n.o.s.	3089	32
Metal Powder, self-heating, n.o.s.	3189	37
Metal Salts of Organic Compounds, flammable, n.o.s.	3181	32
Methacrylaldehyde	2396	28
Methacrylic Acid, inhibited	2531	60

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Methacrylonitrile, inhibited	**3079**	**28**
Methallyl Alcohol	2614	26
Methane, compressed	1971	17
Methane, refrigerated liquid (cryogenic liquid)	1972	22
Methanesulfonyl Chloride	**3246**	**59**
Methanol	1230	28
Methoxymethyl Isocyanate	**2605**	**57**
1-Methoxy-4-Methyl-Pentan-2-One	2293	27
Methoxy-2-Propanol	3092	26
Methyl Acetate	1231	26
Methyl Acetone	1232	26
Methyl Acetylene and Propadiene Mixture, stabilized	1060	17
Methyl Acrylate, inhibited	1919	26
Methylal	1234	26
Methyl Alcohol	1230	28
Methyl Allyl Chloride	2554	26
Methylamine, anhydrous	1061	19
Methylamine, aqueous solution	1235	68
Methyl Amyl Acetate	1233	26
Methyl Amyl Alcohol	2053	26
Methyl Amyl Ketone	1110	26
N-Methylaniline	2294	57
Methyl Benzoate	2938	31
Methylbenzyl Alcohol (alpha)	2937	55
Methyl Bromide	**1062**	**55**
Methyl Bromide and Chloropicrin Mixtures	**1581**	**55**
Methyl Bromide and Ethylene Dibromide Mixtures, liquid	**1647**	**55**
Methyl Bromide and Non-flammable Compressed Gas Mixture	**1955**	**15**
Methyl Bromoacetate	2643	58
3-Methyl-2-Butanone	2397	26
Methylbutene	2460	26
2-Methyl-1-Butene	2459	26
2-Methyl-2-Butene	2460	26
3-Methyl-1-Butene	2561	26
N-Methylbutylamine	2945	29
Methyl tert-Butyl Ether	2398	26
Methyl butyrate	1237	26
Methyl Chloride	1063	18
Methyl Chloride and Chloropicrin Mixtures	**1582**	**18**
Methyl Chloride and Methylene Chloride Mixtures	1912	22
Methyl Chloroacetate	2295	57
Methyl Chlorocarbonate	**1238**	**28**
Methyl Chloroform	2831	74
Methyl Chloroformate	**1238**	**28**
Methyl Chloromethylether	**1239**	**57**
Methyl 2-Chloro-propionate	2933	29
Methyl Chlorosilane	**2534**	**18**
Methyl Cyanide	1648	28
Methyl Cyclohexane	2296	27
Methyl Cyclohexanol	2617	26
Methyl Cyclohexanols, flammable	2617	26
Methyl Cyclohexanone	2297	26
Methyl Cyclopentane	2298	26
Methyl Dichloroacetate	2299	60
Methyl Dichloroarsine	**1556**	**55**
Methyldichlorosilane	1242	29
Methylene Bis(4-Phenylisocyanate) (MDI)	2489	54
Methylene Chloride	1593	74
Methyl Ethyl Ether	1039	26
Methyl Ethyl Ketone	1193	26
Methyl Ethyl Ketone Peroxide	2550	51
2-Methyl-5-Ethyl-piridine	2300	60
Methyl Fluoride	2454	22
Methyl Formate	1243	26
2-Methylfuran	2301	26
5-Methylhexan-2-one	2302	26
Methylhydrazine	**1244**	**57**
Methyl Iodide	**2644**	**55**
Methyl Isobutyl Carbinol	2053	26
Methyl Isobutyl Ketone	1245	26
Methyl Isobutyl Ketone Peroxide	2126	51
Methyl Isocyanate	**2480**	**26**

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Methyl Isopropenyl Ketone, inhibited	1246	26
Methyl Isothiocyanate	**2477**	**28**
Methyl Isovaleriate	2400	27
Methyl Magnesium Bromide in Ethyl Ether	1928	37
Methyl Mercaptan	**1064**	**13**
Methyl Methacrylate, monomer, inhibited	1247	26
Methylmorpholine	2535	29
Methyl Nitrite	2455	17
Methyl Orthosilicate	**2606**	**57**
Methyl Parathion, liquid	2783	55
Methyl Parathion Mixture, dry	2783	55
Methyl Parathiou and Compressed Gas Mixture	**1967**	**15**
Methylpentadienes	2461	26
Methylpentane	2462	26
2-Methylpentan-2-Ol	2560	26
Methylphenyldichlorosilane	2437	29
Methyl Phosphonic Dichloride	**9206**	**39**
Methyl Phosphonothioic Dichloride	1760	60
Methyl Phosphonous Dichloride	**2845**	**40**
Methylpiperidine	2399	68
1-Methylpiperidine	2399	68
Methyl Propionate	1248	26
Methyl Propyl Ether	2612	26
Methyl Propyl Ketone	1249	26
Methyl Sulfate	**1595**	**57**
Methyl Sulfide	1164	27
Methyltetrahydro-furan	2536	26
Methyl Trichloro-acetate	2533	53
Methyltrichlorosilane	1250	29
Methylvaleraldehyde (alpha)	2367	27
Methyl Vinyl Ketone	**1251**	**28**
Meviphos	2783	55
Mexacarbate	2757	55
Mining Reagent, liquid	2022	55
Mixed Acid	1796	73
Mixed Acid, spent	1826	60
Molybdenium Penta-chloride	2508	60
Monochloroacetic Acid, liquid	1750	59
Monochloroacetone, inhibited	**1695**	**59**
Monochloroacetone, stabilized	**1695**	**59**
Monochloroethylene	1086	17
Monoethanolamine	2491	60
Monofluoro-phosphoric Acid	1776	59
Monomethylamine, anhydrous	1061	19
Monomethylamine, aqueous solution	1235	68
Monopropylamine	1277	68
Mono-(Trichloro)-Tetra-(mono-potassium Dichloro)-Penta-S-Triazine-trione, dry	2468	45
Morpholine	2054	29
Morpholine, aqueous, mixture	1760	60
Motor Fuel Anti-Knock Compound	1649	56
Motor Fuel Anti-Knock Mixtures	1649	56
Motor Spirit	1203	27
Muriatic Acid	1789	60
Musk Xylene	2956	32
Naphtha	2553	27
Naphtha, petroleum	1255	27
Naphtha, solvent	1256	27
Naphthalene, crude or refined	1334	32
Naphthalene, molten	2304	32
Naphthylamine (alpha)	2077	55
Naphthylamine (beta)	1650	55
Naphthylthiourea	1651	53
Naphthylurea	1652	53
Natural Gas, compressed with high Methane content	1971	17
Natural Gas, refrigerated liquid (cryogenic liquid) with high Methane content	1972	22
Natural Gas with high Methane content, compressed	1971	17
Natural gasoline	1257	27
Neohexane	1208	27
Neon, compressed	1065	12
Neon, refrigerated liquid (cryogenic liquid)	1913	21
Nickel Carbonyl	**1259**	**57**

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Nickel Catalyst, dry	2881	37
Nickel Cyanide	1653	53
Nickel Nitrate	2725	35
Nickel Nitrite	2726	35
Nicotine	1654	55
Nicotine Compound, liquid, n.o.s.	3144	55
Nicotine Compounds, solid, n.o.s.	1655	55
Nicotine Hydrochloride and solutions	1656	55
Nicotine Preparations, liquid, n.o.s.	3144	55
Nicotine Preparations, solid, n.o.s.	1655	55
Nicotine Salicylate	1657	53
Nicotine Sulfate, liquid	1658	55
Nicotine Sulfate, solid	1658	55
Nicotine Tartrate	1659	53
Nitrates, inorganic, aqueous solution, n.o.s.	3218	35
Nitrates, inorganic, n.o.s.	1477	35
Nitrating Acid	1796	73
Nitrating Acid, mixtures	1796	73
Nitrating Acid Mixtures, spent	1826	60
Nitric Acid, fuming	**2032**	**44**
Nitric Acid, other than fuming, with more than 40% acid	2031	44
Nitric Acid, other than fuming, with not more than 40% acid	1760	60
Nitric Acid, red fuming	**2032**	**44**
Nitric Acid, other than red fuming with more than 70% nitric acid	2031	44
Nitric Acid, other than red fuming with not more than 70% nitric acid	2031	44
Nitric Oxide	**1660**	**20**
Nitric Oxide and Dinitrogen Tetroxide Mixtures	**1975**	**20**
Nitric Oxide and Nitrogen Dioxide Mixtures	**1975**	**20**
Nitric Oxide and Nitrogen Tetroxide Mixtures	**1975**	**20**
Nitriles, flammable, toxic, n.o.s.	3273	28
Nitriles, toxic, flammable, n.o.s.	**3275**	**57**
Nitriles, toxic, n.o.s. (liquid)	3276	55
Nitriles, toxic, n.o.s. (solid)	3276	55
Nitrites, inorganic, aqueous solutions, n.o.s.	3219	35
Nitrites, inorganic, n.o.s.	2627	35
Nitroanilines	1661	55
Nitroanisole	2730	55
Nitrobenzene	1662	55
Nitrobenzenesulfonic Acid	2305	60
Nitrobenzo-trifluorides	2306	54
Nitrobromobenzenes	2732	55
Nitrocellulose, solution in a flammable liquid	2059	26
Nitrocellulose, wet with more than 40% flammable liquid	2059	26
Nitrocellulose, wet with not less than 20% water	2555	33
Nitrocellulose, wet with not less than 25% alcohol	2556	33
Nitrocellulose, with not more than 12.6% nitrogen, by dry mass, mixture, with or without plasticizer or with pigment	2557	32
Nitrocellulose, with plasticizing substance	2557	32
Nitrocellulose Membrane Filters	3270	32
Nitrochlorobenzene, liquid	1578	55
Nitrochlorobenzene, solid	1578	55
3-Nitro-4-Chlorobenzotrifluoride	2307	54
Nitrocresols	2446	55
Nitroethane	2842	26
Nitrogen, compressed	1066	12
Nitrogen, refrigerated liquid (cryogenic liquid)	1977	21
Nitrogen Dioxide, liquefied	**1067**	**20**
Nitrogen Peroxide	**1067**	**20**
Nitrogen Tetroxide	**1067**	**20**
Nitrogen Trifluoride	2451	15
Nitrogen Trioxide	**2421**	**20**
Nitroglycerin Solution in Alcohol, not more than 1% nitroglycerin	1204	26
Nitroglycerin Solution in Alcohol, with more than 1% but not more than 5% nitroglycerin	3064	26

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Nitroguanidine, wetted with not less than 20% water	1336	33
Nitrohydrochloric Acid	1798	60
Nitromethane	1261	26
Nitromuriatic Acid	1798	60
Nitronaphthalene	2538	32
Nitrophenols	1663	55
Nitropropanes	2608	26
p-Nitrosodimethylaniline	1369	32
Nitrostarch, wet with not less than 20% water	1337	33
Nitrostarch, wet with not less than 30% solvent	1337	33
Nitrosyl Chloride	**1069**	**16**
Nitrosylsulfuric Acid	2308	60
Nitrotoluenes	1664	55
Nitrotoludines (mono)	2660	55
Nitrous Oxide, compressed	1070	14
Nitrous Oxide, refrigerated liquid (cryogenic liquid)	2201	23
Nitroxylenes	1665	55
Nitroxylol	1665	55
Nonanes	1920	27
Nonflammable Gas, n.o.s.	1956	12
Nonyltrichlorosilane	1799	60
2,5-Norbornadiene	2251	26
Octadecyltrichloro-silane	1800	39
Octadiene	2309	27
Octafluorobut-2-Ene	2422	12
Octafluorocyclo-butane	1976	12
Octafluoropropane	2424	12
Octanes	1262	27
Octanoyl Peroxide	2129	52
Octyl Aldehydes	1191	26
tert-Octyl Mercaptan	**3023**	**57**
Octyltrichlorosilane	1801	60
Oil, n.o.s., flash point not less than 93°C	9277	31
Oil, petroleum, n.o.s.	1270	27
Oil Gas	**1071**	**18**
Oleum, with less than 30% free sulfur trioxide	1831	39
Oleum, with not less than 30% free sulfur trioxide	**1831**	**39**
ORM-A, n.o.s.	1693	58
ORM-B, n.o.s.	1760	60
ORM-E, liquid or solid, n.o.s.	9188	31
Organic Peroxide, liquid or solution, n.o.s.	9183	52
Organic Peroxide, n.o.s. (including trial quantities)	2899	52
Organic Peroxide, sample, n.o.s.	2255	48
Organic Peroxide, solid, n.o.s.	9187	52
Organic Peroxide Mixture	2756	52
Organic Peroxide Type B, liquid	3101	49
Organic Peroxide Type B, liquid, temperature controlled	3111	52
Organic Peroxide Type B, solid	3102	49
Organic Peroxide Type B, solid, temperature controlled	3112	52
Organic Peroxide Type C, liquid	3103	48
Organic Peroxide Type C, liquid, temperature controlled	3113	52
Organic Peroxide Type C, solid	3104	48
Organic Peroxide Type C, solid, temperature controlled	3114	52
Organic Peroxide Type D, liquid	3105	48
Organic Peroxide Type D, liquid, temperature controlled	3115	52
Organic Peroxide Type D, solid	3106	48
Organic Peroxide Type D, solid, temperature controlled	3116	52
Organic Peroxide Type E, liquid	3107	48
Organic Peroxide Type E, liquid, temperature controlled	3117	52
Organic Peroxide Type E, solid	3108	48
Organic Peroxide Type E, solid, temperature controlled	3118	52
Organic Peroxide Type F, liquid	3109	48
Organic Peroxide Type F, liquid, temperature controlled	3119	52
Organic Peroxide Type F, solid	3110	48

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Organic Peroxide Type F, solid, temperature controlled	3120	52
Organic Phosphate Compound, and mixtures, liquid	2783	55
Organic Phosphate Compound, and mixtures, solid	2783	55
Organic Phosphate, mixed with Compressed Gas	**1955**	**15**
Organic Phosphate Compound, mixed with Compressed Gas	**1955**	**15**
Organic Phosphorous Compound, mixed with Compressed Gas	**1955**	**15**
Organoarsenic Compound, toxic, n.o.s.	3280	55
Organochlorine Pesticides, liquid, flammable, toxic, n.o.s.	2762	28
Organochlorine Pesticides, liquid, toxic, flammable, n.o.s.	2995	28
Organochlorine Pesticides, liquid, toxic, n.o.s.	2996	55
Organochlorine Pesticides, solid, toxic, n.o.s.	2761	55
Organometallic Compounds, toxic, n.o.s.	3282	55
Organometallic Compounds, water-reactive, flammable, n.o.s.	3207	40
Organometallic Dispersion, water-reactive, flammable, n.o.s.	3207	40
Organometallic Solution, water-reactive, flammable, n.o.s.	3207	40
Organophosphorous Compound, toxic, flammable, n.o.s.	**3279**	**28**
Organophosphorous Compound, toxic, n.o.s.(liquid)	3278	55
Organophosphorous Compound, toxic, n.o.s.(solid)	3278	55
Organophosphorous Pesticides, liquid, flammable, toxic, n.o.s.	2784	28
Organophosphorous Pesticides, liquid, toxic, flammable, n.o.s.	3017	28
Organophosphorous Pesticides, liquid, toxic, n.o.s.	3018	55
Organophosphorous Pesticides, solid, toxic, n.o.s.	2783	55
Organotin Compounds, liquid, n.o.s.	2788	55
Organotin Compounds, solid, n.o.s.	3146	55
Organotin Pesticides, liquid, flammable, toxic, n.o.s.	2787	28
Organotin Pesticides, liquid, toxic, n.o.s.	3020	55
Organotin Pesticides, solid, toxic, n.o.s.	2786	55
Osmium Tetroxide	2471	55
Other Regulated Substances, liquid, n.o.s.	3082	31
Other Regulated Substances, solid, n.o.s.	3077	31
Oxalates, water soluble	2449	54
Oxidizer, corrosive liquid, n.o.s.	9193	45
Oxidizer, corrosive solid, n.o.s.	9194	45
Oxidizer, n.o.s.	1479	35
Oxidizer, poisonous liquid, n.o.s.	9199	44
Oxidizer, poisonous solid, n.o.s.	9200	42
Oxidizing Liquid, corrosive, n.o.s.	3098	45
Oxidizing Liquid, poisonous, n.o.s.	3099	44
Oxidizing Liquid, toxic, n.o.s.	3099	44
Oxidizing Material, n.o.s.	1479	35
Oxidizing Solid, corrosive, n.o.s.	3085	42
Oxidizing Solid, n.o.s.	1479	35
Oxidizing Solid, self-heating, n.o.s.	3100	43
Oxidizing Solid, toxic, n.o.s.	3087	44
Oxidizing Solid, water-reactive, n.o.s.	3121	43
Oxidizing Substances, liquid, corrosive, n.o.s.	3098	45
Oxidizing Substances, liquid, n.o.s.	3139	35
Oxidizing Substances, solid, corrosive, n.o.s.	3085	42
Oxidizing Substances, solid, flammable, n.o.s.	3137	35
Oxidizing Substances, solid, n.o.s.	1479	35
Oxidizing Substances, solid, poisonous, n.o.s.	3087	44
Oxidizing Substances, solid, self-heating, n.o.s.	3100	43
Oxidizing Substances, solid, which in contact with water emit Flammable Gases, n.o.s.	3121	43
Oxygen, compressed	1072	14

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Oxygen, refrigerated liquid (cryogenic liquid)	1073	23
Oxygen Difluoride	**2190**	**20**
Paint, corrosive liquid	1760	60
Paint, corrosive liquid	3066	60
Paint, flammable liquid	1263	26
Paint Related Material, corrosive liquid	1760	60
Paint Related Material, corrosive liquid	3066	60
Paint Related Material, flammable liquid	1263	26
Paper, treated with unsaturated oil	1379	32
Paraformaldehyde	2213	32
Paraldehyde	1264	26
Paramenthane Hydroperoxide	2125	51
Parathion and Compressed Gas Mixture	**1967**	**15**
Parathion Mixture, liquid or dry	2783	55
PCBs	2315	31
Pelargonyl Peroxide	2130	52
Pentaborane	**1380**	**75**
Pentachloroethane	1669	55
Pentachlorophenol	3155	15
Pentafluoroethane	3220	12
Pentamethylheptane	2286	27
Pentan-2,4-Dione	2310	26
n-Pentane	1265	27
1-Pentene	1108	26
1-Pentol	2705	60
Peracetic Acid, solution	2131	51
Peracarbonates, inorganic, n.o.s.	3217	35
Perchlorates, inorganic, aqueous solution, n.o.s.	3211	35
Perchlorates, inorganic, n.o.s.	1481	35
Perchloric Acid, more than 50% but not more than 72% acid, by weight	1873	47
Perchloric Acid, not more than 50% acid, by weight	1802	45
Perchloroethylene	1897	74
Perchlormethyl Mercaptan	**1670**	**55**
Perchloryl Fluoride	**3083**	**20**
Perfluoroethylvinyl Ether	3154	22
Perfluoromethylvinyl Ether	3153	22
Perfumery Products, with flammable solvent	1266	26
Permanganates, inorganic, n.o.s.	1482	35
Permanganates, inorganic, aqueous solution, n.o.s.	3214	35
Peroxide, inorganic, n.o.s.	1483	35
Peroxyacetic Acid, solution	2131	51
Permanganates, inorganic, aqueous solution, n.o.s.	3216	35
Permanganates, inorganic, n.o.s.	3215	35
Pesticide, water reactive, containing manganese ethylene-bisdithiocarbamate (maneb)	2210	37
Pesticides, liquid, flammable, toxic, n.o.s.	3021	28
Pesticides, liquid, toxic, flammable, n.o.s.	2903	28
Pesticides, liquid, toxic, n.o.s.	2902	55
Pesticides, solid, toxic, n.o.s.	2588	55
Petrol	1203	27
Petroleum Crude Oil	1267	27
Petroleum Distillates, n.o.s.	1268	27
Petroleum Ether	1271	26
Petroleum Gases, liquefied	1075	22
Petroleum Naphtha	1255	27
Petroleum Oil	1270	27
Petroleum Products, n.o.s.	1268	27
Petroleum Spirit	1271	26
Phenacyl Bromide	2645	55
Phenitidines	2311	55
Phenol, molten	2312	55
Phenol, solid	1671	55
Phenol Solutions	2821	55
Phenolsulfonic Acid, liquid	1803	60
Phenoxy Pesticides, liquid, flammable, toxic, n.o.s.	2766	28
Phenoxy Pesticides, liquid, toxic, flammable, n.o.s.	2999	28
Phenoxy Pesticides, liquid, toxic, n.o.s.	3000	55

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Phenoxy Pesticides, solid, toxic, n.o.s.	2765	55
Phenylacetonitrile, liquid	2470	55
Phenylacetyl Chloride	2577	60
Phenylcarbylamine Chloride	**1672**	**55**
Phenyl Chloroformate	2746	55
Phenyldichloroarsine	1556	55
Phenylenediamines	1673	53
Phenylhydrazine	2572	53
Phenyl Isocyanate	**2487**	**55**
Phenyl Mercaptan	**2337**	**57**
Phenylmercuric Acetate	1674	55
Phenylmercuric Compounds, solid, n.o.s.	2026	53
Phenylmercuric Hydroxide	1894	53
Phenylmercuric Nitrate	1895	53
Phenyl Phosphorous Dichloride	2798	39
Phenyl Phosphorous Thiodichloride	2799	39
Phenyltrichlorosilane	1804	39
Phenyl Urea Pesticides, liquid, flammable,toxic, n.o.s.	2768	28
Phenyl Urea Pesticides, liquid, toxic, flammable, n.o.s.	3001	28
Phenyl Urea Pesticides, liquid, toxic, n.o.s.	3002	55
Phosgene	**1076**	**15**
9-Phosphabicyclo-nonanes	2940	37
Phosphine	**2199**	**18**
Phosphoric Acid	1805	60
Phosphoric Acid Triethyleneimine	2501	55
Phosphoric Anhydride	1807	39
Phosphorous Acid	2834	60
Phosphorous Acid, ortho	2834	60
Phosphorus, amorphous, red	1338	32
Phosphorus, white, molten	2447	38
Phosphorus, white or yellow, dry or under water or in solution	1381	38
Phosphorus Heptasulfide, free from yellow or white phosphorus	1339	32
Phosphorus Oxybromide, molten	2576	39
Phosphorus Oxybromide, solid	1939	39
Phosphorus Oxychloride	**1810**	**39**
Phosphorus Pentabromide	2691	39
Phosphorus Pentachloride	1806	39
Phosphorus Pentafluoride	**2198**	**15**
Phosphorus Pentasulfide, free from yellow or white phosphorus	1341	41
Phosphorus Pentoxide	1807	39
Phosphorus Sesquisulfide, free from yellow or white phosphorus	1341	41
Phosphorus Tribromide	1808	39
Phosphorus Trichloride	**39**	**1809**
Phosphorus Trioxide	2578	60
Phosphorus Trisulfide, free from yellow or white phosphorus	1343	41
Phosphoryl Chloride	**1810**	**39**
Phthalic Anhydride	2214	60
Phthalimide Derivative Pesticides, liquid, flammable, toxic, n.o.s.	2774	28
Phthalimide Derivative Pesticides, liquid, toxic, flammable, n.o.s.	3007	28
Phthalimide Derivative Pesticides, liquid, toxic, n.o.s.	3008	55
Phthalimide Derivative Pesticides, solid, toxic, n.o.s.	2773	55
Picolines	2313	27
Picric Acid, wet with not less than 10% water	1344	33
Picrite, wetted with not less than 20% water	1336	33
Pinane Hydroperoxide, technical pure	2162	51
Pinene (alpha)	2368	26
Pine Oil	1272	26
Piperazine	2579	60
Piperidine	2401	29
Plastic Moulding Material, evolving flammable vapor	2211	32
Plastics, nitro-cellulose-based, spontaneously combustible, n.o.s.	2006	37
Poison B, Liquid, n.o.s.	2810	55
Poison B, Solid, n.o.s.	2811	53
Poisonous Liquids, corrosive, n.o.s.	2927	59
Poisonous Liquids, corrosive, n.o.s. (Inhalation Hazard Zone A)	**2927**	**59**

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Poisonous Liquids, corrosive, n.o.s. (Inhalation Hazard Zone B)	**2927**	**59**
Poisonous Liquids, flammable, n.o.s.	2929	57
Poisonous Liquids, flammable, n.o.s. (Inhalation Hazard Zone A)	**2929**	**57**
Poisonous Liquids, flammable, n.o.s. (Inhalation Hazard Zone B)	**2929**	**57**
Poisonous Liquids, n.o.s.	2810	55
Poisonous Liquids, n.o.s. (Inhalation Hazard Zone A)	**2810**	**55**
Poisonous Liquids, n.o.s. (Inhalation Hazard Zone B)	**2810**	**55**
Poisonous Liquids, oxidizing, n.o.s.	3122	44
Poisonous Liquids, oxidizing, n.o.s. (Inhalation Hazard Zone A)	**3122**	**44**
Poisonous Liquids, oxidizing, n.o.s. (Inhalation Hazard Zone B)	**3122**	**44**
Poisonous Liquids, water-reactive, n.o.s.	3123	40
Poisonous Liquids, which in contact with water emit Flammable Gases, n.o.s.	3123	40
Poisonous Liquids, which in contact with water emit Flammable Gases, n.o.s. (Inhalation Hazard Zone A)	**3123**	**40**
Poisonous Liquids, which in contact with water emit Flammable Gases, n.o.s. (Inhalation Hazard Zone B)	**3123**	**40**
Poisonous Solids, corrosive, n.o.s.	2928	59
Poisonous Solids, flammable, n.o.s.	2930	34
Poisonous Solids, n.o.s.	2811	53
Poisonous Solids, oxidizing, n.o.s.	3086	42
Poisonous Solids, self-heating, n.o.s.	3124	34
Poisonous Solids, water-reactive, n.o.s.	3125	34
Poisonous Solids, which in contact with water emit Flammable Gases, n.o.s.	3125	34
Polish, liquid	1263	26
Polyalkylamines, corrosive, flammable, n.o.s.	2734	29
Polyalkylamines, corrosive, n.o.s.	2735	60
Polyalkylamines, flammable, corrosive, n.o.s.	2733	29
Polyalkylamines, n.o.s.	2733	29
Polyalkylamines, n.o.s.	2734	29
Polyalkylamines, n.o.s.	2735	60
Polyamines, flammable, corrosive, n.o.s.	2733	29
Polyamines, liquid, corrosive, flammable, n.o.s.	2734	29
Polyamines, liquid, corrosive, n.o.s.	2735	60
Polyamines, solid, corrosive, n.o.s	3259	60
Polychlorinated Biphenyls	2315	31
Polyester Resin Kit	3269	26
Polyester Resin Kits	2255	48
Polyhalogenated Biphenyls, liquid	3151	31
Polyhalogenated Biphenyls, solid	3152	31
Polyhalogenated Terphenyls,liquid	3151	31
Polyhalogenated Terphenyls, solid	3152	31
Polymeric Beads, expandable, evolving flammable vapour	2211	32
Polystyrene Beads, expandable, evolving flammable vapour	2211	32
Potassium	2257	40
Potassium, Metal, alloy	1420	40
Potassium, metal, liquid alloy	1420	40
Potassium Arsenate	1677	53
Potassium Arsenite	1678	54
Potassium Bifluoride	1811	59
Potassium Bisulfate	2509	60
Potassium Bisulfite Solution	2693	60
Potassium Borohydride	1870	40
Potassium Bromate	1484	35
Potassium Chlorate	1485	35
Potassium Chlorate, aqueous solution	2427	31
Potassium Cuprocyanide	1679	53
Potassium Cyanide, solid	1680	55
Potassium Cyanide Solution	1680	55
Potassium Dichloro-S-Triazinetrione	2465	45
Potassium Dichromate	1479	35
Potassium Dithionite	1929	32
Potassium Fluoride	1812	54
Potassium Fluoro-acetate	2628	53
Potassium Fluoro-silicate, solid	2655	53

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Potassium Hydrogendifluoride, solid or solution	1811	59
Potassium Hydrogen Fluoride	1811	59
Potassium Hydrogen Sulfate	2509	60
Potassium Hydrosulfite	1929	32
Potassium Hydroxide, dry, solid	1813	60
Potassium Hydroxide Solution	1814	60
Potassium Hypochlorite Solution	1791	60
Potassium Metal	2257	40
Potassium Metavanadate	2864	53
Potassium Monoxide	2033	60
Potassium Nitrate	1486	35
Potassium Nitrate and Sodium Nitrite Mixture	1487	35
Potassium Nitrite	1488	35
Potassium Perchlorate	1489	35
Potassium Permanganate	1490	35
Potassium Peroxide	1491	47
Potassium Persulfate	1492	35
Potassium Phosphide	2012	41
Potassium Sodium Alloys	1422	40
Potassium Sulfide, anhydrous or with less than 30% of hydration	1382	32
Potassium Sulfide, hydrated, with not less than 30% water of hydration	1847	60
Potassium Superoxide	2466	47
Printing Ink, flammable	1210	26
Propadiene	2200	22
Propadiene, inhibited	2200	22
Propane	1978	22
Propane Mixtures	1978	22
Propanethiols	2402	27
Propanoic Acid	1848	60
n-Propanol	1274	26
Propargyl Alcohol	1986	28
Propionaldehyde	1275	26
Propionic Acid	1848	60
Propionic Anhydride	2496	29
Propionitrile	2404	28
Propionyl Chloride	1815	29
Propionyl Peroxide	2132	52
n-Propyl Acetate	1276	26
Propyl Alcohol	1274	26
Propylamine	1277	68
n-Propylbenzene	2364	26
Propyl Chloride	1278	26
n-Propyl Chloroformate	**2740**	**57**
Propylene	1077	22
Propylene Chlorohydrin	2611	57
1,2-Propylenediamine	2258	29
Propylene Dichloride	1279	27
Propylene Oxide	1280	26
Propylene Tetramer	2850	27
Propyleneimine, inhibited	1921	30
Propyl Formates	1281	26
n-Propyl Isocyanate	**2482**	**28**
Propyl Mercaptan	2402	27
n-Propyl Nitrate	1865	30
Propyltrichlorosilane	1816	29
Pyridine	1282	26
Pyrophoric Liquid, inorganic, n.o.s.	3194	37
Pyrophoric Liquid, organic, n.o.s.	2845	40
Pyrophoric Liquid, n.o.s.	2845	40
Pyrophoric Metals or Alloys, n.o.s.	1383	37
Pyrophoric Organo-metallic Compounds, n.o.s.	3203	37
Pyrophoric Solid, inorganic, n.o.s.	3200	37
Pyrophoric Solid, organic, n.o.s.	2846	37
Pyrosulfuryl Chloride	1817	39
Pyroxylin Plastic, rod, sheet, roll, tube or scrap	1325	32
Pyrrolidine	1922	29
Quinoline	2656	29
Radioactive Material, articles manufactured from natural or depleted uranium or natural thorium	2909	61
Radioactive Material, empty package articles manufactured from natural or depleted uranium or thorium	2910	61

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Radioactive Material, excepted package-articles manufactured from natural or depleted uranium or natural thorium	2910	61
Radioactive Material, excepted package-empty packaging	2910	61
Radioactive Material, excepted package-instruments or articles	2910	61
Radioactive Material, excepted package-limited quantity of material	2910	61
Radioactive Material, fissile, n.o.s.	2918	65
Radioactive Material, instruments and articles	2911	61
Radioactive Material, limited quantity, n.o.s.	2910	61
Radioactive Material, low specific (LSA), n.o.s.	2912	62
Radioactive Material, n.o.s.	2982	63
Radioactive Material, special form, n.o.s.	2974	64
Radioactive Material, surface contaminated objects (SCO)	2913	62
Rare Gases and Nitrogen Mixtures	1981	12
Rare Gases and Oxygen Mixtures	1980	14
Rare Gases, Mixtures	1979	12
Receptacles, small, with flammable gas	2037	17
Red Phosphorus	1338	32
Reducing Liquid	1142	26
Refrigerant Gases, flammable, n.o.s.	1954	22
Refrigerant Gases, n.o.s.	1078	12
Refrigerating Machine	1993	27
Refrigerating Machines, containing flammable, non-poisonous, liquefied gas	1954	22
Refrigerating Machines, containing non-flammable, non-poisonous, liquefied gas	2857	21
Refrigerating Machines, containing non-flammable, non-toxic, liquefied gas or ammonia solutions (2073)	2857	21
Regulated Medical Waste, n.o.s.	3291	24
Regulated Medical Waste, n.o.s	9275	24
Removing Liquid	1142	26
Resin Solution, flammable	1866	26
Resin Solution (resin compound), liquid	1866	26
Resorcinol	2876	55
Road Asphalt, liquid	1999	27
Rosin Oil	1286	26
Rubber Scrap, powdered or granulated	1345	32
Rubber Shoddy, powdered or granulated	1345	32
Rubber Solution	1287	26
Rubidium	1423	40
Rubidium Hydroxide, solid	2678	60
Rubidium Hydroxide Solution	2677	60
Rubidium Metal	1423	40
Sea Coal	1361	32
Sea-Belt Modules	3268	31
Sea-Belt Pretensioners	3268	31
Seed cake, with more than 1.5% oil and not more than 11% moisture	1368	31
Seed cake, with not more than 1.5% oil and not more than 11% moisture	2217	31
Selenates and Selenites	2630	53
Selenic Acid	1905	59
Selenium, powder	2658	53
Selenium Compound, toxic, n.o.s.	3283	55
Selenium Disulfide	2657	55
Selenium Hexafluoride	**2194**	**15**
Selenium Oxide	2811	53
Selenium Oxychloride	2879	59
Self-Heating Liquid, corrosive, inorganic, n.o.s.	3188	38
Self-Heating Liquid, corrosive, organic, n.o.s.	3185	38
Self-Heating Liquid, inorganic, corrosive, n.o.s.	3188	38
Self-Heating Liquid, inorganic, n.o.s.	3186	37
Self-Heating Liquid, inorganic, poisonous, n.o.s.	3187	38
Self-Heating Liquid, organic, corrosive, n.o.s.	3185	38
Self-Heating Liquid, organic, n.o.s.	3183	37

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Self-Heating Liquid, organic, poisonous n.o.s.	3184	38
Self-Heating Liquid, toxic, inorganic, n.o.s.	3187	38
Self-Heating Liquid, toxic, organic, n.o.s.	3184	38
Self-Heating Metal Powder, n.o.s.	3189	37
Self-Heating Solid, corrosive, inorganic, n.o.s.	3192	38
Self-Heating Solid, corrosive, organic, n.o.s.	3126	47
Self-Heating Solid, inorganic, corrosive, n.o.s.	3192	38
Self-Heating Solid, inorganic, n.o.s.	3190	37
Self-Heating Solid, inorganic, poisonous, n.o.s.	3191	38
Self-Heating Solid, organic, n.o.s.	3088	37
Self-Heating Solid, organic, poisonous, n.o.s.	3128	34
Self-Heating Solid, oxidizing, n.o.s.	3127	47
Self-Heating Solid, toxic, inorganic, n.o.s.	3191	38
Self-Heating Solid, toxic, organic, n.o.s.	3128	34
Self-Heating Substance, solid, corrosive, n.o.s.	3126	47
Self-Heating Substance, solid, oxidizing, n.o.s.	3127	47
Self-Heating Substance, solid, poisonous, n.o.s.	3128	34
Self-Heating Substances, solid, n.o.s.	3088	37
Self-Reactive Liquid Type B	3221	49
Self-Reactive Liquid Type B, temperature controlled	3231	52
Self-Reactive Liquid Type C	3223	49
Self-Reactive Liquid Type C, temperature controlled	3233	52
Self-Reactive Liquid Type D	3225	48
Self-Reactive Liquid Type D, temperature controlled	3235	52
Self-Reactive Liquid Type E	3227	48
Self-Reactive Liquid Type E, temperature controlled	3237	52
Self-Reactive Liquid Type F	3229	48
Self-Reactive Liquid Type F, temperature controlled	3239	52
Self-Reactive Solid Type B	3222	49
Self-Reactive Solid Type B, temperature controlled	3232	52
Self-Reactive Solid Type C	3224	49
Self-Reactive Solid Type C, temperature controlled	3234	52
Self-Reactive Solid Type D	3226	48
Self-Reactive Solid Type D, temperature controlled	3236	52
Self-Reactive Solid Type E	3228	48
Self-Reactive Solid Type E, temperature controlled	3238	52
Self-Reactive Solid Type F	3230	48
Self-Reactive Solid Type F, temperature controlled	3240	52
Self-Reactive Substances, samples, n.o.s.	3031	71
Self-Reactive Substances, trial quantities, n.o.s.	3032	71
Shale Oil	1288	27
Silane	2203	17
Silicofluoric Acid	1778	60
Silicon Chloride	1818	39
Silicon Powder, amorphous	1346	32
Silicon Tetrachloride	1818	39
Silicon Tetrafluoride	**1859**	**16**
Silver Arsenite	1683	53
Silver Cyanide	1684	53
Silver Nitrate	1493	45
Silver Picrate, wetted with not less than 30% water	1347	33
Sludge Acid	1906	60
Smokeless Powder, small arms	1325	32
Soda Lime	1907	60
Sodium	1428	40
Sodium Aluminate, solid	2812	60
Sodium Aluminate Solution	1819	60
Sodium Aluminum Hydride	2835	40
Sodium Ammonium Vanadate	2863	53
Sodium Arsanilate	2473	53

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Sodium Arsenate	1685	53
Sodium Arsenite, aqueous solutions	1686	54
Sodium Arsenite, solid	2027	53
Sodium Azide	1687	56
Sodium Bifluoride, solid	2439	60
Sodium Bifluoride Solution	2439	60
Sodium Bisulfate Solution	2837	60
Sodium Bisulfite Solution	2693	60
Sodium Borohydride	1426	32
Sodium Bromate	1494	42
Sodium Cacodylate	1688	53
Sodium Chlorate	1495	35
Sodium Chlorate, aqueous solution	2428	31
Sodium Chlorite	1496	43
Sodium Chlorite Solution with more than 5% available chlorine	1908	60
Sodium Chloroacetate	2659	53
Sodium Cupro-cyanide, solid	2316	53
Sodium Cupro-cyanide Solution	2317	54
Sodium Cyanide	1689	55
Sodium 2-Diazo-1-Naphthol-4-Sulfonate	3040	72
Sodium 2-Diazo-1-Naphthol-5-Sulfonate	3041	72
Sodium Dichloroiso-cyanurate	2465	45
Sodium Dichloro-S-Triazinetrione	2465	45
Sodium Dichromate	1479	35
Sodium Dinitro-ortho-Cresolate, wetted with not less than 155 water	1348	36
Sodium Dithionite	1384	37
Sodium Fluoride, solid	1690	54
Sodium Fluoride Solution	1690	54
Sodium Fluoroacetate	2629	53
Sodium Fluoro-silicate	2674	53
Sodium Hydrate	1824	60
Sodium Hydride	1427	40
Sodium Hydrogen Fluoride	2439	60
Sodium Hydrogen Sulfate, solid	1821	60
Sodium Hydrogen Sulfate Solution	2837	60
Sodium Hydrogen Difluoride	2439	60
Sodium Hydro-sulfide, solid with less than 25% of water crystallization	2318	34
Sodium Hydro-sulfide, with not less than 25% of water crystallization	2949	59
Sodium Hydrosulfide Solution	2922	59
Sodium Hydrosulfide Solution	2949	59
Sodium Hydrosulfite	1384	37
Sodium Hydroxide, dry, solid	1823	60
Sodium Hydroxide Solution	1824	60
Sodium Hypochlorite Solution	1791	60
Sodium Metal	1428	40
Sodium Methylate, dry	1431	40
Sodium Methylate, solutions in alcohol	1289	29
Sodium Methylate Solutions in alcohol	1289	29
Sodium Monoxide	1825	60
Sodium Nitrate	1498	35
Sodium Nitrate and Potassium Nitrate Mixtures	1499	35
Sodium Nitrite	1500	35
Sodium Nitrite and Potassium Nitrate Mixtures	1487	35
Sodium Pentachlorophenate	2567	53
Sodium Percarbonate	2467	35
Sodium Perchlorate	1502	35
Sodium Permanganate	1503	35
Sodium Peroxide	1504	47
Sodium Peroxo-borate, Anhydrous	3247	35
Sodium Persulfate	1505	35
Sodium Phenolate, solid	2497	60
Sodium Phosphide	1432	41
Sodium Picramate, wetted with not less than 20% water	1349	33
Sodium Potassium Alloys	1422	40
Sodium Selenite	2630	53
Sodium Sulfide, anhydrous or with less than 30% water of crystallization	1385	34
Sodium Sulfide, hydrated, with not less than 30%	1849	60
Sodium Sulfide Solution	1849	60

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Sodium Superoxide	2547	47
Solids Containing Corrosive Liquid, n.o.s.	3244	60
Solids Containing Flammable Liquid, n.o.s.	3175	32
Solids Containing Poisonous Liquid, n.o.s.	3243	55
Solids Containing Toxic Liquid, n.o.s.	3243	55
Spirits of Nitroglycerine	1204	26
Stannic Chloride, anhydrous	1827	39
Stannic Chloride, hydrated	2440	60
Stannic Phosphide	1433	41
Stannous Chloride, solid	1759	60
Stibine	**2676**	**18**
Strontium Arsenite	1691	53
Strontium Chlorate, solid or solution	1506	35
Strontium Nitrate	1507	35
Strontium Perchlorate	1508	35
Strontium Peroxide	1509	47
Strontium Phosphide	2013	41
Strychnine, and salts	1692	53
Styrene Monomer, inhibited	2055	27
Substances which in contact with water emit Flammable Gases, liquid, corrosive, n.o.s.	3129	39
Substances which in contact with water emit Flammable Gases, liquid, n.o.s.	3148	40
Substances which in contact with water emit Flammable Gases, liquid, poisonous, n.o.s.	3130	39
Substances which in contact with water emit Flammable Gases, solid, corrosive, n.o.s.	3131	40
Substances which in contact with water emit Flammable Gases, solid, flammable, n.o.s.	3132	40
Substances which in contact with water emit Flammable Gases, solid, oxidizing, n.o.s.	3133	40
Substances which in contact with water emit Flammable Gases, solid, poisonous, n.o.s.	3134	40
Substances which in contact with water emit Flammable Gases, solid, self-heating, n.o.s.	3135	40
Substances which in contact with water emit Flammable Gases, solid, n.o.s.	2813	40
Substituted Nitrophenol Pesticides, liquid, flammable, toxic, n.o.s.	2780	28
Substituted Nitrophenol Pesticides, liquid, toxic, flammable, n.o.s.	3013	28
Substituted Nitrophenol Pesticides, liquid, toxic, n.o.s.	3014	55
Substituted Nitrophenol Pesticides, solid, toxic, n.o.s.	2779	53
Succinic Acid Peroxide, technical pure	2135	49
Sulfamic Acid	2967	60
Sulfur	1350	32
Sulfur, molten	2448	32
Sulfur Chlorides	**1828**	**39**
Sulfur Dioxide	**1079**	**16**
Sulfur Dioxide, liquefied	**1079**	**60**
Sulfur Hexafluoride	1080	12
Sulfur Tetrafluoride	**2418**	**15**
Sulfur Trioxide	**1829**	**39**
Sulfur Trioxide, inhibited	**1829**	**39**
Sulfur Trioxide, uninhibited	**1829**	**39**
Sulfuric Acid	1830	39
Sulfuric Acid, fuming, with less than 30% free sulfur trioxide	1831	39
Sulfuric Acid, spent	1832	39
Sulfuric Acid with not more than 51% acid	2796	39
Sulfuric and Hydrofluoric Acid Mixture	1786	59
Sulfuric Anhydride	**1829**	**39**
Sulfurous Acid	1833	60
Sulfuryl Chloride	**1834**	**39**
Sulfuryl Fluoride	**2191**	**15**
2,4,5-T	2765	55
Tars, liquid	1999	27
TDE (1,1-Dichloro-2,2-bis-(p-chlorophenyl)ethane)	2761	55

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Tear Gas Candles	1700	58
Tear Gas Devices	1693	58
Tear Gas Substances, liquid or solid, n.o.s.	1693	58
Tellurium Compound, toxic, n.o.s.	3284	55
Tellurium Hexafluoride	**2195**	**15**
Terpene Hydrocarbons, n.o.s.	2319	27
Terpinolene	2541	27
Tetrabromoethane	2504	58
Tetrachloroethane	1702	55
1,12,2-Tetrachloroethane	1702	55
Tetrachloroethylene	1897	74
Tetraethylammonium Perchlorate, dry	1325	32
Tetraethyl Dithio-pyrophosphate com-pressed gas mixture	**1703**	**15**
Tetraethyl Dithio-pyrophosphate and gases, mixtures, or in solution (LC50 more than 200 ppm but not more than 5000 ppm)	**1703**	**15**
Tetraethyl Dithio-pyrophosphate and gases, mixtures, or in solution (LC50 not more than 200 ppm)	**1703**	**15**
Tetraethyl Dithiopyrophosphate, dry, liquid or mixture	1704	55
Tetraethylenepentamine	2320	60
Tetraethyl Lead, liquid	1649	56
Tetraethyl Pyrophosphate and com-pressed gas mixture	**1705**	**15**
Tetraethyl Pyrophosphate and com-pressed gas mixtures (LC50 more than 200 ppm but not more than 5000 ppm)	**1705**	**15**
Tetraethyl Pyrophosphate and com-pressed gas mixtures (LC50 not more than 200 ppm)	**1705**	**15**
Tetraethyl Pyrophosphate, liquid	3018	55
Tetraethyl Pyrophosphate, solid	2783	55
Tetraethyl Silicate	1292	29
Tetrafluoroethane	3159	12
1,1,2,2-Tetrafluoroethane	3159	12
Tetrafluoroethylene, inhibited	1081	17
Tetrafluoromethane	1982	12
1,2,3,6-Tetrahydro-benzaldehyde	2498	29
Tetrahydrofuran	2056	26
Tetrahydrofurfurylamine	2943	26
Tetrahydrophthalic Anhydrides	2698	60
1,2,3,6-Tetrahydropyridine	2410	26
Tetrahydrothiophene	2412	26
Tetralin Hydroperoxide, technical pure	2136	48
Tetramethyl Ammonium Hydroxide	1835	60
1,1,3,3-Tetramethyl-butyl Hydroperoxide, technical pure	2160	48
1,1,3,3-Tetramethyl-butylperoxy-2-Ethyl Hexanoate, technical pure	2161	52
Tetramethyl-methylenediamine	9069	29
Tetramethyl Silane	2749	29
Tetranitromethane	**1510**	**47**
Tetrapropyl-ortho-Titanate	2413	27
Textile Treating Compound	1760	60
Thallium Chlorate	2573	42
Thallium Compound, n.o.s.	2573	42
Thallium Nitrate	2727	42
Thallium Salt, n.o.s.	1707	53
Thallium Sulfate, solid	1707	53
Thia-4-Pentanal	2785	55
Thioacetic Acid	2436	26
Thioglycol	2966	53
Thioglycolic Acid	1940	60
Thionyl Chloride	1836	39
Thiophene	2414	27
Thiophosgene	**2474**	**55**
Thiophosphoryl Chloride	1837	60
Thiram	2771	55
Thorium Metal, pyrophoric	2975	61
Thorium Nitrate, solid	2976	61
Tin Chloride, fuming	1827	39
Tin Tetrachloride	1827	39
Tinctures, medicinical	1293	26
Titanium, metal, powder, dry	2546	37
Titanium, metal, powder, wet with not less than 20% water	1352	32
Titanium Disulfide	3174	37
Titanium Hydride	1871	32

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Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Titanium Powder, dry	2546	37
Titanium Powder, wetted with not less than 25% water	1352	32
Titanium Sponge, granules or powder	2878	32
Titanium Sulfate Solution	1760	60
Titanium Tetrachloride	**1838**	**39**
Titanium Trichloride, pyrophoric	2441	37
Titanium Trichloride Mixtures	2869	60
Titanium Trichloride Mixtures, pyrophoric	2441	37
Toe Puff, nitro-cellulose base	1353	32
Toluene	1294	27
2,4-Toluenediamine	1709	53
Toluene Diisocyanate (T.D.I.)	2078	54
Toluene Sulfonic Acid, liquid with more than 5% free sulfuric acid	2584	60
Toluene Sulfonic Acid, liquid with not more than 5% free sulfuric acid	2586	60
Toluene Sulfonic Acid, solid with more than 5% free sulfuric acid	2583	60
Toluene Sulfonic Acid, solid with more than 5% free sulfuric acid	2585	60
Toludines	1708	55
2,4-Toluyenediamine	1709	53
Toxaphene	2761	55
Toxic Liquid, corrosive, inorganic, n.o.s.	**3289**	**59**
Toxic Liquid, corrosive, organic, n.o.s	**2927**	**59**
Toxic Liquid, flammable, inorganic, n.o.s	**2929**	**57**
Toxic Liquid, inorganic, n.o.s	3287	55
Toxic Liquid, organic, n.o.s	**2810**	**55**
Toxic Liquid, oxidizing, n.os.	**3122**	**44**
Toxic Liquid, water-reactive, n.o.s	**3123**	**40**
Toxic Solid, corrosive, inorganic, n.o.s.	3290	59
Toxic Solid, corrosive, organic, n.o.s.	2928	59
Toxic Solid, flammable, organic, n.o.s.	2930	34
Toxic Solid, inorganic, n.o.s.	3288	53
Toxic Solid, organic, n.o.s.	2811	53
Toxic Solid, oxidizing, n.o.s.	3086	42
Toxic Solid, self-heating, n.o.s.	3124	34
Toxic Solid, water-reactive, n.o.s.	3125	34
Toxins, extracted from living sources, n.o.s.	3172	55
2,4,5-TP	2765	55
Triallyl Borate	2609	55
Triallylamine	2610	29
Triazine Pesticides, liquid, flammable, toxic, n.o.s.	2764	28
Triazine Pesticides, liquid, toxic, flammable, n.o.s.	2997	28
Triazine Pesticides, liquid, toxic, n.o.s.	2998	55
Triazine Pesticides, solid, toxic, n.o.s.	2763	55
Tri(1-Aziridinyl) phosphine Oxide	2501	55
Tributylamine	2542	68
Tributylphosphane	3254	37
Trichlorfon	2783	55
Trichloroacetic Acid	1839	59
Trichloroacetic Acid Solution	2564	59
Trichloroacetyl Chloride	**2442**	**59**
Trichlorobenzenes, liquid	2321	54
Trichlorobutene	2322	54
1,1,1-Trichloroethane	2831	74
Trichloroethylene	1710	74
Trichloroisocyanuric Acid dry	2468	45
Trichlorophenol	2020	53
2,4,5-Trichlorophenoxyacetic	2765	55
2,4,5-Trichlorophenoxypropionic Acid	2765	55
Trichlorosilane	1295	38
Trichloro-S-triazine-trione, dry	2468	45
Tricresylphosphate	2574	5
Triethylamine	1296	68
Triethyl Phosphite	2323	26
Triethylene Tetramine	2259	60
Trifluoroacetic Acid	2699	60
Trifluoroacetyl Chloride	**3057**	**16**

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Trifluorochloroethylene	**1082**	**18**
Trifluorochloroethylene, inhibited	**1082**	**18**
Trifluorochloromethane	1022	12
Trifluorochloroethane, compressed	2035	22
Trifluoromethane refrigerated liquid (cryogenic liquid)	3136	21
Trifluoromethane and Chlorotrifluoromethane Mixture	2599	12
2-Trifluoromethyl-aniline	2942	55
3-Trifluoromethyl-aniline	2948	55
Triisobutylene	2324	27
Triisocyanatoiso-cyanurate of Isophoronediisocyanate, 70% solution	2906	26
Triisopropyl Borate	2616	26
Trimethoxysilane	**9269**	**57**
Trimethylacetyl Chloride	**2438**	**29**
Trimethylamine, anhydrous	1083	19
Trimethylamine, aqueous solution	1297	29
1,3,5-Trimethyl-benzene	2325	26
Trimethyl Borate	2416	26
Trimethylchloro-silane	1298	29
Trimethylcyclohexyl-amine	2326	29
Trimethylhexa-methylenediamines	2327	60
Trimethylhexa-methylenediisocyanate	2328	53
Trimethyl Phosphite	2329	26
Trinitrobenzene, wet	1354	33
Trinitrobenzene, wetted with not less than 30% water	1354	33
Trinitrobenzoic Acid, wet	1355	33
Trinitrobenzoic Acid, wetted with not less than 30% water	1355	33
Trinitrophenol, wet	1344	33
Trinitrophenol, wetted with not less than 30% water	1344	33
Trinitrotoluene, wet	1356	33
Trinitrotoluene, wetted with not less than 30% water	1356	33
Tripropylamine	2260	68
Tripropylene	2057	27
Tris(1-Aziridinyl) phosphine Oxide	2501	55
Tungsten Hexafluoride	**2196**	**15**
Turpentine	1299	27
Turpentine Substitute	1300	27
Undecane	2330	27
Uranium Hexafluoride, fissile (containing more than 1.0% U-235)	2977	66
Uranium Hexafluoride, fissile excepted or non-fissile	2978	66
Uranium Hexafluoride, low specific activity	2978	66
Uranium Metal, pyrophoric	2979	61
Uranium Nitrate Hexahydrate Solution	2980	61
Uranyl Acetate	9180	62
Uranyl Nitrate, solid	2981	61
Urea Hydrogen Peroxide	1511	35
Urea Nitrate, wet	1357	33
Urea Nitrate, wetted with not less than 20% water	1357	33
Urea Peroxide	1511	35
Valeraldehyde	2058	26
Valeric Acid, (n-Pentanoic Acid)	1760	60
Valeryl Chloride	2502	29
Vanadium Com-pound, toxic, n.o.s.	3285	55
Vanadium Oxytrichloride	2443	39
Vanadium Oxytrichloride and Titanium Tetrachloride Mixture	2443	29
Vanadium Pentoxide	2862	53
Vanadium Tetrachloride	2444	39
Vanadium trichloride	2475	60
Vanadium Sulfate	2931	55
Vinyl Acetate	1301	26
Vinyl Acetate, inhibited	1301	26
Vinyl Bromide, inhibited	1085	26
Vinyl Butyl Ether	1304	26
Vinyl Butyrate, inhibited	2838	26
Vinyl Chloride	1086	17
Vinyl Chloride, inhibited	1086	17
Vinyl Chloride, stabilized	1086	17
Vinyl Chloroacetate	2589	57
Vinyl Ethyl Ether	1302	26

Table 1 Continued

Common Shipping name	U.N. Shipping Number	Fact Sheet Guide
Vinyl Ethyl Ether, inhibited	1302	26
Vinyl Fluoride, inhibited	1860	17
Vinyldene Chloride, inhibited	1303	26
Vinyl Isobutyl Ether	1304	26
Vinyl Isobutyl Ether, inhibited	1304	26
Vinyl Methyl Ether	1087	17
Vinyl Methyl Ether, inhibited	1087	17
Vinyl Pyridines, inhibited	3073	57
Vinyl Toluene, inhibited	2618	27
Vinyl Trichlorosilane	1305	29
Water-Reactive Liquid, corrosive, n.o.s.	3129	39
Water-Reactive Liquid, n.o.s.	3148	40
Water-Reactive Liquid, poisonous, n.o.s.	3130	39
Water-Reactive Liquid, toxic, n.o.s.	3130	39
Water-Reactive Solid, corrosive, n.o.s.	3131	40
Water-Reactive Solid, flammable, n.o.s.	3132	40
Water-Reactive Solid, n.o.s.	2813	40
Water-Reactive Solid, oxidizing, n.o.s.	3133	40
Water-Reactive Solid, poisonous, n.o.s.	3134	40
Water-Reactive Solid, self-heating, n.o.s.	3135	40
Water-Reactive Solid, toxic, n.o.s.	3134	40
Wheelchair, Electric with batteries	3171	60
White Asbestos	2590	31
White Phosphorus, dry	1381	38
White Phosphorus, wet	1381	38
Wood Preservatives, liquid	1306	26
Xenon	2036	12
Xenon, refrigerated liquid (cryogenic liquid)	2591	21
Xylenes, (Xylol)	1307	27
Xylenols	2261	55
Xylidines	1711	55
Xylyl Bromide	1701	55
Yellow Phosphorus, dry	1381	38
Yellow Phosphorus, wet	1381	38
Zinc Ammonium Nitrite	1512	35
Zinc Arsenate	1712	53
Zinc Arsenate and Zinc Arsenite Mixtures	1712	53
Zinc Arsenite	1712	53
Zinc Ashes	1435	40
Zinc Bromate	2469	35
Zinc Chlorate	1513	35
Zinc Chloride, anhydrous	2331	60
Zinc Chloride Solution	1840	60
Zinc Cyanide	1713	53
Zinc Dithionite	1931	32
Zinc Fluorosilicate	2855	53
Zinc Hydrosulfite	1931	332
Zinc Metal, powder or dust	1436	76
Zinc Nitrate	1514	35
Zinc Permanganate	1515	35
Zinc Peroxide	1516	47
Zinc Phosphide	1714	41
Zinc Picramate, wetted with not less than 20% water	1517	33
Zinc Powder, wetted with not less than 25% water	1358	32
Zinc Powder or Dust	1436	76
Zinc Resinate	2714	32
Zirconium, dry, wire, sheet, or strips	2009	37
Zirconium, dry, wire, sheet, or strips (thinner than 254 microns but not thinner than 18 microns)	2858	32
Zirconium Hydride	1437	40
Zirconium Metal, liquid suspension	1308	26
Zirconium Metal, powder, dry	2008	37
Zirconium Metal, powder, wet	1358	32
Zirconium Nitrate	2728	35
Zirconium Picramate, wet	1517	33
Zirconium Powder, dry	2008	37
Zirconium Powder, wet	1358	32
Zirconium Scrap	1932	32
Zirconium Sulfate	9163	31
Zirconium Suspended in a liquid	1308	26
Zirconium Tetrachloride	2503	39

III. HAZARD CHEMICALS LISTING

The following Table was extracted from the DOT Emergency Response Guidebook. It provides a listing of chemicals according to the 4-digit UN shipping number designation. The reader can use this section to identify a hazardous chemical and determine the proper fire and emergency response by matching the Guide Number with the Fact Sheets. Those chemicals that are boldfaced represent chemicals that require an initial isolation distance when involved in a spill or leak from a container. Information and guidelines on isolation distances can be found in Chapter 7.

Table 2. Chronological Listing of Regulated Chemicals

ID No	Guide No	Name of Material
--	46	AMMONIUM NITRATE - FUEL OIL MIXTURES
--	46	BLASTING AGENT, n.o.s.
--	46	EXPLOSIVE A
--	46	EXPLOSIVE B
--	50	EXPLOSIVE C
--	46	EXPLOSIVES, division 1.1,1.2, 1.3,1.5 or 1.6
--	50	EXPLOSIVES, division 1.4
0004	46	AMMONIUM PICRATE, dry or wetted with less than 10% water
0222	46	AMMONIUM NITRATE with more than 0.2% combustible material
0223	46	AMMONIUM NITRATE FERTILIZER, which is more liable to explode than ammonium nitrate with 0.2% combustible material
0331	46	AMMONIUM NITRATE - FUEL OIL MIXTURE (containing only prilled ammonium nitrate and fuel oil)
0402	46	AMMONIUM PERCHLORATE
1001	17	ACETYLENE
1001	17	ACETYLENE, dissolved
1002	12	AIR, compressed
1003	23	AIR, refrigerated liquid (cryogenic liquid)
1005	**15**	**AMMONIA**
1005	**15**	**AMMONIA, ANHYDROUS, liquefied**
1005	**15**	**AMMONIA SOLUTIONS with more than 50% ammonia**
1005	**15**	**ANHYDROUS AMMONIA**
1006	12	ARGON, compressed
1009	12	BROMOTRIFLUOROMETHANE
1010	17	BUTADIENES, inhibited
1011	22	BUTANE or BUTANE MIXTURES
1012	22	BUTYLENE
1013	21	CARBON DIOXIDE
1014	14	CARBON DIOXIDE and OXYGEN MIXTURES
1015	12	CARBON DIOXIDE and NITROUS OXIDE MIXTURES
1016	**18**	**CARBON MONOXIDE**
1017	**20**	**CHLORINE**
1018	12	CHLORODIFLUOROMETHANE
1020	12	CHLOROPENTAFLUOROETHANE
1021	12	CHLOROTETRAFLUOROETHANE
1022	12	CHLOROTRIFLUOROMETHANE
1022	12	TRIFLUOROCHLOROMETHANE
1023	**18**	**COAL GAS**
1026	**18**	**CYANOGEN**
1026	**18**	**CYANOGEN, liquefied**
1026	**18**	**CYANOGEN GAS**
1027	22	CYCLOPROPANE
1027	22	CYCLOPROPANE, liquefied
1028	12	DICHLORODIFLUOROMETHANE
1029	12	DICHLOROFLUOROMETHANE
1029	12	DICHLOROMONOFLUOROMETHANE
1030	22	1,1-DIFLUOROETHANE
1030	22	DIFLUOROETHANE
1032	19	DIMETHYLAMINE, anhydrous
1033	22	DIMETHYL ETHER
1035	22	ETHANE, compressed
1036	68	ETHYLAMINE
1036	68	MONOETHYLAMINE
1037	27	ETHYL CHLORIDE
1038	22	ETHYLENE, refrigerated liquid (cryogenic liquid)
1039	26	ETHYL METHYL ETHER
1039	26	METHYL ETHYL ETHER
1040	**69**	**ETHYLENE OXIDE**

Table 2 Continued

ID No	Guide No	Name of Material
1040	**69**	**ETHYLENE OXIDE with nitrogen**
1041	17	CARBON DIOXIDE and ETHYLENE OXIDE MIXTURE, with more than 6% ethylene oxide
1041	17	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with more than 6% ethylene oxide
1041	17	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE with more than 9% but not more than 87% ethylene oxide
1043	16	FERTILIZER AMMONIATING SOLUTION, with more than 35% free ammonia
1044	12	FIRE EXTINGUISHERS, with compressed or liquefied gas
1045	**20**	**FLUORINE, compressed**
1046	12	HELIUM, compressed
1048	**15**	**HYDROGEN BROMIDE, anhydrous**
1049	22	HYDROGEN, compressed
1050	**15**	**HYDROCHLORIC ACID, anhydrous**
1050	**15**	**HYDROGEN CHLORIDE, anhydrous**
1051	**13**	**HYDROCYANIC ACID**
1051	**13**	**HYDROGEN CYANIDE, anhydrous, stabilized**
1051	**13**	**HYDROGEN CYANIDE, stabilized, containing less than 3% water**
1052	**59**	**HYDROFLUORIC ACID, anhydrous**
1052	**59**	**HYDROGEN FLUORIDE, anhydrous**
1053	**13**	**HYDROGEN SULFIDE**
1053	**13**	**HYDROGEN SULFIDE, liquefied**
1055	22	ISOBUTYLENE
1056	12	KRYPTON, compressed
1057	17	CIGARETTE LIGHTER, with flammable gas
1057	17	FLAMMABLE GAS in LIGHTER for cigars, cigarettes, etc.
1057	17	LIGHTER REFILLS, cigarettes, containing flammable gas
1057	17	LIGHTERS, cigarettes, containing flammable gas
1058	12	LIQUEFIED GAS, nonflammable, charged with nitrogen, carbon dioxide or air
1058	12	LIQUEFIED NONFLAMMABLE GAS charged with nitrogen, carbon dioxide or air
1060	17	METHYL ACETYLENE and PROPADIENE MIXTURE, stabilized
1061	19	METHYLAMINE, anhydrous
1061	19	MONOMETHYLAMINE, anhydrous
1062	**55**	**METHYL BROMIDE**
1063	18	METHYL CHLORIDE
1064	**13**	**METHYL MERCAPTAN**
1065	12	NEON, compressed
1066	12	NITROGEN, compressed
1067	**20**	**DINITROGEN TETROXIDE, liquefied**
1067	**20**	**NITROGEN DIOXIDE, liquefied**
1067	**20**	**NITROGEN PEROXIDE**
1067	**20**	**NITROGEN TETROXIDE**
1069	**16**	**NITROSYL CHLORIDE**
1070	14	NITROUS OXIDE, compressed
1071	**18**	**OIL GAS**
1072	14	OXYGEN, compressed
1073	23	OXYGEN, refrigerated liquid (cryogenic liquid)
1075	22	LIQUEFIED PETROLEUM GAS
1075	22	LPG, liquefied petroleum gas
1075	22	PETROLEUM GASES, liquefied
1076	**15**	**PHOSGENE**
1077	22	PROPYLENE
1078	12	CHLORODIFLUOROMETHANE and CHLOROPENTAFLUOROETHANE MIXTURE
1078	12	CHLOROTRIFLUOROMETHANE and TRIFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and CHLORODIFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and DICHLOROTETRAFLUOROETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and DIFLUOROETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE and TRICHLOROFLUOROMETHANE MIXTURE
1078	12	DICHLORODIFLUOROMETHANE, TRICHLOROFLUOROMETHANE and CHLORODIFLUOROMETHANE MIXTURE

Table 2 Continued

ID No	Guide No	Name of Material
1078	12	DICHLORODIFLUOROMETHANE and TRICHLOROTRIFLUOROETHANE MIXTURE
1078	12	DISPERSANT GAS, n.o.s.
1078	12	REFRIGERANT GASES, n.o.s.
1078	12	TRIFLUOROMETHANE and CHLOROTRIFLUOROMETHANE MIXTURE
1079	**16**	**SULFUR DIOXIDE**
1079	**16**	**SULFUR DIOXIDE, liquefied**
1080	12	SULFUR HEXAFLUORIDE
1081	17	TETRAFLUOROETHYLENE, inhibited
1082	**18**	**TRIFLUOROCHLOROETHYLENE**
1082	**18**	**TRIFLUOROCHLOROETHYLENE, inhibited**
1083	19	TRIMETHYLAMINE, anhydrous
1085	60	VINYL BROMIDE, inhibited
1086	17	MONOCHLOROETHYLENE
1086	17	VINYL CHLORIDE
1086	17	VINYL CHLORIDE, inhibited
1086	17	VINYL CHLORIDE, stabilized
1087	17	VINYL METHYL ETHER
1087	17	VINYL METHYL ETHER, inhibited
1088	26	ACETAL
1089	26	ACETALDEHYDE
1090	26	ACETONE, and solutions
1091	26	ACETONE OILS
1092	**30**	**ACROLEIN, inhibited**
1093	30	ACRYLONITRILE, inhibited
1098	**57**	**ALLYL ALCOHOL**
1099	57	ALLYL BROMIDE
1100	57	ALLYL CHLORIDE
1104	26	AMYL ACETATES
1105	26	AMYL ALCOHOLS
1105	26	ISOAMYL ALCOHOL
1106	68	AMYLAMINES
1107	26	AMYL CHLORIDES
1108	26	n-AMYLENE
1108	26	1-PENTENE
1109	26	AMYL FORMATES
1110	26	AMYL METHYL KETONE
1110	26	METHYL AMYL KETONE
1111	27	AMYL MERCAPTANS
1112	26	AMYL NITRATE
1113	26	AMYL NITRITES
114	27	BENZENE
1115	26	BENZINE
1118	27	BRAKE FLUID, hydraulic
1120	26	BUTANOLS
1120	26	BUTYL ALCOHOL
1123	26	BUTYL ACETATES
1125	68	n-BUTYLAMINE
1126	29	1-BROMOBUTANE
1126	29	n-BUTYL BROMIDE
1127	27	BUTYL CHLORIDE
1127	27	CHLOROBUTANES
1128	26	n-BUTYL FORMATE
1129	26	BUTYRALDEHYDE
1130	27	CAMPHOR OIL
1131	28	CARBON BISULFIDE
1131	28	CARBON DISULFIDE
1133	26	ADHESIVE
1133	26	ADHESIVES, containing flammable liquid
1133	26	CEMENT, containing flammable liquid
1133	26	CEMENT, liquid, n.o.s.
1134	27	CHLOROBENZENE
1135	55	ETHYLENE CHLOROHYDRIN
1136	27	COAL TAR DISTILLATES, flammable
1136	27	COAL TAR OIL
1137	27	COAL TAR DISTILLATE
1137	27	COAL TAR OIL
1139	26	COATING SOLUTION
1142	26	ANTI-FREEZE
1142	26	CLEANING COMPOUND
1142	26	COMPOUNDS, POLISHING liquid, etc. (flammable)
1142	26	FLAMMABLE LIQUID PREPARATIONS, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
1142	26	REDUCING LIQUID
1142	26	REMOVING LIQUID
1143	**28**	**CROTONALDEHYDE, inhibited**
1143	**28**	**CROTONALDEHYDE, stabilized**
1144	27	CROTONYLENE
1145	26	CYCLOHEXANE
1146	27	CYCLOPENTANE
1147	27	DECAHYDRONAPHTHALENE
1148	26	DIACETONE ALCOHOL
1149	26	BUTYL ETHER
1149	26	DIBUTYL ETHERS
1150	29	DICHLOROETHYLENE
1150	29	1,2-DICHLOROETHYLENE
1152	27	DICHLOROPENTANES
1153	26	DIETHOXYETHANE
1153	26	DIETHYL CELLOSOLVE
1153	26	ETHYLENE GLYCOL DIETHYL ETHER
1154	68	DIETHYLAMINE
1155	26	DIETHYL ETHER
1155	26	ETHER
1155	26	ETHYL ETHER
1156	26	DIETHYL KETONE
1157	26	DIISOBUTYL KETONE
1158	68	DIISOPROPYLAMINE
1159	26	DIISOPROPYL ETHER
1159	26	ISOPROPYL ETHER
1160	26	DIMETHYLAMINE SOLUTION
1161	26	DIMETHYL CARBONATE
1162	29	DIMETHYLDICHLOROSILANE
1163	**57**	**DIMETHYLHYDRAZINE, unsymmetrical**
1164	27	DIMETHYL SULFIDE
1164	27	METHYL SULFIDE
1165	26	DIOXANE
1166	26	DIOXOLANE
1167	30	DIVINYL ETHER, inhibited
1168	26	DRIER, paint or varnish, liquid, n.o.s.
1169	26	EXTRACTS, aromatic, liquid
1170	26	ALCOHOL (beverage)
1170	26	ALCOHOL (ethyl)
1170	26	ALCOHOLIC BEVERAGE
1170	26	ETHANOL, and solutions
1170	26	ETHYL ALCOHOL, and solutions
1171	26	ETHOXYETHANOL
1171	26	ETHYLENE GLYCOL MONOETHYL ETHER
1172	26	ETHOXYETHYL ACETATE
1172	26	ETHYLENE GLYCOL MONOETHYL ETHER ACETATE
1173	26	ETHYL ACETATE
1175	26	ETHYL BENZENE
1176	26	ETHYL BORATE
1177	26	2-ETHYLBUTYL ACETATE
1178	26	2-ETHYLBUTYRALDEHYDE
1179	26	ETHYL BUTYL ETHER
1180	26	ETHYL BUTYRATE
1181	55	ETHYL CHLOROACETATE
1182	**28**	**ETHYL CHLOROFORMATE**
1183	29	ETHYLDICHLOROSILANE
1184	26	ETHYLENE DICHLORIDE
1185	**30**	**ETHYLENEIMINE, inhibited**
1188	26	ETHYLENE GLYCOL MONOMETHYL ETHER
1189	26	ETHYLENE GLYCOL MONOMETHYL ETHER ACETATE
1190	26	ETHYL FORMATE
1191	26	ETHYLHEXALDEHYDES
1191	26	OCTYL ALDEHYDES
1192	26	ETHYL LACTATE
1193	26	ETHYL METHYL KETONE
1193	26	METHYL ETHYL KETONE
1194	30	ETHYL NITRITE, and solutions
1195	26	ETHYL PROPIONATE
1196	29	ETHYLTRICHLOROSILANE
1197	26	EXTRACTS, flavoring, liquid
1198	29	FORMALDEHYDE SOLUTIONS (Formalin)
1199	29	FURFURAL
1201	26	FUSEL OIL

Table 2 Continued

ID No	Guide No	Name of Material
1202	27	DIESEL FUEL
1202	27	GAS OIL
1202	27	HEATING OIL, light
1203	27	GASOHOL
1203	27	GASOLINE
1203	27	MOTOR SPIRIT
1203	27	PETROL
1204	26	GLYCERYL TRINITRATE SOLUTION
1204	26	NITROGLYCERIN SOLUTION in ALCOHOL, not more than 1 % nitroglycerin
1204	26	SPIRITS OF NITROGLYCERINE
1206	27	HEPTANES
1207	26	HEXALDEHYDE
1208	27	HEXANES
1208	27	NEOHEXANE
1210	26	INK, printer's, flammable
1210	26	PRINTING INK, flammable
1212	26	ISOBUTANOL
1212	26	ISOBUTYL ALCOHOL
1213	26	ISOBUTYL ACETATE
1214	68	ISOBUTYLAMINE
1216	27	ISOOCTENES
1218	27	ISOPRENE, inhibited
1219	26	ISOPROPANOL
1219	26	ISOPROPYL ALCOHOL
1220	26	ISOPROPYL ACETATE
1221	68	ISOPROPYLAMINE
1222	27	ISOPROPYL NITRATE
1223	27	KEROSENE
1224	26	KETONES, liquid, n.o.s.
1226	26	CIGARETTE LIGHTER, with flammable liquid
1226	26	LIGHTER, for cigars, cigarettes, etc., with flammable liquid
1226	26	LIGHTER FLUID
1228	28	MERCAPTAN MIXTURE, aliphatic
1228	28	MERCAPTAN MIXTURE, liquid flammable, toxic, n.o.s.
1228	28	MERCAPTANS, liquid flammable, toxic, n.o.s.
1228	28	MERCAPTANS and MIXTURES liquid, n.o.s.
1229	26	MESITYL OXIDE
1230	28	METHANOL
1230	28	METHYL ALCOHOL
1231	26	METHYL ACETATE
1232	26	METHYL ACETONE
1233	26	METHYL AMYL ACETATE
1233	26	METHYL AMYL ACETATE
1234	26	METHYLAL
1235	68	METHYLAMINE, aqueous solution
1235	68	MONOMETHYLAMINE, aqueous solution
1237	26	METHYL BUTYRATE
1238	**28**	**METHYL CHLOROCARBONATE**
1238	**28**	**METHYL CHLOROFORMATE**
1239	**57**	**METHYL CHLOROMETHYL ETHER**
1242	29	METHYLDICHLOROSILANE
1243	26	METHYL FORMATE
1244	**57**	**METHYLHYDRAZINE**
1245	26	METHYL ISOBUTYL KETONE
1246	26	METHYL ISOPROPENYL KETONE, inhibited
1247	26	METHYL METHACRYLATE monomer, inhibited
1248	26	METHYL PROPIONATE
1249	26	METHYL PROPYL KETONE
1250	29	METHYLTRICHLOROSILANE
1251	**28**	**METHYL VINYL KETONE**
1255	27	NAPHTHA, petroleum
1255	27	PETROLEUM NAPHTHA
1256	27	NAPHTHA, solvent
1257	27	NATURAL GASOLINE
1259	**57**	**NICKEL CARBONYL**
1261	26	NITROMETHANE
1262	27	ISOOCTANE
1262	27	OCTANES
1263	26	ENAMEL
1263	26	LACQUER
1263	26	LACQUER BASE, liquid

Table 2 Continued

ID No	Guide No	Name of Material
1263	26	PAINT, flammable liquid
1263	26	PAINT RELATED MATERIAL, flammable liquid
1263	26	POLISH, liquid
1264	26	PARALDEHYDE
1265	27	ISOPENTANE
1265	27	n-PENTANE
1265	27	PENTANES, liquid
1266	26	PERFUMERY PRODUCTS, with flammable solvent
1267	27	PETROLEUM CRUDE OIL
1268	27	PETROLEUM DISTILLATES n.o.s.
1268	27	PETROLEUM PRODUCTS, n.o.s.
1270	27	OIL, petroleum, n.o.s.
1270	27	PETROLEUM OIL
1271	26	PETROLEUM ETHER
1271	26	PETROLEUM SPIRIT
1272	26	PINE OIL
1274	26	n-PROPANOL
1274	26	PROPYL ALCOHOL
1275	26	PROPIONALDEHYDE
1276	26	n-PROPYL ACETATE
1277	68	MONOPROPYLAMINE
1277	68	PROPYLAMINE
1278	26	1-CHLOROPROPANE
1278	26	PROPYL CHLORIDE
1279	27	DICHLOROPROPANES
1279	27	PROPYLENE DICHLORIDE
1280	26	PROPYLENE OXIDE
1281	26	PROPYL FORMATES
1282	26	PYRIDINE
1286	26	ROSIN OIL
1287	26	RUBBER SOLUTION
1288	27	SHALE OIL
1289	29	SODIUM METHYLATE, solutions in alcohol
1289	29	SODIUM METHYLATE SOLUTIONS in alcohol
1292	29	ETHYL SILICATE
1292	29	TETRAETHYL SILICATE
1293	26	TINCTURES, medicinal
1294	27	TOLUENE
1295	38	TRICHLOROSILANE
1296	68	TRIETHYLAMINE
1297	29	TRIMETHYLAMINE, aqueous solution
1298	29	TRIMETHYLCHLOROSILANE
1299	27	TURPENTINE
1300	27	TURPENTINE SUBSTITUTE
1301	26	VINYL ACETATE
1301	26	VINYL ACETATE, inhibited
1302	26	VINYL ETHYL ETHER
1302	26	VINYL ETHYL ETHER, inhibited
1303	26	VINYLIDENE CHLORIDE, inhibited
1304	26	VINYL BUTYL ETHER
1304	26	VINYL ISOBUTYL ETHER
1304	26	VINYL ISOBUTYL ETHER, inhibited
1305	29	VINYLTRICHLOROSILANE
1306	26	WOOD PRESERVATIVES, liquid
1307	27	XYLENES, (Xylol)
1308	26	ZIRCONIUM METAL, liquid suspension
1308	26	ZIRCONIUM SUSPENDED IN A LIQUID
1309	32	ALUMINUM POWDER, coated
1310	33	AMMONIUM PICRATE, wetted with not less than 10% water
1312	32	BORNEOL
1313	32	CALCIUM RESINATE
1314	32	CALCIUM RESINATE, fused
1318	32	COBALT RESINATE, precipitated
1320	36	DINITROPHENOL, wetted with not less than 15% water
1321	36	DINITROPHENOLATE, wetted with not less than 15% water
1322	36	DINITRORESORCINOL, wetted with not less than 15% water
1323	32	FERROCERIUM
1324	32	FILM, MOTION PICTURE, nitrocellulose base
1324	32	FILM, NITROCELLULOSE BASE
1325	32	AIR BAG INFLATORS

Table 2 Continued

ID No	Guide No	Name of Material
1325	32	AIR BAG MODULES
1325	32	COSMETICS, flammable solid n.o.s.
1325	32	FLAMMABLE SOLID, n.o.s.
1325	32	FUSEE (rail or highway)
1325	32	MEDICINES, flammable, solid, n.o.s.
1325	32	PYROXYLIN PLASTIC, rod, sheet, roll, tube, or scrap
1325	32	SMOKELESS POWDER, small arms
1325	32	TETRAETHYLAMMONIUM PERCHLORATE, dry
1326	32	HAFNIUM powder, wetted with not less than 25% water
1327	32	HAY, STRAW or BHUSA, wet damp or contaminated with oil
1328	32	HEXAMETHYLENETETRAMINE
1328	32	HEXAMINE
1330	32	MANGANESE RESINATE
1331	32	MATCHES, strike anywhere
1332	32	METALDEHYDE
1333	32	CERIUM, slabs, ingots or rods
1334	32	CREOSOTE SALTS
1334	32	NAPHTHALENE, crude or refined
1336	33	NITROGUANIDINE, wetted with not less than 20% water
1336	33	PICRITE, wetted with not less than 20% water
1337	33	NITROSTARCH, wet with not less than 20% water
1337	33	NITROSTARCH, wet with not less than 30% solvent
1338	32	PHOSPHORUS, amorphous, red
1338	32	RED PHOSPHORUS
1339	32	PHOSPHORUS HEPTASULFIDE, free from yellow or white phosphorus
1340	41	PHOSPHORUS PENTASULFIDE, free from yellow or white phosphorus
1341	41	PHOSPHORUS SESQUISULFIDE, free from yellow or white phosphorus
1343	41	PHOSPHORUS TRISULFIDE, free from yellow or white phosphorus
1344	33	PICRIC ACID, wet with not less than 10% water
1344	33	TRINITROPHENOL, wet
1344	33	TRINITROPHENOL, wetted with not less than 30% water
1345	32	RUBBER SCRAP, powdered or granulated
1345	32	RUBBER SHODDY, powdered or granulated
1346	32	SILICON POWDER, amorphous
1347	33	SILVER PICRATE, wetted with not less than 30% water
1348	36	SODIUM DINITRO-ortho-CRESOLATE, wetted with not less than 15% water
1349	33	SODIUM PICRAMATE, wetted with not less than 20% water
1350	32	SULFUR
1352	32	TITANIUM, metal, powder, wet with not less than 20% water
1352	32	TITANIUM POWDER, wetted with not less than 25% water
1353	32	FABRICS, impregnated with weakly nitrated nitrocellulose n.o.s.
1353	32	FIBERS, impregnated with weakly nitrated nitrocellulose, n.o.s.
1353	32	TOE PUFFS, nitrocellulose base
1354	33	TRINITROBENZENE, wet
1354	33	TRINITROBENZENE, wetted with not less than 30% water
1355	33	TRINITROBENZOIC ACID, wet
1355	33	TRINITROBENZOIC ACID, wetted with not less than 30% water
1356	33	TRINITROTOLUENE, wet
1356	33	TRINITROTOLUENE, wetted with not less than 30% water
1357	33	UREA NITRATE, wet
1357	33	UREA NITRATE, wetted with not less than 20% water
1358	32	ZINC POWDER, wetted with not less than 25% water
1358	32	ZIRCONIUM METAL, powder, wet
1358	32	ZIRCONIUM POWDER, wet
1360	41	CALCIUM PHOSPHIDE
1361	32	CARBON, animal or vegetable origin
1361	32	CHARCOAL
1361	32	COAL, ground bituminous, sea coal, etc.

Table 2 Continued

ID No	Guide No	Name of Material
1361	32	COAL FACINGS
1361	32	SEA COAL
1362	32	ACTIVATED CARBON
1362	32	CARBON, activated
1363	37	COPRA
1364	32	COTTON WASTE, oily
1365	32	COTTON, wet
1366	40	DIETHYLZINC
1369	32	p-NITROSODIMETHYLANILINE
1370	40	DIMETHYLZINC
1372	32	FIBER, animal or vegetable burnt, wet or damp, n.o.s.
1373	32	FABRIC, animal or vegetable or synthetic, with oil, n.o.s.
1373	32	FIBER, animal or vegetable or synthetic, with oil, n.o.s.
1374	32	FISH MEAL or SCRAP, unstabilized
1376	37	IRON OXIDE, spent
1376	37	IRON SPONGE, spent
1378	32	METAL CATALYST, finely divided, activated or spent, wet with not less than 40% water or other suitable liquid
1379	32	PAPER, treated with unsaturated oil
1380	75	PENTABORANE
1381	38	PHOSPHORUS, white or yellow , dry or under water or in solution
1381	38	WHITE PHOSPHORUS, dry
1381	38	WHITE PHOSPHORUS, wet
1381	38	YELLOW PHOSPHORUS, dry
1381	38	YELLOW PHOSPHORUS, wet
1382	32	POTASSIUM SULFIDE, anhydrous or with less than 30% water of hydration
1383	37	PYROPHORIC METALS or ALLOYS, n.o.s.
1384	37	SODIUM DITHIONITE
1384	37	SODIUM HYDROSULFITE
1385	34	SODIUM SULFIDE, anhydrous or with less than 30% water of crystallization
1386	32	SEED CAKE, with more than 1.5% oil and not more than 11% moisture
1389	40	ALKALI METAL AMALGAMS
1390	40	ALKALI METAL AMIDES
1391	40	ALKALI METAL DISPERSIONS
1391	40	ALKALINE EARTH METAL DISPERSIONS
1392	40	ALKALINE EARTH METAL AMALGAMS
1393	40	ALKALINE EARTH METAL ALLOYS, n.o.s.
1394	40	ALUMINUM CARBIDE
1395	41	ALUMINUM FERROSILICON, powder
1396	40	ALUMINUM POWDER, uncoated
1397	41	ALUMINUM PHOSPHIDE
1398	40	ALUMINUM SILICON POWDER, uncoated
1400	40	BARIUM
1401	40	CALCIUM
1402	40	CALCIUM CARBIDE
1403	40	CALCIUM CYANAMIDE, with more than 0.1% calcium carbide
1404	40	CALCIUM HYDRIDE
1405	40	CALCIUM SILICIDE
1406	40	CALCIUM SILICON
1407	40	CAESIUM
1407	40	CESIUM
1408	41	FERROSILICON
1409	40	HYDRIDES, metal, n.o.s.
1409	40	METAL HYDRIDES, water-reactive, n.o.s.
1410	40	LITHIUM ALUMINUM HYDRIDE
1411	40	LITHIUM ALUMINUM HYDRIDE, ethereal
1412	40	LITHIUM AMIDE
1413	40	LITHIUM BOROHYDRIDE
1414	40	LITHIUM HYDRIDE
1415	40	LITHIUM
1415	40	LITHIUM METAL
1417	40	LITHIUM SILICON
1418	76	MAGNESIUM, powder
1418	76	MAGNESIUM ALLOYS, with more than 50% magnesium, powder
1419	41	MAGNESIUM ALUMINUM PHOSPHIDE
1420	40	POTASSIUM, METAL, alloy
1420	40	POTASSIUM, metal, liquid, alloy

Table 2 Continued

ID No	Guide No	Name of Material
1421	40	ALKALI METAL ALLOYS, liquid, n.o.s.
1422	40	POTASSIUM SODIUM ALLOYS
1422	40	SODIUM POTASSIUM ALLOYS
1423	40	RUBIDIUM
1423	40	RUBIDIUM METAL
1426	32	SODIUM BOROHYDRIDE
1427	40	SODIUM HYDRIDE
1428	40	SODIUM
1428	40	SODIUM METAL
1431	40	SODIUM METHYLATE, dry
1432	41	SODIUM PHOSPHIDE
1433	41	STANNIC PHOSPHIDE
1435	40	ZINC ASHES
1436	76	ZINC METAL, powder or dust
1436	76	ZINC POWDER or DUST
1437	40	ZIRCONIUM HYDRIDE
1438	35	ALUMINUM NITRATE
1439	35	AMMONIUM DICHROMATE
1442	43	AMMONIUM PERCHLORATE
1444	35	AMMONIUM PERSULFATE
1445	42	BARIUM CHLORATE
1446	42	BARIUM NITRATE
1447	42	BARIUM PERCHLORATE
1448	42	BARIUM PERMANGANATE
1449	42	BARIUM PEROXIDE
1450	42	BROMATES, inorganic, n.o.s.
1451	35	CAESIUM NITRATE
1451	35	CESIUM NITRATE
1452	35	CALCIUM CHLORATE
1453	35	CALCIUM CHLORITE
1454	35	CALCIUM NITRATE
1455	35	CALCIUM PERCHLORATE
1456	35	CALCIUM PERMANGANATE
1457	35	CALCIUM PEROXIDE
1458	35	BORATE and CHLORATE MIXTURE
1458	35	CHLORATE and BORATE MIXTURES
1459	35	CHLORATE and MAGNESIUM CHLORIDE MIXTURES
1461	35	CHLORATES, inorganic, n.o.s.
1462	43	CHLORITES, inorganic, n.o.s.
1463	42	CHROMIC ACID, solid
1463	42	CHROMIC ANHYDRIDE
1463	42	CHROMIUM TRIOXIDE, anhydrous
1465	35	DIDYMIUM NITRATE
1466	35	FERRIC NITRATE
1467	43	GUANIDINE NITRATE
1469	42	LEAD NITRATE
1470	42	LEAD PERCHLORATE, solid or solution
1471	45	LITHIUM HYPOCHLORITE, dry, including mixtures with more than 39% available chlorine
1472	47	LITHIUM PEROXIDE
1473	35	MAGNESIUM BROMATE
1474	35	MAGNESIUM NITRATE
1475	35	MAGNESIUM PERCHLORATE
1476	35	MAGNESIUM PEROXIDE
1477	35	NITRATES, inorganic, n.o.s.
1479	35	COSMETICS, oxidizer, n.o.s.
1479	35	CUPRIC NITRATE
1479	35	MEDICINES, oxidizing substance, solid, n.o.s.
1479	35	OXIDIZER, n.o.s.
1479	35	OXIDIZING MATERIAL, n.o.s.
1479	35	OXIDIZING SOLID, n.o.s.
1479	35	OXIDIZING SUBSTANCES, solid n.o.s.
1479	35	POTASSIUM DICHROMATE
1479	35	SODIUM DICHROMATE
1481	35	PERCHLORATES, inorganic n.o.s.
1482	35	PERMANGANATES, inorganic n.o.s.
1483	35	PEROXIDE, inorganic, n.o.s.
1484	35	POTASSIUM BROMATE
1485	35	CHLORATE OF POTASH
1485	35	POTASSIUM CHLORATE
1486	35	POTASSIUM NITRATE
1487	35	POTASSIUM NITRATE and SODIUM NITRITE MIXTURE
1487	35	SODIUM NITRITE and POTASSIUM NITRATE MIXTURE

Table 2 Continued

ID No	Guide No	Name of Material
1488	35	POTASSIUM NITRITE
1489	35	POTASSIUM PERCHLORATE
1490	35	POTASSIUM PERMANGANATE
1491	47	POTASSIUM PEROXIDE
1492	35	POTASSIUM PERSULFATE
1493	45	SILVER NITRATE
1494	42	SODIUM BROMATE
1495	35	CHLORATE OF SODA
1495	35	SODIUM CHLORATE
1496	43	SODIUM CHLORITE
1498	35	SODIUM NITRATE
1499	35	SODIUM NITRATE and POTASSIUM NITRATE MIXTURES
1500	35	SODIUM NITRITE
1502	35	SODIUM PERCHLORATE
1503	35	SODIUM PERMANGANATE
1504	47	SODIUM PEROXIDE
1505	35	SODIUM PERSULFATE
1506	35	STRONTIUM CHLORATE, solid or solution
1507	35	STRONTIUM NITRATE
1508	35	STRONTIUM PERCHLORATE
1509	47	STRONTIUM PEROXIDE
1510	**47**	**TETRANITROMETHANE**
1511	35	UREA HYDROGEN PEROXIDE
1511	35	UREA PEROXIDE
1512	35	ZINC AMMONIUM NITRITE
1513	35	ZINC CHLORATE
1514	35	ZINC NITRATE
1515	35	ZINC PERMANGANATE
1516	47	ZINC PEROXIDE
1517	33	ZINC PICRAMATE, wetted with not less than 20% water
1517	33	ZIRCONIUM PICRAMATE, wet
1541	**55**	**ACETONE CYANOHYDRIN, stabilized**
1544	55	ALKALOID SALTS, solid, n.o.s, poisonous
1544	55	ALKALOIDS, solid, n.o.s poisonous
1545	**57**	**ALLYL ISOTHIOCYANATE, inhibited**
1545	**57**	**ALLYL ISOTHIOCYANATE, stabilized**
1546	53	AMMONIUM ARSENATE
1547	57	ANILINE
1548	53	ANILINE HYDROCHLORIDE
1549	60	ANTIMONY COMPOUND, inorganic, n.o.s.
1549	60	ANTIMONY COMPOUNDS, inorganic, n.o.s.
1549	60	ANTIMONY TRIBROMIDE
1549	60	ANTIMONY TRIBROMIDE SOLUTION
1549	60	ANTIMONY TRIFLUORIDE
1549	60	ANTIMONY TRIFLUORIDE SOLUTION
1550	53	ANTIMONY LACTATE
1551	53	ANTIMONY POTASSIUM TARTRATE
1553	55	ARSENIC ACID, liquid
1554	53	ARSENIC ACID, solid
1555	53	ARSENIC BROMIDE
1556	55	ARSENIC COMPOUNDS, liquid n.o.s.
1556	**55**	**METHYLDICHLOROARSINE**
1556	55	PHENYLDICHLOROARSINE
1557	53	ARSENIC COMPOUNDS, solid n.o.s.
1557	53	ARSENIC DISULFIDE
1557	53	ARSENIC IODIDE, solid
1557	53	ARSENIC SULFIDE
1557	53	ARSENIC TRISULFIDE
1558	53	ARSENIC
1559	53	ARSENIC PENTOXIDE
1560	**55**	**ARSENIC CHLORIDE**
1560	**55**	**ARSENIC TRICHLORIDE**
1561	53	ARSENIC, white, solid
1561	53	ARSENIC TRIOXIDE
1562	53	ARSENICAL DUST
1564	55	BARIUM COMPOUNDS, n.o.s.
1565	53	BARIUM CYANIDE
1566	53	BERYLLIUM CHLORIDE
1566	53	BERYLLIUM COMPOUNDS, n.o.s.
1566	53	BERYLLIUM FLUORIDE
1567	32	BERYLLIUM, powder
1569	**55**	**BROMOACETONE**

Table 2 Continued

ID No	Guide No	Name of Material
1570	53	BRUCINE
1571	36	BARIUM AZIDE, wetted with not less than 50% water
1572	53	CACODYLIC ACID
1573	53	CALCIUM ARSENATE
1574	53	CALCIUM ARSENATE and CALCIUM ARSENITE MIXTURES, solid
1574	53	CALCIUM ARSENITE
1575	55	CALCIUM CYANIDE
1577	56	CHLORODINITROBENZENES
1577	56	DINITROCHLOROBENZENE
1578	55	CHLORONITROBENZENES
1578	55	NITROCHLOROBENZENE, liquid
1578	55	NITROCHLOROBENZENE, solid
1579	53	4-CHLORO-o-TOLUIDINE HYDROCHLORIDE
1580	**56**	**CHLOROPICRIN**
1581	**55**	**CHLOROPICRIN and METHYL BROMIDE MIXTURES**
1581	**55**	**METHYL BROMIDE and CHLOROPICRIN MIXTURES**
1582	**18**	**CHLOROPICRIN and METHYL CHLORIDE MIXTURES**
1582	**18**	**METHYL CHLORIDE and CHLOROPICRIN MIXTURES**
1583	**56**	**CHLOROPICRIN MIXTURES n.o.s.**
1584	53	COCCULUS
1585	53	COPPER ACETOARSENITE
1586	53	COPPER ARSENITE
1587	53	COPPER CYANIDE
1588	55	CYANIDE or CYANIDE MIXTURE, dry
1588	55	CYANIDES, inorganic, n.o.s.
1588	55	CYANIDES, inorganic, solid n.o.s.
1589	**15**	**CYANOGEN CHLORIDE inhibited**
1590	55	DICHLOROANILINES, solid or liquid
1591	58	o-DICHLOROBENZENE
1592	58	p-DICHLOROBENZENE
1593	74	DICHLOROMETHANE
1593	74	METHYLENE CHLORIDE
1594	55	DIETHYLSULFATE
1594	**55**	**ETHYL SULFATE**
1595	**57**	**DIMETHYL SULFATE**
1595	57	METHYL SULFATE
1596	56	DINITROANILINES
1597	56	DINITROBENZENE SOLUTION
1597	56	DINITROBENZENES
1598	53	DINITRO-o-CRESOL
1599	57	DINITROPHENOL SOLUTIONS
1600	56	DINITROTOLUENES, molten
1601	55	DISINFECTANT, solid, toxic n.o.s.
1601	55	DISINFECTANTS, solid, n.o.s. poisonous
1602	55	DYE, liquid, toxic, n.o.s.
1602	55	DYE INTERMEDIATE, liquid toxic, n.o.s.
1602	55	DYE INTERMEDIATES, liquid n.o.s. (poisonous)
1602	55	DYES, liquid n.o.s. (poisonous)
1603	55	ETHYL BROMOACETATE
1604	29	ETHYLENEDIAMINE
1605	**55**	**1,2-DIBROMOETHANE**
1605	**55**	**ETHYLENE DIBROMIDE**
1606	53	FERRIC ARSENATE
1607	53	FERRIC ARSENITE
1608	53	FERROUS ARSENATE
1610	58	HALOGENATED IRRITATING LIQUIDS, n.o.s.
1611	55	HEXAETHYL TETRAPHOSPHATE
1612	**15**	**HEXAETHYL TETRAPHOSPHATE and COMPRESSED GAS MIXTURES**
1613	55	HYDROCYANIC ACID, aqueous solution, with less than 5% hydrocyanic acid
1613	55	HYDROCYANIC ACID, aqueous solution, with not less than 5% hydrocyanic acid
1613	**55**	**HYDROCYANIC ACID, aqueous solution, with not more than 20% hydrogen cyanide**
1613	**55**	**HYDROGEN CYANIDE, aqueous solution, with not more than 20% hydrogen cyanide**
1614	**57**	**HYDROGEN CYANIDE, anhydrous, stabilized (absorbed)**
1614	**57**	**HYDROGEN CYANIDE stabilized containing less than 3% water (absorbed in a porous inert material)**

Table 2 Continued

ID No	Guide No	Name of Material
1616	53	LEAD ACETATE
1617	53	LEAD ARSENATES
1618	53	LEAD ARSENITES
1620	53	LEAD CYANIDE
1621	53	LONDON PURPLE
1622	53	MAGNESIUM ARSENATE
1623	53	MERCURIC ARSENATE
1624	53	MERCURIC CHLORIDE
1625	42	MERCURIC NITRATE
1626	53	MERCURIC POTASSIUM CYANIDE
1627	42	MERCUROUS NITRATE
1628	53	MERCUROUS SULFATE
1629	53	MERCURIC ACETATE
1629	53	MERCUROUS ACETATE
1629	53	MERCURY ACETATE
1630	53	MERCURY AMMONIUM CHLORIDE
1631	53	MERCURY BENZOATE
1633	53	MERCURY BISULFATE
1634	53	MERCURIC BROMIDE
1634	53	MERCUROUS BROMIDE
1634	53	MERCURY BROMIDES
1636	53	MERCURIC CYANIDE
1636	53	MERCURY CYANIDE
1637	53	MERCURY GLUCONATE
1638	53	MERCURY IODIDE
1639	53	MERCUROL
1639	53	MERCURY NUCLEATE
1640	53	MERCURY OLEATE
1641	53	MERCURY OXIDE
1642	53	MERCURIC OXYCYANIDE
1642	53	MERCURY OXYCYANIDE, desensitized
1643	53	MERCURY POTASSIUM IODIDE
1644	53	MERCURY SALICYLATE
1645	53	MERCURIC SULFATE
1645	53	MERCURY SULFATE
1646	53	MERCURY THIOCYANATE
1647	**55**	**METHYL BROMIDE and ETHYLENE DIBROMIDE MIXTURES, liquid**
1648	28	ACETONITRILE
1648	28	METHYL CYANIDE
1649	56	ANTI-KNOCK COMPOUND
1649	56	ETHYL FLUID
1649	56	MOTOR FUEL ANTI-KNOCK COMPOUND
1649	56	MOTOR FUEL ANTI-KNOCK MIXTURES
1649	56	TETRAETHYL LEAD, liquid
1650	55	NAPHTHYLAMINE (beta)
1651	53	NAPHTHYLTHIOUREA
1652	53	NAPHTHYLUREA
1653	53	NICKEL CYANIDE
1654	55	NICOTINE
1655	55	NICOTINE COMPOUNDS, solid, n.o.s.
1655	55	NICOTINE PREPARATIONS, solid, n.o.s.
1656	55	NICOTINE HYDROCHLORIDE and solutions
1657	53	NICOTINE SALICYLATE
1658	55	NICOTINE SULFATE, liquid
1658	55	NICOTINE SULFATE, solid
1659	53	NICOTINE TARTRATE
1660	**20**	**NITRIC OXIDE**
1661	55	NITROANILINES
1662	55	NITROBENZENE
1663	55	NITROPHENOLS
1664	55	NITROTOLUENES
1665	55	NITROXYLENES
1665	55	NITROXYLOL
1669	55	PENTACHLOROETHANE
1670	**55**	**PERCHLOROMETHYL MERCAPTAN**
1671	55	CARBOLIC ACID
1671	55	PHENOL, solid
1672	**55**	**PHENYLCARBYLAMINE CHLORIDE**
1673	53	PHENYLENEDIAMINES
1674	55	PHENYLMERCURIC ACETATE
1677	53	POTASSIUM ARSENATE
1678	54	POTASSIUM ARSENITE
1679	53	POTASSIUM CUPROCYANIDE

Table 2 Continued

ID No	Guide No	Name of Material
1680	55	POTASSIUM CYANIDE, solid
1680	55	POTASSIUM CYANIDE SOLUTION
1683	53	SILVER ARSENITE
1684	53	SILVER CYANIDE
1685	53	SODIUM ARSENATE
1686	54	SODIUM ARSENITE, aqueous solutions
1687	56	SODIUM AZIDE
1688	53	SODIUM CACODYLATE
1689	55	SODIUM CYANIDE
1690	54	SODIUM FLUORIDE, solid
1690	54	SODIUM FLUORIDE SOLUTION
1691	53	STRONTIUM ARSENITE
1692	53	STRYCHNINE, and salts
1693	58	IRRITATING AGENT, n.o.s.
1693	58	ORM-A, n.o.s.
1693	58	TEAR GAS DEVICES
1693	58	TEAR GAS SUBSTANCES, liquid or solid, n.o.s.
1694	58	BROMOBENZYL CYANIDES
1695	**59**	**CHLOROACETONE, stabilized**
1695	**59**	**MONOCHLOROACETONE inhibited**
1695	**59**	**MONOCHLOROACETONE stabilized**
1697	55	CHLOROACETOPHENONE
1698	55	DIPHENYLAMINE CHLOROARSINE
1699	55	DIPHENYL CHLOROARSINE, solid or liquid
1700	58	TEAR GAS CANDLES
1701	55	XYLYL BROMIDE
1702	55	TETRACHLOROETHANE
1702	55	1,1,2,2-TETRACHLOROETHANE
1703	**15**	**TETRAETHYL DITHIOPYROPHOSPHATE and compressed gas mixture**
1703	**15**	**TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 more than 200 ppm but not more than 5000 ppm)**
1703	**15**	**TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 not more than 200 ppm)**
1704	55	TETRAETHYL DITHIOPYROPHOSPHATE dry, liquid or mixture
1705	**15**	**TETRAETHYL PYROPHOSPHATE and compressed gas mixture**
1705	**15**	**TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 more than 200 ppm but not more than 5000 ppm)**
1705	**15**	**TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 not more than 200 ppm)**
1707	53	THALLIUM COMPOUND, n.o.s.
1707	53	THALLIUM SALT, n.o.s.
1707	53	THALLIUM SULFATE, solid
1708	55	TOLUIDINES
1709	53	2,4-TOLUENEDIAMINE
1709	53	2,4-TOLUYLENEDIAMINE
1710	74	TRICHLOROETHYLENE
1711	55	XYLIDINES
1712	53	ZINC ARSENATE
1712	53	ZINC ARSENATE and ZINC ARSENITE MIXTURES
1712	53	ZINC ARSENITE
1713	53	ZINC CYANIDE
1714	41	ZINC PHOSPHIDE
1715	39	ACETIC ANHYDRIDE
1716	60	ACETYL BROMIDE
1717	29	ACETYL CHLORIDE
1718	60	ACID BUTYL PHOSPHATE
1718	60	BUTYL ACID PHOSPHATE
1718	60	BUTYL PHOSPHORIC ACID
1719	60	ALKALINE CORROSIVE LIQUID, n.o.s.
1719	60	CAUSTIC ALKALI LIQUIDS, n.o.s.
1722	**57**	**ALLYL CHLOROCARBONATE**
1722	**57**	**ALLYL CHLOROFORMATE**
1723	29	ALLYL IODIDE
1724	29	ALLYL TRICHLOROSILANE, stabilized
1725	39	ALUMINUM BROMIDE, anhydrous
1726	39	ALUMINUM CHLORIDE, anhydrous
1727	60	AMMONIUM BIFLUORIDE, solid

Table 2 Continued

ID No	Guide No	Name of Material
1727	60	AMMONIUM HYDROGEN DIFLUORIDE, solid
1727	60	AMMONIUM HYDROGEN FLUORIDE, solid
1728	29	AMYLTRICHLOROSILANE
1729	60	ANISOYL CHLORIDE
1730	60	ANTIMONY PENTACHLORIDE, liquid
1731	60	ANTIMONY PENTACHLORIDE, SOLUTION
1732	59	ANTIMONY PENTAFLUORIDE
1733	60	ANTIMONY CHLORIDE
1733	60	ANTIMONY TRICHLORIDE
1733	60	ANTIMONY TRICHLORIDE SOLUTION
1736	39	BENZOYL CHLORIDE
1737	59	BENZYL BROMIDE
1738	59	BENZYL CHLORIDE
1739	39	BENZYL CHLOROFORMATE
1740	60	Bifluorides, n.o.s.
1740	60	HYDROGENDIFLOURIDES, n.o.s., solid or solution
1741	**15**	**BORON TRICHLORIDE**
1742	59	BORON TRIFLUORIDE ACETIC ACID COMPLEX
1743	59	BORON TRIFLUORIDE PROPIONIC ACID COMPLEX
1744	**59**	**BROMINE**
1744	**59**	**BROMINE SOLUTIONS**
1745	**44**	**BROMINE PENTAFLUORIDE**
1746	**44**	**BROMINE TRIFLUORIDE**
1747	29	BUTYL TRICHLOROSILANE
1748	45	CALCIUM HYPOCHLORITE, dry, including mixtures with more than 39% available chlorine (8.8% available oxygen)
1749	**44**	**CHLORINE TRIFLUORIDE**
1750	59	CHLOROACETIC ACID, liquid
1750	59	MONOCHLOROACETIC ACID, liquid
1751	60	CHLOROACETIC ACID, solid
1752	**59**	**CHLOROACETYL CHLORIDE**
1753	60	CHLOROPHENYL TRICHLOROSILANE
1754	**39**	**CHLOROSULFONIC ACID**
1754	**39**	**CHLOROSULFONIC ACID and SULFUR TRIOXIDE MIXTURE**
1755	60	CHROMIC ACID SOLUTION
1756	60	CHROMIC FLUORIDE, solid
1757	60	CHROMIC FLUORIDE SOLUTION
1758	39	CHROMIUM OXYCHLORIDE
1759	60	CORROSIVE SOLIDS, n.o.s.
1759	60	COSMETICS, corrosive solid, n.o.s.
1759	60	FERROUS CHLORIDE, solid
1759	60	FUNGICIDE, corrosive, n.o.s.
1759	60	MEDICINES, corrosive, solid n.o.s.
1759	60	STANNOUS CHLORIDE, solid
1760	60	ACID, liquid, n.o.s.
1760	60	ALUMINUM PHOSPHATE SOLUTION
1760	60	ALUMINUM SULFATE SOLUTION
1760	60	AMINOETHOXYETHANOL
1760	60	AMINOPROPYLDIETHANOLAMINE
1760	60	N-AMINOPROPYLMORPHOLINE
1760	60	N-AMINOPROPYLPIPERAZINE
1760	60	CAPROIC ACID (HEXANOIC ACID)
1760	60	CHEMICAL KIT
1760	60	CLEANING COMPOUND, liquid, corrosive
1760	60	COMPOUNDS, cleaning liquid (corrosive)
1760	60	COMPOUNDS, TREE or WEED KILLING, liquid (corrosive)
1760	60	CORROSIVE LIQUIDS, n.o.s.
1760	60	COSMETICS, corrosive liquid, n.o.s.
1760	60	DICHLOROPROPIONIC ACID
1760	60	2,2-DICHLOROPROPIONIC ACID
1760	60	ETHYL PHOSPHONOTHIOIC DICHLORIDE, anhydrous
1760	60	ETHYL PHOSPHORODICHLORIDATE
1760	60	FERROUS CHLORIDE SOLUTION
1760	60	HEXANOIC ACID
1760	60	ISOPENTANOIC ACID
1760	60	MEDICINES, corrosive, liquid, n.o.s.
1760	60	METHYL PHOSPHONOTHIOIC DICHLORIDE
1760	60	MORPHOLINE, aqueous mixture
1760	60	NITRIC ACID, other than fuming, with not more than 40% acid

Table 2 Continued

ID No	Guide No	Name of Material
1760	60	ORM-B, n.o.s.
1760	60	PAINT, corrosive liquid
1760	60	PAINT RELATED MATERIAL, corrosive liquid
1760	60	TEXTILE TREATING COMPOUND
1760	60	TITANIUM SULFATE SOLUTION
1760	60	VALERIC ACID, (n-PENTANOIC ACID)
1761	59	CUPRIETHYLENEDIAMINE SOLUTION
1762	29	CYCLOHEXENYL TRICHLOROSILANE
1763	60	CYCLOHEXYL TRICHLOROSILANE
1764	60	DICHLOROACETIC ACID
1765	60	DICHLOROACETYL CHLORIDE
1766	60	DICHLOROPHENYL TRICHLOROSILANE
1767	29	DIETHYLDICHLOROSILANE
1768	59	DIFLUOROPHOSPHORIC ACID, anhydrous
1769	29	DIPHENYLDICHLOROSILANE
1770	60	DIPHENYLMETHYL BROMIDE
1771	60	DODECYLTRICHLOROSILANE
1773	60	FERRIC CHLORIDE, anhydrous
1773	60	IRON CHLORIDE, solid
1774	60	FIRE EXTINGUISHER CHARGES, corrosive liquid
1775	60	FLUOBORIC ACID
1775	60	FLUOROBORIC ACID
1776	59	FLUOROPHOSPHORIC ACID, anhydrous
1776	59	MONOFLUOROPHOSPHORIC ACID
1777	39	FLUOROSULFONIC ACID
1778	60	FLUOROSILICIC ACID
1778	60	FLUOSILICIC ACID
1778	60	HYDROFLUOSILICIC ACID
1778	60	HYDROSILICOFLUORIC ACID
1778	60	SILICOFLUORIC ACID
1779	60	FORMIC ACID
1780	60	FUMARYL CHLORIDE
1781	60	HEXADECYLTRICHLOROSILANE
1782	59	HEXAFLUOROPHOSPHORIC ACID
1783	60	HEXAMETHYLENEDIAMINE SOLUTION
1784	29	HEXYLTRICHLOROSILANE
1786	59	ACID MIXTURE, hydrofluoric and sulfuric acids
1786	59	HYDROFLUORIC and SULFURIC ACID MIXTURES
1786	59	SULFURIC and HYDROFLUORIC ACID MIXTURE
1787	60	HYDRIODIC ACID, AND SOLUTIONS
1787	60	HYDROGEN IODIDE SOLUTION
1788	60	HYDROBROMIC ACID, AND SOLUTIONS
1788	60	HYDROGEN BROMIDE SOLUTION
1789	60	HYDROCHLORIC ACID SOLUTION
1789	60	HYDROGEN CHLORIDE SOLUTION
1789	60	MURIATIC ACID
1790	59	ETCHING ACID, liquid, n.o.s.
1790	59	FLUORIC ACID
1790	59	HYDROFLUORIC ACID SOLUTION
1790	59	HYDROGEN FLUORIDE SOLUTION
1791	60	HYPOCHLORITE SOLUTION with more than 5% available chlorine
1791	60	POTASSIUM HYPOCHLORITE SOLUTION
1791	60	SODIUM HYPOCHLORITE SOLUTION
1792	59	IODINE MONOCHLORIDE
1793	60	ISOPROPYL ACID PHOSPHATE
179	46	LEAD SULFATE, with more than 3% free acid
1796	73	ACID MIXTURE, nitrating
1796	73	MIXED ACID
1796	73	NITRATING ACID
1796	73	NITRATING ACID, mixtures
1798	60	NITROHYDROCHLORIC ACID
1798	60	NITROMURIATIC ACID
1799	60	NONYLTRICHLOROSILANE
1800	39	OCTADECYLTRICHLOROSILANE
1801	60	OCTYLTRICHLOROSILANE
1802	45	PERCHLORIC ACID, not more than 50% acid, by weight
1803	60	PHENOLSULFONIC ACID, liquid
1804	39	PHENYLTRICHLOROSILANE

Table 2 Continued

ID No	Guide No	Name of Material
1805	60	PHOSPHORIC ACID
1806	39	PHOSPHORUS PENTACHLORIDE
1807	39	PHOSPHORIC ANHYDRIDE
1807	39	PHOSPHORUS PENTOXIDE
1808	39	PHOSPHORUS TRIBROMIDE
1809	**39**	**CHLORIDE OF PHOSPHORUS**
1809	**39**	**PHOSPHORUS TRICHLORIDE**
1810	**39**	**PHOSPHORUS OXYCHLORIDE**
1810	**39**	**PHOSPHORYL CHLORIDE**
1811	59	POTASSIUM BIFLUORIDE
1811	59	POTASSIUM HYDROGEN DIFLUORIDE, solid or solution
1811	59	POTASSIUM HYDROGEN FLUORIDE
1812	54	POTASSIUM FLUORIDE
1813	60	BATTERY, electric storage dry, containing POTASSIUM HYDROXIDE
1813	60	CAUSTIC POTASH, dry, solid
1813	60	POTASSIUM HYDROXIDE, dry, solid
1814	60	CAUSTIC POTASH liquid or solution
1814	60	POTASSIUM HYDROXIDE SOLUTION
1815	29	PROPIONYL CHLORIDE
1816	29	PROPYL TRICHLOROSILANE
1817	39	PYROSULFURYL CHLORIDE
1818	39	SILICON CHLORIDE
1818	39	SILICON TETRACHLORIDE
1819	60	SODIUM ALUMINATE SOLUTION
1821	60	SODIUM BISULFATE, solid
1821	60	SODIUM HYDROGEN SULFATE, solid
1823	60	CAUSTIC SODA, dry, solid
1823	60	SODIUM HYDROXIDE, dry solid
1824	60	CAUSTIC SODA, solution
1824	60	CAUSTIC SODA SOLUTION
1824	60	SODIUM HYDRATE
1824	60	SODIUM HYDROXIDE SOLUTION
1825	60	SODIUM MONOXIDE
1826	60	ACID MIXTURE, spent, nitrating
1826	60	MIXED ACID, spent
1826	60	NITRATING ACID MIXTURES, spent
1827	39	STANNIC CHLORIDE, anhydrous
1827	39	TIN CHLORIDE, fuming
1827	39	TIN TETRACHLORIDE
1828	**39**	**CHLORIDE OF SULFUR**
1828	**39**	**SULFUR CHLORIDES**
1829	**39**	**SULFUR TRIOXIDE**
1829	**39**	**SULFUR TRIOXIDE, inhibited**
1829	**39**	**SULFUR TRIOXIDE, uninhibited**
1829	**39**	**SULFURIC ANHYDRIDE**
1830	39	SULFURIC ACID
1831	39	OLEUM, with less than 30% free sulfur trioxide
1831	**39**	**OLEUM, with not less than 30% free sulfur trioxide**
1831	39	SULFURIC ACID, fuming with less than 30% free sulfur trioxide
1831	**39**	**SULFURIC ACID, fuming, with not less than 30% free sulfur trioxide**
1832	39	SULFURIC ACID, spent
1833	60	SULFUROUS ACID
1834	**39**	**SULFURYL CHLORIDE**
1835	60	TETRAMETHYL AMMONIUM HYDROXIDE
1836	39	THIONYL CHLORIDE
1837	60	THIOPHOSPHORYL CHLORIDE
1838	**39**	**TITANIUM TETRACHLORIDE**
1839	59	TRICHLOROACETIC ACID
1840	60	ZINC CHLORIDE SOLUTION
1841	31	ACETALDEHYDE AMMONIA
1843	42	AMMONIUM DINITRO-o-CRESOLATE
1845	21	CARBON DIOXIDE, solid
1845	21	DRY ICE
1846	55	CARBON TETRACHLORIDE
1847	60	POTASSIUM SULFIDE, hydrated with not less than 30% water of hydration
1848	60	PROPANOIC ACID
1848	60	PROPIONIC ACID
1849	60	SODIUM SULFIDE, hydrated with not less than 30% water
1849	60	SODIUM SULFIDE SOLUTION

Table 2 Continued

ID No	Guide No	Name of Material
1851	55	MEDICINES, liquid, poisonous n.o.s.
1851	55	MEDICINES, liquid, toxic n.o.s.
1854	37	BARIUM ALLOYS, pyrophoric
1855	37	CALCIUM, metal and alloys pyrophoric
1855	37	CALCIUM, PYROPHORIC
1855	37	CALCIUM ALLOY, PYROPHORIC
1858	12	HEXAFLUOROPROPYLENE
1859	**16**	**SILICON TETRAFLUORIDE**
1860	17	VINYL FLUORIDE, inhibited
1862	26	ETHYL CROTONATE
1863	27	FUEL, AVIATION, turbine engine
1864	27	GAS DRIPS, hydrocarbon
1865	30	n-PROPYL NITRATE
1866	26	RESIN SOLUTION, flammable
1866	26	RESIN SOLUTION (resin compound), liquid
1867	32	CIGARETTE, self-lighting
1868	34	DECABORANE
1869	76	MAGNESIUM, pellets, turnings or ribbon
1869	76	MAGNESIUM ALLOY, with more than 50% magnesium pellets, turnings or ribbon
1870	40	POTASSIUM BOROHYDRIDE
1871	32	TITANIUM HYDRIDE
1872	42	LEAD DIOXIDE
1872	42	LEAD PEROXIDE
1873	47	PERCHLORIC ACID, more than 50% but not more than 72% acid, by weight
1884	53	BARIUM OXIDE
1885	53	BENZIDINE
1886	55	BENZYLIDENE CHLORIDE
1887	58	BROMOCHLOROMETHANE
1888	55	CHLOROFORM
1889	55	CYANOGEN BROMIDE
1891	58	ETHYL BROMIDE
1892	**55**	**ETHYLDICHLOROARSINE**
1894	53	PHENYLMERCURIC HYDROXIDE
1895	53	PHENYLMERCURIC NITRATE
1897	74	PERCHLOROETHYLENE
1897	74	TETRACHLOROETHYLENE
1898	60	ACETYL IODIDE
1902	60	DI(2-ETHYLHEXYL)PHOSPHORIC ACID
1902	60	DIISOOCTYL ACID PHOSPHATE
1903	60	DISINFECTANT, liquid, corrosive, n.o.s.
1903	60	DISINFECTANTS, corrosive, liquid, n.o.s.
1905	59	SELENIC ACID
1906	60	ACID, SLUDGE
1906	60	SLUDGE ACID
1907	60	SODA LIME
1908	60	CHLORITE SOLUTION with more than 5% available chlorine
1908	60	SODIUM CHLORITE SOLUTION with more than 5% available chlorine
1910	60	CALCIUM OXIDE
1911	**18**	**DIBORANE**
1911	18	DIBORANE MIXTURES
1912	22	METHYL CHLORIDE and METHYLENE CHLORIDE MIXTURES
1913	21	NEON, refrigerated liquid (cryogenic liquid)
1914	27	BUTYL PROPIONATE
1915	26	CYCLOHEXANONE
1916	55	2,2'-DICHLORODIETHYL ETHER
1916	55	DICHLOROETHYL ETHER
1917	26	ETHYL ACRYLATE, inhibited
1918	28	CUMENE
1918	28	ISOPROPYLBENZENE
1919	26	METHYL ACRYLATE, inhibited
1920	27	NONANES
1921	30	PROPYLENEIMINE, inhibited
1922	29	PYRROLIDINE
1923	37	CALCIUM DITHIONITE
1923	37	CALCIUM HYDROSULFITE
1928	37	METHYL MAGNESIUM BROMIDE in ETHYL ETHER
1929	32	POTASSIUM DITHIONITE
1929	32	POTASSIUM HYDROSULFITE
1931	32	ZINC DITHIONITE
1931	32	ZINC HYDROSULFITE
1932	32	ZIRCONIUM SCRAP

Table 2 Continued

ID No	Guide No	Name of Material
1935	55	CYANIDE SOLUTION, n.o.s.
1935	55	CYANIDE SOLUTIONS
1938	60	BROMOACETIC ACID, solid
1938	60	BROMOACETIC ACID, solution
1939	39	PHOSPHORUS OXYBROMIDE, solid
1940	60	THIOGLYCOLIC ACID
1941	58	DIBROMODIFLUOROMETHANE
1942	43	AMMONIUM NITRATE, with not more than 0.2% combustible material
1942	43	AMMONIUM NITRATE, with organic coating
1944	32	MATCHES, safety
1945	32	MATCHES, wax (Vesta)
1950	12	Aerosols
1951	21	ARGON, refrigerated liquid (cryogenic liquid)
1952	12	CARBON DIOXIDE and ETHYLENE OXIDE MIXTURE, with not more than 6% ethylene oxide
1952	12	CARBON DIOXIDE and ETHYLENE OXIDE MIXTURE with not more than 9% ethylene oxide
1952	12	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with not more than 6% ethylene oxide
1952	12	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE with not more than 9% ethylene oxide
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone A)**
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone B)**
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone C)**
1953	**18**	**COMPRESSED GAS, toxic flammable, n.o.s. (Inhalation Hazard Zone D)**
1953	**18**	**COMPRESSED GASES, flammable, poisonous, n.o.s.**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone A)**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone B)**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone C)**
1953	**18**	**COMPRESSED GASES, flammable, toxic, n.o.s Inhalation Hazard Zone D)**
1953	**18**	**LIQUEFIED GASES, flammable poisonous, n.o.s.**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone A)**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone B)**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone C)**
1953	**18**	**LIQUEFIED GASES, flammable toxic, n.o.s. (Inhalation Hazard Zone D)**
1954	22	COMPRESSED GASES, flammable, n.o.s.
1954	22	DISPERSANT GAS, flammable n.o.s.
1954	22	FLAMMABLE GAS, n.o.s.
1954	22	LIQUEFIED GAS, flammable n.o.s.
1954	22	REFRIGERANT GASES, flammable, n.o.s.
1954	22	REFRIGERATING MACHINES, containing flammable nonpoisonous, liquefied gas
1955	**15**	**CHLOROPICRIN and NON-FLAMMABLE COMPRESSED GAS MIXTURES**
1955	**15**	**COMPRESSED GASES, poisonous, n.o.s.**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone A)**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone B)**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone C)**
1955	**15**	**COMPRESSED GASES, toxic n.o.s. (Inhalation Hazard Zone D)**
1955	**15**	**LIQUEFIED GASES, poisonous n.o.s.**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone A)**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone B)**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone C)**
1955	**15**	**LIQUEFIED GASES, toxic, n.o.s (Inhalation Hazard Zone D)**
1955	**15**	**METHYL BROMIDE and NON-FLAMMABLE COMPRESSED GAS MIXTURE**
1955	**15**	**ORGANIC PHOSPHATE, mixed with COMPRESSED GAS**
1955	**15**	**ORGANIC PHOSPHATE COMPOUND, mixed with COMPRESSED GAS**

Table 2 Continued

ID No	Guide No	Name of Material
1955	**15**	**ORGANIC PHOSPHORUS COMPOUND, mixed with COMPRESSED GAS**
1956	12	ACCUMULATORS, pressurized
1956	12	COMPRESSED GASES, n.o.s.
1956	12	HEXAFLUOROPROPYLENE OXIDE
1956	12	LIQUEFIED GAS, n.o.s.
1956	12	NONFLAMMABLE GAS, n.o.s.
1957	22	DEUTERIUM
1958	12	DICHLOROTETRAFLUOROETHANE
1959	22	DIFLUOROETHYLENE
1959	22	1,1-DIFLUOROETHYLENE
1960	22	ENGINE STARTING FLUID
1961	22	ETHANE, refrigerated liquid (cryogenic liquid)
1961	22	ETHANE-PROPANE MIXTURE, refrigerated liquid (cryogenic liquid)
1962	22	ETHYLENE, compressed
1963	21	HELIUM, refrigerated liquid (cryogenic liquid)
1964	22	HYDROCARBON GAS MIXTURES, compressed, n.o.s
1964	22	HYDROCARBON GASES, compressed, n.o.s.
1965	22	HYDROCARBON GAS MIXTURES, liquefied, n.o.s.
1965	22	HYDROCARBON GASES, liquefied, n.o.s.
1966	22	HYDROGEN, refrigerated liquid (cryogenic liquid)
1967	**15**	**INSECTICIDE GASES, toxic**
1967	**15**	**METHYL PARATHION and COMPRESSED GAS MIXTURE**
1967	**15**	**PARATHION and COMPRESSED GAS MIXTURE**
1968	12	INSECTICIDE GASES, n.o.s.
1969	22	ISOBUTANE or ISOBUTANE MIXTURES
1970	21	KRYPTON, refrigerated liquid (cryogenic liquid)
1971	17	METHANE, compressed
1971	17	NATURAL GAS, compressed with high METHANE content
1971	17	NATURAL GAS with high METHANE content, compressed
1972	22	LIQUEFIED NATURAL GAS
1972	22	LNG, liquefied natural gas
1972	22	METHANE, refrigerated liquid (cryogenic liquid)
1972	22	NATURAL GAS, refrigerated liquid (cryogenic liquid) with high METHANE content
1973	12	CHLORODIFLUOROMETHANE and CHLOROPENTAFLUOROETHANE MIXTURE
1974	12	CHLORODIFLUOROBROMOMETHANE
1975	**20**	**NITRIC OXIDE and DINITROGEN TETROXIDE MIXTURES**
1975	**20**	**NITRIC OXIDE and NITROGEN DIOXIDE MIXTURES**
1975	**20**	**NITRIC OXIDE and NITROGEN TETROXIDE MIXTURES**
1976	12	OCTAFLUOROCYCLOBUTANE
197	72	NITROGEN, refrigerated liquid (cryogenic liquid)
1978	22	PROPANE
1978	22	PROPANE MIXTURES
1979	12	RARE GASES, MIXTURES
1980	14	HELIUM-OXYGEN MIXTURE
1980	14	RARE GASES and OXYGEN MIXTURES
1981	12	RARE GASES and NITROGEN MIXTURES
1982	12	TETRAFLUOROMETHANE
1983	12	CHLOROTRIFLUOROETHANE
1984	12	TRIFLUOROMETHANE
1986	28	ALCOHOL, denatured (toxic)
1986	28	ALCOHOLS, toxic, n.o.s.
1986	28	DENATURED ALCOHOL (toxic)
1986	28	PROPARGYL ALCOHOL
1987	26	ALCOHOL, denatured
1987	26	ALCOHOL, nontoxic, n.o.s.
1987	26	ALCOHOLS, n.o.s.
1987	26	DENATURED ALCOHOL
1988	28	ALDEHYDES, toxic, n.o.s.
1989	26	ALDEHYDES, n.o.s.
1989	26	BENZALDEHYDE
1990	26	BENZALDEHYDE

Table 2 Continued

ID No	Guide No	Name of Material
1991	30	CHLOROPRENE, inhibited
1992	28	FLAMMABLE LIQUID, toxic, n.o.s.
1992	28	FLAMMABLE LIQUIDS, poisonous, n.o.s.
1993	27	COMBUSTIBLE LIQUID, n.o.s.
1993	27	COMPOUNDS, cleaning liquid (flammable)
1993	27	COMPOUNDS, TREE or WEED KILLING, liquid (flammable)
1993	27	COSMETICS, flammable liquid n.o.s.
1993	27	CREOSOTE, coal tar
1993	27	DIESEL FUEL
1993	27	ETHYL NITRATE
1993	27	FLAMMABLE LIQUIDS, n.o.s.
1993	27	FUEL OIL
1993	27	INSECTICIDE, liquid, n.o.s.
1993	27	MEDICINES, flammable, liquid n.o.s.
1993	27	REFRIGERATING MACHINE
1994	**57**	**IRON PENTACARBONYL**
1999	27	ASPHALT
1999	27	ASPHALT, CUT BACK
1999	27	ROAD ASPHALT, liquid
1999	27	TARS, liquid
2000	32	CELLULOID, in blocks, rods, rolls, sheets, tubes, etc except celluloid scrap
2001	32	COBALT NAPHTHENATES, powder
2002	33	CELLULOID SCRAP
2003	40	METAL ALKYLS, n.o.s.
2004	37	MAGNESIUM DIAMIDE
2005	40	MAGNESIUM DIPHENYL
2006	37	PLASTICS, nitrocellulose-based spontaneously combustible, n.o.s.
2008	37	ZIRCONIUM METAL, powder, dry
2008	37	ZIRCONIUM POWDER, dry
2009	37	ZIRCONIUM, dry, wire, sheet or strips
2010	40	MAGNESIUM HYDRIDE
2011	41	MAGNESIUM PHOSPHIDE
2012	41	POTASSIUM PHOSPHIDE
2013	41	STRONTIUM PHOSPHIDE
2014	45	HYDROGEN PEROXIDE AQUEOUS SOLUTIONS, with not less than 20% but not more than 60% peroxide
2015	47	HYDROGEN PEROXIDE, stabilized
2015	47	HYDROGEN PEROXIDE AQUEOUS SOLUTIONS, stabilized with more than 60% hydrogen peroxide
2016	15	AMMUNITION, toxic, non-explosive
2016	15	CHEMICAL AMMUNITION, nonexplosive, with poisonous material
2016	15	GRENADE, without bursting charge, with poisonous gas
2017	58	AMMUNITION, tear producing, non-explosive
2017	58	CHEMICAL AMMUNITION, nonexplosive, with irritant
2017	58	GRENADE, tear gas
2018	53	CHLOROANILINES, solid
2019	55	CHLOROANILINES, liquid
2020	53	CHLOROPHENOLS, solid
2020	53	TRICHLOROPHENOL
2021	55	CHLOROPHENOLS, liquid
2022	55	CRESYLIC ACID
2022	55	MINING REAGENT, liquid
2023	30	EPICHLOROHYDRIN
2024	53	MERCURY COMPOUNDS, liquid, n.o.s.
2025	53	MERCURY COMPOUNDS, solid, n.o.s.
2026	53	PHENYLMERCURIC COMPOUNDS, solid, n.o.s.
2027	53	SODIUM ARSENITE, solid
2028	60	BOMBS, SMOKE, NON-EXPLOSIVE, with corrosive liquid, without initiating device
2029	28	HYDRAZINE, ANHYDROUS
2029	28	HYDRAZINE AQUEOUS SOLUTIONS, with more than 64% hydrazine
2030	59	HYDRAZINE, AQUEOUS SOLUTION with not less than 37% but not more than 64% hydrazine
2030	59	HYDRAZINE AQUEOUS SOLUTION, with not more than 64% hydrazine
2030	59	HYDRAZINE HYDRATE
2030	59	HYDRAZINE HYDRATE with not less than 37% but not more than 64% hydrazine
2030	59	HYDRAZINE SOLUTION, with not more than 64% hydrazine
2031	44	NITRIC ACID, other than fuming, with more than 40% acid

Table 2 Continued

ID No	Guide No	Name of Material
2031	44	NITRIC ACID, other than red fuming with more than 70% nitric acid
2031	44	NITRIC ACID, other than red fuming with not more than 70% nitric acid
2032	**44**	**NITRIC ACID, fuming**
2032	**44**	**NITRIC ACID, red fuming**
2033	60	POTASSIUM MONOXIDE
2034	22	HYDROGEN and METHANE MIXTURES, compressed
2035	22	TRIFLUOROETHANE, compressed
2036	12	XENON
2037	17	RECEPTACLES, small, with flammable gas
2038	56	DINITROTOLUENES
2044	22	2,2-DIMETHYLPROPANE
2045	26	ISOBUTYL ALDEHYDE
2045	26	ISOBUTYRALDEHYDE
2046	27	CYMENES
2047	29	DICHLOROPROPENE
2047	29	DICHLOROPROPENE and PROPYLENE DICHLORIDE MIXTURE
2047	29	DICHLOROPROPENES
2048	26	DICYCLOPENTADIENE
2049	29	DIETHYLBENZENE
2050	26	DIISOBUTYLENE, ISOMERIC COMPOUNDS
2051	29	DIMETHYLAMINOETHANOL
2051	29	2-DIMETHYLAMINOETHANOL
2051	29	DIMETHYLETHANOLAMINE
2052	27	DIPENTENE
2053	26	METHYL AMYL ALCOHOL
2053	26	METHYL ISOBUTYL CARBINOL
2054	29	MORPHOLINE
2055	27	STYRENE MONOMER, inhibited
2056	26	TETRAHYDROFURAN
2057	27	TRIPROPYLENE
2058	26	VALERALDEHYDE
2059	26	COLLODION
2059	26	NITROCELLULOSE, solution in a flammable liquid
2059	26	NITROCELLULOSE, wet with more than 40% flammable liquid
2067	43	AMMONIUM NITRATE FERTILIZER
2068	43	AMMONIUM NITRATE FERTILIZER, with calcium carbonate
2069	43	AMMONIUM NITRATE FERTILIZER, with ammonium sulfate
2069	43	AMMONIUM NITRATE MIXED FERTILIZERS
2069	43	AMMONIUM NITRATE-SULFATE MIXTURE
2070	43	AMMONIUM NITRATE FERTILIZER, with phosphate or potash
2071	35	AMMONIUM NITRATE FERTILIZER, with not more than 0.4% of combustible material
2071	35	AMMONIUM NITRATE FERTILIZERS
2072	43	AMMONIUM NITRATE FERTILIZERS
2072	43	AMMONIUM NITRATE FERTILIZERS, n.o.s.
2073	15	AMMONIA SOLUTIONS, with more than 35% but not more than 50% ammonia
2074	55	ACRYLAMIDE
2075	55	CHLORAL, anhydrous, inhibited
2076	55	CRESOL (o-, m-, and p-)
2076	55	CRESOLS
2077	55	NAPHTHYLAMINE (alpha)
2078	54	TOLUENE DIISOCYANATE (T.D.I.)
2079	29	DIETHYLENETRIAMINE
2080	48	ACETYL ACETONE PEROXIDE
2081	48	ACETYL BENZOYL PEROXIDE
2082	52	ACETYL CYCLOHEXANE SULFONYL PEROXIDE
2083	52	ACETYL CYCLOHEXANE SULFONYL PEROXIDE
2084	49	ACETYL PEROXIDE
2085	49	BENZOYL PEROXIDE
2087	49	BENZOYL PEROXIDE
2088	49	BENZOYL PEROXIDE
2089	49	BENZOYL PEROXIDE
2090	49	BENZOYL PEROXIDE
2091	48	tert-BUTYL CUMENE PEROXIDE
2091	48	tert-BUTYL CUMYL PEROXIDE
2091	48	tert-BUTYL ISOPROPYL BENZENE HYDROPEROXIDE

Table 2 Continued

ID No	Guide No	Name of Material
2092	48	tert-BUTYL HYDROPEROXIDE, not more than 80% in DI-tert-BUTYL PEROXIDE and/or solvent
2093	51	tert-BUTYL HYDROPEROXIDE
2094	51	tert-BUTYLHYDROPEROXIDE
2095	49	tert-BUTYLPEROXYACETATE
2096	48	tert-BUTYLPEROXYACETATE
2097	48	tert-BUTYLPEROXYBENZOATE
2098	48	tert-BUTYLPEROXYBENZOATE
2099	49	tert-BUTYL MONOPEROXYMALEATE, technical pure
2099	49	tert-BUTYL PEROXYMALEATE, technical pure
2100	48	tert-BUTYL PEROXYMALEATE, solution or paste
2101	48	tert-BUTYL PEROXYMALEATE
2102	48	DI-tert-BUTYL PEROXIDE, technical pure
2103	49	tert-BUTYL PEROXYISOPROPYL CARBONATE, technical pure
2104	48	tert-BUTYL PEROXYISONONANOATE
2104	48	tert-BUTYL PEROXY-3,5,5-TRIMETHYLHEXANOATE
2105	48	tert-BUTYL PEROXYPHTHALATE
2106	48	DI-tert-BUTYL PEROXYPHTHALATE
2107	48	DI-tert-BUTYL PEROXYPHTHALATE
2108	48	DI-tert-BUTYL PEROXYPHTHALATE
2110	52	tert-BUTYL PEROXYPIVALATE
2111	48	2,2-DI (tert-BUTYLPEROXY)-BUTANE
2112	48	DI-(2-tert-BUTYLPEROXY-ISOPROPYL) BENZENE
2112	48	1 4-DI (2-tert-BUTYLPEROXY-ISOPROPYL) BENZENE and 1,3-DI(2-tert-BUTYLPEROXY-ISOPROPYL) BENZENE
2113	48	p-CHLOROBENZOYL PEROXIDE
2114	48	p-CHLOROBENZOYL PEROXIDE
2115	48	p-CHLOROBENZOYL PEROXIDE
2116	51	CUMENE HYDROPEROXIDE, technical pure
2118	51	CYCLOHEXANONE PEROXIDE, not more than 72% in solution
2119	51	CYCLOHEXANONE PEROXIDE, not more than 90%, with not less than 10% water
2120	52	DECANOYL PEROXIDE, technical pure
2121	48	DICUMYL PEROXIDE
2122	52	DI-(2-ETHYLHEXYL)PEROXY-DICARBONATE
2123	52	DI-(2-ETHYLHEXYL)PEROXY-DICARBONATE
2124	48	LAUROYL PEROXIDE, technical pure
2125	51	MENTHANE HYDROPEROXIDE, para, technical pure
2125	51	PARAMENTHANE HYDROPEROXIDE
2126	51	METHYL ISOBUTYL KETONE PEROXIDE
2128	52	ISONONANOYL PEROXIDE, technical pure or in solution
2129	52	CAPRYLYL PEROXIDE
2129	52	OCTANOYL PEROXIDE
2130	52	PELARGONYL PEROXIDE
2131	51	PERACETIC ACID, solution
2131	51	PEROXYACETIC ACID, solution
2132	52	PROPIONYL PEROXIDE
2133	52	ISOPROPYL PEROXYDICARBONATE
2134	52	ISOPROPYL PEROXYDICARBONATE
2135	49	SUCCINIC ACID PEROXIDE, technical pure
2136	48	TETRALIN HYDROPEROXIDE, technical pure
2137	48	2,4-DICHLOROBENZOYL PEROXIDE
2138	48	2.4-DICHLOROBENZOYL PEROXIDE
2139	48	2,4-DICHLOROBENZOYL PEROXIDE
2140	48	n-BUTYL-4,4-DI (tert-BUTYLPEROXY) VALERATE
2141	48	n-BUTYL-4,4-DI (tert-BUTYLPEROXY) VALERATE
2142	52	tert-BUTYL PEROXYISOBUTYRATE
2143	52	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, technical pure
2144	52	tert-BUTYL PEROXYDIETHYLACETATE
2145	48	1,1-DI (tert-BUTYLPEROXY)-3,3,5-TRIMETHYLCYCLOHEXANE
2146	48	1,1-DI (tert-BUTYLPEROXY)-3,3,5-TRIMETHYLCYCLOHEXANE

Table 2 Continued

ID No	Guide No	Name of Material
2147	48	1,1-DI(tert-BUTYLPEROXY)-3,3,5-TRIMETHYLCYCLOHEXANE
2148	48	DI-(1-HYDROXYCYCLOHEXYL) PEROXIDE
2149	52	DIBENZYL PEROXYDICARBONATE
2150	52	DI-sec-BUTYL PEROXYDICARBONATE
2151	52	DI-sec-BUTYL PEROXY DICARBONATE
2152	52	DICYCLOHEXYL PEROXYDICARBONATE
2153	52	DICYCLOHEXYL PEROXYDICARBONATE
2154	52	DI(4-tert-BUTYLCYCLOHEXYL) PEROXYDICARBONATE
2155	48	2,5-DIMETHYL-2,5-DI(tert-BUTYL-PEROXY)HEXANE, technical pure
2156	48	2,5-DIMETHYL-2,5-DI (tert-BUTYL-PEROXY) HEXANE
2157	52	2,5-DIMETHYL-2,5-DI(2-ETHYL-HEXANOYLPEROXY) HEXANE, technical pure
2158	49	2,5-DIMETHYL-2,5-DI(tert-BUTYL-PEROXY) HEXYNE-3, technical pure
2159	48	2,5-DIMETHYL-2,5-DI(tert-BUTYL-PEROXY) HEXYNE-3, with not more than 52% peroxide in inert solid
2160	48	1,1,3,3-TETRAMETHYLBUTYL-HYDROPEROXIDE, technical pure
2161	52	1,1,3,3-TETRAMETHYLBUTYLPEROXY-2-ETHYL HEXANOATE, technical pure
2162	51	PINANE HYDROPEROXIDE, technical pure
2163	52	DIACETONE ALCOHOL PEROXIDE
2164	52	DICETYL PEROXYDICARBONATE, technical pure
2165	49	3,3,6,6,9,9-HEXAMETHYL-1,2,4,5-TETR A-OXOCYCLONONANE, technical pure
2166	48	3,3,6,6,9,9-HEXAMETHYL-1,2,4,5-TETR A-OXOCYCLONONANE
2167	48	3,3,6,6,9,9-HEXAMETHYL-1,2,4,5-TETR A-OXOCYCLONONANE
2168	48	2,2-DI (4,4-DI-tert-BUTYLPEROXY-CYCLOHEXYL) PROPANE
2169	52	BUTYL PEROXYDICARBONATE
2170	52	BUTYL PEROXYDICARBONATE
2171	48	DIISOPROPYLBENZENE HYDROPEROXIDE
2172	49	2,5-DIMETHYL-2,5-DI (BENZOYL-PEROXY) HEXANE, technical pure
2173	49	2,5-DIMETHYL-2,5-DI-(BENZOYL-PEROXY) HEXANE
2174	49	2,5-DIMETHYL-2,5-DIHYDROPEROXY-HEXANE
2175	52	DIETHYLPEROXYDICARBONATE
2176	52	DI-n-PROPYL PEROXYDICARBONATE, technical pure
2177	52	tert- BUTYLPEROXYNEODECANOATE
2178	49	2,2-DIHYDROPEROXY PROPANE
2179	49	1,1-DI (tert-BUTYLPEROXY) CYCLOHEXANE
2180	49	1,1-DI(tert-BUTYLPEROXY) CYCLOHEXANE
2181	48	1,2-DI (tert-BUTYLPEROXY) CYCLOHEXANE
2182	52	DIISOBUTYRYL PEROXIDE
2183	48	tert-BUTYL PEROXYCROTONATE
2184	49	ETHYL 3,3-DI (tert-BUTYL-PEROXY) BUTYRATE
2185	48	ETHYL 3,3-DI(tert-BUTYLPEROXY) BUTYRATE, not more than 77%
2186	**15**	**HYDROGEN CHLORIDE refrigerated liquid (cryogenic liquid)**
2187	21	CARBON DIOXIDE, refrigerated liquid (cryogenic liquid)
2188	**18**	**ARSINE**
2189	**19**	**DICHLOROSILANE**
2190	**20**	**OXYGEN DIFLUORIDE**
2191	**15**	**SULFURYL FLUORIDE**
2192	**18**	**GERMANE (germanium hydride)**
2193	**12**	**HEXAFLUOROETHANE**
2194	**15**	**SELENIUM HEXAFLUORIDE**
2195	**15**	**TELLURIUM HEXAFLUORIDE**
2196	**15**	**TUNGSTEN HEXAFLUORIDE**
2197	**15**	**HYDROGEN IODIDE, anhydrous**
2198	**15**	**PHOSPHORUS PENTAFLUORIDE**
2199	**18**	**PHOSPHINE**
2200	22	PROPADIENE
2200	22	PROPADIENE, inhibited

Table 2 Continued

ID No	Guide No	Name of Material
2201	23	NITROUS OXIDE, refrigerated liquid (cryogenic liquid)
2202	**13**	**HYDROGEN SELENIDE, anhydrous**
2203	17	SILANE
2204	**18**	**CARBONYL SULFIDE**
2205	55	ADIPONITRILE
2206	55	ISOCYANATE SOLUTION, toxic, n.o.s.
2206	55	ISOCYANATES and solutions, n.o.s., b.p. less than 300°C
2206	55	ISOCYANATES, toxic, n.o.s.
2207	55	ISOCYANATES and solutions n.o.s., b.p. not less than 300°C
2208	35	BLEACHING POWDER
2208	35	CALCIUM HYPOCHLORITE MIXTURE, dry, with more than 10% but not more than 39% available chlorine
2209	29	FORMALDEHYDE SOLUTIONS (Formalin)
2210	37	MANEB, or MANEB PREPARATION(S) with 50% or more MANEB
2210	37	PESTICIDE, water reactive containing manganese ethylenebisdithiocarbamate (maneb)
2211	32	PLASTIC MOULDING MATERIAL, evolving flammable vapor
2211	32	POLYMERIC BEADS, expandable, evolving flammable vapor
2211	32	POLYSTYRENE BEADS, expandable, evolving a flammable vapor
2212	31	ASBESTOS
2212	31	ASBESTOS, blue or brown
2212	31	BLUE ASBESTOS
2212	31	BROWN ASBESTOS
2213	32	PARAFORMALDEHYDE
2214	60	PHTHALIC ANHYDRIDE
2215	60	MALEIC ACID
2215	60	MALEIC ANHYDRIDE
2216	31	FISH MEAL or SCRAP, stabilized
2217	73	SEED CAKE, with not more than 1.5% oil and not more than 11% moisture
2218	29	ACRYLIC ACID, inhibited
2219	29	ALLYL GLYCIDYL ETHER
2222	26	ANISOLE
2224	55	BENZONITRILE
2225	59	BENZENE SULFONYL CHLORIDE
2226	60	BENZOTRICHLORIDE
2227	26	n-BUTYL METHACRYLATE
2228	55	BUTYL PHENOLS, liquid
2229	53	BUTYL PHENOLS, solid
2232	**55**	**CHLOROACETALDEHYDE**
2232	**55**	**2-CHLOROETHANAL**
2233	53	CHLOROANISIDINES
2234	27	CHLOROBENZOTRIFLUORIDES
2235	55	CHLOROBENZYLCHLORIDES
2236	55	3-CHLORO-4-METHYLPHENYL-ISOCYANATE
2237	53	CHLORONITROANILINES
2238	27	CHLOROTOLUENES
2239	55	CHLOROTOLUIDINES, liquid or solid
2240	39	CHROMOSULFURIC ACID
2241	27	CYCLOHEPTANE
2242	27	CYCLOHEPTENE
2243	27	CYCLOHEXYL ACETATE
2244	26	CYCLOPENTANOL
2245	26	CYCLOPENTANONE
2246	27	CYCLOPENTENE
2247	27	n-DECANE
2248	68	DI-n-BUTYLAMINE
2249	55	DICHLORODIMETHYL ETHER, symmetrical
2250	53	DICHLOROPHENYL ISOCYANATES
2251	26	DICYCLOHEPTADIENE
2251	26	2,5-NORBORNADIENE
2252	27	1,2-DIMETHOXYETHANE
2253	57	N,N-DIMETHYLANILINE
2254	32	MATCHES, fusee
2255	48	ORGANIC PEROXIDE, sample n.o.s.
2255	48	POLYESTER RESIN KITS
2256	29	CYCLOHEXENE
2257	40	POTASSIUM
2257	40	POTASSIUM METAL

Table 2 Continued

ID No	Guide No	Name of Material
2258	29	1,2-PROPYLENEDIAMINE
2259	60	TRIETHYLENE TETRAMINE
2260	68	TRIPROPYLAMINE
2261	55	XYLENOLS
2262	60	DIMETHYLCARBAMOYL CHLORIDE
2263	27	DIMETHYLCYCLOHEXANES
2264	60	DIMETHYLCYCLOHEXYLAMINE
2265	26	N,N-DIMETHYLFORMAMIDE
2266	29	DIMETHYL-N-PROPYLAMINE
2267	59	DIMETHYL CHLOROTHIOPHOSPHATE
2267	59	DIMETHYL PHOSPHOROCHLORIDO-THIOATE
2267	59	DIMETHYLTHIOPHOSPHORYL CHLORIDE
2269	60	IMINOBISPROPYLAMINE
2269	60	3,3'-IMINODIPROPYLAMINE
2270	29	ETHYLAMINE, aqueous solution with not less than 50^% but not more than 70% ethylamine
2271	26	ETHYL AMYL KETONE
2272	55	N-ETHYLANILINE
2273	55	2-ETHYLANILINE
2274	53	N-ETHYL-N-BENZYLANILINE
2275	26	2-ETHYLBUTANOL
2276	29	2-ETHYL HEXYLAMINE
2277	26	ETHYL METHACRYLATE
2278	27	n-HEPTENE
2279	55	HEXACHLOROBUTADIENE
2280	60	HEXAMETHYLENEDIAMINE, solid
2281	53	HEXAMETHYLENE DIISOCYANATE
2282	26	HEXANOLS
2283	27	ISOBUTYL METHACRYLATE
2284	28	ISOBUTYRONITRILE
2285	55	ISOCYANATOBENZOTRIFLUORIDES
2286	27	PENTAMETHYLHEPTANE
2287	27	ISOHEPTENES
2288	27	ISOHEXENES
2289	60	ISOPHORONEDIAMINE
2290	53	IPDI
2290	53	ISOPHORONE DIISOCYANATE
2291	53	LEAD CHLORIDE
2291	53	LEAD COMPOUNDS, soluble n.o.s.
2291	53	LEAD FLUOBORATE
2293	27	1-METHOXY-4-METHYL-PENTAN-2-ONE
2294	57	N-METHYLANILINE
2295	57	METHYL CHLOROACETATE
2296	27	METHYL CYCLOHEXANE
2297	26	METHYL CYCLOHEXANONE
2298	26	METHYL CYCLOPENTANE
2299	60	METHYL DICHLOROACETATE
2300	60	2-METHYL-5-ETHYLPYRIDINE
2301	26	2-METHYLFURAN
2302	26	5-METHYLHEXAN-2-ONE
2303	27	ISOPROPENYLBENZENE
2304	32	NAPHTHALENE, molten
2305	60	NITROBENZENESULFONIC ACID
2306	54	NITROBENZOTRIFLUORIDES
2307	54	3-NITRO-4-CHLOROBENZO-TRIFLUORIDE
2308	60	NITROSYLSULFURIC ACID
2309	27	OCTADIENE
2310	26	PENTAN-2,4-DIONE
2311	55	PHENETIDINES
2312	55	PHENOL, molten
2313	27	PICOLINES
2315	31	PCBs
2315	31	POLYCHLORINATED BIPHENYLS
2316	53	SODIUM CUPROCYANIDE, solid
2317	54	SODIUM CUPROCYANIDE SOLUTION
2318	34	SODIUM HYDROSULFIDE, solid with less than 25% water of crystallization
2319	27	TERPENE HYDROCARBONS, n.o.s.
2320	60	TETRAETHYLENEPENTAMINE
2321	54	TRICHLOROBENZENES, liquid
2322	54	TRICHLOROBUTENE
2323	26	TRIETHYL PHOSPHITE
2324	27	TRIISOBUTYLENE
2325	26	1,3,5-TRIMETHYLBENZENE

Table 2 Continued

ID No	Guide No	Name of Material
2326	29	TRIMETHYLCYCLOHEXYLAMINE
2327	60	TRIMETHYLHEXAMETHYLENE-DIAMINES
2328	53	TRIMETHYLHEXAMETHYLENE DIISOCYANATE
2329	26	TRIMETHYL PHOSPHITE
2330	27	UNDECANE
2331	60	ZINC CHLORIDE, anhydrous
2332	26	ACETALDEHYDE OXIME
2333	28	ALLYL ACETATE
2334	**28**	**ALLYLAMINE**
2335	28	ALLYL ETHYL ETHER
2336	28	ALLYL FORMATE
2337	**57**	**PHENYL MERCAPTAN**
2338	28	BENZOTRIFLUORIDE
2339	27	2-BROMOBUTANE
2340	27	2-BROMOETHYL ETHYL ETHER
2341	27	1-BROMO-3-METHYLBUTANE
2342	27	BROMOMETHYLPROPANES
2343	27	2-BROMOPENTANE
2344	29	2-BROMOPROPANE
2345	29	3-BROMOPROPYNE
2346	26	BUTANEDIONE
2346	26	DIACETYL
2347	27	BUTYL MERCAPTANS
2348	26	BUTYL ACRYLATE
2350	26	BUTYL METHYL ETHER
2351	26	BUTYL NITRITES
2352	26	BUTYL VINYL ETHER, inhibited
2353	29	BUTYRYL CHLORIDE
2354	28	CHLOROMETHYL ETHYL ETHER
2356	26	2-CHLOROPROPANE
2357	68	CYCLOHEXYLAMINE
2358	27	CYCLOOCTATETRAENE
2359	29	DIALLYLAMINE
2360	28	DIALLYL ETHER
2361	68	DIISOBUTYLAMINE
2362	27	1,1-DICHLOROETHANE
2363	27	ETHYL MERCAPTAN
2364	26	n-PROPYLBENZENE
2366	26	DIETHYL CARBONATE
2367	27	METHYLVALERALDEHYDE (alpha)
2368	26	PINENE (alpha)
2369	26	ETHYLENE GLYCOL MONOBUTYL ETHER
2370	27	1-HEXENE
2371	27	ISOPENTENES
2372	26	1,2-DI-(DIMETHYLAMINO)ETHANE
2373	26	DIETHOXYMETHANE
2374	26	DIETHOXYPROPENE
2375	28	DIETHYL SULFIDE
2376	26	2,3-DIHYDROPYRAN
2377	27	1,1-DIMETHOXYETHANE
2378	28	2-DIMETHYLAMINOACETONITRILE
2379	68	1,3-DIMETHYLBUTYLAMINE
2380	26	DIMETHYLDIETHOXYSILANE
2381	27	DIMETHYL DISULFIDE
2382	**57**	**DIMETHYLHYDRAZINE, symmetrical**
2383	68	DIPROPYLAMINE
2384	26	DIPROPYL ETHER
2385	26	ETHYL ISOBUTYRATE
2386	68	ETHYL PIPERIDINE
2386	68	1-ETHYLPIPERIDINE
2387	27	FLUOROBENZENE
2388	27	FLUOROTOLUENES
2389	26	FURAN
2390	26	2-IODOBUTANE
2391	26	IODOMETHYLPROPANES
2392	26	IODOPROPANES
2393	29	ISOBUTYL FORMATE
2394	26	ISOBUTYL PROPIONATE
2395	29	ISOBUTYRYL CHLORIDE
2396	28	METHACRYLALDEHYDE
2397	26	3-METHYL-2-BUTANONE
2398	26	METHYL tert-BUTYL ETHER

Table 2 Continued

ID No	Guide No	Name of Material
2399	68	METHYLPIPERIDINE
2399	68	1-METHYLPIPERIDINE
2400	27	METHYL ISOVALERATE
2401	29	PIPERIDINE
2402	27	ISOPROPYL MERCAPTAN
2402	27	PROPANETHIOLS
2402	27	PROPYL MERCAPTAN
2403	26	ISOPROPENYL ACETATE
2404	28	PROPIONITRILE
2405	26	ISOPROPYL BUTYRATE
2406	28	ISOPROPYL ISOBUTYRATE
2407	**57**	**ISOPROPYL CHLOROFORMATE**
2408	27	ISOPROPYL FORMATE
2409	27	ISOPROPYL PROPIONATE
2410	26	1,2,3,6-TETRAHYDROPYRIDINE
2411	28	BUTYRONITRILE
2412	26	TETRAHYDROTHIOPHENE
2413	27	TETRAPROPYL-ortho-TITANATE
2414	27	THIOPHENE
2416	26	TRIMETHYL BORATE
2417	**15**	**CARBONYL FLUORIDE**
2418	**15**	**SULFUR TETRAFLUORIDE**
2419	17	BROMOTRIFLUOROETHYLENE
2420	**15**	**HEXAFLUOROACETONE**
2421	**20**	**NITROGEN TRIOXIDE**
2422	12	OCTAFLUOROBUT-2-ENE
2424	12	OCTAFLUOROPROPANE
2426	35	AMMONIUM NITRATE, LIQUID (hot concentrated solution)
2426	35	AMMONIUM NITRATE SOLUTION, with not less than 15% water
2427	31	POTASSIUM CHLORATE, aqueous solution
2428	31	SODIUM CHLORATE, aqueous solution
2429	35	CALCIUM CHLORATE, aqueous solution
2430	55	ALKYLPHENOLS, solid, n.o.s.
2431	55	ANISIDINES
2432	57	N,N-DIETHYL ANILINE
2433	53	CHLORONITROTOLUENES
2434	60	DIBENZYLDICHLOROSILANE
2435	39	ETHYL PHENYL DICHLOROSILANE
2436	26	THIOACETIC ACID
2437	29	METHYLPHENYLDICHLOROSILANE
2438	**29**	**TRIMETHYLACETYL CHLORIDE**
2439	60	SODIUM BIFLUORIDE, solid
2439	60	SODIUM BIFLUORIDE SOLUTION
2439	60	SODIUM HYDROGEN FLUORIDE
2439	60	SODIUM HYDROGENDIFLUORIDE
2440	60	STANNIC CHLORIDE, hydrated
2441	37	TITANIUM TRICHLORIDE, pyrophoric
2441	37	TITANIUM TRICHLORIDE MIXTURES, pyrophoric
2442	**59**	**TRICHLOROACETYL CHLORIDE**
2443	39	VANADIUM OXYTRICHLORIDE
2443	39	VANADIUM OXYTRICHLORIDE and TITANIUM TETRACHLORIDE MIXTURE
2444	39	VANADIUM TETRACHLORIDE
2445	40	LITHIUM ALKYLS
2446	55	NITROCRESOLS
2447	38	PHOSPHORUS, white, molten
2448	32	SULFUR, molten
2449	54	AMMONIUM OXALATE
2449	54	OXALATES, water soluble
2451	15	NITROGEN TRIFLUORIDE
2452	17	ETHYL ACETYLENE, inhibited
2453	12	ETHYL FLUORIDE
2454	22	METHYL FLUORIDE
2455	17	METHYL NITRITE
2456	27	2-CHLOROPROPENE
2457	27	2,3-DIMETHYLBUTANE
2458	29	HEXADIENES
2459	26	2-METHYL-1-BUTENE
2460	26	METHYLBUTENE
2460	26	2-METHYL-2-BUTENE
2461	26	METHYLPENTADIENES
2462	26	METHYLPENTANE
2463	40	ALUMINUM HYDRIDE

Table 2 Continued

ID No	Guide No	Name of Material
2464	42	BERYLLIUM NITRATE
2465	45	DICHLOROISOCYANURIC ACID, and its salts, dry
2465	45	DICHLORO-S-TRIAZINETRIONE and its salts, dry
2465	45	POTASSIUM DICHLORO-S-TRIAZINE-TRIONE
2465	45	SODIUM DICHLOROISOCYANURATE
2465	45	SODIUM DICHLORO-S-TRIAZINETRIONE
2466	47	POTASSIUM SUPEROXIDE
2467	35	SODIUM PERCARBONATE
2468	45	MONO-(TRICHLORO)-TETRA (MONO-POTASSIUM DICHLORO)-PENTA-S-TRIAZINETRIONE, dry
2468	45	TRICHLOROISOCYANURIC ACID, dry
2468	45	TRICHLORO-S-TRIAZINETRIONE, dry
2469	35	ZINC BROMATE
2470	55	PHENYLACETONITRILE, liquid
2471	55	OSMIUM TETROXIDE
2473	53	SODIUM ARSANILATE
2474	**55**	**THIOPHOSGENE**
2475	60	VANADIUM TRICHLORIDE
2477	**28**	**METHYL ISOTHIOCYANATE**
2478	28	ISOCYANATE SOLUTION, flammable, toxic, n.o.s.
2478	28	ISOCYANATES and solutions, n.o.s. (flammable)
2478	28	ISOCYANATES, flammable toxic, n.o.s.
2480	**30**	**METHYL ISOCYANATE**
2481	**28**	**ETHYL ISOCYANATE**
2482	**28**	**n-PROPYL ISOCYANATE**
2483	**28**	**ISOPROPYL ISOCYANATE**
2484	**57**	**tert-BUTYL ISOCYANATE**
2485	**57**	**n-BUTYL ISOCYANATE**
2486	**57**	**ISOBUTYL ISOCYANATE**
2487	**55**	**PHENYL ISOCYANATE**
2488	**57**	**CYCLOHEXYL ISOCYANATE**
2489	54	DIPHENYLMETHANE-4,4'-DIISO-CYANATE (MDI)
2489	54	METHYLENE BIS(4-PHENYLISO-CYANATE) (MDI)
2490	59	DICHLOROISOPROPYL ETHER
2491	60	ETHANOLAMINE, and solutions
2491	60	MONOETHANOLAMINE
2493	29	HEXAMETHYLENEIMINE
2495	44	IODINE PENTAFLUORIDE
2496	29	PROPIONIC ANHYDRIDE
2497	60	SODIUM PHENOLATE, solid
2498	29	1,2,3,6-TETRAHYDROBENZALDEHYDE
2501	55	1-AZIRIDINYL PHOSPHINE OXIDE (TRIS)
2501	55	PHOSPHORIC ACID TRIETHYLENEIMINE
2501	55	TRI (1-AZIRIDINYL) PHOSPHINE OXIDE
2501	55	TRIS(1-AZIRIDINYL)-PHOSPHINE OXIDE
2502	29	VALERYL CHLORIDE
2503	39	ZIRCONIUM TETRACHLORIDE
2504	58	ACETYLENE TETRABROMIDE
2504	58	TETRABROMOETHANE
2505	54	AMMONIUM FLUORIDE
2506	60	AMMONIUM HYDROGEN SULFATE
2507	60	CHLOROPLATINIC ACID, solid
2508	60	MOLYBDENUM PENTACHLORIDE
2509	60	POTASSIUM BISULFATE
2509	60	POTASSIUM HYDROGEN SULFATE
2511	60	alpha-CHLOROPROPIONIC ACID
2511	60	2-CHLOROPROPIONIC ACID
2512	55	AMINOPHENOLS (o-, m-, p-)
2513	60	BROMOACETYL BROMIDE
2514	26	BROMOBENZENE
2515	58	BROMOFORM
2516	53	CARBON TETRABROMIDE
2517	22	1-CHLORO-1,1-DIFLUOROETHANE
2517	22	CHLORODIFLUOROETHANES
2517	22	DIFLUOROCHLOROETHANES
2518	59	1,5,9-CYCLODODECATRIENE
2520	27	CYCLOOCTADIENES
2521	**57**	**DIKETENE**
2522	55	DIMETHYLAMINOETHYL METHACRYLATE

Table 2 Continued

ID No	Guide No	Name of Material
2524	26	ETHYL ORTHOFORMATE
2525	54	ETHYL OXALATE
2526	28	FURFURYLAMINE
2527	27	ISOBUTYL ACRYLATE
2528	26	ISOBUTYL ISOBUTYRATE
2529	29	ISOBUTYRIC ACID
2530	29	ISOBUTYRIC ANHYDRIDE
2531	60	METHACRYLIC ACID, inhibited
2533	53	METHYL TRICHLOROACETATE
2534	**18**	**METHYLCHLOROSILANE**
2535	29	METHYLMORPHOLINE
2536	26	METHYLTETRAHYDROFURAN
2538	32	NITRONAPHTHALENE
2541	27	TERPINOLENE
2542	68	TRIBUTYLAMINE
2545	40	HAFNIUM powder, dry
2546	37	TITANIUM, metal, powder, dry
2546	37	TITANIUM POWDER, dry
2547	47	SODIUM SUPEROXIDE
2548	**44**	**CHLORINE PENTAFLUORIDE**
2550	51	ETHYL METHYL KETONE PEROXIDE
2550	51	METHYL ETHYL KETONE PEROXIDE
2551	48	tert-BUTYLPEROXYDIETHYLACETATE with tert-BUTYLPEROXYBENZOATE
2552	55	HEXAFLUOROACETONE HYDRATE
2553	27	COAL TAR NAPHTHA
2553	27	NAPHTHA
2554	26	METHYL ALLYL CHLORIDE
2555	33	NITROCELLULOSE, wet with not less than 20% water
2556	33	NITROCELLULOSE, wet with not less than 25% alcohol
2557	32	LACQUER BASE, dry
2557	32	NITROCELLULOSE with not more than 12.6% nitrogen, by dry mass, mixture, with or without plasticizer or with pigment
2557	32	NITROCELLULOSE, with plasticizing substance
2558	57	EPIBROMOHYDRIN
2560	26	2-METHYLPENTAN-2-OL
2561	26	3-METHYL-1-BUTENE
2562	52	tert -BUTYL PEROXYISOBUTYRATE
2564	59	TRICHLOROACETIC ACID SOLUTION
2565	60	DICYCLOHEXYLAMINE
2567	53	SODIUM PENTACHLOROPHENATE
2570	53	CADMIUM COMPOUNDS
2571	60	ALKYLSULFURIC ACIDS
2571	60	ETHYLSULFURIC ACID
2572	53	PHENYLHYDRAZINE
2573	42	THALLIUM CHLORATE
2574	55	TRICRESYLPHOSPHATE
2576	39	PHOSPHORUS OXYBROMIDE, molten
2577	60	PHENYLACETYL CHLORIDE
2578	60	PHOSPHORUS TRIOXIDE
2579	60	PIPERAZINE
2580	60	ALUMINUM BROMIDE, SOLUTION
2581	60	ALUMINUM CHLORIDE, SOLUTION
2582	60	FERRIC CHLORIDE SOLUTION
2582	60	IRON CHLORIDE SOLUTION
2583	60	ALKYLSULFONIC ACIDS, solid with more than 5% free sulfuric acid
2583	60	ARYLSULFONIC ACIDS, solid with more than 5% free sulfuric acid
2583	60	TOLUENE SULFONIC ACID, solid with more than 5% free sulfuric acid
2584	60	ALKYLSULFONIC ACIDS, liquid with more than 5% free sulfuric acid
2584	60	ARYLSULFONIC ACIDS, liquid with more than 5% free sulfuric acid
2584	60	DODECYLBENZENESULFONIC ACID
2584	60	TOLUENE SULFONIC ACID, liquid with more than 5% free sulfuric acid
2585	60	ALKYLSULFONIC ACIDS, solid with not more than 5% free sulfuric acid
2585	60	ARYLSULFONIC ACIDS, solid with not more than 5% free sulfuric acid
2585	60	TOLUENE SULFONIC ACID, solid with not more than 5% free sulfuric acid
2586	60	ALKYLSULFONIC ACIDS, liquid with not more than 5% free sulfuric acid
2586	60	ARYLSULFONIC ACIDS, liquid with not more than 5% free sulfuric acid

Table 2 Continued

ID No	Guide No	Name of Material
2586	60	TOLUENE SULFONIC ACID, liquid with not more than 5 % free sulfuric acid
2587	55	BENZOQUINONE
2588	55	INSECTICIDE, dry, n.o.s.
2588	55	PESTICIDES, solid, toxic n.o.s.
2589	57	VINYL CHLOROACETATE
2590	31	ASBESTOS, white
2590	31	WHITE ASBESTOS
2591	21	XENON, refrigerated liquid (cryogenic liquid)
2592	48	DISTEARYL PEROXYDICARBONATE
2593	52	DI (2-METHYLBENZOYL) PEROXIDE
2594	52	tert-BUTYLPEROXYNEODECANOATE
2595	52	DIMYRISTYL PEROXYDICARBONATE
2596	48	tert-BUTYL PEROXY-3-PHENYLPHTHALIDE
2597	52	DI(3,5,5-TRIMETHYL-1,2-DIOXOL-ANYL-3) PEROXIDE
2598	48	ETHYL 3,3-DI(tert-BUTYLPEROXY) BUTYRATE
2599	12	CHLOROTRIFLUOROMETHANE and TRIFLUOROMETHANE MIXTURE
2599	12	TRIFLUOROMETHANE and CHLOROTRIFLUOROMETHANE MIXTURE
2600	**18**	**CARBON MONOXIDE and HYDROGEN MIXTURE**
2601	22	CYCLOBUTANE
2602	12	DICHLORODIFLUOROMETHANE and DIFLUOROETHANE AZEOTROPIC MIXTURE
2603	28	CYCLOHEPTATRIENE
2604	29	BORON TRIFLUORIDE DIETHYL ETHERATE
2605	**57**	**METHOXYMETHYL ISOCYANATE**
2606	**57**	**METHYL ORTHOSILICATE**
2607	26	ACROLEIN DIMER, stabilized
2608	26	NITROPROPANES
2609	55	TRIALLYL BORATE
2610	29	TRIALLYL AMINE
2611	57	PROPYLENE CHLOROHYDRIN
2612	26	METHYL PROPYL ETHER
2614	26	METHALLYL ALCOHOL
2615	26	ETHYL PROPYL ETHER
2616	26	TRIISOPROPYL BORATE
2617	26	METHYL CYCLOHEXANOL
2617	26	METHYLCYCLOHEXANOLS, flammable
2618	27	VINYL TOLUENE, inhibited
2619	68	BENZYLDIMETHYLAMINE
2620	27	AMYL BUTYRATES
2621	26	ACETYL METHYL CARBINOL
2622	28	GLYCIDALDEHYDE
2623	32	FIRE LIGHTERS, solid with flammable liquid
2624	40	MAGNESIUM SILICIDE
2626	35	CHLORIC ACID, aqueous solution
2627	35	NITRITES, inorganic, n.o.s.
2628	53	POTASSIUM FLUOROACETATE
2629	53	SODIUM FLUOROACETATE
2630	53	SELENATES and SELENITES
2630	53	SODIUM SELENITE
2642	59	FLUOROACETIC ACID
2643	58	METHYL BROMOACETATE
2644	**55**	**METHYL IODIDE**
2645	55	PHENACYL BROMIDE
2646	**55**	**HEXACHLOROCYCLOPENTADIENE**
2647	53	MALONONITRILE
2648	55	1,2-DIBROMOBUTAN-3-ONE
2649	55	1,3-DICHLOROACETONE
2650	57	1,1-DICHLORO-1-NITROETHANE
2651	53	4,4'-DIAMINODIPHENYL METHANE
2653	53	BENZYL IODIDE
2655	53	POTASSIUM FLUOROSILICATE, solid
2656	29	QUINOLINE
2657	55	SELENIUM DISULFIDE
2658	53	SELENIUM, powder
2659	53	SODIUM CHLOROACETATE
2660	55	NITROTOLUIDINES (mono)
2661	54	HEXACHLOROACETONE
2662	53	HYDROQUINONE

Table 2 Continued

ID No	Guide No	Name of Material
2664	74	DIBROMOMETHANE
2666	55	ETHYL CYANOACETATE
2667	27	BUTYLTOLUENES
2668	**57**	**CHLOROACETONITRILE**
2669	55	CHLOROCRESOLS
2670	60	CYANURIC CHLORIDE
2671	55	AMINOPYRIDINES (o-, m-, p-)
2672	60	AMMONIA SOLUTIONS with more than 10% but not more than 35 % ammonia
2672	60	AMMONIUM HYDROXIDE
2673	53	2-AMINO-4-CHLOROPHENOL
2674	53	SODIUM FLUOROSILICATE
2676	**18**	**STIBINE**
2677	60	RUBIDIUM HYDROXIDE SOLUTION
2678	60	RUBIDIUM HYDROXIDE, solid
2679	60	LITHIUM HYDROXIDE SOLUTION
2680	60	LITHIUM HYDROXIDE, solid
2680	60	LITHIUM HYDROXIDE MONOHYDRATE
2681	60	CAESIUM HYDROXIDE SOLUTION
2681	60	CESIUM HYDROXIDE SOLUTION
2682	60	CAESIUM HYDROXIDE
2682	60	CESIUM HYDROXIDE
2683	28	AMMONIUM HYDROSULFIDE SOLUTION
2683	28	AMMONIUM SULFIDE SOLUTION
2684	29	DIETHYLAMINOPROPYLAMINE
2685	29	N,N-DIETHYLETHYLENEDIAMINE
2686	29	DIETHYLAMINOETHANOL
2687	53	DICYCLOHEXYLAMMONIUM NITRITE
2688	58	1-CHLORO-3-BROMOPROPANE
2689	55	GLYCEROL-alpha-MONOCHLOROHYDRIN
2690	55	N-n-BUTYL IMIDAZOLE
2691	39	PHOSPHORUS PENTABROMIDE
2692	**59**	**BORON TRIBROMIDE**
2693	60	AMMONIUM BISULFITE, solid
2693	60	AMMONIUM BISULFITE SOLUTION
2693	60	BISULFITES, aqueous solution, n.o.s.
2693	60	BISULFITES, inorganic, aqueous solution, n.o.s.
2693	60	CALCIUM BISULFITE SOLUTION
2693	60	CALCIUM HYDROGEN SULFITE SOLUTION
2693	60	POTASSIUM BISULFITE SOLUTION
2693	60	SODIUM BISULFITE SOLUTION
2698	60	TETRAHYDROPHTHALIC ANHYDRIDES
2699	60	TRIFLUOROACETIC ACID
2705	60	1-PENTOL
2707	27	DIMETHYLDIOXANES
2708	26	BUTOXYL
2709	27	BUTYL BENZENES
2710	26	DIPROPYL KETONE
2711	26	DIBROMOBENZENE
2713	32	ACRIDINE
2714	32	ZINC RESINATE
2715	32	ALUMINUM RESINATE
2716	55	1,4-BUTYNEDIOL
2717	32	CAMPHOR
2717	32	CAMPHOR, synthetic
2719	42	BARIUM BROMATE
2720	35	CHROMIUM NITRATE
2721	35	COPPER CHLORATE
2722	35	LITHIUM NITRATE
2723	35	MAGNESIUM CHLORATE
2724	35	MANGANESE NITRATE
2725	35	NICKEL NITRATE
2726	35	NICKEL NITRITE
2727	42	THALLIUM NITRATE
2728	35	ZIRCONIUM NITRATE
2729	53	HEXACHLOROBENZENE
2730	55	NITROANISOLE
2732	55	NITROBROMOBENZENES
2733	29	ALKYLAMINES, n.o.s.
2733	29	AMINES, flammable, corrosive n.o.s.
2733	29	POLYALKYLAMINES, flammable, corrosive, n.o.s.
2733	29	POLYALKYLAMINES, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
2733	29	POLYAMINES, flammable, corrosive, n.o.s.
2734	29	ALKYLAMINES, n.o.s.
2734	29	AMINES, liquid, corrosive, flammable, n.o.s.
2734	29	POLYALKYLAMINES, corrosive, flammable, n.o.s.
2734	29	POLYAMINES, liquid, corrosive, flammable, n.o.s.
2735	60	ALKYLAMINES, n.o.s.
2735	60	AMINES, liquid, corrosive, n.o.s.
2735	60	POLYALKYLAMINES, corrosive, n.o.s.
2735	60	POLYALKYLAMINES, n.o.s.
2735	60	POLYAMINES, liquid, corrosive, n.o.s.
2738	55	N-BUTYLANILINE
2739	60	BUTYRIC ANHYDRIDE
2740	**57**	**n-PROPYL CHLOROFORMATE**
2741	45	BARIUM HYPOCHLORITE
2742	**57**	**sec-BUTYL CHLOROFORMATE**
2742	57	CHLOROFORMATES, n.o.s.
2742	57	CHLOROFORMATES, toxic, corrosive, flammable, n.o.s.
2742	**57**	**ISOBUTYL CHLOROFORMATE**
2743	**57**	**n-BUTYL CHLOROFORMATE**
2744	57	CYCLOBUTYLCHLOROFORMATE
2745	55	CHLOROMETHYL CHLORO-FORMATE
2746	55	PHENYL CHLOROFORMATE
2747	55	tert -BUTYLCYCLOHEXYL CHLOROFORMATE
2748	55	2-ETHYLHEXYL CHLOROFORMATE
2749	29	TETRAMETHYLSILANE
2750	55	L3-DICHLOROPROPANOL-2
2751	59	DIETHYLTHIOPHOSPHORYL CHLORIDE
2752	26	L2-EPOXY-3-ETHOXYPROPANE
2753	53	N-ETHYLBENZYLTOLUIDINES
2754	55	N-ETHYLTOLUIDINES
2755	49	3-CHLOROPEROXYBENZOIC ACID
2756	52	ORGANIC PEROXIDE MIXTURE
2757	55	CARBAMATE PESTICIDES, solid, toxic, n.o.s.
2757	55	CARBARYL
2757	55	CARBOFURAN
2757	55	MEXACARBATE
2758	28	CARBAMATE PESTICIDES, liquid, flammable, toxic, n.o.s.
2759	55	ARSENICAL PESTICIDES, solid, toxic, n.o.s.
2759	55	BORDEAUX ARSENITE, liquid or solid
2760	28	ARSENICAL PESTICIDES, liquid, flammable, toxic, n.o.s.
2761	55	ALDRIN and its mixtures
2761	55	DDT
2761	55	DICHLORODIPHENYL TRICHLOROETHANE, DDT
2761	55	DIELDRIN
2761	55	ENDOSULFAN
2761	55	ENDRIN MIXTURE, dry or liquid
2761	55	LINDANE
2761	55	ORGANOCHLORINE PESTICIDES, solid, toxic n.o.s.
2761	55	TDE (1,1-Dichloro-2,2-bis (p-chlorophenyl) ethane)
2761	55	TOXAPHENE
2762	28	CHLORDANE, flammable liquid
2762	28	ORGANOCHLORINE PESTICIDES, liquid, flammable, toxic, n.o.s.
2763	55	TRIAZINE PESTICIDES, solid, toxic, n.o.s.
2764	28	TRIAZINE PESTICIDES, liquid, flammable, toxic, n.o.s.
2765	55	2,4-D
2765	55	2,4-DICHLOROPHENOXYACETIC ACID
2765	55	PHENOXY PESTICIDES, solid, toxic, n.o.s.
2765	55	2,4,5-T
2765	55	2,4,5-TP
2765	55	2,4,5-TRICHLOROPHENOXYACETIC ACID
2765	55	2,4,5-TRICHLOROPHENOXYPROPIONIC ACID
2766	28	PHENOXY PESTICIDES, liquid, flammable, toxic, n.o.s.
2767	55	PHENYL UREA PESTICIDES solid, toxic, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
2768	28	PHENYL UREA PESTICIDES, liquid, flammable, toxic n.o.s.
2769	55	BENZOIC DERIVATIVE PESTICIDES, solid, toxic n.o.s.
2770	28	BENZOIC DERIVATIVE PESTICIDES, liquid, flammable, toxic, n.o.s.
2771	55	DITHIOCARBAMATE PESTICIDES, solid, toxic, n.o.s.
2771	55	THIRAM
2772	28	DITHIOCARBAMATE PESTICIDES, liquid, flammable, toxic, n.o.s.
2773	55	PHTHALIMIDE DERIVATIVE PESTICIDES, solid, toxic n.o.s.
2774	28	PHTHALIMIDE DERIVATIVE PESTICIDES, liquid, flammable, toxic, n.o.s.
2775	53	COPPER-BASED PESTICIDES, solid, toxic, n.o.s.
2776	28	COPPER-BASED PESTICIDES, liquid, flammable, toxic, n.o.s.
2777	55	MERCURY-BASED PESTICIDES, solid, toxic, n.o.s.
2778	28	MERCURY-BASED PESTICIDES, liquid, flammable, toxic, n.o.s.
2779	53	SUBSTITUTED NITROPHENOL PESTICIDES, solid, toxic, n.o.s.
2780	28	SUBSTITUTED NITROPHENOL PESTICIDES, liquid, flammable, toxic, n.o.s.
2781	55	BIPYRIDILIUM PESTICIDES, solid, toxic, n.o.s.
2782	28	BIPYRIDILIUM PESTICIDES, liquid, flammable, toxic n.o.s.
2783	55	AZINPHOS METHYL (Guthion)
2783	55	CHLORPYRIFOS
2783	55	COUMAPHOS
2783	55	DIAZINON
2783	55	DICHLORVOS
2783	55	DISULFOTON
2783	55	ETHION
2783	55	GUTHION
2783	55	HEXAETHYL TETRAPHOSPHATE MIXTURE
2783	55	MALATHION
2783	55	METHYL PARATHION, liquid
2783	55	METHYL PARATHION MIXTURE, dry
2783	55	MEVINPHOS
2783	55	ORGANIC PHOSPHATE COMPOUND, and mixtures, liquid
2783	55	ORGANIC PHOSPHATE COMPOUND, and mixtures, solid
2783	55	ORGANOPHOSPHORUS PESTICIDES, solid, toxic, n.o.s.
2783	55	PARATHION MIXTURE, liquid or dry
2783	55	TETRAETHYL PYROPHOSPHATE, solid
2783	55	TRICHLORFON
2784	28	ORGANOPHOSPHORUS PESTICIDES, liquid, flammable toxic, n.o.s.
2785	55	THIA-4-PENTANAL
2785	55	4-THIAPENTANAL
2786	55	ORGANOTIN PESTICIDES, solid, toxic, n.o.s.
2787	28	ORGANOTIN PESTICIDES, liquid, flammable, toxic n.o.s.
2788	55	ORGANOTIN COMPOUNDS, liquid, n.o.s.
2789	29	ACETIC ACID, GLACIAL
2789	29	ACETIC ACID SOLUTION, more than 80% acid
2790	60	ACETIC ACID SOLUTION, more than 10% but not more than 80% acid
2793	32	FERROUS METAL, borings, cuttings, shavings, or turnings
2794	60	BATTERIES, electric storage wet, filled with acid
2794	60	BATTERIES, wet, filled with acid (electric storage)
2795	60	BATTERIES, electric storage, wet, filled with alkali
2795	60	BATTERIES, wet, filled with alkali (electric storage)
2796	39	BATTERY FLUID, acid
2796	39	ELECTROLYTE, BATTERY FLUID acid
2796	39	SULFURIC ACID with not more than 51% acid
2797	60	BATTERY FLUID, alkali
2797	60	BATTERY FLUID, alkali, with battery
2797	60	BATTERY FLUID, alkali, with electronic equipment or actuating device

Table 2 Continued

ID No	Guide No	Name of Material
2798	39	BENZENE PHOSPHORUS DICHLORIDE
2798	39	PHENYL PHOSPHORUS DICHLORIDE
2799	39	BENZENE PHOSPHORUS THIODICHLORIDE
2799	39	PHENYL PHOSPHORUS THIODICHLORIDE
2800	60	BATTERIES, dry, containing POTASSIUM HYDROXIDE solid (electric storage)
2800	60	BATTERIES, electric storage, wet, nonspillable
2800	60	BATTERIES, wet, nonspillable (electric storage)
2801	60	DYE, liquid, corrosive, n.o.s.
2801	60	DYE, liquid, n.o.s. (corrosive)
2801	60	DYE INTERMEDIATE, liquid, corrosive, n.o.s.
2801	60	DYE INTERMEDIATE, liquid n.o.s. (corrosive)
2802	60	COPPER CHLORIDE
2803	60	GALLIUM
2803	60	GALLIUM, metal
2805	40	LITHIUM HYDRIDE, fused, solid
2806	37	LITHIUM NITRIDE
2807	31	MAGNETIZED MATERIAL
2809	60	MERCURY
2809	60	MERCURY METAL
2810	55	COMPOUNDS TREE or WEED KILLING, liquid (poisonous)
2810	55	MEDICINES, poisonous, liquid, n.o.s.
2810	55	POISON B, LIQUID, n.o.s.
2810	55	POISONOUS LIQUIDS, n.o.s.
2810	**55**	**POISONOUS LIQUIDS, n.o.s (Inhalation Hazard Zone A)**
2810	**55**	**POISONOUS LIQUIDS, n.o.s. (Inhalation Hazard Zone B)**
2810	**55**	**TOXIC LIQUID, organic, n.o.s.**
2811	53	FLUE DUST, poisonous
2811	53	LEAD FLUORIDE
2811	53	MEDICINES, poisonous, solid n.o.s.
2811	53	POISON B, SOLID, n.o.s.
2811	53	POISONOUS SOLIDS, n.o.s.
2811	53	SELENIUM OXIDE
2811	53	TOXIC SOLID, organic, n.o.s.
2812	60	SODIUM ALUMINATE, solid
2813	40	LITHIUM ACETYLIDE-ETHYLENEDIAMINE COMPLEX
2813	40	SUBSTANCES, which, when in contact with water, emit flammable gases, solid n.o.s.
2813	40	WATER REACTIVE SOLID, n.o.s.
2814	24	ETIOLOGIC AGENT, n.o.s.
2814	24	INFECTIOUS SUBSTANCES, affecting humans
2815	60	N-AMINOETHYLPIPERAZINE
2817	60	AMMONIUM BIFLUORIDE, solution
2817	60	AMMONIUM HYDROGENDIFLUORIDE SOLUTION
2817	60	AMMONIUM HYDROGEN FLUORIDE SOLUTION
2818	60	AMMONIUM POLYSULFIDE SOLUTION
2819	60	AMYL ACID PHOSPHATE
2820	60	BUTYRIC ACID
2821	55	PHENOL SOLUTIONS
2822	54	2-CHLOROPYRIDINE
2823	60	CROTONIC ACID
2826	**59**	**ETHYL CHLOROTHIOFORMATE**
2829	60	CAPROIC ACID
2830	41	LITHIUM FERROSILICON
2831	74	METHYL CHLOROFORM
2831	74	1,1,1-TRICHLOROETHANE
2834	60	PHOSPHOROUS ACID
2834	60	PHOSPHOROUS ACID, ortho
2835	40	SODIUM ALUMINUM HYDRIDE
2837	60	BISULFATES, aqueous solution
2837	60	SODIUM BISULFATE SOLUTION
2837	60	SODIUM HYDROGEN SULFATE SOLUTION
2838	26	VINYL BUTYRATE, inhibited
2839	55	ALDOL
2840	26	BUTYRALDOXIME
2841	68	DI-N-AMYLAMINE
2842	26	NITROETHANE

Table 2 Continued

ID No	Guide No	Name of Material
2844	40	CALCIUM MANGANESE SILICON
2845	40	ALUMINUM ALKYL
2845	**40**	**ETHYL PHOSPHONOUS DICHLORIDE, anhydrous**
2845	**40**	**METHYL PHOSPHONOUS DICHLORIDE**
2845	40	PYROPHORIC LIQUID, organic n.o.s.
2845	40	PYROPHORIC LIQUIDS, n.o.s.
2846	37	PYROPHORIC SOLID, organic n.o.s.
2846	37	PYROPHORIC SOLIDS, n.o.s.
2849	53	3-CHLOROPROPANOL-1
2850	27	PROPYLENE TETRAMER
2851	59	BORON TRIFLUORIDE DIHYDRATE
2852	33	DIPICRYL SULFIDE, wetted with not less than 10% water
2853	53	MAGNESIUM FLUOROSILICATE
2854	53	AMMONIUM FLUOROSILICATE
2854	53	AMMONIUM SILICOFLUORIDE, solid
2855	53	ZINC FLUOROSILICATE
2856	53	FLUOROSILICATES, n.o.s.
2857	21	REFRIGERATING MACHINES, containing non-flammable, non-poisonous, liquefied gas
2857	21	REFRIGERATING MACHINES, containing non-flammable non-toxic, liquefied gas or ammonia solutions (2073)
2858	32	ZIRCONIUM, dry, wire, sheet or strips (thinner than 254 microns but not thinner than 18 microns)
2859	53	AMMONIUM METAVANADATE
2860	53	VANADIUM TRIOXIDE
2861	55	AMMONIUM POLYVANADATE
2862	53	VANADIUM PENTOXIDE
2863	53	SODIUM AMMONIUM VANADATE
2864	53	POTASSIUM METAVANADATE
2865	60	HYDROXYLAMINE SULFATE
2869	60	TITANIUM TRICHLORIDE MIXTURES
2870	37	ALUMINUM BOROHYDRIDE
2870	37	ALUMINUM BOROHYDRIDE IN DEVICES
2871	53	ANTIMONY, powder
2871	53	ANTIMONY POWDER
2872	58	DIBROMOCHLOROPROPANES
2873	55	DIBUTYLAMINOETHANOL
2874	55	FURFURYL ALCOHOL
2875	53	HEXACHLOROPHENE
2876	55	RESORCINOL
2878	32	TITANIUM SPONGE, granules or powder
2879	59	SELENIUM OXYCHLORIDE
2880	45	CALCIUM HYPOCHLORITE, hydrated, including mixtures with not less than 5.5% but not more than 10% water
2881	37	METAL CATALYST, dry
2881	37	NICKEL CATALYST, dry
2883	48	2,2-DI (tert-BUTYLPEROXY)-PROPANE
2884	48	2,2-DI (tert-BUTYLPEROXY)-PROPANE
2885	48	1,1-DI (tert-BUTYLPEROXY) CYCLOHEXANE
2886	48	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, with 2,2-DI-(tert-BUTYL-PEROXY) BUTANE
2887	48	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, with 2,2-DI-(tert-BUTYL-PEROXY)BUTANE
2888	52	tert-BUTYL PEROXY-2-ETHYL-HEXANOATE, not more than 50%, with phlegmatizer
2889	52	DIISOTRIDECYLPEROXYDI-CARBONATE
2890	48	tert-BUTYL PEROXYBENZOATE
2891	52	tert -AMYL PEROXYNEODECANOATE
2892	52	DIMYRISTYL PEROXYDICARBONATE, not more than 42% in water
2893	48	LAUROYL PEROXIDE, not more than 42%
2894	52	DI(4-tert-BUTYLCYCLOHEXYL) PEROXYDICARBONATE
2895	52	DICETYLPEROXYDICARBONATE, not more than 42%
2896	51	CYCLOHEXANONE PEROXIDE, not more than 72% as a paste
2897	48	1,1-DI(tert-BUTYLPEROXY) CYCLOHEXANE
2898	52	tert-AMYL PEROXY-2-ETHYL HEXANOATE
2899	52	ORGANIC PEROXIDE, n.o.s. (including trial quantities)

Table 2 Continued

ID No	Guide No	Name of Material
2900	24	INFECTIOUS SUBSTANCES, affecting animals only
2901	**20**	**BROMINE CHLORIDE**
2902	55	ALLETHRIN
2902	55	FUNGICIDE, poisonous, n.o.s.
2902	55	INSECTICIDE, liquid poisonous, n.o.s.
2902	55	PESTICIDES, liquid, toxic n.o.s.
2903	28	PESTICIDES, liquid, toxic flammable, n.o.s.
2904	55	CHLOROPHENATES, liquid
2904	55	CHLOROPHENOLATES, liquid
2904	55	PHENOLATES, liquid
2905	53	CHLOROPHENATES, solid
2905	53	CHLOROPHENOLATES, solid
2905	53	PHENOLATES, solid
2906	26	TRIISOCYANATOISOCYANURATE of ISOPHORONEDIISOCYANATE, 70% solution
2907	32	ISOSORBIDE DINITRATE MIXTURE
2909	6	RADIOACTIVE MATERIAL, articles manufactured from natural or depleted uranium or natural thorium
2910	6	RADIOACTIVE MATERIAL, empty package-articles manufactured from natural or depleted uranium or thorium
2910	6	RADIOACTIVE MATERIAL, excepted package-articles manufactured from natural or depleted uranium or natural thorium
2910	61	RADIOACTIVE MATERIAL, excepted package-empty packaging
2910	61	RADIOACTIVE MATERIAL excepted package-instruments or articles
2910	61	RADIOACTIVE MATERIAL, excepted package-limited quantity of material
2910	61	RADIOACTIVE MATERIAL, limited quantity, n.o.s.
2911	61	RADIOACTIVE MATERIAL, instruments and articles
2912	62	RADIOACTIVE MATERIAL, low specific activity (LSA), n.o.s.
2913	62	RADIOACTIVE MATERIAL, surface contaminated objects (SCO)
2918	65	RADIOACTIVE MATERIAL, fissile, n.o.s.
2920	29	CORROSIVE LIQUIDS, flammable, n.o.s.
2920	29	DICHLOROBUTENE
2921	34	CORROSIVE SOLIDS, flammable, n.o.s.
2922	59	CORROSIVE LIQUID, toxic n.o.s.
2922	59	CORROSIVE LIQUIDS, poisonous, n.o.s.
2922	59	SODIUM HYDROSULFIDE SOLUTION
2923	59	CORROSIVE SOLID, toxic n.o.s.
2923	59	CORROSIVE SOLIDS, poisonous n.o.s.
2923	59	SODIUM HYDROSULFIDE, solid with not less than 25% water of crystallization
2924	29	DICHLOROBUTENE
2924	29	FLAMMABLE LIQUIDS, corrosive, n.o.s.
2925	34	FLAMMABLE SOLID, corrosive, n.o.s.
2925	34	FLAMMABLE SOLID, corrosive, organic, n.o.s.
2926	34	FLAMMABLE SOLID, poisonous, n.o.s.
2926	34	FLAMMABLE SOLID, toxic, organic, n.o.s.
2927	**59**	**ETHYL PHOSPHONOTHIOIC DICHLORIDE, anhydrous**
2927	**59**	**ETHYL PHOSPHORODICHLORIDATE**
2927	59	POISONOUS LIQUID, corrosive, n.o.s.
2927	**59**	**POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone A)**
2927	**59**	**POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone B)**
2927	**59**	**TOXIC LIQUID, corrosive, organic, n.o.s.**
2928	59	POISONOUS SOLIDS, corrosive, n.o.s.
2928	59	TOXIC SOLID, corrosive, organic, n.o.s.
2929	57	CHLOROPICRIN MIXTURE, FLAMMABLE
2929	57	POISONOUS LIQUIDS, flammable, n.o.s.
2929	57	POISONOUS LIQUIDS flammable, n.o.s. (Inhalation Hazard Zone A)
2929	57	POISONOUS LIQUIDS flammable, n.o.s. (Inhalation Hazard Zone B)
2929	57	TOXIC LIQUID, flammable organic, n.o.s.
2930	34	POISONOUS SOLIDS flammable, n.o.s.
2930	34	TOXIC SOLID, flammable organic, n.o.s.
2931	55	VANADYL SULFATE
2933	29	METHYL 2-CHLOROPROPIONATE
2934	29	ISOPROPYL 2-CHLOROPROPIONATE

Table 2 Continued

ID No	Guide No	Name of Material
2935	29	ETHYL 2-CHLOROPROPIONATE
2936	59	THIOLACTIC ACID
2937	55	METHYLBENZYL ALCOHOL (alpha)
2938	31	METHYL BENZOATE
2940	37	CYCLOOCTADIENE PHOSPHINES
2940	37	9-PHOSPHABICYCLONONANES
2941	55	FLUOROANILINES
2942	55	2-TRIFLUOROMETHYLANILINE
2943	26	TETRAHYDROFURFURYLAMINE
2945	29	N-METHYLBUTYLAMINE
2946	31	2-AMINO-5-DIETHYLAMINOPENTANE
2947	29	ISOPROPYL CHLOROACETATE
2948	55	3-TRIFLUOROMETHYLANILINE
2949	59	SODIUM HYDROSULFIDE, with not less than 25% water of crystallization
2949	59	SODIUM HYDROSULFIDE SOLUTION
2950	40	MAGNESIUM GRANULES, coated
2951	72	DIPHENYLOXIDE-4,4'-DISULFO-HYDRAZIDE
2952	70	AZODIISOBUTYRONITRILE
2953	70	2,2'-AZODI-(2,4-DIMETHYLVALERO-NITRILE)
2954	72	1,1'-AZODI(HEXAHYDROBENZO-NITRILE)
2955	70	2,2'-AZODI-(2,4-DIMETHYL-4-METHOX YVALERONITRILE)
2956	32	5-tert-BUTYL-2,4,6-TRINITRO-m-XYLENE
2956	32	MUSK XYLENE
2965	29	BORON TRIFLUORIDE DIMETHYL ETHERATE
2966	53	THIOGLYCOL
2967	60	SULFAMIC ACID
2968	37	MANEB, or MANEB PREPARATION(S), stabilized against self-heating
2969	31	CASTOR BEANS, MEAL, POMACE or FLAKE
2970	72	BENZENE SULFOHYDRAZIDE
2971	72	BENZENE-1,3-DISULFOHYDRAZIDE
2972	71	N,N'-DINITROSOPENTAMETHYLENE TETRAMINE
2973	71	N,N'-DINITROSO-N,N'-DIMETHYL TEREPHTHALAMIDE
2974	64	RADIOACTIVE MATERIAL, special form, n.o.s.
2975	61	THORIUM METAL, pyrophoric
2976	61	THORIUM NITRATE, solid
2977	66	URANIUM HEXAFLUORIDE, fissile (containing more than 1.0% U-235)
2978	66	URANIUM HEXAFLUORIDE, fissile excepted or non-fissile
2978	66	URANIUM HEXAFLUORIDE, low specific activity
2979	61	URANIUM METAL, pyrophoric
2980	61	URANIUM NITRATE HEXAHYDRATE SOLUTION
2981	61	URANYL NITRATE, solid
2982	63	RADIOACTIVE MATERIAL, n.o.s.
2983	26	ETHYLENE OXIDE and PROPYLENE OXIDE MIXTURES
2984	45	HYDROGEN PEROXIDE AQUEOUS SOLUTIONS with not less than 8% but less than 20% peroxide
2985	29	CHLOROSILANES, flammable, corrosive, n.o.s.
2985	29	CHLOROSILANES, n.o.s (flammable, corrosive)
2986	29	CHLOROSILANES, corrosive, flammable, n.o.s.
2986	29	CHLOROSILANES, n.o.s (flammable, corrosive)
2987	60	CHLOROSILANES, corrosive, n.o.s.
2987	60	CHLOROSILANES, n.o.s (corrosive)
2988	40	CHLOROSILANES, n.o.s. (emits flammable gas when wet)
2988	40	CHLOROSILANES, water-reactive, flammable, corrosive, n.o.s.
2989	32	LEAD PHOSPHITE, dibasic
2990	31	LIFE-SAVING APPLIANCES, SELF-INFLATING
2991	28	CARBAMATE PESTICIDES, liquid, toxic, flammable, n.o.s.
2992	55	CARBAMATE PESTICIDES, liquid, toxic, n.o.s.
2993	28	ARSENICAL PESTICIDES, liquid, toxic, flammable, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
2994	55	ARSENICAL PESTICIDES, liquid, toxic, n.o.s.
2995	28	ORGANOCHLORINE PESTICIDES, liquid, toxic, flammable, n.o.s.
2996	55	ORGANOCHLORINE PESTICIDES, liquid, toxic, n.o.s.
2997	28	TRIAZINE PESTICIDES, liquid, toxic, flammable, n.o.s.
2998	55	TRIAZINE PESTICIDES, liquid, toxic, n.o.s.
2999	28	PHENOXY PESTICIDES, liquid, toxic, flammable, n.o.s.
3000	55	PHENOXY PESTICIDES, liquid, toxic, n.o.s.
3001	28	PHENYL UREA PESTICIDES, liquid, toxic, flammable, n.o.s.
3002	55	PHENYL UREA PESTICIDES, liquid, toxic, n.o.s.
3003	28	BENZOIC DERIVATIVE PESTICIDES, liquid, toxic, flammable, n.o.s.
3004	55	BENZOIC DERIVATIVE PESTICIDES, liquid, toxic, n.o.s.
3005	28	DITHIOCARBAMATE PESTICIDES, liquid, toxic, flammable, n.o.s.
3006	55	DITHIOCARBAMATE PESTICIDES, liquid, toxic, n.o.s.
3007	2	PHTHALIMIDE DERIVATIVE PESTICIDES, liquid, toxic, flammable, n.o.s.
3008	55	PHTHALIMIDE DERIVATIVE PESTICIDES, liquid, toxic, n.o.s.
3009	28	COPPER-BASED PESTICIDES liquid, toxic, flammable, n.o.s.
3010	55	COPPER-BASED PESTICIDES, liquid, toxic, n.o.s.
3011	28	MERCURY-BASED PESTICIDES, liquid, toxic, flammable n.o.s.
3012	55	MERCURY-BASED PESTICIDES, liquid, toxic, n.o.s.
3013	28	SUBSTITUTED NITROPHENOL PESTICIDES, liquid, toxic, flammable, n.o.s.
3014	55	SUBSTITUTED NITROPHENOL PESTICIDES, liquid, toxic n.o.s.
3015	28	BIPYRIDILIUM PESTICIDES, liquid, toxic, flammable, n.o.s.
3016	55	BIPYRIDILIUM PESTICIDES, liquid, toxic, n.o.s.
3017	28	ORGANOPHOSPHORUS PESTICIDES, liquid, toxic, flammable, n.o.s.
3018	55	ORGANOPHOSPHORUS, PESTICIDES, liquid, toxic, n.o.s.
3018	55	TETRAETHYL PYROPHOSPHATE, liquid
3019	28	ORGANOTIN PESTICIDES, liquid, toxic, flammable, n.o.s.
3020	55	ORGANOTIN PESTICIDES, liquid, toxic, n.o.s.
3021	28	PESTICIDES, liquid, flammable toxic, n.o.s.
3022	26	1,2-BUTYLENE OXIDE, stabilized
3023	**57**	**tert-OCTYL MERCAPTAN**
3024	28	COUMARIN DERIVATIVE PESTICIDES, liquid, flammable, toxic, n.o.s.
3025	28	COUMARIN DERIVATIVE PESTICIDES, liquid, toxic, flammable, n.o.s.
3026	55	COUMARIN DERIVATIVE PESTICIDES, liquid, toxic, n.o.s.
3027	55	COUMARIN DERIVATIVE PESTICIDES, solid, toxic, n.o.s.
3028	60	BATTERIES, electric storage, dry, containing POTASSIUM HYDROXIDE
3030	70	2,2'-AZODI-(2-METHYL-BUTYRONITRILE)
3031	71	SELF-REACTIVE SUBSTANCES, samples, n.o.s.
3032	71	SELF-REACTIVE SUBSTANCES, trial quantities, n.o.s.
3033	72	3-CHLORO-4-DIETHYLAMINOBENZENE-DIAZONIUM ZINC CHLORIDE
3034	72	4-DIPROPYLAMINOBENZENE-DIAZONIUM ZINC CHLORIDE
3035	70	3-(2-HYDROXYETHOXY)-4-PYRROLIDIN-1-YLBENZENEDIAZONIUM ZINC CHLORIDE
3036	72	2,5-DIETHOXY-4-MORPHOLINOBENZENEDIAZONIUM ZINC CHLORIDE
3037	70	4-(BENZYL(ETHYL)AMINO)-3-ETHOXY-BENZENEDIAZONIUM ZINC CHLORIDE
3038	70	4-(BENZYL(METHYL)AMINO)-3-ETHOXY-BENZENEDIAZONIUM ZINC CHLORIDE
3039	70	4-DIMETHYLAMINO-6 (2-DIMETHYLAMINOETHOXY) TOLUENE-2-DIAZONIUM ZINC CHLORIDE

Table 2 Continued

ID No	Guide No	Name of Material
3040	72	SODIUM 2-DIAZO-1-NAPHTHOL-4-SULFONATE
3041	72	SODIUM 2-DIAZO-1-NAPHTHOL-5-SULFONATE
3042	71	2-DIAZO-1-NAPHTHOL-4-SULFO-CHLORIDE
3043	71	2-DIAZO-1-NAPHTHOL-5-SULFO-CHLORIDE
3048	53	ALUMINUM PHOSPHIDE PESTICIDES
3049	40	METAL ALKYL HALIDES, n.o.s.
3050	40	METAL ALKYL HYDRIDES, n.o.s.
3051	40	ALUMINUM ALKYLS
3052	40	ALUMINUM ALKYL HALIDES
3053	40	MAGNESIUM ALKYLS
3054	28	CYCLOHEXYL MERCAPTAN
3055	60	2-(2-AMINOETHOXY)ETHANOL
3056	26	n-HEPTALDEHYDE
3057	**16**	**TRIFLUOROACETYL CHLORIDE**
3064	26	NITROGLYCERIN, SOLUTION in ALCOHOL, with more than 1 % but not more than 5% nitroglycerin
3065	26	ALCOHOLIC BEVERAGES
3066	60	PAINT, corrosive liquid
3066	60	PAINT RELATED MATERIAL, corrosive liquid
3070	12	DICHLORODIFLUOROMETHANE and ETHYLENE OXIDE MIXTURE with not more than 12% ETHYLENE OXIDE
3070	12	ETHYLENE OXIDE and DICHLORODIFLUOROMETHANE MIXTURE with not more than 12% ethylene oxide
3070	12	ETHYLENE OXIDE and DICHLORODIFLUOROMETHANE MIXTURE, with not more than 12.5% ethylene oxide
3071	28	MERCAPTAN MIXTURE, liquid toxic, flammable, n.o.s.
3071	28	MERCAPTAN MIXTURES, liquid, n.o.s.
3071	28	MERCAPTANS, liquid, n.o.s.
3071	28	MERCAPTANS, liquid, toxic, flammable, n.o.s.
3072	31	LIFE-SAVING APPLIANCES NOT SELF-INFLATING
3073	57	VINYL PYRIDINES, inhibited
3076	40	ALUMINUM ALKYL HYDRIDES
3077	31	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, solid, n.o.s.
3077	31	HAZARDOUS WASTE, solid n.o.s.
3077	31	OTHER REGULATED SUBSTANCES, solid, n.o.s.
3078	40	CERIUM, turnings or gritty powder
3079	**28**	**METHACRYLONITRILE, inhibited**
3080	28	ISOCYANATE SOLUTIONS, n.o.s.
3080	28	ISOCYANATE SOLUTIONS, toxic, flammable, n.o.s.
3080	28	ISOCYANATES, n.o.s.
3080	28	ISOCYANATES, toxic, flammable, n.o.s.
3082	31	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, liquid, n.o.s.
3082	31	HAZARDOUS WASTE, liquid, n.o.s.
3082	31	OTHER REGULATED SUBSTANCES, liquid, n.o.s.
3083	**20**	**PERCHLORYL FLUORIDE**
3084	35	CORROSIVE SOLIDS, oxidizing, n.o.s.
3085	42	OXIDIZING SOLID, corrosive, n.o.s.
3085	42	OXIDIZING SUBSTANCES, solid, corrosive, n.o.s.
3086	42	POISONOUS SOLIDS, oxidizing, n.o.s.
3086	42	TOXIC SOLID, oxidizing, n.o.s.
3087	44	OXIDIZING SOLID, toxic, n.o.s.
3087	44	OXIDIZING SUBSTANCES, solid, poisonous, n.o.s.
3088	37	SELF-HEATING SOLID, organic, n.o.s.
3088	37	SELF-HEATING SUBSTANCES, solid, n.o.s.
3089	32	METAL POWDER, flammable, n.o.s.
3090	40	LITHIUM BATTERY
3091	40	LITHIUM BATTERIES, contained in equipment
3091	40	LITHIUM BATTERIES, packed with equipment
3092	26	1-METHOXY-2-PROPANOL
3093	45	CORROSIVE LIQUIDS, oxidizing, n.o.s.
3094	39	CORROSIVE LIQUIDS water-reactive, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
3094	39	CORROSIVE LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3095	37	CORROSIVE SOLIDS, self-heating, n.o.s.
3096	40	CORROSIVE SOLIDS, water-reactive, n.o.s.
3096	40	CORROSIVE SOLIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3097	32	FLAMMABLE SOLID, oxidizing, n.o.s.
3098	45	OXIDIZING LIQUID, corrosive n.o.s.
3098	45	OXIDIZING SUBSTANCES, liquid, corrosive, n.o.s.
3099	44	OXIDIZING LIQUID, poisonous, n.o.s.
3099	44	OXIDIZING LIQUID, toxic, n.o.s.
3099	44	OXIDIZING SUBSTANCES, liquid, poisonous, n.o.s.
3100	43	OXIDIZING SOLID, self-heating, n.o.s.
3100	43	OXIDIZING SUBSTANCES, solid, self-heating,, n.o.s.
3101	49	ORGANIC PEROXIDE TYPE B, liquid
3102	49	ORGANIC PEROXIDE TYPE B, solid
3103	48	ORGANIC PEROXIDE TYPE C, liquid
3104	48	ORGANIC PEROXIDE TYPE C, solid
3105	48	ORGANIC PEROXIDE TYPE D, liquid
3106	48	ORGANIC PEROXIDE TYPE D, solid
3107	48	ORGANIC PEROXIDE TYPE E, liquid
3108	48	ORGANIC PEROXIDE TYPE E, solid
3109	48	ORGANIC PEROXIDE TYPE F, liquid
3110	48	ORGANIC PEROXIDE TYPE F, solid
3111	52	ORGANIC PEROXIDE TYPE B, liquid, temperature controlled
3112	52	ORGANIC PEROXIDE TYPE B, solid, temperature controlled
3113	52	ORGANIC PEROXIDE TYPE C, liquid, temperature controlled
3114	52	ORGANIC PEROXIDE TYPE C, solid, temperature controlled
3115	52	ORGANIC PEROXIDE TYPE D, liquid, temperature controlled
3116	52	ORGANIC PEROXIDE TYPE D, solid, temperature controlled
3117	52	ORGANIC PEROXIDE TYPE E, liquid, temperature controlled
3118	52	ORGANIC PEROXIDE TYPE E, solid, temperature controlled
3119	52	ORGANIC PEROXIDE TYPE F, liquid, temperature controlled
3120	52	ORGANIC PEROXIDE TYPE F, solid, temperature controlled
3121	43	OXIDIZING SOLID, water-reactive, n.o.s.
3121	43	OXIDIZING SUBSTANCES, solid which in contact with water emit FLAMMABLE GASES, n.o.s.
3122	44	POISONOUS LIQUIDS, oxidizing, n.o.s.
3122	**44**	**POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Zone A)**
3122	**44**	**POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Lone B)**
3122	**44**	**TOXIC LIQUID, oxidizing, n.o.s.**
3123	40	POISONOUS LIQUIDS, water-reactive, n.o.s.
3123	40	POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3123	**40**	**POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s (Inhalation Hazard Zone A)**
3123	**40**	**POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s (Inhalation Hazard Zone B)**
3123	**40**	**TOXIC LIQUID, water-reactive n.o.s.**
3124	34	POISONOUS SOLIDS, self-heating, n.o.s.
3124	34	TOXIC SOLID, self-heating, n.o.s.
3125	34	POISONOUS SOLIDS, water-reactive, n.o.s.
3125	34	POISONOUS SOLIDS, which in contact with water emit FLAMMABLE GASES, n.o.s.
3125	34	TOXIC SOLID, water-reactive n.o.s.
3126	47	SELF-HEATING SOLID, corrosive, organic, n.o.s.
3126	47	SELF-HEATING SUBSTANCE, solid, corrosive, n.o.s.
3127	47	SELF-HEATING SOLID, oxidizing, n.o.s.
3127	47	SELF-HEATING SUBSTANCE, solid, oxidizing, n.o.s.
3128	34	SELF-HEATING SOLID, organic, poisonous, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
3128	34	SELF-HEATING SOLID, toxic, organic, n.o.s.
3128	34	SELF-HEATING SUBSTANCE ,solid, poisonous, n.o.s.
3129	39	SUBSTANCES which in contact with water emit FLAMMABLE GASES, liquid, corrosive n.o.s.
3129	39	WATER-REACTIVE LIQUID, corrosive, n.o.s.
3130	39	SUBSTANCES, which in contact with water emit FLAMMABLE GASES, liquid, poisonous n.o.s.
3130	39	WATER-REACTIVE LIQUID, poisonous, n.o.s.
3130	39	WATER-REACTIVE LIQUID, toxic, n.o.s.
3131	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, corrosive n.o.s.
3131	40	WATER-REACTIVE SOLID, corrosive, n.o.s.
3132	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, flammable n.o.s.
3132	40	WATER-REACTIVE SOLID, flammable, n.o.s.
3133	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, oxidizing n.o.s.
3133	40	WATER-REACTIVE SOLID, oxidizing, n.o.s.
3134	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, poisonous n.o.s.
3134	40	WATER-REACTIVE SOLID, poisonous, n.o.s.
3134	40	WATER-REACTIVE SOLID, toxic n.o.s.
3135	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, solid, self-heating n.o.s.
3135	40	WATER-REACTIVE SOLID, self-heating, n.o.s.
3136	21	TRIFLUOROMETHANE, refrigerated liquid (cryogenic liquid)
3137	35	OXIDIZING SUBSTANCES, solid, flammable, n.o.s.
3138	17	ETHYLENE, ACETYLENE and PROPYLENE MIXTURE, refrigerated liquid (cryogenic liquid), containing at least 71.5% ETHYLENE with not more than 22.5% ACETYLENE and not more than 6% PROPYLENE
3139	35	OXIDIZING SUBSTANCES, liquid, n.o.s.
3140	53	ALKALOID SALTS, liquid, n.o.s., poisonous
3140	53	ALKALOIDS, liquid, n.o.s, poisonous
3141	53	ANTIMONY COMPOUNDS, inorganic, liquid, n.o.s.
3142	55	DISINFECTANTS, liquid, n.o.s, poisonous
3142	55	DISINFECTANTS, liquid, toxic, n.o.s.
3143	55	DYE, solid, n.o.s. or DYE INTERMEDIATE, solid, n.o.s poisonous
3143	55	DYE, solid, toxic, n.o.s.
3143	55	DYE INTERMEDIATE, solid, toxic, n.o.s
3144	55	NICOTINE COMPOUND, liquid, n.o.s.
3144	55	NICOTINE PREPARATION, liquid, n.o.s.
3145	55	ALKYL PHENOLS, liquid, n.o.s.
3146	55	ORGANOTIN COMPOUNDS, solid, n.o.s.
3147	60	DYE, solid, corrosive, n.o.s
3147	60	DYE, solid, n.o.s. or DYE INTERMEDIATE, solid, n.o.s, corrosive
3147	60	DYE INTERMEDIATE, solid, corrosive, n.o.s.
3148	40	SUBSTANCES which in contact with water emit FLAMMABLE GASES, liquid, n.o.s.
3148	40	WATER-REACTIVE LIQUID ,n.o.s.
3149	45	HYDROGEN PEROXIDE - PEROXYACETIC ACID MIXTURES, with acid(s), water and not more than 5% PEROXYACETIC acid stabilized
3150	22	DEVICES, small, HYDROCARBON GAS powered, with release device
3150	22	HYDROCARBON GAS REFILLS for small devices, with release device
3151	31	POLYHALOGENATED BIPHENYLS, liquid
3151	31	POLYHALOGENATED TERPHENYLS, liquid
3152	31	POLYHALOGENATED BIPHENYLS, solid
3152	31	POLYHALOGENATED TERPHENYLS, solid

Table 2 Continued

ID No	Guide No	Name of Material
3153	22	PERFLUOROMETHYLVINYL ETHER
3154	22	PERFLUOROETHYLVINYL ETHER
3155	55	PENTACHLOROPHENOL
3156	14	COMPRESSED GAS, oxidizing, n.o.s.
3157	14	LIQUEFIED GAS, oxidizing, n.o.s.
3158	21	GAS, refrigerated liquid, n.o.s.
3159	12	TETRAFLUOROETHANE
3159	12	1,1,1,2-TETRAFLUOROETHANE
3160	**18**	**LIQUEFIED GAS, toxic, flammable, n.o.s.**
3161	22	LIQUEFIED GAS, flammable, n.o.s.
3162	**15**	**LIQUEFIED GAS, toxic, n.o.s.**
3163	12	LIQUEFIED GAS, n.o.s.
3164	12	ARTICLES, pressurized pneumatic or hydraulic (containing non-flammable gas)
3165	28	AIRCRAFT HYDRAULIC POWER TANK
3166	27	ENGINES, internal combustion including when fitted in machinery or vehicles
3167	22	GAS SAMPLE, non-pressurized flammable, n.o.s., not refrigerated liquid
3167	22	GAS SAMPLES, non-pressurized flammable, n.o.s., not deeply refrigerated
3168	18	GAS SAMPLE, non-pressurized, toxic, flammable, n.o.s., not refrigerated liquid
3168	18	GAS SAMPLES, non-pressurized, toxic, flammable, n.o.s., not deeply refrigerated
3169	15	GAS SAMPLE, non-pressurized, toxic, n.o.s., not refrigerated liquid
3169	15	GAS SAMPLES, non-pressurized, toxic, n.o.s., not deeply refrigerated
3170	40	ALUMINUM DROSS
3170	40	ALUMINUM PROCESSING BY-PRODUCTS
3171	60	BATTERY-POWERED EQUIPMENT (wet battery)
3171	60	BATTERY-POWERED VEHICLE (wet battery)
3171	60	WHEELCHAIR, ELECTRIC with batteries
3172	55	TOXINS, extracted from living sources, n.o.s.
3174	37	TITANIUM DISULFIDE
3175	32	SOLIDS CONTAINING FLAMMABLE LIQUID, n.o.s.
3176	32	FLAMMABLE SOLID, organic molten, n.o.s.
3178	32	FLAMMABLE SOLID, inorganic, n.o.s.
3179	34	FLAMMABLE SOLID, inorganic, poisonous, n.o.s.
3179	34	FLAMMABLE SOLID, toxic, inorganic, n.o.s.
3180	34	FLAMMABLE SOLID, corrosive, inorganic, n.o.s.
3180	34	FLAMMABLE SOLID, inorganic, corrosive, n.o.s.
3181	32	METAL SALTS OF ORGANIC COMPOUNDS, flammable n.o.s.
3182	32	METAL HYDRIDES, flammable n. o. s.
3183	37	SELF-HEATING LIQUID, organic, n.o.s.
3184	38	SELF-HEATING LIQUID, organic, poisonous, n.o.s.
3184	38	SELF-HEATING LIQUID, toxic, organic, n.o.s.
3185	38	SELF-HEATING LIQUID, corrosive, organic, n.o.s.
3185	38	SELF-HEATING LIQUID, organic, corrosive, n.o.s.
3186	37	SELF-HEATING LIQUID, inorganic, n.o.s.
3187	38	SELF-HEATING LIQUID, inorganic, poisonous, n.o.s.
3187	38	SELF-HEATING LIQUID, toxic, inorganic, n.o.s.
3188	38	SELF-HEATING LIQUID, corrosive, inorganic, n.o.s.
3188	38	SELF-HEATING LIQUID, inorganic, corrosive, n.o.s.
3189	37	METAL POWDER, self-heating n.o.s.
3189	37	SELF-HEATING METAL POWDER, n.o.s.
3190	37	SELF-HEATING SOLID, inorganic, n.o.s.
3191	38	SELF-HEATING SOLID, inorganic, poisonous, n.o.s.
3191	38	SELF-HEATING SOLID, toxic, inorganic, n.o.s.
3192	38	SELF-HEATING SOLID, corrosive, inorganic, n.o.s.
3192	38	SELF-HEATING SOLID, inorganic, corrosive, n.o.s.
3194	37	PYROPHORIC LIQUID, inorganic, n.o.s.

Table 2 Continued

ID No	Guide No	Name of Material
3200	37	PYROPHORIC SOLID, inorganic, n.o.s.
3203	37	PYROPHORIC ORGANOMETALLIC COMPOUNDS, n.o.s.
3205	37	ALKALINE EARTH METAL ALCOHOLATES, n.o.s.
3206	38	ALKALI METAL ALCOHOLATES, n.o.s.
3206	38	ALKALI METAL ALCOHOLATES, self-heating, corrosive n.o.s.
3207	40	ORGANOMETALLIC COMPOUND, wafer-reactive, flammable, n.o.s.
3207	40	ORGANOMETALLIC DISPERSION, water-reactive, flammable, n.o.s.
3207	40	ORGANOMETALLIC SOLUTION, water-reactive, flammable n.o.s.
3208	40	METALLIC SUBSTANCE, water-reactive, n.o.s.
3209	40	METALLIC SUBSTANCE, water-reactive, self-heating, n.o.s.
3210	35	CHLORATES, inorganic, aqueous solution, n.o.s.
3211	35	PERCHLORATES, inorganic, aqueous solution, n.o.s.
3212	35	HYPOCHLORITES, inorganic n.o.s.
3213	35	BROMATES, inorganic, aqueous solution, n.o.s.
3214	35	PERMANGANATES, inorganic, aqueous solution, n.o.s.
3215	35	PERSULFATES, inorganic, n.o.s.
3216	35	PERSULFATES, inorganic, aqueous solution, n.o.s.
3217	35	PERCARBONATES, inorganic n.o.s.
3218	35	NITRATES, inorganic, aqueous solution, n.o.s.
3219	35	NITRITES, inorganic, aqueous solutions, n.o.s.
3220	12	PENTAFLUOROETHANE
3221	49	SELF-REACTIVE LIQUID TYPE B
3222	49	SELF-REACTIVE SOLID TYPE B
3223	49	SELF-REACTIVE LIQUID TYPE C
3224	49	SELF-REACTIVE SOLID TYPE C
3225	48	SELF-REACTIVE LIQUID TYPE D
3226	48	SELF-REACTIVE SOLID TYPE D
3227	48	SELF-REACTIVE LIQUID TYPE E
3228	48	SELF-REACTIVE SOLID TYPE E
3229	48	SELF-REACTIVE LIQUID TYPE F
3230	48	SELF-REACTIVE SOLID TYPE F
3231	52	SELF-REACTIVE LIQUID TYPE B, temperature controlled
3232	52	SELF-REACTIVE SOLID TYPE B, temperature controlled
3233	52	SELF-REACTIVE LIQUID TYPE C, temperature controlled
3234	52	SELF-REACTIVE SOLID TYPE C, temperature controlled
3235	52	SELF-REACTIVE LIQUID TYPE D, temperature controlled
3236	52	SELF-REACTIVE SOLID TYPE D, temperature controlled
3237	52	SELF-REACTIVE LIQUID TYPE E, temperature controlled
3238	52	SELF-REACTIVE SOLID TYPE E, temperature controlled
3239	52	SELF-REACTIVE LIQUID TYPE F, temperature controlled
3240	52	SELF-REACTIVE SOLID TYPE F, temperature controlled
3241	53	2-BROMO-2-NITROPROPANE-1,3-DIOL
3242	32	AZODICARBONAMIDE
3243	55	SOLIDS CONTAINING POISONOUS LIQUID, n.o.s.
3243	55	SOLIDS CONTAINING TOXIC LIQUID, n.o.s.
3244	60	SOLIDS CONTAINING CORROSIVE LIQUID, n.o.s.
3245	31	GENETICALLY MODIFIED MICROORGANISMS
3246	**59**	**METHANESULFONYL CHLORIDE**
3247	35	SODIUM PEROXOBORATE, ANHYDROUS
3248	28	MEDICINES, liquid, flammable, poisonous, n.o.s.
3248	28	MEDICINES, liquid, flammable, toxic, n.o.s.
3249	55	MEDICINES, solid, poisonous, n.o.s.
3249	55	MEDICINES, solid, toxic, n.o.s.
3250	59	CHLOROACETIC ACID, molten
3251	32	ISOSORBIDE-5-MONONITRATE

Table 2 Continued

ID No	Guide No	Name of Material
3252	22	DIFLOUROMETHANE
3253	60	DISODIUM TRIOXOSILICATE, pentahydrate
3254	37	TRIBUTYLPHOSPHANE
3255	37	tert-BUTYL HYPOCHLORITE
3256	27	ELEVATED TEMPERATURE LIQUID, flammable, n.o.s, with flash point above 60.5°C, at or above its flash point
3257	27	ELEVATED TEMPERATURE LIQUID, n.o.s, at or above 100°C and below its flash point
3258	31	ELEVATED TEMPERATURE SOLID, n.o.s., at or above 240°C
3259	60	AMINES, solid, corrosive n.o.s.
3259	60	POLYAMINES, solid, corrosive, n.o.s.
3260	60	CORROSIVE SOLID, acidic inorganic, n.o.s.
3261	60	CORROSIVE SOLID, acidic organic, n.o.s.
3262	60	CORROSIVE SOLID, basic inorganic, n.o.s.
3263	60	CORROSIVE SOLID, basic organic, n.o.s.
3264	60	CORROSIVE LIQUID, acidic inorganic, n.o.s.
3265	60	CORROSIVE LIQUID, acidic organic, n.o.s.
3266	60	CORROSIVE LIQUID, basic, inorganic, n.o.s.
3267	60	CORROSIVE LIQUID, basic, organic, n.o.s.
3268	31	AIR BAG INFLATORS
3268	31	AIR BAG MODULES
3268	31	SEAT-BELT MODULES
3268	31	SEAT-BELT PRE-TENSIONERS
3269	26	POLYESTER RESIN KIT
3270	32	NITROCELLULOSE MEMBRANE FILTERS
3271	26	ETHERS, n.o.s.
3272	26	ESTERS, n.o.s.
3273	28	NITRILES, flammable, toxic n.o.s.
3274	26	ALCOHOLATES SOLUTION, n.o.s. in alcohol
3275	**57**	**NITRILES, toxic, flammable, n.o.s.**
3276	55	NITRILES, toxic, n.o.s (liquid)
3276	55	NITRILES, toxic, n.o.s, (solid)
3277	59	CHLOROFORMATES, toxic, corrosive, n.o.s.
3278	55	ORGANOPHOSPHORUS COMPOUND, toxic, n.o.s. (liquid)
3278	55	ORGANOPHOSPHORUS COMPOUND, toxic, n.o.s. (solid)
3279	**28**	**ORGANOPHOSPHORUS COMPOUND, toxic, flammable, n.o.s.**
3280	55	ORGANOARSENIC COMPOUND, toxic, n.o.s.
3281	55	METAL CARBONYLS, toxic, n.o.s.
3282	55	ORGANOMETALLIC COMPOUND, toxic, n.o.s.
3283	55	SELENIUM COMPOUND, toxic, n.o.s.
3284	55	TELLURIUM COMPOUND, toxic, n.o.s.
3285	55	VANADIUM COMPOUND, toxic, n.o.s.
3286	28	FLAMMABLE LIQUID, toxic, corrosive, n.o.s.
3287	55	TOXIC LIQUID, inorganic, n.o.s.
3288	53	TOXIC SOLID, inorganic, n.o.s.
3289	**59**	**TOXIC LIQUID, corrosive, inorganic, n.o.s.**
3290	59	TOXIC SOLID, corrosive, inorganic, n.o.s.
3291	24	BIOMEDICAL WASTE, n.o.s.
3291	24	CLINICAL WASTE, unspecified n.o.s.
3291	24	MEDICAL WASTE, n.o.s.
3291	24	REGULATED MEDICAL WASTE, n.o.s.
3292	40	BATTERIES, containing SODIUM
3292	40	CELLS, containing SODIUM
3293	53	HYDRAZINE, AQUEOUS SOLUTIONS, with not more than 37% hydrazine
3294	**28**	**HYDROGEN CYANIDE, solution in alcohol with not more than 45% hydrogen cyanide**
3295	27	HYROCARBONS, LIQUID n.o.s.
3296	12	HEPTAFLUOROPROPANE
3297	12	ETHYLENE OXIDE and CHLOROTETRAFLUOROETHANE MIXTURES, with not more than 8.8% ethylene oxide
3298	12	ETHYLENE OXIDE and PENTAFLUOROETHANE MIXTURES, with not more than 7.9% ethylene oxide

Table 2 Continued

ID No	Guide No	Name of Material
3299	12	ETHYLENE OXIDE and TETRAFLUOROETHANE MIXTURES, with not more than 5.6% ethylene oxide
3300	**18**	**ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with more than 87% ethylene oxide**
3301	37	CORROSIVE LIQUID, self-heating, n.o.s.
9011	58	CAMPHENE
9018	74	DICHLORODIFLUOROETHYLENE
9026	53	DINITROCYCLOHEXYL PHENOL
9035	15	GAS IDENTIFICATION SET
9037	53	HEXACHLOROETHANE
9069	29	TETRAMETHYLMETHYLENEDIAMINE
9083	31	AMMONIUM CARBAMATE
9084	31	AMMONIUM CARBONATE
9088	31	AMMONIUM FLUOBORATE
9163	31	ZIRCONIUM SULFATE
9180	62	URANYL ACETATE
9183	52	ORGANIC PEROXIDE, liquid or solution, n.o.s.
9187	52	ORGANIC PEROXIDE, solid, n.o.s.
9188	31	HAZARDOUS SUBSTANCE, liquid or solid, n.o.s.
9188	31	ORM-E, liquid or solid, n.o.s.
9189	31	HAZARDOUS WASTE, liquid or solid, n.o.s.
9190	43	AMMONIUM PERMANGANATE
9191	47	CHLORINE DIOXIDE HYDRATE, frozen
9192	25	FLUORINE, refrigerated liquid (cryogenic liquid)
9193	45	OXIDIZER, corrosive liquid, n.o.s.
9194	45	OXIDIZER, corrosive solid, n.o.s.
9195	40	METAL ALKYL SOLUTION, n.o.s.
9199	44	OXIDIZER, poisonous, liquid, n.o.s.
9200	42	OXIDIZER, poisonous, solid, n.o.s.
9202	**67**	**CARBON MONOXIDE, refrigerated liquid (cryogenic liquid)**
9206	**39**	**METHYL PHOSPHONIC DICHLORIDE**
9259	27	ELEVATED TEMPERATURE MATERIAL, liquid, n.o.s. (at or above 100° C (212° F) and below its flash point)
9260	77	ALUMINUM, molten
9263	**59**	**CHLOROPIVALOYL CHLORIDE**
9264	**5**	**3,5-DICHLORO-2,4,6-TRIFLUORO YRIDINE**
9269	**57**	**TRIMETHOXYSILANE**
9274	74	1,1-DICHLORO-1-FLUOROETHANE
9275	24	REGULATED MEDICAL WASTE, n.o.s.
9276	27	FLAMMABLE LIQUIDS, elevated temperature material, n.o.s.
9277	31	OIL, n.o.s. flash point not less than 93°C
9278	31	GENETICALLY MODIFIED ORGANISMS

IV. EMERGENCY RESPONSE FACT SHEETS

The following are Guides on the potential hazards and emergency response actions for a generic class of chemicals. The Guide number (recommended by the U.S. Department of Transportation) corresponds to the chemicals listed in the previous sections. For example, if we were dealing with the chemical Zirconium Sulfate (UN designation 9163), the chemical's fact sheet is Guide number 31, which provides appropriate emergency response information.

GUIDE 11

POTENTIAL HAZARDS

Fire or Explosion Hazards

Flammable/combustible material; may be ignited by heat, sparks or flames.

May ignite other combustible materials (wood, paper, oil, etc.).

Container may explode in heat or fire.

Reaction with fuels may be violent.

Runoff to sewer may create fire or explosion hazard.

Health Hazards

May be fatal if inhaled, swallowed or absorbed through skin.

Contact may cause burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Do not touch or walk through spilled material.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running
water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 12

POTENTIAL HAZARDS

Fire or Explosion Hazards

Some of these materials may burn, but none of them ignites readily.
Cylinder may explode in heat or fire.

Health Hazards

Vapors may cause dizziness or suffocation.
Contact with liquid may cause frostbite.
Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire

Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire. Some of these materials, if spilled, may evaporate leaving a flammable residue

Spill or leak

Stop leak if you can do it without risk.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

GUIDE 13

POTENTIAL HAZARDS

Health Hazards

Poison: **extremely hazardous.**
May be fatal if inhaled or absorbed through skin.
Initial odor may be irritating, foul or absent and may deaden your sense of smell.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Some of these materials are **extremely flammable.**
May be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Cylinder may explode in heat or fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces

before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
See Chapter 7 which provides information on Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Fire
Small fires: Let burn unless leak can be stopped immediately.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Cool container with water using unmanned device until well after fire is out.
Isolate area until gas has dispersed.
Hydrogen Cyanide Fires: Let burn unless leak can be stopped immediately.
Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Shut off ignition sources; no flares, smoking or flames in hazard area.
Use water spray to reduce vapor; **do not** put water directly on leak or spill area.
Isolate area until gas has dispersed.
For **hydrogen cyanide,** consider igniting spill or leak to eliminate toxic gas concerns.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 14

POTENTIAL HAZARDS
Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Cylinder may explode in heat or fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Health Hazards
Contact with liquid may cause frostbite.
Vapors may cause dizziness or suffocation.
Fire may produce irritating or poisonous gases.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Stop leak if you can do it without risk.
Isolate area until gas has dispersed.
First aid
Move victim to fresh air; call emergency medical core.
Keep victim quiet and maintain normal body temperature.

GUIDE 15

POTENTIAL HAZARDS
Health Hazards
Poisonous; may be fatal if inhaled or absorbed through skin.
Contact may cause burns to skin and eyes.
Contact with liquid may cause frostbite.
Clothing frozen to the skin should be thawed before being

removed.
Run off from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Cylinder may explode in heat or fire.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Do not get water inside container.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Isolate area until gas has dispersed.
Spill or leak
Stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapor; do not put water directly on leak or spill area.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.
Do not get water inside container.
Isolate area until gas has dispersed.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 16

POTENTIAL HAZARDS
Health Hazards
May be poisonous if inhaled.
Vapor **extremely irritating.**
Contact may cause burns to skin and eyes.
Contact with liquid may cause frostbite.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Cylinder may explode in heat or fire.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed space before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Fire
Small fires: Dry chemical or CO_2.
Large fires: Water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Isolate area until gas has dispersed.
Spill or leak
Stop leak if you can do it without risk.
Use water spray to reduce vapor; **do not** put water directly on leak or spill area.
Isolate area until gas has dispersed.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or

eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 17

POTENTIAL HAZARDS
Fire or Explosion
Extremely flammable.
May be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode violently in heat or fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Health Hazards
May be poisonous it inhaled.
Contact may cause burns lo skin and eyes.
Vapors may cause dizziness or suffocation.
Contact with liquid may cause frostbite.
Fire may produce irritating or poisonous gases.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Fire
Let tank, tank car or tank truck burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Cool container with water using unmanned device until well after fire is out.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Isolate area until gas has dispersed.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 18

POTENTIAL HAZARDS
Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact causes burns to skin and eyes.
Contact with liquid may cause frostbite.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat or fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: let burn unless leak can be stopped immediately.

Large fires: water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Fully encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.

Stop leak if you can do it without risk.

Use water spray to reduce vapors; isolate area until gas has dispersed.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

Effects may be delayed; keep victim under observation.

GUIDE 19

POTENTIAL HAZARDS

Fire or Explosion

Extremely flammable; may be ignited by heat, sparks or flames.

Vapors may travel to a source of ignition and flash back.

Container may explode in heat or fire.

Vapor explosion hazard indoors, outdoors or in sewers.

Health Hazards

May be poisonous if inhaled.

Vapor **extremely irritating;** contact causes burns to skin and eyes.

Contact with liquid may cause frostbite.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.

Isolate the leak or spill area immediately for at least 150 feet in all directions.

Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

If water pollution occurs, notify the appropriate authorities.

Fire

Let tank, tank car or tank truck burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.

Small fires: dry chemical or CO_2.

Large fires: water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Stop leak if you con do it without risk.

Use water spray to reduce vapors; isolate area until gas has dispersed.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

GUIDE 20

POTENTIAL HAZARDS

Health Hazards

Poisonous; may be fatal if inhaled.

Contact may cause burns to skin and eyes.
Contact with liquid may cause frostbite.
Runoff from fire control or dilution water may cause pollution

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Cylinder may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: **water only; no dry chemical, CO_2 or halon.**
Contain and let burn. If fire must be fought, water spray or fog is recommended.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Water spray may be used to reduce or direct vapors.
Isolate area until gas has dispersed.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation

GUIDE 21

POTENTIAL HAZARDS

Fire or Explosion

Cannot catch fire.
Container may explode in heat of fire.

Health Hazards

Vapors may cause dizziness or suffocation.
Contact with liquid may cause frostbite.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire

Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak

Do not touch or walk through spilled material.
Stop leak if you can do it without risk.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 22

POTENTIAL HAZARDS

Fire or Explosion

Extremely flammable; may be ignited by heat, sparks or

flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Health Hazards
Vapors may cause dizziness or suffocation.
Contact will cause severe frostbite.
Fire may produce irritating or poisonous gases.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Fire
Let tank, tank car or tank truck burn unless leak can be stopped; with smaller tanks or cylinders, extinguish/isolate from other flammables.
Small fires: dry chemical or CO_2.
Large fires: water spray or fog.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapors; isolate area until gas has dispersed.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 23

POTENTIAL HAZARDS
Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Health Hazards
Vapors may cause dizziness or suffocation.
Contact will cause severe frostbite.
Fire may produce irritating or poisonous gases.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Fire
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.
Isolate area until gas has dispersed.
First aid
Move victim to fresh air; call emergency medical care.
Remove and isolate contaminated clothing and shoes at the site.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.

GUIDE 24

POTENTIAL HAZARDS
Health Hazards
Contact with material may cause infection and disease.

If inhaled, may be harmful.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Some of these materials may burn, but none of them ignites readily.
May be ignited if carrier liquid is flammable.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, soda ash, lime or sand.
Use extinguishing agent suitable for type of surrounding fire.
Move container from fire area if you can do it without risk.
Do not scatter spilled material with high-pressure water streams.

Spill or leak

Do not touch or walk through spilled material.
Do not touch damaged containers or spilled material.
Damage to outer container may not affect primary inner container.
If inner container damaged or leaking, cover with damp towel or rag and keep wet with liquid bleach.
Spills: dike for later disposal; do not apply water unless directed to do so.
Cleanup only under supervision of an expert.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Effects of exposure (inhalation, ingestion or skin contact) to material may be delayed.

GUIDE 25

POTENTIAL HAZARDS

Health Hazards

Poisonous; may be fatal if inhaled.
Vapor **extremely irritating.**
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action. If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, soda ash, lime or sand.
Large fires: water spray, fog (flooding amounts).
Do not get solid stream of water on spilled material.
Do not get water inside container.
Move container from fire area if you can do it without risk.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

If you have not donned special protective clothing approved for this material, do not expose yourself to any risk of this material touching you.
Stop leak if you can do it without risk.
Use water spray to reduce vapor; do not put water directly on leak or spill area.
Isolate area until gas has dispersed.
A fine water spray remotely directed to the edge of the spill pool can be used to direct and maintain a hot flare fire which will burn the spilled material in a controlled manner.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is

difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 26

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

Health Hazards
May be poisonous if inhaled or absorbed through skin.
Vapors may cause dizziness or suffocation.
Contact may irritate or burn skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may give off poisonous gases and cause water pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire
Small fires: dry chemical, CO_2, water spray or alcohol-resistant foam.
Do not use dry chemical extinguishers to control fires involving nitromethane or nitroethane.
Large fires: water spray, fog or alcohol-resistant foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent
material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 27

POTENTIAL HAZARDS

Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.
Material may be transported hot.

Health Hazards
May be poisonous if inhaled or absorbed through skin.
Vapors may cause dizziness or suffocation.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Stop leak if you can do it without risk.

Water spray may reduce vapor; but it may not prevent ignition in closed spaces.

Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.

Large spills: dike far ahead of liquid spilt for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.

GUIDE 28

POTENTIAL HAZARDS

Health Hazards

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.

Contact may cause burns to skin and eyes.

Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Flammable/combustible material; may be ignited by heat, sparks or flames.

Vapors may travel to a source of ignition and flash back.

Container may explode in heat of fire.

Vapor explosion and poison hazard indoors, outdoors or in sewers.

Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection

Structural firefighters' protective clothing is not effective for these materials.

See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire

Small fires: dry chemical, CO_2, water spray or alcohol-resistant foam.

Large fires: water spray, fog or alcohol -resistant foam.

Move container from fire area if you can do it without risk.

Dike fire control water for later disposal; do not scatter the material.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Water spray may reduce vapor; but it may not prevent ignition in closed spaces.

Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.

Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is

difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 29

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

Health Hazards

May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire

Some of these materials may react violently with water.
Small fires: dry chemical, H_2O, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Do not get water inside container.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Use water spray to reduce vapor; do not get water inside container.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 30

POTENTIAL HAZARDS

Health Hazards

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode violently in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewer
Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.

Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Do not get water inside container.
Apply cooling water to sides of containers that are exposed to after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 31

POTENTIAL HAZARDS
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Material may be transported hot.
Health Hazards
Contact may cause burns lo skin and eyes.
Inhalation of asbestos dust may have a damaging effect on the lungs.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Do not scatter spilled material with high-pressure water streams.
Dike fire control water for later disposal.
Spill or leak
Stop leak if you can do it without risk.
Avoid inhalation of asbestos dust.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.
First aid
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 32

POTENTIAL HAZARDS
Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.

May burn rapidly with flare-burning effect.
Material may be transported in a molten form.

Health Hazards

Fire may produce irritating or poisonous gases.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, sand, earth, water spray or regular foam
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.
Magnesium fires: use dry sand, sodium chloride powder or graphite powder.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 33

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material; may be ignited by heat, sparks or flames.
Dried out material may explode if exposed to heat, flame or shock; keep material wet with water or treat it as an explosive (refer to Guide 46).
Runoff to sewer may create fire or explosion hazard.

Health Hazards

Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Tire fires: flood with water; if no water is available, use dry chemical or dirt. Caution: tire fires may start again.
Do not move cargo or vehicle if cargo has been exposed to heat.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small spills: flush area with flooding amounts of water.
Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 34

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material; may be ignited by heat, sparks or flames.

May burn rapidly with flare-burning effect.

Health Hazards

Poisonous if swallowed.
Skin contact poisonous.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Dike fire control water for later disposal; do not scatter the material.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 35

POTENTIAL HAZARDS

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.
Runoff to sewer may create fire or explosion hazard.

Health Hazards

Contact may cause burns to skin and eyes.
Vapors or dust may be irritating.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: water only; no dry chemical, CO_2 or halon
Large fires: flood fire area with water from a distance.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers exposed to flames until well after fire is out.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Do not touch or walk through spilled material.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Small liquid spills: take up with sand, earth or other noncombustible absorbent material.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 36

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material; may be ignited by heat,

sparks or flames.
Dried out material may explode if exposed to heat, flame or shock; keep material wet with water or treat it as an explosive (refer to Guide 46).
Runoff to sewer may create fire or explosion hazard.

Health Hazards

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Tire fires: flood with water; if no water is available, use dry chemical or dirt. Caution: tire fires may start again.
Do not move cargo or vehicle if cargo has been exposed to heat.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Small spills: flush area with flooding amounts of water.
Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 37

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material.
May ignite itself if exposed to air.
May re-ignite after fire is extinguished.
May burn rapidly with flare-burning effect.
Runoff to sewer may create fire or explosion hazard.

Health Hazards

If inhaled, may be harmful.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Some of these materials may react violently with water.
Hydrosulfite fires: use flooding quantities of water for any size fire.
Small fires: dry chemical, soda ash, lime or sand.
Large fires: flood fire area with water from a distance.
Do not get water inside container.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do if without risk.
Do not get water inside container.
Small spills: flush area with flooding amounts of water.
Large spills: dike liquid spill for later disposal.

First aid

Move victim lo fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 38

POTENTIAL HAZARDS

Fire or Explosion

Extremely flammable; will ignite itself if exposed to air.
Will re-ignite itself after fire is extinguished.
Burns rapidly, releasing dense, white, irritating fumes.

Runoff to sewer may create fire or explosion hazard.
Material may be transported in a molten form.

Health Hazards

Poisonous if swallowed or if fumes from fire are inhaled repeatedly.
Contact causes burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, sand, earth or water spray.
Large fires: water spray or fog.
Do not scatter spilled material with high-pressure water streams.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: cover with water, sand or earth. Shovel into metal container and keep material under water.
Large spills: dike for later disposal and cover with wet sand or earth.
Cleanup only under supervision of an expert.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, keep exposed skin areas immersed in water or covered with wet bandages until medical attention is received.
Remove and isolate contaminated clothing and shoes at the site and place in metal container filled with water. Fire hazard if allowed to dry.
Effects may be delayed; keep victim under observation.

GUIDE 39

POTENTIAL HAZARDS

Health Hazards

Poisonous if inhaled or swallowed.
Contact causes severe burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Some of these materials may burn, but none of them ignites readily.
May ignite other combustible materials (wood, paper, oil, etc.).
Violent reaction with water.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Runoff to sewer may create fire or explosion hazard.
Material may be transported in a molten form.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in oil directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire

Do not get water inside container.
Small fires: dry chemical or CO_2.
Large fires: flood fire area with water from a distance.
Do not get solid stream of water on spilled material.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapor; do not put water directly on leak, spill area or inside container.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Spills: dike for later disposal; do not apply water unless directed to do so.
Cleanup only under supervision of an expert.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 40

POTENTIAL HAZARDS
Fire or Explosion
May ignite itself if exposed to air.
May re-ignite after fire is extinguished.
May ignite in presence of moisture.
Violent reaction with water produces flammable gas.
Runoff to sewer may create fire or explosion hazard.
Health Hazards
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing may provide limited protection.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
If water pollution occurs, notify the appropriate authorities.
Fire
Do not use water or foam.
Small fires: dry chemical, soda ash, lime or sand.
Large fires: withdraw from area and let fire burn.
Magnesium fires: use dry sand, sodium chloride powder or graphite powder.
Lithium fires: use dry sand, sodium chloride powder, graphite powder or copper powder.
Move container from fire area if you can do it without risk.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
No water on spilled material; do not get water inside container.
Small dry spills: with clean shovel place material info clean, dry container and cover loosely; move containers from spill area.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.
First aid
Move victim to fresh air; call emergency medical care.
Wipe material from skin immediately; flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 41

POTENTIAL HAZARDS
Fire or Explosion
May ignite in presence of moisture.
Contact with water produces flammable gas.
Runoff to sewer may create fire or explosion hazard.
Health Hazards
Contact with water produces poisonous gas.
Skin contact poisonous.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer

may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
If water pollution occurs, notify the appropriate authorities.

Fire

Do not use water or foam.
Small fires: dry chemical, soda ash, lime or sand.
Large fires: withdraw from area and let fire burn.
Move container from fire area if you can do it without risk.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Do not touch or walk through spilled material.
No water on spilled material; do not get water inside container.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike liquid spill for later disposal.
Cover powder spill with plastic sheet or tarp to minimize spreading.
Cleanup only under supervision of an expert.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 42

POTENTIAL HAZARDS

Health Hazards

Poisonous if swallowed.
Inhalation of dust poisonous.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

May burn rapidly.
May ignite other combustible materials (wood, paper, oil, etc.)
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: water only; no dry chemical, CO_2 or halon
Large fires: flood fire area with water from a distance.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.

Spill or leak

Do not touch or walk through spilled material.
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 43

POTENTIAL HAZARDS

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).
Mixture with fuels may explode.
Container may explode in heat of fire.
May explode from heat or contamination.
Runoff to sewer may create fire or explosion hazard.

Health Hazards

Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.

Structural firefighters' protective clothing is **not** effective for these materials.

Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: **water only;** no dry chemical, CO_2 or halon.

Large fires: flood fire area with water from a distance.

Do not move cargo or vehicle if cargo has been exposed to heat.

Apply cooling water to sides of containers exposed to flames until well after fire is out.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.

Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Use water spray to reduce vapors.

Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.

Large spills: dike liquid spill for later disposal.

First aid

Move victim to fresh air; call emergency medical care.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

GUIDE 44

POTENTIAL HAZARDS

Health Hazards

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.

Contact may cause burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).

Violent reaction with water.

Reaction with fuels may be violent.

Flammable/poisonous gases may accumulate in tanks and hopper cars.

Runoff to sewer may create fire or explosion hazard.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind, out of low areas, and ventilate closed spaces before entering.

Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.

Structural firefighters' protective clothing is not effective for these materials.

See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: water, dry chemical or soda ash.

Large fires: flood fire area with water.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.

Fully-encapsulating, vapor-protective clothing should be worn for spills leaks with no fire.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Use water spray to reduce vapor; do not get water inside container.

Small spills: flush area with flooding amounts of water.

Large spills: dike far ahead of liquid spill for later

disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

Effects may be delayed; keep victim under observation.

GUIDE 45

POTENTIAL HAZARDS

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).

These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.

Flammable/poisonous gases may accumulate in tanks and hopper cars.

Runoff to sewer may create fire or explosion hazard.

Health Hazards

If inhaled, may be harmful.

Contact may cause burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: **water only;** no dry chemical, CO_2 or halon.

Large fires: flood fire area with water.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Use water spray to reduce vapor; do not get water inside container.

Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.

Small spills: flush area with flooding amounts of water.

Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

Effects may be delayed; keep victim under observation.

GUIDE 46

POTENTIAL HAZARDS

Fire or Explosion

May explode and throw fragments 1 mile or more if fire reaches cargo.

Health Hazards

Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

IF FIRE REACHES CARGO, DO NOT FIGHT FIRE.

If you know or suspect that heavily-encased explosives, such as bombs or artillery projectiles are involved, stop all traffic and begin to evacuate all persons, including emergency responders, from the area in all directions for 5000 feet (1 mile) for rail car or 4000 feet (3/4 mile) for tractor/trailer. When heavily-encased explosives are not involved, the area for 2500 feet (½ mile) in all directions.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Fire

Cargo Fires: **DO NOT FIGHT FIRE WHEN IT REACHES CARGO**

Withdraw from area and let fire burn.

Truck and Equipment Fires: Try to prevent fire from reaching the explosive cargo compartment. Flood with water; if no water is available use Halon, dry chemical or earth.

Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. First, move people out of line-of-sight of the scene and away from windows. Then, obtain more information and specific guidance from competent authorities listed on the shipping papers.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Do not touch or walk through spilled material.

First aid

Call emergency medical care.

Use first aid treatment according to the nature of the injury.

GUIDE 47

POTENTIAL HAZARDS

Fire or Explosion

May ignite other combustible materials (wood, paper, oil, etc.).

Mixture with fuels may explode.

Flammable/poisonous gases may accumulate in tanks and hopper cars.

Container may explode in heat of fire.

May explode from friction, heat or contamination.

Runoff to sewer may create fire or explosion hazard.

Health Hazards

May be poisonous if inhaled.

Contact causes severe burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: water only; no dry chemical, CO_2 or halon.

Large fires: flood fire area with water from a distance.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Keep combustibles (wood, paper, oil, etc.) away from spilled material.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Use water spray to reduce vapors.

Small spills: flush area with flooding amounts of water.

Large spills: dike liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

GUIDE 48

POTENTIAL HAZARDS

Fire or Explosion

May be ignited by heat, sparks or flames.

Container may explode in heat of fire.

May explode from heat or contamination.

Runoff to sewer may create fire or explosion hazard.

Health Hazards

Contact may cause burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: flood fire area with water.

Apply cooling water to sides of containers that are exposed to after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Small spills: take up with inert, damp noncombustible material; move containers from spill area.

Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

GUIDE 49

POTENTIAL HAZARDS

Fire or Explosion

May be ignited by heat, sparks or flames.

May burn rapidly with flare-burning effect.

Container may explode in heat of fire.

May explode from friction, heat or contamination.

Runoff to sewer may create fire or explosion hazard.

Health Hazards

Contact may cause burns to skin and eyes.

Fire may produce irritating or poisonous gases.

Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.

Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: flood fire area with water from a distance.

Do not move cargo or vehicle if cargo has been exposed to heat.

If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.

If this is impossible, withdraw from area and let fire burn.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Small spills: take up with inert, damp noncombustible material; move containers from spill area.

Large spills: wet down with water and dike for later disposal.

First aid

Move victim to fresh air; call emergency medical care.

In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

GUIDE 50

POTENTIAL HAZARDS

Fire or Explosion

May explode and throw fragments 1 /3 mile or more if fire reaches cargo.

Health Hazards

Fire may produce irritating or poisonous gases.

EMERGENCY ACTION

IF FIRE REACHES CARGO, DO NOT FIGHT FIRE

-Stop all traffic and begin to evacuate all persons. Including emergency responders, from the area for 1500 feet (1/3 mile) in all directions.

Positive pressure self-contained breathing apparatus (SCBA) firefighters' protective clothing will provide limited protection.

Fire

Cargo Fires: **DO NOT FIGHT FIRE WHEN IT REACHES CARGO.**

Withdraw from area and let fire burn.

Truck and Equipment Fires: Try to prevent fire from reaching the explosive cargo compartment. Flood with water; if no water is available use Halon, dry chemical or earth.

Promptly isolate the scene by removing all persons from incident if there is a fire. First, move people out of line-of-sight of the scene and away from windows. Then, obtain more information and guidance from competent authorities

listed on the shipping papers.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
First aid
Call emergency medical care.
Use first aid treatment according to the nature of the injury.
SUPPLEMENTAL INFORMATION
Packages bearing the 1.4S label contain explosive substances or articles that are designed or packaged in such a manner that when involved in a fire, may burn vigorously with localized detonations and projection of fragments; effects are usually confined to immediate vicinity of packages.
If fire threatens cargo area containing packages bearing 1.4S label, consider initial isolation of at least 50 feet in all directions. Fight fire with normal precaution from a reasonable distance.

GUIDE 51

POTENTIAL HAZARDS
Fire or Explosion
May be ignited by heat, sparks or flames.
Container may explode in heat of fire.
May explode from heat or contamination.
Runoff to sewer may create fire or explosion hazard.
Health Hazards
Vapor **extremely irritating.**
Contact of material or its vapor with eyes may cause blindness.
Poisonous if swallowed.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Stop leak if you can do it without risk.
Small spills: take up with inert, damp noncombustible material; move containers from spill area.
Large spills: wet down with water and dike for later disposal.
First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 52

POTENTIAL HAZARDS
Fire or Explosion
May ignite itself if exposed to air.
May be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.
May explode from heat, contamination or loss of temperature control.
Runoff to sewer may create fire or explosion hazard.
Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.
Loss of cooling
Specified control temperature of material must be maintained. Obtain liquid nitrogen, dry ice or ice for

cooling. If none can be obtained, evacuate area.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water from a distance.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.
Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Shut off ignition sources; no flares, smoking or flames in hazard area.
Small spills: take up with sand or other noncombustible material; move containers from spill area.
Large spills: dike liquid spill for later disposal.
First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 53

POTENTIAL HAZARDS
Health Hazards
Poisonous if swallowed.
Inhalation of dust or mist may be poisonous.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 54

POTENTIAL HAZARDS
Health Hazards
Poisonous if swallowed.
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.

Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with sand or other noncombustible material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.

GUIDE 55

POTENTIAL HAZARDS
Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may give off poisonous gases and cause water pollution.
Fire may produce irritating or poisonous gases.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Container may explode violently in heat of fire.
Material may be transported in a molten form.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is **not** effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Remove and isolate contaminated clothing at the site.
Fire
Small fires: dry chemical, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Fight fire from maximum distance. Stay away from ends of tanks.
Dike fire control water for later disposal; do not scatter the material.
Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapors.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 56

POTENTIAL HAZARDS
Health Hazards
Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
May explode from friction, heat or contamination.
Material may be transported in a molten form.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind, out of low areas, and ventilate closed spaces before entering.

Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.

Structural firefighters' protective clothing is not effective for these materials.

See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.

Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.

Use water spray to reduce vapors.

Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.

Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.

Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

Speed in removing material from skin is of extreme importance.

Removal of solidified molten material from skin requires medical assistance.

Remove and isolate contaminated clothing and shoes at the site.

Keep victim quiet and maintain normal body temperature.

Effects may be delayed; keep victim under observation.

GUIDE 57

POTENTIAL HAZARDS

Health Hazards

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.

Contact may cause burns to skin and eyes.

Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

May be ignited by heat, sparks or flames.

Container may explode in heat of fire.

Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.

Stay upwind, out of low areas, and ventilate closed spaces before entering.

Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.

Structural firefighters' protective clothing is not effective for these materials.

Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: water spray, fog or regular foam.

Move container from fire area if you can do it without risk.

Cool container with water using unmanned device until well after fire is out.

Fight fire from maximum distance. Stay away from ends of tanks.

Dike fire control water for later disposal; do not scatter the material.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.

Fully-encapsulating, vapor-protective clothing should be

worn for spills and leaks with no fire.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Speed in removing material from skin is of extreme importance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 58

POTENTIAL HAZARDS
Health Hazards
Inhalation of vapor or dust is **extremely irritating.**
May cause burning of eyes and flow of tears.
May cause coughing, difficult breathing and nausea.
Brief exposure effects last only a few minutes.
Exposure in an enclosed area may be very harmful.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
If water pollution occurs, notify the appropriate authorities.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Spill or leak
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Effects should disappear after individual has been exposed to fresh air for approximately 10 minutes.

GUIDE 59

POTENTIAL HAZARDS
Health Hazards
Poisonous if inhaled or swallowed.
Skin contact poisonous.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
Fire or Explosion
Some of these materials may burn, but none of them ignites readily.
Some of these materials may ignite combustibles (wood, paper, oil, etc.
Material may be transported in a molten form.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus

(SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.

Fire

Some of these materials may react violently with water.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Use water spray to reduce vapors.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Any contact with hydrogen fluoride or hydrofluoric acid solution requires immediate and specialized medical attention.
Removal of solidified molten material from skin requires medical assistance.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 60

POTENTIAL HAZARDS

Health Hazards

Contact causes burns to skin and eyes.
If inhaled, may be harmful.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Some of these materials may burn, but none of them ignites readily.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Some of these materials may ignite combustibles (wood, paper, oil, etc.).

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Some of these materials may react violently with water.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.
Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 61

POTENTIAL HAZARDS

Health Hazards

Radiation presents minimal risk to lives of persons during transportation accidents.

Low-level radioactive materials; very little radiation hazard to people.

Some radioactive materials cannot be detected by commonly available instruments.

Packages do not have RADIOACTIVE I, II, or III labels. Some may have EMPTY labels or be marked with the word "Radioactive".

Fire or Explosion

Radioactivity does not change flammability or other properties of the materials.

Some of these materials may burn, but none of them ignites readily.

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.

Priorities are life saving, control of fire and other hazards, and first aid.

Keep unnecessary people away; isolate hazard area and deny entry.

Notify Radiation Authority of accident conditions.

Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection.

Pollution from cargo fire control runoff is not expected; if any radioactive contamination occurs, it will be extremely low hazard.

Fire

Do not move damaged packages; move undamaged packages out of fire zone.

Small fires: dry chemical, CO_2, water spray or regular foam.

Large fires: water spray, fog (flooding amounts).

Spill or leak

Do not touch damaged packages or spilled material.

Small liquid spills: cover with sand, earth or other noncombustible absorbent material.

Cover powder spill with plastic sheet or tarp to minimize spreading.

First aid

Use first aid treatment according to the nature of the injury.

If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notifications to authorities.

GUIDE 62

POTENTIAL HAZARDS

Health Hazards

Radiation presents minimal risk to lives of persons during transportation accidents.

Low radiation hazard when material is inside container. If material is released from package or bulk container, hazard will vary from little to moderate depending on the type and amount of radioactivity, the kind of material it is in, and/or the surfaces it is on.

Full-load shipments and packages often do not have "RADIOACTIVE" labels.

Occasionally, packages may have a "RADIOACTIVE" label and a second hazard label; usually the second hazard is greater than the radiation hazard.

Some radioactive materials cannot be detected by commonly available instruments.

Spilled radioactive materials usually will be visible if packaging fails.

Runoff from control of cargo fire may cause low-level pollution.

Fire or Explosion

Some of these materials may burn, but most do not ignite readily.

Radioactivity does not change flammability or other properties of the materials.

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.

Priorities are life saving, control of fire and other hazards, and first aid.

Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.

Keep unnecessary people at least 150 feet upwind of spill; greater distances may be necessary for people downwind, or if advised by Radiation Authority.

Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection.

If water pollution occurs, notify the appropriate authorities.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Spill or leak
Do not touch damaged containers or spilled material.
Small liquid spills: cover with sand, earth or other noncombustible absorbent material.
Dike to collect large liquid spills or cargo fire control water.
Cover powder spill with plastic sheet or tarp to minimize spreading.
First aid
Use first aid treatment according to the nature of the injury.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notifications to authorities.

GUIDE 63

POTENTIAL HAZARDS
Health Hazards
Radiation presents minimal risk to lives of persons during transportation accidents.
Undamaged packages are safe; damaged packages or released material can cause external radiation exposure; released material entering or contaminating the body can cause internal radiation exposure.
Type A packages (cartons, boxes, drums, articles, etc.) identified as "Type A" by marking on packages or by shipping papers contain non-life endangering amounts. Partial releases might be expected if packages are damaged in moderately severe accidents.
Type B packages (large and small, usually metal) identified as "Type B" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing of packages, life endangering releases are not expected in accidents except those of utmost severity.
Some radioactive materials cannot be detected by commonly available instruments.
Water from control of cargo fire may cause pollution.
Fire or Explosion
Some of these materials may burn, but most do not ignite readily.
Radioactivity does not change flammability or other properties of the materials.
Type B packages are designed to withstand temperatures of 1475°F (800°C).
EMERGENCY ACTION
Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Keep unnecessary people at least 150 feet upwind of spill; greater distances may be necessary for people downwind, or if advised by Radiation Authority.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external exposure.
If water pollution occurs, notify the appropriate authorities.
Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).
Spill or leak
Do not touch damaged packages or spilled material.
Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
Small liquid spills: cover with sand, earth or other noncombustible absorbent material.
Dike to collect cargo fire control water.
First aid
Use first aid treatment according to the nature of the injury.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notification to authorities.

GUIDE 64

POTENTIAL HAZARDS
Health Hazards
Radiation presents minimal risk to lives of persons during transportation accidents.
Undamaged packages are safe; damaged packages or materials released from packages can cause external

radiation hazards. Contamination is not expected.
Type A packages (cartons, boxes, drums, articles, etc.) identified as "Type A" by marking on packages or by shipping papers contain non-life endangering amounts. Radioactive sources may be released if packages are damaged in moderately severe accidents.
Type B packages (large and small, usually metal) identified as "Type B" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing packages, life endangering releases are not expected in accidents except those of utmost severity.
Commonly available instruments can detect most of these materials.
Water from cargo fire control is not expected to cause pollution.

Fire or Explosion

Packagings can be consumed without content loss from sealed source capsule.
Radioactive source capsules and Type B packages are designed to withstand temperatures of 1475°F (800°C).

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Delay final cleanup until instruction or advice of Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external exposure.

Fire

Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).

Spill or leak

Do not touch damaged packages or spilled material.
Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
If source is identified as being out of package, stay away and await advice from radiation authority.

First aid

Use first aid treatment according to the nature of the injury.
Persons exposed to special form sources are not likely to be contaminated with radioactive material.

GUIDE 65

POTENTIAL HAZARDS

Health Hazards

Radiation presents minimal risk to lives of persons during transportation accidents.
Undamaged packages are safe; damaged packages or released material can cause external radiation exposure; released material entering or contaminating the body can cause internal radiation exposure.
Packages (drums, metal boxes, etc.) identified as "Type A" or "AF" by marking on packages or by shipping papers contain materials that are not life endangering if released. External radiation levels are low and packages are designed, evaluated, and tested to control releases and to prevent fission accidents under severe transport accident conditions.
Packages (metal and usually very heavy) identified as "Type B", "B(U)F", or "B(M)F" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing of packages, fission accidents are prevented and releases are not expected to be life endangering for all accidents except those of utmost severity.
Some radioactive materials cannot be detected by commonly available instruments.
Water from cargo fire control is not expected to cause pollution.

Fire or Explosion

These materials are not flammable and packagings are designed to withstand fires without damage to contents.
Radioactivity does not change flammability or other properties of the materials.
Packages are designed to withstand temperatures of 1475°F (800°C).

EMERGENCY ACTION

Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external exposure.

Fire
Do not move damaged packages; move undamaged packages out of fire zone.
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog (flooding amounts).
Spill or leak
Do not touch damaged packages or spilled material.
Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
Liquid spills: package contents are seldom liquid. If released liquids have radioactive contamination it will be low-level, if any.
First aid
Use first aid treatment according to the nature of the injury.
Persons exposed to fissile radioactive material packages are not expected to be contaminated, unless the packages are badly damaged in utmost severity accidents.

GUIDE 66

POTENTIAL HAZARDS
Health Hazards
Chemical hazard greatly exceeds radiation hazard.
Material reacts with water and water vapor in air to form a poisonous, corrosive vapor and an extremely irritating, white-colored, water-soluble residue.
If inhaled may be fatal.
Contact causes chemical burns to skin, eyes, and respiratory tract.
Radiation presents minimal risk to lives of persons during transportation accidents.
Low-level radioactive materials; very little radiation hazard to people.
Runoff from control of cargo fire may cause low-level pollution.
Fire or Explosion
Containers in protective overpacks (identified as "AF" or "B(U)F" by marking on packages or by shipping papers) are designed to withstand severe accidents and temperatures of 1475°F (800°C).
Bare containers may explode if engulfed in fire; the material may react violently with fuels.
Radioactivity does not change flammability or other properties of the materials.
EMERGENCY ACTION
Priority response actions may be performed before taking radiation measurements.
Priorities are life saving, control of fire and other hazards, and first aid.
Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
Uninjured persons or equipment with suspected contamination should be detained or isolated; delay cleanup until instructions are received from Radiation Authority.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. Structural firefighters' protective clothing will not provide protection from vapors.
Avoid vapors, stay upwind and out of low areas.
Fire
Move container from fire area if you can do it without risk.
Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. If this is impossible, withdraw from area and let fire burn.
Spill or leak
Without fire or smoke, leak will be evident by visible and irritating vapors and residue forming at point of the release.
Use water fine spray to reduce vapors; **do not** put water directly on point of material release from container.
Dike far ahead of spill to collect runoff water.
First aid
Use first aid treatment according to the nature of the injury.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes. Burns may be similar to those from hydrogen fluoride.
If persons have contacted released material, use standard hazmat procedures for care of contaminated persons, for transport of the injured, and for notifications to authorities.

GUIDE 67

POTENTIAL HAZARDS
Health Hazards
Poison; **extremely hazardous.**
Inhalation **extremely dangerous**; may be fatal.
Contact with liquid may cause frostbite.
Initial odor may be irritating, foul or absent and may deaden your sense of smell.
Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or

flames.
Flame may be invisible.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion and poison hazard indoors, outdoors or in sewers.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.

Fire

Let burn unless leak can be stopped immediately.
Small fires: dry chemical, CO_2 or water spray.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Isolate area until gas has dispersed.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of frostbite, thaw frosted parts with water.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 68

POTENTIAL HAZARDS

Fire or Explosion

Flammable/combustible material; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Vapor explosion hazard indoors, outdoors or in sewers.
Runoff to sewer may create fire or explosion hazard.

Health Hazards

Poisonous if swallowed.
May be poisonous if inhaled.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: water spray, fog or regular foam.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material; stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.

Small spills: take up with sand or other noncombustible absorbent material and place into containers for later disposal.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 69

POTENTIAL HAZARDS
Fire or Explosion
Extremely flammable; may be ignited by heat, sparks or flames.
Vapors may travel to a source of ignition and flash back.
Container may explode in heat of fire.
Health Hazards
Poisonous; may be fatal if inhaled.
Vapor **extremely irritating;** contact causes burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is **not** effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
See the Table of Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Fire
Small fires: dry chemical, CO_2, water spray or alcohol-resistant foam.
Large fires: water spray, fog or alcohol-resistant foam.
Let burn unless leak can be stopped immediately.
Move container from fire area if you can do it without risk.
Fight fire from maximum distance. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
Stop leak if you can do it without risk.
Water spray may reduce vapor; but it may not prevent ignition in closed spaces.
Small spills: flush area with flooding amounts of water.
Do not get water inside container.
Large spills: dike liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 70

POTENTIAL HAZARDS
Fire or Explosion
Extremely flammable.
May ignite itself if control temperature is exceeded.
May explode from heat or loss of temperature control.
Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.

Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Loss of cooling

Specified control temperature of material must be maintained. Obtain liquid nitrogen, dry ice or ice for cooling. If none can be obtained, evacuate area.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
If fire can be controlled, cool container with water from unmanned hose or monitor nozzles until well after fire is out.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Spills: moisten material with water and place it into loosely-covered plastic or fiberboard containers for later disposal.

First aid

Move victim to fresh air.
In case of contact with material, immediately flush eyes with running water at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 71

POTENTIAL HAZARDS

Fire or Explosion

May be ignited by heat, sparks or flames.
May burn rapidly.
Container may explode violently in heat of fire.
May explode from friction, heat or contamination.

Health Hazards

Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire.
If fire can be controlled, cool container with water from unmanned hose holder or monitor nozzles until well after fire is out.
If this is impossible, withdraw from area and let fire burn.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Spills: moisten material with water and place it into loosely-covered plastic or fiberboard containers for later disposal.

First aid

Move victim to fresh air.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 72

POTENTIAL HAZARDS

Fire or Explosion

May be ignited by heat, sparks or flames.
Container may explode in heat of fire.

Health Hazards

Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus

(SCBA) and structural firefighters' protective clothing will provide limited protection.
If water pollution occurs, notify the appropriate authorities.
Fire
Small fires: dry chemical, CO_2, water spray or regular foam.
Large fires: flood fire area with water.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Spill or leak
Shut off ignition sources; no flares, smoking or flames in hazard area.
Do not touch or walk through spilled material.
Spills: moisten material with water and place it into loosely-covered plastic or fiberboard containers for later disposal.
First aid
Move victim to fresh air; call emergency medical care.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 73

POTENTIAL HAZARDS
Fire or Explosion
May ignite other combustible materials (wood, paper, oil, etc.).
These materials will accelerate burning when they are involved in a fire; some may react violently with fuels.
Flammable/poisonous gases may accumulate in tanks and hopper cars.
Runoff to sewer may create fire or explosion hazard.
Health Hazards
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
If water pollution occurs, notify the appropriate authorities.
Fire
Some of these materials may react violently with water.
Do not get water inside container.
Small fires: water only; no dry chemical, CO_2 or halon.
Large fires: flood fire area with water.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Spill or leak
Keep combustibles (wood, paper, oil, etc.) away from spilled material.
Fully-encapsulating, vapor-protective clothing should be worn for spills and leaks with no fire.
If you have not donned special protective clothing approved for this material, do not expose yourself to any risk of this material touching you.
Use water spray to reduce vapor; do not get water inside container.
Small spills: flush area with flooding amounts of water.
Large spills: dike far ahead of liquid spill for later disposal.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.
Effects may be delayed; keep victim under observation.

GUIDE 74

POTENTIAL HAZARDS
Health Hazards
Vapors may cause dizziness or suffocation.

Exposure in an enclosed area may be very harmful.
Contact may irritate or burn skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

Fire or Explosion

Some of these materials may burn, but none of them ignites readily.
Most vapors heavier than air.
Air/vapor mixtures **may explode** when ignited.
Container may explode in heat of fire.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
Remove and isolate contaminated clothing at the site.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: dry chemical or CO_2.
Large fires: water spray, fog or regular foam.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.

Spill or leak

Shut off ignition sources; no flares, smoking or flames in hazard area.
Stop leak if you can do it without risk.
Small liquid spills: take up with sand, earth or other noncombustible absorbent material.
Large spills: dike far ahead of liquid spill for later disposal.

First aid

Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush eyes with running water for at least 15 minutes. Wash skin with soap and water.
Remove and isolate contaminated clothing and shoes at the site.
Use first aid treatment according to the nature of the injury.

GUIDE 75

POTENTIAL HAZARDS

Fire or Explosion

Extremely flammable; will ignite itself if exposed to air.
May burn rapidly with flare-burning effect.
Runoff to sewer may create fire or explosion hazard.

Health Hazards

Poisonous; may be fatal if inhaled, swallowed or absorbed through skin.
Contact may cause burns to skin and eyes.
Fire may produce irritating or poisonous gases.
Runoff from fire control or dilution water may cause pollution.

EMERGENCY ACTION

Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind, out of low areas, and ventilate closed spaces before entering.
Positive pressure self-contained breathing apparatus (SCBA) and chemical protective clothing which is specifically recommended by the shipper or manufacturer may be worn. It may provide little or no thermal protection.
Structural firefighters' protective clothing is not effective for these materials.
Isolate the leak or spill area immediately for at least 150 feet in all directions.
Refer to Chapter 7 for Initial Isolation and Protective Action Distances. If you find the ID Number and the name of the material there, begin protective action.
Isolate for ½ mile in all directions if tank, rail car or tank truck is involved in fire.
If water pollution occurs, notify the appropriate authorities.

Fire

Small fires: let burn unless leak can be stopped immediately.
Large fires: withdraw from area and let fire burn.
Move container from fire area if you can do it without risk.
Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

Spill or leak

Do not touch or walk through spilled material; stop leak if you can do it without risk.
Fully-encapsulating, vapor-protective clothing should be

worn for spills and leaks with no fire.
Spills: dike for later disposal; do not apply water unless directed to do so.
Cleanup only under supervision of an expert.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 76

POTENTIAL HAZARDS
Fire or Explosion
Flammable/combustible material; may be ignited by heat, sparks or flames.
May burn rapidly with flare-burning effect.
May ignite in presence of moisture.
Violent reaction with water.
Health Hazards
Fire may produce irritating or poisonous gases.
Contact may cause burns to skin and eyes.
Runoff from fire control or dilution water may cause pollution.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area and deny entry.
Stay upwind; keep out of low areas.
Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide limited protection.
Fire
Use water spray to reduce vapor; do not get water inside container.
Do not use water or foam.
Do not get water inside container.
Small fires: dry chemical, soda ash, lime or sand.
Magnesium fires: use dry sand, sodium chloride powder or graphite powder.
Move container from fire area if you can do it without risk.
For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
Spill or leak
Do not touch or walk through spilled material.
Shut off ignition sources; no flares, smoking or flames in hazard area.
Small dry spills: with clean shovel place material into clean, dry container and cover loosely; move containers from spill area.
No water on spilled material; do not get water inside container.
Spills: dike for later disposal; do not apply water unless directed to do so.
Magnesium spills: cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.
Cleanup only under supervision of an expert.
Move undamaged packages from spill area.
First aid
Move victim to fresh air and call emergency medical care; if not breathing, give artificial respiration; if breathing is difficult, give oxygen.
Wipe material from skin immediately; flush skin or eyes with running water for at least 15 minutes.
Remove and isolate contaminated clothing and shoes at the site.
Keep victim quiet and maintain normal body temperature.

GUIDE 77

POTENTIAL HAZARDS
Fire or Explosion
Material is transported in molten form at a temperature above 1300°F (705°C).
Violent reaction with water; contact may cause an explosion or may produce a flammable gas.
Will ignite combustible materials (wood, paper, oil, debris, etc.).
Contact with nitrates or other oxidizers may cause an explosion.
Contact with containers or other materials, including cold, wet or dirty tool may cause an explosion.
Contact with concrete will cause spalling and small pops.
Health Hazards
Contact causes severe burns to skin and eyes.
Fire may produce irritating or poisonous gases from the materials ignited.
EMERGENCY ACTION
Keep unnecessary people away; isolate hazard area for at least 150 feet in all directions, and deny entry.
Where possible allow molten material to solidify naturally.
Avoid contact even after material solidifies. Molten, heated and cold aluminum look alike; do not touch unless you know it is cold.
Positive pressure self-contained breathing apparatus

(SCBA) and flame-retardant structural firefighters' protective clothing, including face shield, helmet and gloves, will provide limited thermal protection.

Fire

Do not use water, except in life threatening situations and then only in a fine spray.

Do not use halogenated extinguishing agents or foam.

Move combustibles out of path of advancing pool if you can do so without risk.

Extinguish fires started by molten material by using appropriate method for burning material; keep water, halogenated extinguishing agents and foam away from the molten material.

Spill or leak

Do not touch or walk through spilled material.

Do not attempt to stop leak, due to danger of explosion.

Keep combustibles (wood, paper, oil, debris, etc.) away from spilled material.

Material is very fluid, spreads quickly, and may splash. Do not try to stop it with shovels or other objects.

Dike far ahead of spill; use dry sand to contain the flow of material.

Cleanup under the supervision of an expert after material has solidified.

First aid

Move victim to fresh air; call emergency medical care.

In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.

For severe burns, immediate medical attention is required.

Removal of solidified molten material from skin requires medical assistance.

7

ISOLATION DISTANCES FOR FIRES AND SPILLS

I. INTRODUCTION

The spill or leak from a container, storage vessel or any type of transport vehicle of a potentially flammable or even combustible material can pose a serious fire hazard and health risk. In the United States it is the U.S. Department of Transportation's (DOT) responsibility to enforce regulations that ensure that transporters not only follow all safety precautions and meet technical requirements for the safe transport of hazardous materials, but that in the event of an emergency such as a spill or leak, that proper emergency response action is implemented. Additionally, the DOT is in part responsible for enforcing environmental regulations in that it must work along with the environmental regulatory agencies to ensure that both the general public and the environment are not exposed to a hazardous chemical spill and that proper clean up action is implemented.

The U.S. DOT has prepared a guidebook, from which a great deal of the information in earlier chapters has been extracted, for use by firefighters, police, and other emergency services personnel who may be the first to arrive at the scene of a hazardous materials incident. That guidebook, or in fact this publication, can be used to assist first responders in:

- Quickly identifying the specific or generic classification of the material(s) involved in the incident, and
- Protecting themselves and the general public during the initial response phase of the incident.

The *initial response phase* is defined as that period following arrival at the scene of an incident during which the presence and/or identification of a hazardous material is confirmed; protective actions and area securement are initiated; and assistance of qualified personnel is requested.

One organization supported by industry in the United States is the Chemical Transportation Emergency Center or CHEMTREC, which is an emergency information center that can provide technical advice on how best to handle a specific hazard materials incident. In the U.S., the toll free number to contact CHEMTREC is 1-800-424-9300. CHEMTREC is a service of the chemical industry that operates in two stages. First, on receipt of a call providing the name of the chemical, it provides immediate advice on the nature of the material and the steps to be taken in handling the early stages of the incident. Second, CHEMTREC promptly contacts the shipper of the material involved for more detailed information and on the scene assistance when feasible. When contacting CHEMTREC or a similar agency in other parts of the world, the following information should be provided:

- Your name and a call back telephone number
- Location and nature of the incident
- Shipper and/or manufacturer
- Container type
- Rail car or truck number
- Carrier name
- Consignee
- Local conditions

In any spill or leak of a hazardous material, it is essential that first responders immediately identify the product. In the U.S., because there are strict transportation safety regulations, hazardous materials shipments are normally well documented and there is normally sufficient information to identify the product and its dangerous properties. One can identify the material readily by finding any one of the following:

- The 4-digit ID number on the vehicle's placard or orange colored panel

- The 4-digit ID number (after UN or NA) on a shipping paper or package. UN stands for United Nations, signifying that the shipment is allowed internationally. NA stands for North America, indicating that the shipment is only permitted within the continental United States or Canada (often applied to wastes)
- The name of the material on a shipping paper, placard, or package.

A second important way to identify the material in a hazard materials incident is to look up the material's 2-digit Guide Number. Chapter 6 can be consulted for the DOT listing of hazardous chemicals according to their 4-digit UN/NA identification number, along with reference to the emergency response information for first responders. Hence, Chapter 6 can be used to identify the material involved in a spill, and to obtain general safety precautions and emergency action responses.

The hazard class of a material is indicated either by its class (or division) number, or its class name. For a placard corresponding to the primary hazard class of a material, the hazard class or division number must be displayed in the lower corner of the placard. The UN hazard classes are defined in Chapter 1.

With this as an introduction, we turn our attention to the subject of spills and leaks, from an emergency standpoint and with emphasis given to a first responder having the concern over potential fire and explosion. The general approaches and concepts presented in this chapter apply to all hazardous materials for indeed there are potential risks and dangers other than fire such as exposure to toxic or lethal chemicals. The general guidelines to follow in approaching any hazard materials incident can be summarized by the following:

- Approach the scene with caution - Resist the urge to rush in; you cannot help others until you know what you are facing.
- Identify the hazards - Placards, container labels, shipping papers and/or knowledgeable persons on the scene are valuable information sources. Evaluate all of them, and then consult recommended safe response procedures before placing yourself and others at risk.
- Secure the scene - Without entering the immediate hazard area, do what you can to isolate the area and assure the safety of people and the environment. Move and keep people away from the scene and the perimeter of the incident. Allow room enough to move and remove any necessary equipment.
- Call for assistance - Advise your headquarters to notify responsible agencies and call for assistance from qualified personnel.
- Decide on site entry - Any efforts that are made to rescue persons, protect property or the environment must be weighed against the possibility that responders could become part of the problem. Enter the area only when wearing appropriate protective equipment and if you are fully trained and qualified to do so.

II. PREPLANS AND APPROACHING THE SCENE

Preplans for spills or leaks that are not on fire upon the arrival of emergency response forces require that several factors receive attention. The major items to be considered and evaluated include:

- *The type and nature of the product* - Is the material a flammable or a combustible product? An emergency involving a flammable liquid requires that immediate controlling actions be initiated to alleviate the vapor problem. Steps for blanketing, disposal, or otherwise securing the spill area must be taken immediately upon arrival at the scene. Combustible liquids usually can be gathered in a temporary compound and retained until picked up and removed since the higher flash point of these liquids allows this without presenting a significant fire hazard. Regardless of the category of product, all sources of ignition must he prohibited from the vicinity of the spill.

- *The condition and arrangement of any sewer systems within the vicinity of the incident* -If the spill occurs within the grounds of a plant operation, many refineries, bulk storage terminals, and similar chemical and petroleum- handling facilities have sewer systems that are designed and constructed to accommodate the flushing of spilled liquids into them for disposal. Unless similarly constructed, however, a public sewer system could present a serious problem if hazardous chemicals in any quantity enter it. An absolute necessity is that the appropriate local authorities be consulted to ascertain if spills can be safely flushed into sewer inlets.

- *The proximity of waterways* - Every effort should be made to prevent spills from entering local waterways which can result in serious environmental damage and /or endangerment to the public. Recall the properties of water solubility and specific gravity, because these will determine the extent of the problem should a hazardous

liquid spill discharge to a waterway. The lighter-than-water chemical product will float on the water's surface, thus spreading the spill over a larger area, and if highly miscible in water like alcohol, the chemical will disperse creating a costly and difficult clean up problem, not to mention a potentially greater nightmare from an environmental liability standpoint.

- *Atmospheric conditions* - Preplans that take into consideration atmospheric temperatures, wind direction, and velocity can only be general in nature, for example, the direction of the prevailing winds would influence the choice of a preplanned response route. However, at the time of the hazard materials incident, priority would be given to the necessity of approaching the scene from an upwind direction. In summer months, parts of the country may experience daytime temperatures higher than the flash point of certain combustible liquids. Whether a specific liquid is to be treated as a flammable or a combustible might depend upon the hour of the day. This eventually must he taken into account, depending upon the location and magnitude of the spill. Additionally, there are a number of hazardous chemicals that pose serious enough inhalation hazards that initial isolation distances should be defined in approaching the problem.

- *The availability of clean-up equipment* - All spills should be reported to the proper regulatory agency and in the United States, CHEMTREC should be consulted. In the U.S., a spill on land would require notifying the office of the Environmental Protection Agency (EPA). The U.S. Coast Guard should be notified of any spill on water. The various regulations require the owner or operator of the equipment causing the spill to make the notification. Both the EPA and the Coast Guard have the authority under U.S. law to initiate clean-up activities. If the party responsible for causing the spill is unable to do so, or if there is a question concerning responsibility, both these federal agencies are empowered to implement clean-up contingency plans.

If the spill involves a flammable liquid and the possibility of a fire exists, it is the emergency response coordinator's duty and concern to protect the public. Protective hose lines, stand-by equipment, or foam coverage may be needed until the spill-containment team is functioning. For the protection of the community and public, the emergency response force's activities are normally directed toward the following:

- Protection of life and property. This may mean flushing the spill to a safe location or blanketing it with foam or both. On occasion, conditions might dictate evacuation of the civilian population from the area.
- Containment of the spill by the erection of dikes or dams.
- Policing the area to remove all sources of ignition.
- Halting the flow of liquid at its source.

There are a number of chemical dispersants available that, when properly used, will render a liquid incapable of being ignited. These products are a worthwhile method for handling a relatively small spill. The major difficulty when confronted with a spill of a large size is that the various dispersants require a mix ratio of about one part dispersant to one part flammable liquid. It is easy to visualize the logistics involved if the decision was made to use a material of this type to attempt to save a spill from a severely ruptured 7000-gallon tank truck. If dispersants are considered, the mix ratio and then the method of application should be investigated.

In contrast to a non-fire spill, spill fires can be more serious and require coordination not only of fire fighting forces, but evacuation of local communities. The identical quantities of liquid can be involved in either event. The spill, however, has the potential for covering much more area. When encountering flowing or pooled petroleum and other chemical liquids in a fire situation, the factors previously identified for spills not on fire must be evaluated. A basic consideration, after safety, is the protection of exposures. The immediate application of water for cooling purposes will be the initial activity. A second method by which the needed protection might be accomplished is the use of hose streams to drive the burning liquid into a field or other open area. Presumably, the area selected is one where the liquid can burn harmlessly until consumed or extinguished. Flushing the burning liquid away from exposures usually means that the total water requirements for control will be less.

The decision to allow the fire to consume all fuel present will be influenced by three factors. First is: "What category of liquid is involved?" A flammable liquid, if extinguished, will present the likelihood of a hazardous vapor condition developing. Vapor clouds can be more difficult to control than a fire. The second factor to consider is the surrounding area. Will the plume of thick, black smoke interfere with the safety of the community? Are schools or a hospital downwind that might need evacuation? The third point to consider would be the

volume of product present versus the resources available. Can control be retained while the product continues to burn for many hours? Conversely, if extinguished, is the capability of control obtainable until the liquid is eliminated?

Spills or leaks within fixed facilities can be preplanned more readily than for an incident occurring while products are in transit. The terrain, the product, the volume, and the type of extinguishing agent can all be determined with reasonable accuracy. When preplanning for a rail car or tank car emergencies, those considerations cannot be predetermined as easily. The main reason for this is because the exact location is not known until the event happens. Without this information, the preplan can only be prepared in anticipation of the worst-case situation. In any event however, plans should be flexible enough to accommodate both a 100-gallon spill fire and a 10,000-gallon one. The type of chemical handling facilities within a fire district will determine the maximum spill potential. Some basic considerations include:

- If the potential is from a bulk storage plant, what is the capacity of the tanks? Are the critical block valves known to all employees? If the potential is an underground pipeline, what size is it? Are the telephone numbers of the pumping stations readily available?
- If the potential is a truck loading rack, is it manned around-the- clock? If not, who must be notified? How many trucks can load simultaneously?
- If the potential hazard is from tank trucks or rail cars, are fire department personnel trained in the operation of shut-off devices?

Special items included in the plan would be provisions for quantities or foam and proportioning and dispensing equipment. Spills do not cover a nice well-defined area. Instead, the liquid follows the contours of the ground. To provide maximum maneuverability to counter this tendency, foam nozzles of 100 to 200 gal/min with in-line proportioners would be advantageous. A selection of hard rubber or wooden plugs suitable for the plugging of small leaks should also be on hand. A source which can be depended upon any hour of the day or night, for shovels, sand, and bags for building dams or dikes will prove worthwhile.

III. INITIAL ISOLATION AND PROTECTIVE ACTION DISTANCES

This section provides a table (Table 1) on initial isolation and protective action distances recommended by the United States Department of Transportation for high hazard chemicals that could be spilled or leak. The table provides the information for small and large spills in a non-fire situation. What distinguishes between large and small spills is a matter of judgement and experience on the part of the first responder, and is closely related to how dangerous the chemical is. As a rough rule of thumb, a small spill is one which involves a single, small package (i.e., up to a 55 gallon drum), small cylinder, or a small leak from a large package. A large spill is one which involves a spill from a large package, or multiple spills from many small packages. For each size category of spill, guidelines are given for an initial isolation distance in all directions from the spill, and a protection distance downwind from the spill for both day and night conditions. The time of day for the incident is important because meteorological conditions will change thus effecting wind patterns and strength.

To use the information in Table 1, we must first identify the material that has spilled. This can be readily done from the 4-digit UN shipping number designation. If the chemical name is only known, refer to the table of hazardous chemicals in Chapter 6 which is an alphabetical listing of high hazard chemicals. If the chemical you look up in the Chapter 6 table is highlighted (boldface lettering), then it has a recommended isolation distance. Obtain the 4-digit ID number, and then locate the chemical in Table 1 in this chapter. After identifying the product, look up the initial isolation distance. Use this guideline to direct all persons to move, in an upwind or crosswind direction, away from the spill to the specified distance - in feet.

Next, look up the initial **Protective Action Distance** given in Table 1. For a given hazardous material, spill size, and whether day or night, the table provides the distance - in miles - downwind for which protective actions should be considered. The *Protective Action Zone* is defined as the area in which people are at risk of harmful exposure. From a practical standpoint, we define this by the configuration of a square, whose length and width are the same as the downwind distance shown in the table. This definition is illustrated in Figure 1.

Protective actions should be initiated to the extent furthest possible, beginning with those closest to the spill site and working away from the site in the downwind direction. Again, the shape of the area in which protective actions should be taken (the Protective Action Zone) is illustrated in Figure 1. In this figure, the spill is located at the center of the small circle. The larger circle represents the initial isolation zone around the spill.

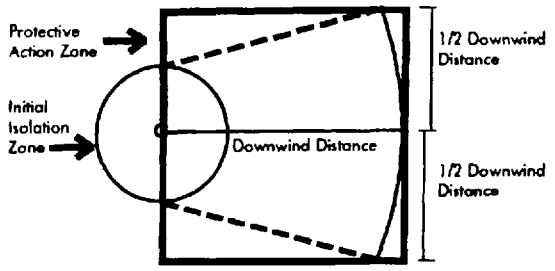

Figure 1. Illustrates protective action and initial isolation zones.

The basis for the protective action distances given in Table 1 is based on analysis using state-of-the-art source term and vapor cloud dispersion modeling, probabilistic application of actual atmospheric data, and information on toxicological exposure guidelines for each chemical.

Source term modeling considered three factors - (1) DOT package sizes authorized to transport each hazardous material, (2) spill rates from damage to each package, and (3) release of vapors by evaporation from a liquid pool, direct release or gaseous vapors from a package into the atmosphere, or a combination of both. Liquid pool evaporation rates were calculated assuming a sunny, 35°C (95°F) day. Analysis of small and large spills is as follows: A leaking package of 55 gallons or less (such as a drum, jerrican, or box with inner containers) is considered a "small spill." Larger packages leaking less than 55 gallons and compressed gas leaking from a small cylinder are also considered small spills. A large spill involves many smaller leaking packages or a leaking package greater than 55 gallons (such as a cargo tank, portable tank, or "one-ton" compressed gas cylinder).

Dispersion models calculated downwind vapor concentrations based on actual, 24-hour, groundlevel and upper-air meteorological data from 61 cities (including one each in Alaska and Hawaii) over a 5-year period. The models approximated atmospheric conditions at over 40,000 U.S. hypothetical incident sites derived from truck-fatal accident locations in the same 5-year period. A sensitivity study indicated heavy gas effects on vapor plume dispersion were minimal for the incident release sizes considered when compared to uncertainty in other input parameters. Data also showed nighttime atmospheric conditions generally transported vapor plumes much greater distances than daytime conditions, therefore, daytime and nighttime protective action guidance is provided to more accurately describe risk. Specific local daytime hours are a function of the season, geographic latitude, and use of daylight savings time, however, for Table 1 a "Day" incident should be considered as occurring anytime after sunrise and before sunset, while "Night" includes all hours between sunset and sunrise.

Toxicological short-term exposure guidelines for the materials were applied to vapor concentrations to determine how far downwind the public is in danger. An independent panel of toxicological experts from industry and academia recommended that toxicological exposure guidelines be chosen from emergency response guidelines, occupational health guidelines (TLV, PEL, REL, WEEL, etc.), and lethal concentrations determined from animal studies (LC_{50}). Specific means of application of these health criteria and adjustments based on time-of-exposure were made when recommended by the panel of experts.

Following this analysis, the resulting protective action distances were ordered from the 100th to the 0th percentile (largest protective action distance to the smallest) for both daytime and nighttime scenarios. The distances appearing in Table 1 provides guidance describing the 90th percentile incident. This means that for a specific material analyzed at the incident locations mentioned above, 90 percent required protective actions less than the table indicates, while 10 percent required larger distances.

The Protective Action Zone assumes random changes in wind direction confining the vapor plume to an area within 30 degrees on either side of the predominant wind direction; resulting in a crosswind protective action distance equal to the downwind protective action distance. Within the protective action zone a level of vapor concentration may exist resulting in nearly all unprotected persons becoming incapacitated and unable to take protective action and/or incurring serious or irreversible health effects . The Initial Isolation Zone is determined as an area, including upwind from the incident, within which a high probability of localized wind reversal could potentially expose nearly all persons without appropriate protection to life threatening concentrations of the released material.

Table 1. Initial Isolation and Protection Action Distances

ID#	NAME OF MATERIAL	SMALL SPILLS (For a small package or small leak from a large package)			LARGE SPILLS (For a large package or from many small packages)		
		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1005	AMMONIA	500	0.1	0.6	500	0.3	2.2
1005	AMMONIA, ANHYDROUS, liquefied	500	0.1	0.6	500	0.3	2.2
1005	AMMONIA SOLUTIONS with more than 50% ammonia	500	0.1	0.6	500	0.3	2.2
1005	ANHYDROUS AMMONIA	500	0.1	0.6	500	0.3	2.2
1008	BORON TRIFLUORIDE	500	0.3	2.0	500	0.8	2.9
1016	CARBON MONOXIDE	500	0.3	2.0	500	0.7	2.8
1017	CHLORINE	500	0.7	2.8	1500	2.4	4.6
1023	COAL GAS	500	0.1	1.2	500	0.7	2.8
1026	CYANOGEN	500	0.1	1.1	500	0.7	2.8
1026	CYANOGEN, liquefied	500	0.1	1.1	500	0.7	2.8
1026	CYANOGEN GAS	500	0.1	1.1	500	0.7	2.8
1040	ETHYLENE OXIDE	500	0.1	0.9	500	0.2	1.5
1040	ETHYLENE OXIDE with nitrogen	500	0.1	0.9	500	0.2	1.5
1045	FLUORINE, compressed	1000	1.7	3.8	1500	3.9	6.5
1048	HYDROGEN BROMIDE, anhydrous	500	0.1	0.7	500	0.3	2.2
1050	HYDROCHLORIC ACID, anhydrous	500	0.3	1.9	1000	1.1	3.2
1050	HYDROGEN CHLORIDE, anhydrous	500	0.3	1.9	1000	1.1	3.2
1051	HYDROCYANIC ACID	500	0.2	1.4	500	0.3	2.2
1051	HYDROGEN CYANIDE, anhydrous, stabilized	500	0.2	1.4	500	0.3	2.2
1051	HYDROGEN CYANIDE, stabilized, containing less than 3% water	500	0.2	1.4	500	0.3	2.2
1052	HYDROFLUORIC ACID, anhydrous	500	0.1	0.5	500	0.3	2.2
1052	HYDROGEN FLUORIDE, anhydrous	500	0.1	0.5	500	0.3	2.2
1053	HYDROGEN SULFIDE	500	0.2	1.8	1000	1.3	3.4
1053	HYDROGEN SULFIDE, liquefied	500	0.2	1.8	1000	1.3	3.4
1062	METHYL BROMIDE	500	0.1	0.4	500	0.3	2.1
1064	METHYL MERCAPTAN	500	0.1	0.4	500	0.3	2.0
1067	DINITROGEN TETROXIDE, liquefied	500	0.1	0.4	500	0.7	2.8
1067	NITROGEN DIOXIDE, liquefied	500	0.1	0.4	500	0.7	2.8
1067	NITROGEN PEROXIDE	500	0.1	0.4	500	0.7	2.8
1067	NITROGEN TETROXIDE	500	0.1	0.4	500	0.7	2.8
1069	NITROSYL CHLORIDE	500	0.3	2.1	1000	1.8	3.9
1071	OIL GAS	500	0.3	2.1	1500	2.2	4.3
1076	PHOSGENE	500	0.6	2.6	1500	3.2	5.5
1079	SULFUR DIOXIDE	500	0.5	2.5	1500	2.0	4.1
1079	SULFUR DIOXIDE, liquefied	500	0.5	2.5	1500	2.0	4.1
1082	TRIFLUOROCHLOROETHYLENE	500	0.1	0.4	500	0.3	2.1
1082	TRIFLUOROCHLOROETHYLENE, inhibited	500	0.1	0.4	500	0.3	2.1
1092	ACROLEIN, inhibited	500	1.0	3.1	1000	1.8	3.9
1098	ALLYL ALCOHOL	500	0.1	0.8	500	0.3	2.2
1135	ETHYLENE CHLOROHYDRIN	500	0.1	0.5	500	0.1	1.0
1143	CROTONALDEHYDE, inhibited	500	0.1	0.1	500	0.1	0.6

Table 1 Continued

ID#	NAME OF MATERIAL	SMALL SPILLS (For a small package or small leak from a large package)			LARGE SPILLS (For a large package or from many small packages)		
		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1185	ETHYLENEIMINE, inhibited	500	0.5	2.5	500	0.7	2.8
1238	METHYL CHLOROCARBONATE	500	0.2	1.4	500	0.2	1.8
1238	METHYL CHLOROFORMATE	500	0.2	1.4	500	0.2	1.8
1239	METHYL CHLOROMETHYLETHER	500	0.1	1.1	500	0.3	2.1
1244	METHYLHYDRAZINE	500	0.8	3.0	1500	3.1	5.3
1251	METHYL VINYL KETONE	1000	1.3	3.4	1500	2.0	4.1
1259	NICKEL CARBONYL	1500	2.1	4.2	1500	4.4	7.0+
1380	PENTABORANE	1000	1.2	3.3	1500	3.3	5.0
1510	TETRANITROMETHANE	500	0.1	0.1	500	0.1	0.9
1541	ACETONE CYANOHYDRIN, stabilized	500	0.1	0.1	500	0.1	0.5
1545	ALLYL ISOTHIOCYANATE, inhibited	500	0.1	0.1	500	0.1	0.2
1545	ALLYL ISOTHIOCYANATE, stabilized	500	0.1	0.1	500	0.1	0.2
1556	METHYLDICHLOROARSINE	500	0.2	1.9	1000	1.0	3.2
1560	ARSENIC CHLORIDE	1500	2.9	5.1	1500	3.5	5.8
1560	ARSENIC TRICHLORIDE	1500	2.9	5.1	1500	3.5	5.8
1569	BROMOACETONE	500	0.1	1.4	1000	1.4	3.5
1580	CHLOROPICRIN	500	0.5	2.6	500	0.8	2.9
1581	CHLOROPICRIN and METHYL BROMIDE MIXTURES	500	0.5	2.6	500	0.8	2.9
1581	METHYL BROMIDE and CHLOROPICRIN MIXTURES	500	0.5	2.6	500	08	2.9
1582	CHLOROPICRIN and METHYL CHLORIDE MIXTURES	500	0.5	2.6	500	0.8	2.9
1582	METHYL CHLORIDE and CHLOROPICRIN MIXTURES	500	0.5	2.6	500	0.8	2.9
1583	CHLOROPICRIN MIXTURES, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.5	2.6	500	0.8	2.9
1589	CYANOGEN CHLORIDE, inhibited	500	0.5	2.4	500	0.9	3.1
1595	DIMETHYL SULFATE	500	0.1	0.2	500	0.1	0.4
1595	METHYL SULFATE	500	0.1	0.2	500	0.1	0.4
1605	1,2-DIBROMOETHANE	500	0.1	0.2	500	0.1	0.2
1605	ETHYLENE DIBROMIDE	500	0.1	0.2	500	0.1	0.2
1612	HEXAETHYL TETRAPHOSPHATE and COMPRESSED GAS MIXTURES	500	0.6	2.6	1500	3.2	5.5
1613	HYDROCYANIC ACID, aqueous solution, with not more than 20% hydrogen cyanide (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.4	500	0.3	2.2
1613	HYDROGEN CYANIDE, aqueous solution, with not more 20% hydrogen cyanide (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.4	500	0.3	2.2
1614	HYDROGEN CYANIDE anhydrous, stabilized (absorbed)	500	0.2	1.4	500	0.3	2.2
1614	HYDROGEN CYANIDE, stabilized, containing less than 3% water (absorbed in a porous inert material)	500	0.2	1.4	500	0.3	2.2
1647	METHYL BROMIDE and ETHYLENE DIBROMIDE MIXTURES, liquid	500	0.1	0.4	500	0.3	2.1
1660	NITRIC OXIDE	500	0.1	0.1	500	0.3	1.9
1670	PERCHLOROMETHYL MERCAPTAN	500	0.1	1.0	500	0.1	1.4
1672	PHENYLCARBYLAMINE CHLORIDE	500	0.2	1.9	1500	3.2	5.4
1695	CHLOROACETONE, stabilized	500	0.1	0.1	500	0.1	0.3

Table 1 Continued

ID#	NAME OF MATERIAL	SMALL SPILLS (For a small package or small leak from a large package)			LARGE SPILLS (For a large package or from many small packages)		
		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1695	MONOCHLOROACETONE, inhibited	500	0.1	0.1	500	0.1	0.3
1695	MONOCHLOROACETONE, stabilized	500	0.1	0.1	500	0.1	0.3
1703	TETRAETHYL DITHIOPYROPHOSPHATE and compressed gas mixture	500	0.6	2.6	1500	3.2	5.5
1703	TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 more than 200 ppm but not more than 5000 ppm)	500	0.6	2.6	1500	3.2	5.5
1703	TETRAETHYL DITHIOPYROPHOSPHATE and gases, mixtures, or in solution (LC50 not more than 200 ppm)	500	0.6	2.6	1500	3.2	5.5
1705	TETRAETHYL PYROPHOSPHATE and compressed gas mixture	500	0.6	2.6	1500	3.2	5.5
1705	TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 more than 200 ppm but not more than 5000 ppm)	500	0.6	2.6	1500	3.2	5.5
1705	TETRAETHYL PYROPHOSPHATE and compressed gas mixtures (LC50 not more than 200 ppm)	500	0.6	2.6	1500	3.2	5.5
1722	ALLYL CHLOROCARBONATE	500	0.1	1.3	500	0.2	1.6
1722	ALLYL CHLOROFORMATE	500	0.1	1.3	500	0.2	1.6
1741	BORON TRICHLORIDE	500	0.1	0.1	500	0.1	1.1
1744	BROMINE	500	0.7	2.8	1000	1.1	3.2
1744	BROMINE SOLUTIONS (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.6	500	0.3	1.9
1745	BROMINE PENTAFLUORIDE	500	0.7	2.8	1500	2.3	4.4
1746	BROMINE TRIFLUORIDE	500	0.1	1.2	500	0.1	1.4
1749	CHLORINE TRIFLUORIDE	500	0.2	1.9	1000	1.7	3.8
1752	CHLOROACETYL CHLORIDE	500	0.2	1.9	500	0.3	2.1
1754	CHLOROSULFONIC ACID	500	0.1	0.2	500	0.1	1.2
1754	CHLOROSULFONIC ACID and SULFUR TRIOXIDE MIXTURE	500	0.1	0.2	500	0.1	1.2
1809	CHLORIDE OF PHOSPHORUS	500	0.5	2.5	500	0.8	2.9
1809	PHOSPHORUS TRICHLORIDE	500	0.5	2.5	500	0.8	2.9
1810	PHOSPHORUS OXYCHLORIDE	500	0.4	2.3	500	0.6	2.6
1810	PHOSPHORYL CHLORIDE	500	0.4	2.3	500	0.6	2.6
1828	CHLORIDE OF SULFUR	500	0.1	0.1	500	0.1	0.5
1828	SULFUR CHLORIDES	500	0.1	0.1	500	0.1	0.5
1829	SULFURIC ANHYDRIDE	500	0.1	0.5	500	0.3	1.9
1829	SULFUR TRIOXIDE	500	0.1	0.5	500	0.3	1.9
1829	SULFUR TRIOXIDE, inhibited	500	0.1	0.5	500	0.3	1.9
1829	SULFUR TRIOXIDE, uninhibited	500	0.1	0.5	500	0.3	1.9
1831	OLEUM, with not less than 30% free sulfur trioxide	500	0.1	0.1	500	0.1	0.2
1831	SULFURIC ACID, fuming, with not less than 30% free sulfur trioxide	500	0.1	0.1	500	0.1	0.2
1834	SULFURYL CHLORIDE	500	0.2	1.8	500	0.3	2.1
1838	TITANIUM TETRACHLORIDE	500	0.1	0.9	500	0.1	1.3
1859	SILICON TETRAFLUORIDE	1500	2.0	4.1	1500	4.3	6.9
1892	ETHYLDICHLOROARSINE	500	0.1	0.2	500	0.1	1.4
1911	DIBORANE	1000	2.0	4.1	1500	4.3	6.9
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	6.9
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6

Table 1 Continued

ID#	NAME OF MATERIAL	SMALL SPILLS (For a small package or small leak from a large package)			LARGE SPILLS (For a large package or from many small packages)		
		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone C)	500	0.2	1.7	1000	1.7	3.8
1953	COMPRESSED GAS, toxic, flammable, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1953	COMPRESSED GASES, flammable, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	6.9
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	6.9
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1953	COMPRESSED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1953	LIQUEFIED GASES, flammable, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	7.0+
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1953	LIQUEFIED GASES, flammable, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1955	CHLOROPICRIN and NON-FLAMMABLE COMPRESSED GAS MIXTURE	500	0.5	2.6	500	0.8	2.9
1955	COMPRESSED GASES, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	6.9
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	6.9
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1955	COMPRESSED GASES, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1955	LIQUEFIED GASES, poisonous, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone A)	1000	1.0	3.2	1500	5.9	7.0+
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone B)	500	0.8	2.9	1500	2.4	4.6
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone C)	500	0.3	2.1	1500	2.2	4.3
1955	LIQUEFIED GASES, toxic, n.o.s. (Inhalation Hazard Zone D)	500	0.2	1.7	1000	1.7	3.8
1955	METHYL BROMIDE and NON-FLAMMABLE COMPRESSED GAS MIXTURE	500	0.1	0.4	500	0.3	2.1
1955	ORGANIC PHOSPHATE, mixed with COMPRESSED GAS	500	0.6	2.6	1500	3.2	5.5
1955	ORGANIC PHOSPHATE COMPOUND, mixed with COMPRESSED GAS	500	0.6	2.6	1500	3.2	5.5
1955	ORGANIC PHOSPHORUS COMPOUND, mixed with COMPRESSED GAS	500	0.6	2.6	1500	3.2	5.5
1967	INSECTICIDE GASES, toxic, n.o.s.	500	0.1	0.6	1000	1.0	3.2
1967	METHYL PARATHION and COMPRESSED GAS MIXTURE	500	0.1	0.6	1000	1.0	3.2
1967	PARATHION and COMPRESSED GAS MIXTURE	500	0.1	0.1	1000	1.0	3.2
1975	NITRIC OXIDE and DINITROGEN TETROXIDE MIXTURES	500	0.1	0.1	500	0.3	1.9
1975	NITRIC OXIDE and NITROGEN DIOXIDE MIXTURES	500	0.1	0.1	500	0.3	1.9
1975	NITRIC OXIDE and NITROGEN TETROXIDE MIXTURES	500	0.1	0.1	500	0.3	1.9
1994	IRON PENTACARBONYL	500	0.1	1.3	1000	1.4	3.5
2032	NITRIC ACID, fuming	500	0.1	1.2	500	0.2	1.6
2032	NITRIC ACID, red fuming	500	0.1	1.2	500	0.2	1.6

Table 1 Continued

ID#	NAME OF MATERIAL	SMALL SPILLS (For a small package or small leak from a large package)			LARGE SPILLS (For a large package or from many small packages)		
		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
2186	HYDROGEN CHLORIDE, refrigerated liquid (cryogenic liquid)	500	0.3	1.9	1000	1.1	3.2
2188	ARSINE	1500	2.5	4.7	1500	7.0+	7.0+
2189	DICHLOROSILANE	500	0.1	0.3	500	0.3	2.2
2190	OXYGEN DIFLUORIDE	1500	4.2	7.0+	1500	7.0+	7.0+
2191	SULFURYL FLUORIDE	500	0.2	1.7	1000	1.7	3.8
2192	GERMANE (germanium hydride)	1000	1.9	4.0	1500	5.3	7.0+
2194	SELENIUM HEXAFLUORIDE	1500	2.8	5.0	1500	5.4	7.0+
2195	TELLURIUM HEXAFLUORIDE	500	0.3	2.1	1500	3.6	6.1
2196	TUNGSTEN HEXAFLUORIDE	500	0.2	1.4	500	0.5	2.5
2197	HYDROGEN IODIDE, anhydrous	500	0.1	0.4	500	0.3	2.0
2198	PHOSPHORUS PENTAFLUORIDE	1000	1.6	3.7	1500	3.8	6.2
2199	PHOSPHINE	1500	2.0	4.1	1500	4.1	6.7
2202	HYDROGEN SELENIDE, anhydrous	1500	2.6	4.8	1500	6.7	7.0+
2204	CARBONYL SULFIDE	500	0.1	1.2	500	0.7	2.8
2232	CHLOROACETALDEHYDE	500	0.1	0.3	500	0.2	1.6
2232	2-CHLOROETHANAL	500	0.1	0.3	500	0.2	1.6
2334	ALLYLAMINE	500	0.1	1.1	500	0.2	1.6
2337	PHENYL MERCAPTAN	500	0.1	0.1	500	0.1	0.2
2382	DIMETHYLHYDRAZINE, symmetrical	500	0.1	0.2	500	0.2	1.4
2407	ISOPROPYL CHLOROFORMATE	500	0.1	0.1	500	0.1	0.5
2417	CARBONYL FLUORIDE	500	0.6	2.7	1500	2.4	4.6
2418	SULFUR TETRAFLUORIDE	1000	1.4	3.5	1500	4.9	7.0+
2420	HEXAFLUOROACETONE	500	0.8	2.9	1500	4.3	6.9
2421	NITROGEN TRIOXIDE	500	0.9	3.1	1500	4.4	6.9
2438	TRIMETHYLACETYL CHLORIDE	500	0.1	0.1	500	0.3	2.0
2442	TRICHLOROACETYL CHLORIDE	500	0.1	0.9	500	0.1	1.3
2474	THIOPHOSGENE	1000	1.6	3.6	1500	2.2	4.3
2477	METHYL ISOTHIOCYANATE	500	0.1	0.2	500	0.3	2.1
2480	METHYL ISOCYANATE	1000	1.2	3.3	1500	3.5	5.9
2481	ETHYL ISOCYANATE	500	0.2	1.9	1500	3.2	5.4
2482	n-PROPYL ISOCYANATE	500	0.1	0.2	500	0.1	1.3
2483	ISOPROPYL ISOCYANATE	500	0.2	1.9	1500	3.2	5.4
2484	tert-BUTYL ISOCYANATE	500	0.1	0.4	500	0.2	1.8
2485	n-BUTYL ISOCYANATE	1000	1.0	3.2	1000	1.8	3.9
2486	ISOBUTYL ISOCYANATE	1000	1.2	3.3	1500	3.5	5.9
2487	PHENYL ISOCYANATE	500	0.1	0.1	500	0.1	0.8
2488	CYCLOHEXYL ISOCYANATE	500	0.1	0.6	500	0.1	1.3
2521	DIKETENE	500	0.1	0.1	500	0.1	0.7
2534	METHYLCHLOROSILANE	500	0.2	1.6	500	0.3	2.1
2548	CHLORINE PENTAFLUORIDE	500	0.3	1.9	1500	2.6	4.8
2600	CARBON MONOXIDE and HYDROGEN MIXTURE	500	0.3	2.0	500	0.7	2.8

Table 1 Continued

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		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
2605	METHOXYMETHYL ISOCYANATE	500	0.2	1.9	1500	3.2	5.4
2606	METHYL ORTHOSILICATE	500	0.1	0.1	500	0.1	0.8
2644	METHYL IODIDE	500	0.1	0.1	500	0.1	1.1
2646	HEXACHLOROCYCLOPENTADIENE	500	0.1	0.5	500	0.1	0.8
2668	CHLOROACETONITRILE	500	0.1	0.1	500	0.1	0.4
2676	STIBINE	500	0.5	2.5	1500	2.1	4.2
2692	BORON TRIBROMIDE	500	0.1	1.0.5	500	0.1	0.7
2740	n-PROPYL CHLOROFORMATE	500	0.1	0.1	500	0,1	0.4
2742	sec-BUTYL CHLOROFORMATE	500	0.1	0.2	500	0.3	2.2
2742	ISOBUTYL CHLOROFORMATE	500	0.1	1.3	1000	2.0	4.1
2743	n-BUTYL CHLOROFORMATE	500	0.1	1.3	1000	2.0	4.1
2810	POISONOUS LIQUIDS, n.o.s. (Inhalation Hazard Zone A)	1500	2.1	4.2	1500	4.4	6.9
2810	POISONOUS LIQUIDS, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
2810	TOXIC LIQUID, organic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.5	2.5	1500	4.4	6.9
2826	ETHYL CHLOROTHIOFORMATE	500	0.1	0.1	500	0.1	0.2
2845	ETHYL PHOSPHOROUS DICHLORIDE, anhydrous	500	0.1	1.4	1500	2.1	4.2
2845	METHYL PHOSPHONOUS DICHLORIDE	500	0.1	1.4	1500	2.1	4.2
2901	BROMINE CHLORIDE	500	0.1	0.2	500	0.4	2.3
2927	ETHYL PHOSPHONOTHIOIC DICHLORIDE, anhydrous	500	0.1	1.4	1500	2.1	4.2
2927	ETHYL PHOSPHORODICHLORIDATE	500	0.3	2.2	500	0.6	2.7
2927	POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
2927	POISONOUS LIQUIDS, corrosive, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
2927	TOXIC LIQUID, corrosive, organic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.5	2.5	1500	4.4	6.9
2929	POISONOUS LIQUIDS, flammable, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
2929	POISONOUS LIQUIDS, flammable, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
2929	TOXIC LIQUID, flammable, organic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3023	tert-OCTYL MERCAPTAN	500	0.1	0.3	500	0.1	0.6
3057	TRIFLUOROACETYL CHLORIDE	500	0.1	0.2	500	0.3	2.2
3079	METHACRYLONITRILE, inhibited	500	0.1	0.2	500	0.2	1.5
3083	PERCHLORYL FLUORIDE	500	0.3	2.1	1500	2.2	4.3
3122	POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
3122	POISONOUS LIQUIDS, oxidizing, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
3122	TOXIC LIQUID, oxidizing, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3123	POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s. (Inhalation Hazard Zone A)	1000	1.2	3.3	1500	3.5	5.9
3123	POISONOUS LIQUIDS, which in contact with water emit FLAMMABLE GASES, n.o.s. (Inhalation Hazard Zone B)	500	0.1	1.3	1000	2.0	4.1
3123	TOXIC LIQUID, water-reactive, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3160	LIQUEFIED GAS, toxic, flammable, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+

Table 1 Continued

ID#	NAME OF MATERIAL	SMALL SPILLS (For a small package or small leak from a large package)			LARGE SPILLS (For a large package or from many small packages)		
		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND		First ISOLATE in all direction (Feet)	Then, PROTECT persons DOWNWIND	
			DAY (Miles)	NIGHT (Miles)		DAY (Miles)	NIGHT (Miles)
3162	LIQUEFIED GAS, toxic, n.o.s.	1000	1.0	3.2	1500	5.9	7.0+
3246	METHANESULFONYL CHLORIDE	500	0.1	0.2	500	0.1	1.3
3275	NITRILES, toxic, flammable, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3279	ORGANOPHOSPHORUS COMPOUND, toxic, flammable, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3289	TOXIC LIQUID, corrosive, inorganic, n.o.s. (When "Inhalation Hazard" is on a package or shipping paper.)	1000	1.2	3.3	1500	3.5	5.9
3294	HYDROGEN CYANIDE, solution in alcohol with not more than 45% hydrogen cyanide (When "Inhalation Hazard" is on a package or shipping paper.)	500	0.2	1.4	500	0.3	2.2
3300	ETHYLENE OXIDE and CARBON DIOXIDE MIXTURE, with more than 87% ethylene oxide	500	0.1	0.9	500	0.2	1.5
9192	FLUORINE, refrigerated liquid (cryogenic liquid)	1000	1.7	3.8	1500	3.9	6.5
9202	CARBON MONOXIDE, refrigerated liquid (cryogenic liquid)	500	0.3	2.0	500	0.7	2.8
9206	METHYL PHOSPHONIC DICHLORIDE	500	0.1	0.7	1000	1.2	3.3
9263	CHLOROPIVALOYL CHLORIDE	500	0.1	0.3	500	0.5	2.6
9264	3,5-DICHLORO-2,4,6-TRIFLUOROPYRIDINE	500	0.1	0.7	1000	1.3	3.4

IV. FINAL COMMENTS ON FIRE AND SPILL CONTROL

A. Fire Control

Water is the most common and generally most available fire extinguishing agent. Exercise caution in selecting a fire extinguishing method since there are many factors to be considered in any individual case. Water may be ineffective in fighting fires involving some materials; much depends on the method of application. Chapter 4 should be consulted for the fire characteristics and behavior of specific chemicals.

Spill fires involving flammable liquids are generally controlled by applying a firefighting foam to the surface of the burning material. Fighting flammable liquid fires requires foam concentrate which is chemically compatible with the burning material, correct mixing of the foam concentrate with water and air, and careful application and maintenance of the foam blanket. There are two general types of firefighting foam: "regular" and "alcohol-resistant." Examples of "regular" foam are "protein-base," "fluoroprotein," and aqueous film forming foam (AFFF). Some flammable liquids, including many petroleum products, can be controlled by applying "regular" foam. Other flammable liquids, including polar solvents such as alcohols and ketones, have different chemical properties. A fire involving these materials cannot be controlled with "regular" foam and requires application of alcohol-resistant type foam. Polar-solvent (flammable liquids which are water soluble) fires may be difficult to control and require a higher foam application rate than other flammable liquid fires (see NFPA/ANSI Standards 11 and 11A for further information). "Regular" foam is recommended for the materials covered by Guide 27, alcohol-resistant foam is recommended for the materials covered by Guide 26 (refer to Guides in Chapter 6). Although it is impossible to make specific recommendations for flammable liquids which have subsidiary corrosive or poison hazards, alcohol-resistant foam may be effective for many of these materials. The emergency response telephone number on the shipping document, or CHEMTREC (1-800-424-9300), should be contacted as soon as possible for guidance on the proper extinguishing agent to use. The final selection of an agent and method depends on many factors such as incident location, exposure hazards, size of the fire, environmental concerns, as well as the availability of extinguishing agents and equipment at the scene.

B. Water Reactive Materials

Water is sometimes used to flush spills and to reduce or direct vapors in spill situations. Some chemicals can react

violently or even explosively with water. In these cases, consider letting the fire burn or leaving the spill alone until technical advice can be obtained. The applicable guides clearly warn of these potentially dangerous reactions. These materials require technical advice since

(1) water getting inside a ruptured or leaking container may cause an explosion.
(2) water may be needed to cool adjoining containers to prevent their rupturing (exploding) or further spread of the fires;
(3) water may be effective in mitigating an incident involving a water-reactive material only if it can be applied at a sufficient "flooding" rate for an extended period; and
(4) the products from the reaction with water may be more toxic, corrosive, or otherwise more undesirable than the product of the fire without water applied.

Chemical specific information on fire properties and chemical reactivity are provided in Chapter 4 for a number of chemicals.

When responding to an incident involving water-reactive chemicals, take into account the existing conditions such as wind, precipitation, location and accessibility to the incident, as well as the availability of the agents to control the fire or spill. Because of the great number of variables, the decision to use water on fires or spills involving water-reactive materials should be made by an authoritative source.

C. Vapor Control

Limiting the amount of vapor released from a pool of flammable or corrosive liquids is an operational concern. This technique requires the use of proper protective clothing, specialized equipment, appropriate chemical agents, and skilled personnel. Before engaging in vapor control, get advice from an authoritative source as to the proper tactics.

There are several ways to minimize the amount of vapors escaping from pools of spilled liquids, such as special foams, adsorbing agents, absorbing agents, and neutralizing agents. To be effective, these vapor control methods must be selected for the specific material involved and performed in a manner that will mitigate, not worsen, the incident.

Where specific materials are known, such as at manufacturing or storage facilities, it is desirable for the hazardous materials response team to arrange with the facility operators to select and stockpile these control agents in advance of a spill. In the field, first responders may not have the most effective vapor control agent for the material. They are likely to have only water and only one type of firefighting foam. Therefore, it is likely that water spray will be used. Because the water is being used to form a vapor seal, care must be taken not to churn or further spread the spill during application. Vapors that do not react with water may be directed away from the site using the air currents surrounding the water spray.

Water spray has been used on large spills of some flammable materials in an attempt to reduce vapor concentration below the explosive limit. However, water sprayed into a confined area may actually increase the air concentration, possibly creating an explosive mixture of air and the flammable vapor. Before using water spray or other methods to safely control vapor emission or to suppress ignition, obtain trained technical advice, based on specific chemical name identification.

8

GLOSSARY OF TOXICOLOGY AND HAZARDOUS MATERIALS HANDLING TERMS

I. INTRODUCTION

Following is a glossary of terms that are widely used by industrial hygienists and hazardous materials handling specialists. Approximately 700 terms are explained with cross reference to related terminology in the glossary as well as other sections of the handbook. Some terms are given more extensive explanation than others depending on their relevance and importance to the information compiled in the handbook. Definitions have been paraphrased from literature sources however specific references are not cited unless the definition is based upon a legal standard. If the reader cannot find a particular term, Chapters 1 and 2 should be consulted. Those chapters, and particularly Chapter 1, provide definitions of terminology most pertinent to the application of data and information on chemicals described in this volume.

II. GLOSSARY

A

Abiotic: Unconnected with living organisms.
Acaricide: The name of a chemical pesticide used to control spiders, ticks, mites; miticide.
Accelerant: A chemical substance used to initiate or promote fire. Flammable liquids may be referred to as accelerants.
Acceptable Daily Intake (ADI): The dally intake of a chemical that is considered without appreciable risk on the basis of all the facts known at the time it is defined.
Accident: An uncontrolled event which has the potential for damaging life or property; synonym for incident.
Accident Mechanism: The series of events which constitute the course of events culminating in the release of hazardous chemicals outside of their normal containment.
Accumulative Chemicals: Those chemicals which tend to build up in the tissues of humans or animals or remain persistent in the environment.
Accumulative Pesticides: Those pesticides which tend to build up in the tissue of animals or remain persistent in the environment.
Acetylcholinesterase (AChE): In pesticides, an enzyme that will most rapidly hydrolyze acetylcholine as substrate, will not hydrolyze most non-choline esters, is inhibited by excess substrate, and is derived primarily from nervous tissue.
Acid: A hydrogen-containing compound which reacts with water producing hydrogen ions; a proton donor; a liquid having a pH of less than 2. Acidic chemicals are corrosive.
Acid Gas: A gas that forms an acid when dissolved in water.
Acidosis: body acid imbalance.
Activated Carbon (activated charcoal): Activated carbon or charcoal is commonly used in gas-adsorption.
Acuity: Pertains to the sensitivity of a bodily organ to perform its function.
Acute: Severe, often dangerous effect. Also used to denote an exposure to high concentrations of a contaminant for short duration.
Acute Dermal Poisoning: A single dose of toxic chemicals absorbed through the skin in amounts capable of causing death.
Acute Effects: Acute effects usually occur rapidly as a

result of short-term exposures, and are of a short duration. Examples include irritation, corrosivity, sensitization and lethal dose. Note that these examples do not adequately define the entire range of acute effects which may occur as a result of occupational exposure, such as, for example, narcosis.

Acute Inhalation Poisoning: A single dose of toxic chemicals absorbed into the lungs in amounts capable of causing death.

Acute Hepatitis: liver damage without jaundice.

Acute Oral Poisoning: A single exposure of a toxic chemical of high toxicity that, if untreated, would be lethal.

Acute Radiation Exposure: Exposure to high radiation levels over a short period of time, usually less than 24 hours.

Acute Toxicity: The term refers to short-term poisonous effects. The toxicity of a chemical determined at the end of 24 hours which causes death or injury from a single or limited exposure.

Adapter: A device for making a connection when threads do not match or when they are different sizes.

Additive Effect: An effect which is the result of two chemicals acting together and which is the simple sum of the effects of the chemicals acting independently. See *Antagonistic effect* and *Synergistic effect*.

Adenoma: A tumor, usually benign (q.v.), occurring in glandular tissue.

Adenocarcinoma: A malignant tumor originating in glandular tissue.

Adiabatic Ignition: Refers to the rapid compression of flammable vapors that generates a sufficient amount of heat to cause the ignition of those vapors.

Adjuvant: In immunology, a substance injected with antigens (usually mixed with them but sometimes given prior to or following the antigen) which non-specifically enhances or modifies the immune response to that antigen.

Adrenal Gland: organ attached to the kidney.

Adverse Effect: An undesirable or harmful effect to an organism, indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme levels or visible pathological change.

Aerodynamic Diameter: The diameter of a unit density sphere having the same settling velocity as the particle in question of whatever shape and density.

Aerosol: A gaseous colloidal system. A system in which liquid, solid or solid-liquid combinations are distributed in a finely divided state through a gas, usually in air. Particles within aerosols are usually less than one micron (0.001 mm) in diameter.

Aetiology: The science of the investigation of the cause or origin of disease.

AFFF: Abbreviation for *Aqueous Film Forming Foam*, which is an extinguishing agent that may be used on many flammable liquids. Discussions and examples may be found in Chapter 4 of the handbook.

Air Sampling: Refers to the collection and analysis by instrument of samples of air to determine the presence of hazardous materials. The reader should review Chapter 2 for the objectives and types of air sampling techniques.

Air Monitoring: The sampling for and measuring of contaminants in the air.

Alarm: Any signal indicating the need for emergency response; also, the device that transmits an alarm.

Albuminuria: protein in the urine.

Alcohol: The hydrocarbon derivative in which a hydroxyl radical (-OH) is substituted for a hydrogen atom and which has the general formula R-OH.

Aldehyde: A hydrocarbon derivative with the general formula R-CHO.

Aliphatic: Chemical compounds comprised of straight chain molecules as opposed to a ring structure.

Alkali: Any compound which forms the hydroxyl ion in its water solution. Common synonyms are base; hydroxide; caustic.

Alkanes: An analogous series of saturated hydrocarbons with the general formula C_nH_{2n+2}. These materials may be solids or liquids under normal conditions depending upon carbon content. The solids (paraffins) are major constituents of natural gas and petroleum. Alkanes are usually gases at room temperature (an example is methane) when containing less than 5 carbon atoms per molecule. Low carbon number alkanes produce anaesthesia and narcosis at low concentrations and at high concentrations they can cause cell damage and death. The higher carbon number alkanes are generally not toxic but have been shown to interfere with normal metabolic processes.

Alkalosis: increase in body alkalinity.

Alkenes: A class of hydrocarbons referred to as olefins. These are usually liquids, but can also be gases at room temperature conditions. These are generally more toxic than the alkanes, but less toxic than aromatics.

Alkyl: The general name for a radical of an alkane; an alkyl halide is a halogenated hydrocarbon whose hydrocarbon backbone originated from an alkane.

Alkynes: An analogous series of unsaturated hydrocarbons with the general formula C_nH_{2n-2}; the alkynes all contain just one triple bond between carbon atoms.

Allergy: A response of a hypersensitive person to chemical and physical stimuli.

Alpha Particle: A positively charged particle emitted by certain radioactive particles. An alpha particle consists of

two neurons and two protons and is identical with the nucleus of the helium atom. It is the least penetrating of the three common forms of radioactive substances (alpha, beta, gama). It is not normally considered dangerous to plants, animals or humans unless expose to large quantities internally.

Alveoli: Tiny air sacs of the lungs at the end of a bronchiole, through which gas exchange takes place by which the blood takes in oxygen and gives up its carbon dioxide in the process of respiration.

Amine: The hydrocarbon derivative in which an amine group (NH_2) is substituted for a hydrogen atom and which has the general formula R-NH_2.

Anaerobic: Able to live where there is no oxygen; opposite of aerobic.

Analogue: A compound in one analogous series that has a property common with a compound in another analogous series; for example, methyl chloride is an analogue of methyl fluoride.

Anaphylactic: pertaining to an extreme allergic reaction.

Aneuploidy: Deviation from the normal number of chromosomes, excluding exact multiples of the normal haploid (q.v.) complement.

Anemia: fewer red blood cells than normal.

Angstrom (Å): Unit of measure of wavelength equal to 10 meters or 0.1 nanometers (millimicrons).

Aniline Point: The lowest temperature a chemical aniline and a solvent (such as the oil in oil-in-base muds) will completely mix.

ANSI: The *American National Standard Institute*. A professional group that works to create voluntary standards.

Antagonistic Effect: The effect of a chemical in counteracting the effect of another; for example, the situation where exposure to two chemicals together has less effect than the simple sum of their independent effects; such chemicals are said to show antagonism.

Antigen: A substance that elicits a specific immune response when introduced into the tissues of an animal.

API Gravity: A scale devised by the *American Petroleum Institute* (API) designating an oil's specific gravity or the ratio of the weight of oil to pure water.

Aromatic: The name originally given to cyclical compounds containing the benzene "ring" because the first benzene-type compounds isolated smelled "good".

Arson: Arson is the willful and malicious burning of the property of another. This meaning has been broadened by statute in many jurisdictions to include one's own property.

Arteriosclerosis: hardening of the arteries.

ASME: Abbreviation for the American Society of Mechanical Engineers.

ASP: Abbreviation for Associate Safety Professional, a designation devised by the American Society of Safety Engineers.

Asphalt: Hydrocarbon material ranging in consistency from heavy liquid to a solid. Most common source is residue left after fractional distillation of crude oils; used primarily for surfacing roads.

Asphyxia: Suffocation from lack of oxygen. Chemical asphyxia is produced by a substance, such as carbon monoxide, that combines with hemoglobin to reduce the blood's capacity to transport oxygen. Simple asphyxia is the result of exposure to a substance, such as carbon dioxide, that displaces oxygen.

Asphyxiant: A gas or vapor which, when inhaled, may lead to asphyxia. Examples of asphyxiating materials are carbon dioxide and carbon monoxide.

Aspirate: to inhale liquid into the lungs.

ASSE: Abbreviation for American Society of Safety Engineers.

ASTM: Abbreviation for American Society for Testing and Materials.

Atmospheric Pressure: The pressure exerted over the surface of the earth by the weight of the atmosphere; at sea level, approximately 14.7 psi.

Atomic Energy Commission (AEC): The independent civilian agency of the federal government with statutory responsibility for atomic energy matters; the body of five persons appointed by the President to direct the agency.

Atomic Number: Number of protons in nucleus of an atom. Each chemical element has been assigned a number in a complete series from 1 (hydrogen) to 103 (lawrencium).

Atomic Weight: The mass of an element relative to its atoms.

Atrophy: Wasting of a tissue or an organ.

Auto-Ignition Temperature: The minimum temperature to which a material must be heated to initiate self-sustained combustion, independent of any open flame.

Automatic Nervous System: control voluntary movements.

Autophagosome: A membrane-bound body within a cell, containing degenerating cell organelles (q.v.).

B

Backdraft: The term given to a type of explosion caused by the sudden influx of air into a mixture of gases, which have been heated to above the ignition temperature of at least one of them.

Bacteria: Small, relatively simple organisms found in soil, water, and alimentary tract of animals and man. Some

cause diseases in man.

Base Pairing: The linking of the complementary pair of polynucleotide chains of nucleic acids by means of hydrogen bonds between the opposite purine and pyrimidine pairs.

Benign: Relating to a growth which does not invade surrounding tissue (Not malignant).

Beta: A type of radiation, essentially an electron or positron, which can cause skin burns. Beta emitters are harmful if they enter the body but can be shielded by protective clothing.

Beta Particle: An elementary particle emitted from a nucleus during radioactive decay.

Bill of Lading: Commercial document which accompanies a shipment of materials and lists all items in the shipment.

Bioaccumulation: Refers to the process occurring when toxic substances are passed through the food chain from soil to plants to grazing animals to humans.

Bioassay: The utilization of living organisms to determine the biological effect of some substance, factor, or condition.

Biochemical Mechanism: A chemical reaction or series of reactions, usually enzyme catalyzed, which produces a given physiological effect in a living organism.

Biochemical Oxygen Demand (BOD): The amount of oxygen required by bacteria stabilize decomposable organic matter under aerobic conditions.

Bioconcentration: Refers to the process in which chemicals concentrate in plant and animal tissues.

Biodegradable: Refers to waste material that is capable of being broken down by bacteria into basic elements.

Biological Agents: Microorganisms (e.g., bacteria or certain nutrients) added to the water column or soil to increase the rate of biodegradation of contaminants.

Biological Half-Life ($t_{1/2}$): The time taken for the concentration of a xenobiotic in a body fluid or tissue to fall by half by a first-order process.

Biological Hazardous Wastes: Substances of human or animal origin other than food wastes, which is to be disposed of and could harbor or transmit pathogenic organisms. Examples are pathological specimens such as tissues, blood elements, excreta, secretions, bandages.

Biological Monitoring: Refers to the analysis of the amounts of potentially toxic substances or their metabolites present in body tissues and fluids as a means of assessing exposure to these substances and aiding timely action to prevent adverse effects. The term is also used to mean assessment of the biological status of populations and communities of organisms at risk in order to protect them and to have an early warning of possible hazards to human health.

Biomagnification: Bioconcentration of xenobiotics up a food chain e.g. from prey to predator.

Biotransformation: The enzyme-mediated transformation of xenobiotics via Phase 1 (q.v.) and Phase 2 (q.v.) reactions.

Bilirubinuria: bilirubin in urine.

Bipyridyls: A group of synthetic organic pesticides which includes the herbicide Paraquat.

Blasting Agents: Any material or mixture consisting of fuel and oxidizer intended for blasting, not otherwise defined as an explosive.

BLEVE (Boiling Liquid Expanding Vapor Explosion): *See Boilover;* the same phenomenon may occur in a pressurized container, resulting in an explosion or bursting of the tank or vessel in which a fire is occurring. The term is almost exclusively used to describe a disastrous effect from a crude oil fire.

Boiling Point: The temperature at which the vapor pressure of a liquid just equals atmospheric pressure.

Boilover: Crude oil often contains some entrained water and/or an emulsion layer. In addition, crude-oil storage tanks will have some accumulations of water on the uneven tank bottoms. In a fire, when a heat wave is formed and comes in contact with any water, a steam explosion occurs, thus agitating the hot oil above it with great force. The evolution of the steam explosion can be understood by examining the reaction of water to high temperatures. When water is heated to its boiling point of 212°F., water vapor, or *steam,* is generated. The steam that is produced expands approximately 1,700 times in volume over the volume of the water that boiled away. Should a heat wave of a temperature well above 212°F. contact any water entrained in the oil, or some of the bottom water, which is usually in larger quantities, it can be readily imagined that this instantaneous generation of steam will act like a piston, causing the oil to be flung upward with considerable violence. When the reaction is so strong, it causes the oil to overflow the tank shell. This sudden eruption is what is known as a *boilover.* Boilovers of sufficient magnitude, to cascade enough burning crude oil out of the tank to not only cover the entire dike area but even enough to overflow the dike wall as well, have occurred. When the hot oil and steam reaction takes place, the oil is made frothy, or sudsy, which in turn further increases its volume. The reaction resulting from the heat wave contacting entrained water can be expected to be of lesser activity than from contact with bottom water. The reason for this difference is that the quantities of water converted to steam in a given spot are usually less. Of course, with entrained water, there possibly can be several of these "frothover"-type eruptions during the progress of

the fire.

Bone Marrow Depression: inactivity of blood-forming organ.

Branching: A configuration in which a carbon atom attaches itself to another carbon atom that has two or three other carbon atoms attached to it, forming a *branch,* or side chain. When the carbon attaches to another carbon that has only one other carbon attached to it, a straight chain is formed, rather than a branched chain.

Bronchial Tubes (Bronchioles): Branches or subdivisions of the trachea (windpipe) which carry air into and out of the lungs.

BTU: British Thermal Unit: The amount of energy required to raise one pound of water 1°F.

Building Codes: There are several building codes that are widely adopted throughout the United States: (1) The Southern Standard Building Code; (2) The Uniform Building Code; (3) The Basic Building Code; (4) The National Building Code; and (5) Building Officials and Code Administrators (BOCA). The purpose of the building codes are to regulate the safe construction of buildings.

Building Survey: That portion of the pre-fire planning process that involves the gathering of all the necessary information to develop a pre-fire plan of a building or property.

Buffer: Any substance in a liquid which tends to resist the change in pH when acid or alkali is added.

Bulk Container: A cargo container, such as may be transported by truck or railroad, or an ocean-going vessel designed to transport large quantities of a single product.

Bunker "B" Oil: A relatively viscous fuel oil (No. 5 fuel) used primarily as a fuel for marine and industrial boilers.

Bunker "C" Oil: A very viscous fuel oil (No.6) used as a fuel for marine and industrial boilers.

Burning Agent: Compounds such as gasoline which are used to ignite and sustain combustion of material that would not otherwise burn.

C

Calcification: deposition of calcium in tissues.

Calorie: The amount of energy required to raise one gram of water 1°C.

Cancer: The disease which results from the development of a malignant tumor and its spread into surrounding tissues.

Carbonyl: The functional group with the structural formula -C-.

Carcinogen: A cancer-causing agent. A chemical is considered to be a carcinogen if: (a) It has been evaluated by the International Agency for Research on Cancer (IARC) and found to be a carcinogen or potential carcinogen; or (b) It is listed as a carcinogen in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or (c) It is regulated by OSHA as a carcinogen. The reader may refer to 52 FR 31884.

Carcinogenesis: The production of cancer. Any chemical which can cause cancer is said to be carcinogenic.

Carcinogenic: capable of causing cancer.

Carcinoma: A malignant epithelial tumor.

Cardiopulmonary Resuscitation (CPR) (EMS): Opening and maintaining an airway, providing artificial ventilation, and providing artificial circulation by means of external cardiac compression as defined by the American Health Association.

Cardiovascular: pertaining to heart and blood vessels.

Catalase: A haem-based enzyme which catalyzes the decomposition of hydrogen peroxide into oxygen and water. It is found e.g. in peroxisome located in the liver.

Catalyst: A substance which changes the speed of a chemical reaction but undergoes no permanent change itself.

Ceiling Value (CV): The airborne concentration of a potentially toxic substance which should never be exceeded in the breathing zone.

Cell Line: A defined population of cells which has been maintained in a culture for an extended period and which has usually undergone a spontaneous process of transformation conferring an unlimited culture lifespan on the cells.

Central Nervous System: controls involuntary bodily functions such as breathing and heart beat.

Celebral: pertaining to brain.

CFR: Abbreviation for Code of Federal Regulations.

Chain: The way carbon atoms react with each other, producing covalent bonds between them, resembling a chain with carbon atoms as the links.

Chemical Dispersion: In oil spills, the process of spraying chemical dispersants to remove stranded oil from areas not considered biologically sensitive.

Chemical Oxygen Demand (COD): Means of measuring the pollution strength of domestic and industrial wastes based on the fact that most organic compounds can be oxidized by the action of strong oxidizing agents under acid conditions to carbon dioxide and water.

Chemical Properties: Properties of a material that relate to toxicity, flammability, or chemical reactivity.

Chemical Protective Clothing and Equipment: Safe use of this type of protective clothing and equipment requires specific skills developed through training and experience. It is generally not available to, or used by, first

responders. This type of special clothing may protect against one chemical, yet be readily permeated by chemicals for which it was not designed. It offers little to no protection against heat. Examples of this type of equipment have been described as Vapor Protective Suits, also known as Totally-Encapsulating Chemical Protective (TECP) Suits or Level A protection, and Liquid Splash Protective Suits, also known as Level B protection. No one suit will protect you from all hazardous materials. Do not assume any protective clothing is resistant to heat or flame exposure unless so certified by the manufacturer. Refer to *Protective Materials*, and to Chapters 2 and 6.

Chemosis: A swelling around the eye - a consequence of oedema of the conjunctiva.

CHEMTREC: An organization established in the United States, which stands for the Chemical Transportation Emergency Center. CHEMTREC is an emergency information center that can provide technical advise on how best to handle a specific hazard materials incident. In the U.S., the toll free number is 1-800-424-9300. Further information can be found in Chapters 1 and 8 of the handbook.

Chloracne: a skin desease resembling childhood acne but caused by exposure to chlorinated aromatic organic compounds.

Cholinesterase: Also referred to as an pseudocholinesterase inhibitor. A substance which inhibits the enzyme cholinesterase and thus prevents transmission of nerve impulses from one nerve cell to another or to a muscle.

Chromatograph: An instrument which can separate and analyze mixtures of chemical substances.

Chromosomal Aberration: An abnormality of chromosome number or structure.

Chromosome: The heredity-bearing gene carrier situated within the cell nucleus and composed of DNA and protein.

Chronic Effects: Chronic effects generally occur as a result of long-term exposure, and are of long duration. The term is often used to cover only carcinogenicity, teratogenicity, and mutagenicity. These effects are serious concerns in the workplace, however there are many other chronic effects such as blood dyscrasia (e.g., anemia), chronic bronchitis, and liver atrophy. The reader may refer to 52 FR 31884.

Chronic Toxicity: The effect of a chemical (or test substance) in a mammalian species (usually rodent) following prolonged and repeated exposure for the major part of the lifetime of the species used for the test. Chronic exposure studies over two years are often used to assess the carcinogenic potential of chemicals.

Cilia: Tiny hair-like "whips" in the bronchi and other respiratory passages that normally aid in the removal of dust trapped on these moist surfaces.

Cirrhosis: progressive disease of the liver.

Class A Explosive: Under the U.S. Department of Transportation (DOT) safety regulations, as per 49 CFR 173.53, there are nine types of Class A explosives including solid or liquid explosives, and ammunition, which can be detonated under conditions specified by DOT. These regulations provide specific descriptions of tests for the different types of Class A explosives. Refer to *Classifications of Explosives*.

Class B Explosive: Under the U.S. Department of Transportation (DOT) safety regulations, as per 49 CFR 173.88, Class B explosives are defined as those explosives which in general function by rapid combustion rather than detonation and include some explosive devices such as special fireworks, flash powders, some pyrotechnic signal devices and liquid or solid propellant explosives which include some smokeless powders. The regulations provide specific descriptions of and tests for Class B explosives. Refer to *Classifications of Explosives*.

Class C Explosive: Under the U.S. Department of Transportation (DOT) safety regulations, as per 49 CFR 173.100, Class C explosives are defined as certain types of manufactured articles which contain Class A, or Class B explosives, or both as components but in restricted quantities, and certain types of fireworks. The regulations include specific descriptions of, prescribed uses for, and tests for Class C explosives. Refer to *Classifications of Explosives*.

Classification of Explosives: A system of classifiying the hazard level of shipments involving explosive articles. In the United States, the classifcation system changed in January 1991, although it is still referenced in State and local laws. The following may be used to compare old and new hazard class names:

Current Classification	Class name prior to Jan.1, 1991
Division 1.1	Class A explosives
Division 1.2	Class A or Class B Explosives
Division 1.3	Class B explosive
Division 1.4	Class C explosive
Division 1.5	Blasting agents
Division 1.6	No applicable hazard class

Clastogens: Agents which cause chromosome breakage.

Cohort: A group of individuals, identified by a common characteristic, who are studied over a period of time.

Colitis: inflammation of the large intestine.

Combustible Gas Indicator (CGI): Hazard Monitored: Flammable vapors and gases including alcohols, acids, aldehydes, ketones, esters, aromatics, amines, nitro compounds, high (lethal) concentrations of hydrogen sulfide, hydrogen cyanide, carbon monoxide, and ammonia. Application: This instrument is used to determine the concentration of flammable vapors and gases. This information is used to assess explosive potential and the risk of working in that type of atmosphere. This is a qualitative measurement only. Components: Aspirator bulb or pump to draw sample; meter readout with needle or LCD; audio and/or visual alarm; NICAD or regular batteries; zero and/or voltage adjustment. Detection Method: Combustion of vapor/gas on heated platinum filament. Operation: A sample of the atmosphere is drawn through the detector. The flammable components of the sample will combust on the surface of the platinum filament which increases the temperature of the filament. The increased temperature increases the electrical resistance reducing the current through the detector which is detected by a potentiometer. The change in current is indicated by an increase in the deflection of the meter needle. Readout: The meter provides an indication of 0 to 100 % of the LEL (lower explosion limit). When the concentrations are above the LEL, the meter will indicate greater than 100 %. With most CGIs, the meter will return to 0 when the concentrations are greater than the UEL (upper explosion limit). Instruments with audio and visual alarms can be set at whatever level desired by the operator. Calibration : The following is a list of commonly used CGIs and their calibration gases: MSA 260 (Pentane); MSA 2A (Pentane); Gastech (Hexane); National Mine (Methane). Calibration of CGIs should be checked before and after use. Actual calibration requires return of the instrument to the factory or by trained technicians. Limitations : Instrument sensitivity can be reduced by the following compounds: selenium compounds including hydrogen selenide, silicon compounds including silicone, arsenic, volatile heavy metals such as tetraethyl lead. High humidity may also reduce the instrument's sensitivity. Halogenated hydrocarbons can corrode the detector. The sensitivity of the CGI varies with different vapors and gases so it is only truly accurate when measuring the calibration gas.

Combustible Liquids: Any liquid having a flash point temperature above 100 °F but below 200 °F except any mixture having components with flash points of 200 °F or higher, the total volume of which make up 99 % or more of the total volume of the mixture. This definition can be found in 52 FR 31878. Also refer to 49 CFR 173.115.

Combustion: A chemical reaction caused by oxidation that produces light and heat. The production of light in the combustion process is the difference between oxidation and combustion: Oxidation, regardless of slowness, will give off heat but no light will be produced.

Common Name: The name originally given to a compound upon its discovery, prior to the adoption of an organized system of assigning proper names.

Complexing Agent: A material which forms a chemical complex with a second material (very tightly bound at the molecular level) when the two come in contact.

Compressed Gas: A gas that is under pressure, either still in the gaseous state, or liquified. The term *compressed gas* means: (i) a gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 °F; or (ii) a gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 °F, regardless of the pressure at 70 °F; or (iii) a liquid having a vapor pressure exceeding 40 psi at 70 °F as determined by ASTM D-323-72. Refer to 49 CFR 173.300.

Compressed Gas (Flammable): Under U.S. Department of Transportation regulations (refer to 49 CFR 173.300), any compressed gas is designated a flammable compressed gas if: (a) Either a mixture of 13 percent or less (by volume) with air forms a flammable mixture or the flammable range with air is wider than 12 percent regardless of the lower limit; (b) Using the Bureau of Explosives' (i) Flame Protection Apparatus, the flame projects more than 18 inches beyond the ignition source with the valve fully opened, or, the flame flashes back and burns at the valve with any degree of valve opening; (ii) Open Drum Apparatus, there is any significant propagation of flame away from the ignition source; (iii) Closed Drum Apparatus, there is any explosion of the vapor-air mixture in the drum.

Compressed Gas (Liquefied): Under U.S. Department of Transportation regulations (refer to 49 CFR 173.300), a liquefied compressed gas is defined as a gas which, under the charged pressure, is partially liquid at a temperature of 70 °F.

Compressed Gas (Non-liquefied): Under U.S. Department of Transportation regulations (refer to 49 CFR 173.300), a non-liquefied compressed gas is defined as a gas other than gas in solution which under the charged pressure is entirely gaseous at a temperature of 70 °F.

Compressed Gas (Refrigerant Gas or Dispersant Gas): The term *refrigerant gas* or *dispersant gas* applies to all flammable or nonflammable, nonpoisonous refrigerant gases, dispersant gases (fluorocarbons) referred to in 49 CFR 173.300 (i) and mixtures thereof, or any other compressed gas meeting one of the following: (a) a

nonflammable mixture containing not less than 50 % fluorocarbon content, having a vapor pressure not exceeding 260 psig at 130 °F; (b) a flammable mixture containing not less than 50 % fluorocarbon content, not over 40 % by weight of a flammable component, having a vapor pressure not exceeding 260 psig at 130 °F.

Condensation: Act or process of reducing from one form to another denser form such as steam to water.

Conduction: The transfer of heat through a medium.

Conjugate: A water soluble derivative of a chemical formed by its combination with glucuronic acid, glutathione, sulphate, acetate, glycine etc.

Conjunctiva: The mucous membrane that covers the eyeball and the under-surface of the eyelid.

Contaminant (Air): A harmful, irritating, or nuisance material that is foreign to the normal atmosphere.

Control Limit: The limiting airborne concentration of potentially toxic substances which are judged to be "reasonably practicable" for the whole spectrum of work activities and which must not normally be exceeded.

Convection: The transfer of heat with a medium.

Cornea: transparent covering of the eye.

Corrosive: The term refers to a chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact. For example, a chemical is considered to be corrosive if, when tested on the intact skin of albino rabbits by the method described by the U.S. Department of Transportation in Appendix A to 49 CFR Part 173, it destroys or changes irreversibly the structure of the tissue at the site of contact following an exposure period of four hours.

Corrosive Poison: A type of poison containing a strong acid or base which will severely burn the skin, mouth, stomach, etc.

Covalent Binding: The irreversible interaction of xenobiotics or their metabolites with macromolecules such as lipids, proteins, nucleic acids.

CSP: Abbreviation for Certified Safety Professional; a designation devised by the American Society of Safety Engineers.

Cracking: The breaking of covalent bonds, usually between carbon atoms.

Critical Pressure: The pressure required to liquify a gas at its critical temperature.

Critical Temperature: The temperature above which it is impossible to liquify a gas.

Crude Oil: Petroleum in its natural form before subjected to any refining process.

Cryogenic: Pertaining to liquified gases stored at temperatures approaching absolute zero. Normally, they have a boiling point of about -100°C.

Cryogens: Gases that must be cooled to a very low temperature in order to bring about a change from a gas to a liquid.

Cryogenic Gas: A gas with a boiling point of -150°F. or lower.

Cryogenic Liquid: A cryogenic liquid is a refrigerated liquefied gas having a boiling point colder than -130 °F at one atmosphere, absolute. A material that meets this definition is subject to the same requirements for compressed gases without regard to whether it meets the standard definition of a compressed gas.

Cumulative Effect: The result of some poisons which build up or are stored in the body so that small amounts contacted over a period of time can sicken or kill a person or animal.

Cutaneous Hazards: The term refers to a specific target organ characterization of effect. These are chemicals which affect the dermal layer of the body. Signs and symptoms include defatting of the skin; rashes; irritation. Examples are ketones and chlorinated compounds.

Cyanosis: Blue appearance of the skin, especially on the face and extremities, indicating a lack of sufficient oxygen in the arterial blood.

Cyclical: The structure of certain molecules where there is no end to the carbon chain; the molecule is a closed structure resembling a ring, where what would be the "last" carbon in the chain is bonded to the "first" carbon in the chain. There are cyclical compounds in which the closed structure contains the atoms of other elements in addition to carbon.

Cytochrome P-450: A haemprotein involved, e.g. in the liver, with Phase 1 reactions of xenobiotics.

Cytogenetics: The branch of genetics that correlates the structure and number of chromosomes with heredity and variation.

Cytoplasm: The ground substance of the cell In which are situated the nucleus, endoplasmic reticulum, mitochondria and other organelles.

Cytotoxic: Causing disturbance to cellular structure or function often leading to cell death.

Cystitis: inflammation of the bladder.

D

Databank: A databank contains preselected factual information in summary form, with a sophisticated search system to enable the right information to be located.

Database: Usually online computer-based bibliographic databases which provide references and in some cases abstracts of papers in the more recent literature.

Daughter: The term is used to describe the nuclide formed

by the radioactive decay of another nuclide, which in this context is called the parent.

Decay Product: Refers to a nuclide, either radioactive or stable, resulting from the disintegration of a radioactive material.

Decomposition: The term is often used to describe a change in the composition of organic matter to a less complex form; may be accomplished by the introduction of heat, through the addition of neutralized chemicals, or through the process of biodegradation.

Decontamination: This term refers to the removal of hazardous materials from personnel and equipment to the extent necessary to prevent potential adverse health effects. Contaminated clothing and equipment should be removed after use and stored in a controlled area (referred to as the *hot zone*) until cleanup procedures can be initiated. In some cases, protective clothing and equipment cannot be decontaminated and must be disposed of in a proper manner.

Deflagration: This term refers to an exothermic reaction in a material which propagates from the burning gases to the unreacted material via conduction, convection and radiation. In this process the reaction zone progresses at a rate less than the velocity of sound.

Deflocculating Agent: An adjuvant which inhibits precipitation or the settling of solids in the suspension fluid.

Defoamer: Any chemical that prevents or minimizes frothing or foaming in another agent.

Degeneration: deterioration; worsening.

Degradability: Refers to the ability of a chemical to break down into less complex compounds or elements. The term *degradation* refers to the breakdown of a more complex chemical into a less complex form; the process can be the result of the action of microbes, oxidation, water, sunlight, or other agents.

Demyelination: A chemically produced condition which removes or severely damages the myelin sheath around the spinal cord and nerves.

Deoxyribonucleic acid (DNA): The constituent of chromosomes which stores the hereditary information of an organism in the form of a sequence of nitrogenous bases. Much of this information relates to the synthesis of proteins.

other agents.

Derivative: A compound made from a hydrocarbon by substituting another atom or group of atoms for one of the hydrogen atoms in the compound.

Dermal: Through or by the skin; of or penetrating the skin.

Dermal Irritation: A localized skin reaction resulting from either a single or multiple exposure to a physical or chemical entity at the same site. It is characterized by the presence of irritation (redness), oedema and may or may not result in cell death.

Dermal Toxicity: Refers to the degree that a poison is absorbed through the skin.

Dermatitis: Inflammation of the skin from any cause. There are two general types of skin reaction: primary irritation dermatitis and sensitization dermatitis.

Desiccant: A chemical that is capable of absorbing or removing moisture. The term *desiccation* refers to dehydration (removal of tissue moisture) by chemical or physical action.

Desiccation: Dehydration (removal of tissue moisture) by chemical or physical action.

Detector Tubes: Hazard Monitored: Specific vapors and gases. Application: This instrument is used to determine the concentrations of specific vapors or gases in atmosphere. Information can be used to assess hazards and to establish control methods. Components: Bellows or piston pump; detector tubes. Detection Method: Chemical reaction with color change. Operation: The sample is drawn through the detector tube at a constant flow rate. If the sample contains the vapor or gas in question, it will react with the chemical on the packing material. The result of the reaction is a color change. The chemical's concentration is directly proportional to the length of the colored stain. Readout: The tubes are normally read directly in ppm or % from a scale on the tube. Some tubes have scales in millimeters. With the latter type, the length of the stain is read in mm and referenced on the instructions; e.g., 10 mm = 150 ppm. Calibration: The tubes are supplied calibrated. The pump must be checked regularly to verify flow rate and sample volume per pump stroke. Limitations: Following is a list of problems that contribute to poor accuracy with this instrument: leaks in the pump, insufficient contact or analysis time, high humidity, high temperature, difficulty in reading the scale, interferences from other chemical compounds, improperly stored tubes, out-of-date tubes, operator error.

Detonation: The term is generally used to describe an exothermic reaction that is characterized by the presence of a shock wave in the material that establishes and maintains the reaction. The reaction propagates at a rate equal to or exceeding the speed of sound.

Deuterium: An isotope of hydrogen whose nucleus contains one neutron and one proton, thus making it nearly twice as heavy as the nucleus of normal hydrogen (normal hydrogen has a single proton). This material is commonly referred to as *heavy hydrogen*. It occurs naturally as 1 atom to 6,500 atoms of normal hydrogen and is not

radioactive.

"Di-": The prefix that means two.

Diatomic: Two atoms, as in a *diatomic* molecule, which contains two atoms bound covalently to each other.

Diffusion Flame: The flame produced by the spontaneous mixture of fuel vapors or gases and air.

Dispersants: These are chemicals which reduce the surface tension between oil and water, thus facilitating he breakup and dispersal of an oil slick in the form of an oil-in-water emulsion.

Dispersing Agent: An adjuvant that reduces the attraction between particles.

Distribution: Dispersal of a xenobiotic and its derivatives throughout an organism or environmental matrix, including tissue binding and localization.

Dose: In the context of chemicals, the term *dose* means the amount, quantity, or portion of the chemical exposed to or applied to the target (e.g., a human being). It may also refer to a consistent measure used in toxicological testing to determine acute and chronic toxicities. An alternate definition is the amount of ionizing radiation energy absorbed per unit mass of irradiated material at a specific location, such as a part of the human body, measured in REMS, or an inanimate body, measured in rads.

Dose-Effect Curves: Demonstrate the relation between dose and the magnitude of a graded effect, either in an individual or in a population. Such curves may have a variety of forms. Within a given dose range they may be linear but more often they are not.

Dose Equivalent: The amount of effective radiation when modifying factors have been taken into account. The product of absorbed dose multiplied by a quality factor multiplied by a distribution factor, expressed numerically in units of REMS.

Dose Projections: A computed estimate of the potential dose to individuals at a given location. The projection is based upon the amount of pollutant released from a source or multiple sources and prevailing meteorological transport and dispersion parameters.

Dose Rate: The chemical's dose delivered per unit time; or the radiation dose delivered per unit time.

Dose-Response Curves: Demonstrate the relation between dose and the proportion of individuals responding with a quantal effect (q.v.). In general, dose-response curves are S-shaped (increasing), and they have upper and lower asymptotes, usually but not always 100 and 0%.

Dose-Response Relationship: The systematic relationship between the dose (or effective concentration) of a drug or xenobiotic and the magnitude (or intensity) of the response it elicits.

Dosimeter (Dose Meter): An instrument which measures the accumulated energy to which one may be exposed, i.e., noise, radiation, etc.

DOT: Abbreviation for the United States Department of Transportation.

Downwind: Refers to the direction toward which the prevailing wind is blowing. This term is important in evaluating the risks for potential receptors in the pathways of pollutant discharges. The reader should refer to Chapter 8 for a discussion of spills and isolation distances downwind from the source.

Dry Bulb Temperature: Temperature of air as determined by a standard thermometer.

Dry Chemical: A term applied to an extinguishing agent suitable for use on flammable liquids and electrical fires.

Dry-pipe Sprinkler Systems: A fire protection sprinkler system that has air instead of water under pressure in its piping; dry systems are often installed in areas subject to freezing.

Dry-pipe Valve: A valve in a dry-pipe sprinkler system designed so that moderate air pressure will hold back a much greater water pressure.

Dry Powder: A term applied to the extinguishing agent suitable for use on combustible metals.

Dusts: Solid particles generated by mechanical processes such as crushing and grinding, without any chemical change from the paren material. Their size range is typically between 0.1 and 100 microns.

E

Ecotoxicology: Is concerned with the toxic effects of chemical and physical agents in living organisms, especially on populations and communities within defined ecosystems; it includes transfer pathways of these agents and their interaction with the environment.

ED_{50}: The median effective dose (normally expressed as mg/kg or mg/g of body weight) producing a designated effect in 50 percent of the exposed test organism population.

Effective Concentration: The concentration of a chemical effective in producing a specified result such as an increase in oxygen consumption, paralysis, death, etc.

Electromagnetic Radiation: The propagation of varying electric and magnetic fields through space at the speed of light, exhibiting the characteristics of wave motion.

Elevated Storage System: A system of storing impounded water supplies above the grade level at which the water will be used.

Elutriator: A device used to separate respirable and non-respirable particulates such as the cyclone or horizontal types.

Emergency Action Plan: A written statement covering the actions employers and employees must take to insure employee safety from fire and other emergencies.
Emergency Medical Services (EMS): Functions required to provide urgent medical care for ill or injured patients, such as communications, transportation, medical personnel and/or administration.
Emetic: a chemical that induces vomiting.
Emission Standard: A quantitative limit on the emission or discharge of a potentially toxic substance from a particular source. The simplest system is uniform emission standard where the same limit is placed on all emissions of a particular contaminant.
Emphysema: A lung disease resulting from the enlargement of the alveoli accompanied by destruction of normal tissue.
Encephalitis: inflammation of the brain.
Encephalopathy: brain disease.
Endocrine gland: hormone-secreting gland.
Endolytic Insecticides: Systemic insecticides remaining in their original form until decomposed by the biological system.
Endoplasmic Reticulum: A complex pattern of membranes that permeates the cytoplasmic matrix of cells.
Endothermic: The absorption of heat. Endothermic materials produce products with more total energy than the reacting substance.
Environmental Protection Agency (EPA): The United States federal agency having the responsibility of implementing the Resource Conservation and Recovery Act and having responsibilities in administering and enforcing programs dealing with environmental problems of water and air pollution, toxic substances, pesticides, radiation, noise, and solid waste management.
Environmental Quality Standard (EQS): The concentration of a potentially toxic substance which can be allowed in an environmental component, usually air (air quality standard - or water, over a defined period. Synonym: ambient standard.
Enzymic (or enzymatic) Process: A chemical reaction or series of reactions catalyzed by an enzyme or enzymes. An enzyme is a protein which acts as a highly selective catalyst permitting reactions to take place rapidly in living cells under physiological conditions.
Epidemiology: The statistical study of categories of persons and the patterns of diseases from which they suffer in order to determine the events or circumstances causing these diseases.
Epigenetic Changes: Changes in an organism brought about by alterations in the action of genes. Epigenetic transformation refers to those processes which cause normal cells to become tumor cells without any mutations having occurred.
Epileptiform Fits: seizures.
Epithelium: outermost living layer of the skin.
Eradicant Fungicide: Pesticides which kill fungus after it appears on or in a plant.
Erythema: Refers to a condition where abnormal redness of the skin appears, as in inflammation.
Eschar: The slough or dry scab that forms for example on an area of skin that has been burnt.
Esophagus: tube connecting mouth and stomach.
Essential Plant Operations: Plant operations such as the monitoring of plant power supplies, water supplies, and other essential services which cannot be shut down for every emergency alarm. They may also include chemical or manufacturing processes that must be shut down in stages or steps.
Ester: The hydrocarbon derivative with the general formula R-C-O-O-R'.
Esters: Organic compounds which may be made by interaction between an alcohol and an acid, and by other means and includes solvents and natural fats.
Etiologic Agent: An etiologic agent is a viable microorganism, or its toxin, which causes or may cause human disease. Refer to those agents listed by the U.S. Department of Health, Education, and Welfare in 42 CFR 72.3. The reader may also refer to 49 CFR 173.386.
Etiology: The study or knowledge of the causes of disease.
Ether: A hydrocarbon derivative with the general formula R-O-R'.
European Inventory of Existing Chemical Substances (ENMECS): This is a list of all chemicals either alone or as components in preparations supplied to a person in a Community Member State at any time between 1st January 1971 and 18th September 1981.
Eutrophication: A complex series of inter-related changes in the chemical and biological status of a water body most often manifested by a depletion of the oxygen content caused by decay of organic matter resulting from a high level of primary productivity and typically caused by enhanced nutrient input.
Evacuate: Means move all people from a threatened area to a safer place. To perform an evacuation, there must be enough time for people to be warned, to get ready, and to leave an area. If there is enough time, evacuation is the best protective action. Begin evacuating people nearby and those outdoors in direct view of the scene. When additional help arrives, expand the area to be evacuated downwind and crosswind to at least the extent recommended in this guidebook. Even after people move to the distances recommended, they may not be completely safe from

harm. They should not be permitted to congregate at such distances. Send evacuees to a definite place, by a specific route, far enough away so they will not have to be moved again if the wind shifts.

Evacuation warden: An employee designated to assist in the evacuation of employees from the workplace.

Evaporation: The process by which molecules of a liquid escape through the surface of the liquid into the air space above.

Evaporation Rate: The ratio of the time required to evaporate a measured volume of a liquid to the time required to evaporate the same volume of a reference liquid under ideal test conditions. The higher the ratio, the slower the evaporation rate.

Exclusion Zone: The area surrounding a particular incident site (such as a spill, a fire, or a hazardous waste pile or subarea under remediation), wherein only trained and fully protected hazardous materials workers may enter to perform necessary operation.

Exothermic: The liberation of heat.

Explosive: The term refers to a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature. Refer to Class A, B and C Explosive for definitions important to hazardous materials transportation.

Explosive Range: The *explosive range* tells us that a certain mixture of fuel vapor and air is required for the vapor to become ignitable. It is essentially a concentration range for fuel in air, in which the vapors of a flammable material will burn. The terms *flammable limit* and *combustible limit* are often used to describe the explosive range. These three terms have identical meaning and are interchangeable with each other. See lower explosion limit and upper explosion limit.

Exposure: Property that may be endangered by a fire.

F

FDA: Abbreviation for the United States Food and Drug Administration.

FEMA: Abbreviation for the United States Federal Emergency Management Agency.

Fibrosis: The formation of fibrous tissue usually as a reparative or reactive process.

Field Sampling Instrumentation: Field sampling instrumentation are commonly employed for air quality sampling and to determine action levels that may warrant personal protection for worker safety. The purpose of conducting air monitoring falls into four primary objectives: namely for the purpose of selecting personal protective equipment such as respirators; to delineate areas within the work site where protection is needed; to assess potential health effects on workers; to determine medical monitoring requirements. Field instruments are useful because they can provide real time measurements; that is, they can provide an immediate measure of the quality of air or existence of contaminants and their potential threat to workers. Most field instruments have the disadvantage of providing more qualitative information as opposed to quantitative data that a laboratory could provide. The characteristics of filed instruments include portability, reliability, sensitivity, selectivity, amplification of measurement signals, they are designed to be inherently safe, and as already noted they provide fast response times to detection. The types of general survey instruments typically fall into the direct reading category. In general, they may be characterized as being able to detect and/or measure only specific classes of chemicals and are normally not designed to measure airborne concentrations below 1 ppm. Also, they are based on obtaining grab samples. Examples of direct reading survey instruments are oxygen meters (MSA, Industrial Scientific Corp.), combustible gas indicator or CGI (MSA, Industrial Scientific Corp.), photoionization detectors or the PID (HnU meter or Photovac TIP), the flame ionization detector or FID (the Foxboro Century OVA), the spectrophotometer or IR instrument (Foxboro MIRAN), chemical specific instruments (MSA H_2S and CO Monitor), and real time dust monitors (MIE Miniram). In contrast to direct reading instruments the other option is sample collection followed by post laboratory analysis. This approach enables detection and measurement of specific chemical compounds. Airborne concentrations below 1 ppm can be readily detected, and the additional advantage of generating a TWA (time weighted average) sample is possible. Examples include sampling pump and adsorption tubes (Gilian and MSA models) and the sampling pump and filter cassettes (Gilian and MSA models).

Fire Brigade: An organization of industrial plant personnel who are trained to use the fire fighting equipment and to carry out fire prevention activities within the plant.

Fire Brigade Organization Statement: A written statement that identifies the scope of the fire brigade, organizational structure, training requirements, brigade size, and functions of the brigade members.

Fire Department Connection: Connections provided at ground level through which the fire department supplies sprinkler systems or standpipe systems.

Fire Detection Devices: The devices and connections installed in a building for the purpose of detecting the

presence of heat, smoke, and/or flame.

Fire Door: A specially constructed, tested, and approved door installed for the purpose of preventing the spread of fire.

Fire Hazards: Conditions that are conducive to fire or are likely to increase the extent or severity of fire. The terms *hazard* or *hazardous* are also used to indicate the type of material or rate of burning.

Fire Point Temperature: The temperature a liquid must be before the released vapor is in sufficient quantity to continue to burn, once ignited.

Fire Prevention: Fire protection activities that deal with preventing fires starting by eliminating fire hazards through inspection and education programs.

Fire prevention code or ordinance: A law enacted in a political jurisdiction for the purpose of enforcing fire prevention and safety regulations.

Fireproof: The word *fireproof* is a misnomer as it means that something absolutely will not burn. Other terms such as *fire resistive* or *fire resistant* should be used to indicate the degree of resistance to fire.

Fire Protection Engineer: A graduate of an accredited institution of higher learning who has specialized in engineering problems related to fire protection.

Fire Pump: A water pump used in private fire protection for providing additional water supply to installed fire protection systems.

Fire Report: The official report of a fire, generally prepared by the person in charge of the fire incident.

Fire Resistive: Material and design of building construction meant to withstand the maximum effect of a fire for a specific period of time.

Fire Stream: A stream of water from a fire nozzle, used to control and combat fires.

Fire Tetrahedron: A four-sided, solid geometric figure that resembles a pyramid, with one of the sides forming the base. Each side indicates one of the four elements required to have fire.

Fire Triangle: A plane geometric figure in which the three sides of an equilateral triangle represent oxygen, heat, and fuel, the elements necessary to sustain combustion.

First Order Process: A chemical process where the rate of reaction is directly proportional to the amount of chemical present.

First-Pass Effect: Biotransformation of a xenobiotic before it reaches the systemic circulation. The biotransformation of an intestinally absorbed xenobiotic by the liver is referred to as a hepatic first-pass effect.

First Responder: A trained hazard materials specialist who is first to arrive at a hazard materials incident such as a spill.

Fissile Material: This term refers to radioactive materials. The term means any material consisting of or containing one or more fissile radionuclides. Fissile radionuclides are plutonium-238, plutonium-239, plutonium-241, uranium-233, and uranium-235. Neither natural nor depleted uranium are fissile material. **Fission**: The process in which large radionuclides fragment into smaller pieces and release radiation in the form of particles of energy. The splitting of an atomic nucleus into two parts accompanied by the release of a large amount of radioactivity and heat.

Fission Products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

Fit Factor (FF): The FF is the protection for a particular individual wearing a specific respirator. The FF must be measured using quantitative fit testing methods.

Flame Impingement: The points where flames contact the surface of a container or designated surface.

Flame Spread: The speed at which a flame will cross the surface of a material, influenced by the physical form of the fuel, air supply, the moisture content of the fuel, specific gravity, size and form, the rate and period of heating, and the characteristics/nature of the heat source. A higher flame-spread critically affects the severity of the fire in a given period of time.

Flammable: The term refers to a chemical that falls into one of the following categories: (a) aerosol, flammable, (b) gas, flammable, (c) liquid, flammable, (d) solid flammable.

Flammable Gas: The term *gas, flammable* means: (a) a gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 % by volume or less: or (b) a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 % by volume, regardless of the lower limit. The U.S. DOT defines a flammable gas (Hazard Class 2, Division 2.1) as any material which is a gas at 20 °C (65 °F) or less, and 101.3 kPa (14.7 psi) of pressure (a material which has a boiling point of 20 °C (68 °F) or less at 101.3 kPa (14.7 psi) which (1) is ignitable at 101.3 kPa (14.7 psi) when in a mixture of 13 percent or less by volume with air; or (2) has a flammable range at 101.3 kPa (14.7 psi) with air of at least 12 percent regardless of the lower limit.

Flammable Liquids: Any liquid having a flash point temperature below 100 °F. The U.S. defines this as a Class 3 Hazard, which is a liquid having a flash point of not more than 60.5 °C (141 °F), or any material in a liquid phase with a flash point at or above 37.8 °C (100 °F) that is intentionally heated and offered for tranportation or transported at or above its flash point in a bulk packaging.

Refer to section 173.120 of 49 CFR, Parts 100 to 177 for exceptions to this definition.

Flammable Solid: The term *flammable, solid* means a solid other than a blasting agent or explosive that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. Flammable solids are Class 4, Division 4.1 Hazards. Refer to Section 173.124 of 49 CFR, Parts 100 to 177 for detailed shipping information.

Flashover: The stage of a fire in which a room or other confined area becomes heated to the point that flames flash over the entire surface of the area.

Flash Point Temperature: The lowest temperature a liquid may be and still have the capability of liberating flammable vapor at a sufficient rate that, when united with the proper amounts of air, the air-fuel mixture will flash if a source of ignition is presented. The amounts of vapor being released at the exact flash point temperature will not sustain the fire and, after flashing across the liquid surface, the flame will go out.

Fly Ash: These are fine particles of ash of a solid fuel which are either carried out of the flue with waste gases produced during combustion or are recovered from the waste gases.

Foam: A sudslike extinguishing agent formed by mixing a foam-producing compound with water. Mechanical foam is produced by agitation, chemical foam is produced when two or more chemicals react.

Foaming Agent: A material which causes a chemical to form a thick foam; often applied to reduce drift or assist in the containment of certain types of chemical spills or fires.

Foam Generators: Devices for mixing chemical or mechanical foam in proper proportion with a stream of water to produce foam.

Foci: A small group of cells occurring e.g. in the liver distinguishable, in appearance or histochemically, from the surrounding tissue. They are indicative of an early stage of a lesion which may lead to the formation of neoplastic nodules or hepatocellular carcinomas.

Foetus: The young of mammals when fully developed in the womb. In human beings, this stage is reached after about 3 months of pregnancy. Prior to this, the developing mammal is at the embryo stage.

Fog Stream: A water stream of finely divided particles used for fire control.

Frame-Shift Mutation: A change in the structure of DNA such that the transcription of genetic information into RNA is completely altered because the start point for reading has been altered: i.e. the reading frame has been altered.

Frangible Disc: A safety release device that will burst at a predetermined pressure.

Free Burning: The second phase of burning in which materials or structures are burning in the presence of adequate oxygen.

Free Radical: An atom or group of atoms bound together chemically with at least one unpaired electron. A free radical is formed by the introduction of energy to a covalently bonded molecule, when that molecule is broken apart by the energy. It cannot exist free in nature and, therefore, must react quickly with other free radicals present.

Freezing Point: The temperature at which a liquid changes to a solid.

Fuel: Anything that will burn.

Fuel Oils: Refined petroleum products having specific gravities in the range of 0.85 to 0.98 and flash point temperatures above 55°C. This includes auto diesel, industrial heating fuels, various bunker fuels, furnace fuels. Refer to Chapter 4 for specific examples and discussion of properties.

Fuel Value: Refers to the amount of potential energy that can be released by a fuel during combustion. Expressed in units of BTUs per pond of fuel. Examples are asphalt (17,158 BTU/lb typical value), LPG (18,000 BTU/lb), wood shavings (8,250 BTU/lb).

Fuel Oils: Refined petroleum products having specific gravities in the range from 0.85-0.98 and flash points greater than 55°C; includes furnace, auto diesel, and stove fuels, plant or industrial heating fuels and various bunker fuels.

Fugacity: The tendency for a substance to transfer from one environmental medium to another.

Full Protective Clothing: Clothing that will prevent gases, vapors, liquids, and solids from contacting the skin; includes helmet, self- contained breathing apparatus, coat and pants customarily worn by firefighters, rubber boots, gloves, bands around legs, arms and waist, and face mask, as well as covering for neck, ears, and other parts of head not protected by the helmet, breathing apparatus or face mask.

Fully Encapsulating Suit (FES): Sometimes referred to as a *Moon Suit*; personal protective clothing that provides complete skin, eye, and respiratory protection, and includes positive-pressure SCBA. The reader should refer to Chapter 2 for detailed discussions. Refer to Protective Materials.

Fumes: Solid particles formed by the condensation of vaporized solids, usually molten metals. Particles are much

smaller than dusts with typical size ranges between 0.01 and 1.0 microns.

Functional Group: An atom or group of atoms, bound together chemically, that has an unpaired electron, which when it attaches itself to the hydrocarbon backbone, imparts special properties to the new compound thus formed.

Fungicide: Pesticide that controls or inhibits fungus growth.

Fusible Link: A connecting link device that fuses or melts when exposed to heat. Used in sprinkler heads, fire doors, and ventilators.

Fusible Plug: A safety relief device that will melt at a predetermined temperature.

G

Gallbladder: organ that secretes bile.

Gamma: A type of electromagnetic radiation; a form of ionizing radiation.

Gamma Rays: High energy, short wave-length electromagnetic waves, comprised of photons or fine packets of energy which travel in straight paths at the speed of light. Gamma rays are very penetrating but do not make the target radioactive. Gamma rays can be shielded against by the use of dense materials such as lead or depleted uranium.

Gas: A state of matter defined as a fluid with a vapor pressure exceeding 40 psia at 100° F.

Gasolines: Mixture of volatile, flammable liquid hydrocarbons used in internal combustion engines. Typical flash point temperature is around -40 °C.

Gastric: pertaining to the stomach.

Gastrointestinal Syndrome: Illness resulting from acute exposure to a chemical or ionizing radiation, resulting in damage to the gastrointestinal tract.

Gated Wye: A hose appliance that has one female inlet and two or more male outlets with a gate valve on each of the male outlets.

Gelling Agents: Chemicals that are used to increase the viscosity of oils or other substances; applied to reduce the rate of spread over a water body's surface during a spill.

Gene: A part of the DNA (q.v.) molecule which directs the synthesis of a specific polypeptide chain.

General Formula: The general molecular formula for an analogous series of compounds that will give the actual molecular formula for any member of the series as long as the number of carbon atoms in the compound is known. This number is substituted for the letter "*n*" in the formula.

Genetic Toxicology: The study of chemicals which can produce harmful heritable changes in the genetic information carried by living organisms in the form of deoxyribonucleic acid (DNA).

Genome: All the genes (q.v.) carried by a cell.

Genotoxic: Able to cause harmful heritable changes in DNA.

Genotype: The genetic constitution of an organism cf. Phenotype.

Glaucoma: increased pressure inside the eyes.

Glycerol: A series of substituted hydrocarbons with three hydroxyl radicals substituted for hydrogen atoms.

Glycol: A hydrocarbon derivative with two hydroxyl radicals substituted for two hydrogen atoms.

Glycosuria: glucose in the urine.

Gravimetric: Of or pertaining to measurement by weight.

Gravity Tank: An aboveground water storage tank for fire protection and water service. A water level of 100 feet provides a static pressure head of 43.3 psi minus friction loss in piping when water is flowing.

Grid System Water Mains: An interconnecting system of water mains in a cris-cross or rectangular pattern.

Guinea Pig Maximization Test: One of a number of skin tests for screening possible contact allergens. Considered to be a useful model for predicting likely moderate and strong sensitizers in humans.

H

H.A.D. (Heat Actuating Devices): Thermostatically controlled devices used to activate fire equipment, alarms, or appliances.

Haemosiderin: An iron-protein molecule; inter alia, a source of the iron required for hemoglobin synthesis.

Halide: A halogenated compound.

Halogenated: A compound that has had a halogen atom substituted for another hydrogen atom. A halogenated hydrocarbon is a hydrocarbon that has had at least one hydrogen atom removed and replaced by a halogen.

Halogenated Aromatic Hydrocarbons: A group of chemical compounds constructed primarily of carbon and hydrogen, containing one or more ring structures, thus giving then distinctive odors (aromatics). These compounds contain halogens (chlorine or bromine) which impart toxic effects. Examples are dioxin, PCBs, DDT (dichlorodiphenyltrichloroethane), and PBBs. To most biological substances, halogenated aromatic hydrocarbons are foreign, unnatural substances, metabolized with difficulty or not at all. They are soluble in fats and oils; most are not soluble in water. They tend to accumulate in the fatty tissue of animals and remain there indefinitely, their concentration increasing with the age of the animals.

Halogenation: The chemical reaction whereby a halogen

is substituted for another atom, usually a hydrogen atom.
Halogens: The elements of group VIIA: fluorine, chlorine, bromine, iodine, and astatine.
Halon: Halogenated extinguishing agent. Halon extinguishes fires by inhibiting the chemical reaction of fuel and oxygen.
Handline: Small hoselines that can be handled and maneuvered without mechanical assistance.
Haploid: The condition in which the cell contains one set of chromosomes.
Hazardous Materials Classes: The hazard class of a hazardous material is indicated by its class (or division) number, or its class name. For a placard corresponding to the primary hazard class of a material, the hazard class or division number must be displayed in the lower corner of the placard. However, no hazard class or division may be displayed on a placard representing the subsidiary hazard of the material. The class or division number must appear on the shipping paper after each shipping name. The reader should refer to Chapter 1 for detailed information on hazardous materials classes.
Hazard (Toxic): The set of inherent properties of a chemical substance or mixture which makes it capable of causing adverse effects in man or the environment when a particular degree of exposure occurs.
Head Wave: A term important to oil spills. The term refers to an area of oil concentration which occurs behind and at some distance from containment booms. This area is significant to the positioning of mechanical recovery devices and is the region where droplet breakaway boom failure phenomenon is initiated when current flow exceeds critical velocity.
Health Hazard: The term refers to a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees.
Heat: A form of energy; the total amount of vibration in a group of molecules.
Heat Stress: The burden, or load of heat, that must be dissipated if the body is to remain in thermal equilibrium.
Heat Transfer: The movement and dispersion of heat by conduction, convection, or radiation.
Heavy Metals: High-density metallic elements generally toxic to plant and animal life in low concentrations (e.g. mercury, chromium, cadmium, arsenic, and lead).
Hematoma: swelling containing blood.
Hematopoietic: formation of blood cells.
Hematopoietic Agents: The term refers to a specific target organ characterization of effect. Hematopoietic agents are chemicals which act on the blood or hematopoietic system by decreasing hemoglobin function or depriving the body tissues of oxygen. Signs and symptoms include cyanosis; loss of consciousness. Examples are carbon monoxide and cyanides.
Hemoglobin: The red coloring matter of the blood which carries the oxygen.
Hemoglobinuria: hemoglobin in the urine.
Hemolysis: destruction of red blood cells.
Hemolytic anemia: loss of red blood cells resulting from destruction.
Hepatocyte: Liver cell; more specifically a parenchymal cell of the liver.
Hepatotoxic: Harmful to the liver.
Hepatotoxins: The term refers to a specific target organ characterization of effect. Hepatotoxins are chemicals which produce liver damage. Signs and symptoms are jaundice and liver enlargement. Examples are carbon tetrachloride and nitrosamines.
High Efficiency Particulate Air (HEPA) Filter: A HEPA filter is a particulate filter that has a removal efficiency of at least 99.97 % for 0.03 micron size particles. This types of filter is most often used when working with asbestos abatement projects.
Histology: The study of the anatomy of tissues and their cellular structure.
Histopathology: The study of microscopic changes in tissues.
HNU Photoionizer: Hazard Monitored: Organic and inorganic vapors and gases. Application: This instrument is used to determine the relative concentrations of air contaminants. Information can be used to establish levels of protection and other control measures such as action levels. It will not detect methane. Components: Survey probe with ultraviolet lamp (9.5, 10.2, 11.7 eV); needle meter readout; lead-acid gel battery; span potentiometer; range selector; zero control. Detection Method: Photoionization. Operation: Ultraviolet light photons are generated by the UV lamp and directed at the sample. If the energy of the photons is sufficient it will ionize the molecules of the vapor/gas in the sample. The amount of energy necessary to photoionize a molecule is represented by its Ionization Potential (IP). Thus the lamp energy must be equal to or greater than the IP of a compound. Once ionized, the freed electrons are collected at an electrode to generate a current. The greater the current, the higher the concentration. Readout: The meter can be read on the following ranges: 0-20, 0-200, 0-2000 ppm (span = 9.8 benzene equivalents). Calibration: The instrument is factory calibrated to benzene. The calibration should be checked before and after use with a calibration check gas. Once calibrated, the span setting can be changed. HNU

Systems supplies isobutylene as a check as for the instrument. Limitations: Because the instrument is sensitive to many organic and inorganic vapors/gases, it cannot be used as a qualitative instrument in unknown situations. It is strictly qualitative except when the nature of the contamination is known and the instrument has been calibrated to or a calibration curve has been generated for the contaminant being monitored. High humidity reduces the instrument's sensitivity. Atmospheres with concentrations of vapors and gases above the detection limits of the instrument will cause inconsistent instrument behavior.

Homeostasis: The tendency in an organism toward maintenance of physiological and psychological stability.

Hormone: a biochemical secreted by the body that exerts an effect on an organ elsewhere in the body.

Horsepower: A measure of power; one horsepower is equivalent to a force that will raise 33,000 pounds one foot in one minute.

Hose Cabinet (Rack): A recessed cabinet in a wall that contains a wall hydrant and connected length of hose.

Hose Clamp: A mechanical device for compressing fire hose to stop the flow of water.

Hose Reel: Cylinders around which fire hose may be manually or mechanically rolled to keep it neat and orderly.

Hydrant Hose House: A structure built around a yard hydrant containing fire hose, nozzles, axes, and other fire fighting tools.

Hydrant Wrench: A specially designed tool used to open or close a hydrant and to remove hydrant caps.

Hydration: Process in which particles go into a water solution and become surrounded by a sheath of water molecules.

Hydrocarbon: A covalent compound containing *only* hydrogen and carbon.

Hydrocarbons: The basic building blocks of all organic chemicals which are composed solely of carbon and hydrogen. Hygroscopic. Readily absorbing or retaining moisture.

Hydrocarbon Backbone: The molecular fragment that remains after hydrogen atom is removed from a hydrocarbon; the hydrocarbon portion of a hydrocarbon derivative.

Hydrocarbon Derivative: A compound that began as a hydrocarbon, had a hydrogen atom removed from the chain somewhere, and had functional group attached to replace the hydrogen atom.

Hydrolysis: Hazardous waste chemical treatment method wherein chemical compounds are decomposed by a reaction with water; agents such as alkaline solutions as well as high temperatures and pressures are often used to promote desired reaction.

Hydrophilic: Refers to a substance or chemical that has a high affinity for moisture or water.

Hydrophobic: Refers to a substance or chemical that is poorly soluble in water; water repellant. A *hydrophobic agent* is a chemical having the ability to resist wetting by water. It can be used in the treatment of synthetic sorbents to decrease the amount of water absorbed, hence increasing the volume of oil they can absorb before becoming saturated.

Hydrosphere: Water above, on or in the Earth's crust, including oceans, seas, lakes, groundwater and atmospheric moisture.

Hydroxyl: The functional group of the alcohols; the structural formula is -O-H, usually written -OH.

Hygroscopic: The ability of a material to absorb moisture from air.

Hyperemia: congestion of blood vessels from excess blood.

Hyperglycemia: high blood sugar level.

Hypergolic: Any material that spontaneously ignites upon contact with another. Many hygroscopics are used as rocket fuels.

Hypertension: high blood pressure.

Hypertrophy: exaggerated growth of a tissue.

Hypocholesterolaemia: A lowering of the cholesterol content of the blood.

Hypotension: low blodd pressure.

Hypotriglyceridaemia: A lowering of the triglyceride content of blood.

I

IDLH: Immediately Dangerous to Life and Health. The OSHA definition for IDLH is the maximum concentration of contaminant from which one can escape in 30 minutes without suffering irreversible health effects or escape-impairing effects such as dizziness, fatigue, impaired judgement, or slowing. Based on human and animal studies IDLH may be considered the LOEL (lowest observable effect level); or 500 x PEL if no other data are available; or any concentration that is above the chemical's Lower Explosive Limit (LEL). IDLH values can be found in AIHA Hygienic Guides, the NIOSH Pocket Guide, and commercial databases.

Ignitable Waste: A liquid with a flash point less than 60°C (140°F), a waste which is an oxidizer, or ignitable compressed gas or non-liquid which is liable to cause fires through friction, absorption of moisture, spontaneous chemical changes or when ignited burns so vigorously and persistently as to create a hazard.

Ignition Continuity: The continuation of burning caused by the radiated heat of the flame.

Ignition Temperature: The exact minimum temperature that has the capability of igniting a flammable vapor mixture.

Immediately Dangerous to Life or Health Concentration (IDLHC): The maximum exposure concentration from which one could escape within 30 minutes without any escape impairing symptoms or any irreversible health effects. This value should be referred to in respirator selection.

Immobilization Threshold: The minimal amount of a substance causing cessation of movement in a test organism when applied in a particular manner.

Immune response: The development of specifically altered reactivity following exposure to an antigen. This may take several forms, e.g. antibody production, cell-mediated immunity, immunological tolerance.

Immunotoxic: Harmful to the immune system.

Incident Command System (ICS): An ICS is an organized approach to control and manage operations at an emergency incident. The OSHA Hazardous Waste Operations and Emergency Response regulations (29 CFR 1910.120 (q) (3) (iii)) require that and ICS be implemented by the senior emergency response official on the scene. The reader should refer to Appendix 6, of the OSHA rule for more information on ICS.

Incipient Stage Fire: A fire in its beginning stage that can be controlled or extinguished using portable fire extinguishers, Class II standpipe, or small hose systems without the need for protective clothing or breathing equipment.

Incompatible Waste: (1) A hazardous waste unsuitable for placement within a specific portion of a landfill because it may cause containment material to corrode or decay or, when combined with other wastes, might produce heat, pressure, fire, explosion, violent reaction, toxic dusts, mists, fumes, or gases. (2) Hazardous wastes which, if mixed, would become more hazardous than either waste individually.

Indirect Application: A method of extinguishing fire by applying water fog into a superheated atmosphere to obtain the maximum heat absorption and steam generation for smothering and cooling the fire area.

Inert (chemical): Not having active properties.

Inflammable Liquids: Liquids emitting vapors which become combustible at a certain temperature.

Initiator: An agent which starts the process of tumor formation, usually by action on the genetic material.

Inorganic: Term used to designate compounds that generally do not contain carbon.

In-Place Protection: Means people go inside a building and remain inside until the danger passes. In the case of short-term spills and toxic vapor clouds, the material may be deflected by a multi-story building and pass by without affecting the occupants of the building. In-place protection if used when evacuating the public would cause greater risk than staying where they are, or when an evacuation cannot be performed. Direct the people inside to close all doors and windows and to shut off all ventilating, heating and cooling systems. In-place protection may not be the best option if

(a) the vapors are flammable;

(b) if it will take a long time for the gas to clear the area; or

(c) if buildings cannot be tightly closed.

Vehicles can offer some protection for a short period if the windows are closed and the ventilating systems are shut off. They are not as effective as buildings for in-place protection.

Input Heat: The amount of heat required to produce the evolution of vapors from a solid or liquid.

In Vitro: Biological processes occurring (experimentally) in isolation from the whole organism.

Interior Structural Fire Fighting: The act of fire suppression and rescue inside buildings or enclosed structures where a fire has gone beyond the incipient stage.

Intoxication: state of being poisoned by a toxic chemical.

Irritant: The term refers to a chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A chemical is a skin irritant if, when tested on the intact skin of albino rabbits by the methods of 16 CFR 1500.41 for four hours exposure or by other appropriate techniques, it results in an empirical score of five or more. A chemical is an eye irritant if so determined under the procedure listed in 16 CFR 1500.42 or other appropriate techniques.

Ischaemia: A deficiency of blood supply to a part of the body relative to its localized requirements.

"Iso": The prefix (meaning the same) given to a compound having the same number and kind of atoms as another compound, as in *iso*mer.

ISO: International Organization for Standardization. An international standards-writing body headquartered in Geneva, Switzerland, composed of national standards associations from some 55 countries. All member countries are given equal status and are entitled to one vote regardless of size or economic development. Technical work is carried on in committees.

Isomer: A compound with a molecular formula identical to another compound but with a different structural

formula. That is, a compound may possess exactly the same elements, and exactly the same number of atoms of those elements as another compound, but those atoms are arranged in a different order from the first compound.
Isotope: One of two or more atoms with the same atomic number (the same chemical element) but with different atomic weights; isotopes usually have very nearly the same chemical properties but somewhat different physical properties.
i. v.: Abbreviation for intravenous (administration).

K

Keratosis: inflammation of the cornea.
Ketone: A hydrocarbon derivative with the general formula R-C-R'.
Kinetic Molecular Theory: A theory that states all molecules are in constant motion at all temperatures above absolute zero; molecules will move (or vibrate) faster at higher temperatures because of the energy absorbed.

L

Laryngeal: upper throat area.
Larynx: voice box.
Latent Heat of Vaporization: The amount of heat a substance must absorb when it changes from a liquid to a vapor or gas.
Latent Period: The time which elapses between exposure and the first manifestation of damage.
LC_{50}: Concentration of an active ingredient in the air which, when inhaled, kills half of the test animals exposed to it; expression of a compound's toxicity when present in the air as a gas, vapor, dust, or mist; generally expressed in ppm when a gas or vapor, and in micrograms per liter when a dust or mist: often used as the measure of acute inhalation toxicity. The lower the LC_{50} number value the more poisonous the pesticide.
LD_{50} : Dosage or amount of an active ingredient which, when taken by mouth or absorbed by the skin, kills half of the test animals exposed; an expression used to measure acute oral or acute dermal toxicity.
LD_{100}: The dose of an active ingredient taken by mouth or absorbed by the skin which is expected to cause death in 100% of the test animals so exposed.
Lesion: A pathological disturbance such as an injury, an infection or a tumor.
Lethal Concentration: Amount of toxic substance in air which will likely cause death if inhaled.
Lethal Dosage: (1) Amount of a toxic substance which is likely to cause death when ingested. (2) Dose of ionizing radiation sufficient to cause death; media lethal dose (MLD or LD50) is amount required to kill within a specified period of time (usually 30 days) half of the organisms exposed; the LD50/30 for people is about 400-450 roentgens.
Lethal Time (LT): The time required for a defined dose of toxicant to produce a given mortality level in a test organism.
Lesion: deseased or damaged tissue.
Levels of Protection: These are designated levels of skin, eye and respiratory protection for hazard materials workers. There are four levels of protection defined under OSHA standards. Following is a summary of the OSHA recommended levels of personal protection. *Level A* - Recommended Personal Protective Equipment: Positive pressure-demand, full face SCBA or positive-pressure demand supplied air respirator with escape SCBA. Fully encapsulating, chemical-resistant suit. Inner chemical-resistant gloves. Chemical-resistant, safety boots/shoes. Two-way radio communications. Optional Recommended Equipment: Cooling unit. Coveralls. Long Cotton Underwear. Hard Hat. Disposable Gloves and Boot Covers. Protection Provided: The highest level of respiratory, skin, and eye protection. Conditions Under Which Should Be Used: The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system on either: - measured (or potential for) high concentration of atmospheric vapors, gases, or particulates or - site operations and work functions involving a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to the skin or capable of being absorbed through the intact skin. Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible. Operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined. Limiting Criteria: Fully encapsulating suit material must be compatible with the substances involved. *Level B* - Recommended Personal Protective Equipment: Positive pressure-demand, full facepiece SCBA or positive pressure-demand supplied-air respirator with escape SCBA. Chemical-resistant clothing (overalls and long-sleeved jacket; hooded one- or two-piece chemical splash suit; disposable chemical-resistant one-piece-suit). Inner and outer chemical-resistant gloves. Chemical-resistant safety-boots/shoes. Hard hat. Two-way radio communications. Optional Recommended Equipment: Coveralls. Long Cotton Underwear. Face Shield. Hard Hat. Disposable Gloves and Boot Covers. Protection Provided: The same level of respiratory protection, but less skin

protection than Level A. It is the minimum level recommended for initial site entries until the hazards have been further identified. Conditions under Which Should Be Used: The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection. This involves atmospheres which have IDLH concentrations of specific substances that do not represent a severe skin hazard; or atmospheres that do not meet the criteria for use of air-purifying respirators; or atmospheres that contain less than 19.5 % oxygen, which is the minimum safe level. This level of protection should be used when the presence of incompletely identified vapors or gases is indicated by direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin. This level of protection should also be used when operations must be conducted in confined, poorly ventilated areas until the absence of conditions requiring Level A protection is determined. Limiting Criteria: Use only when the gases and vapors present are not suspected of containing high concentrations of chemicals that are harmful to shin or capable of being absorbed through the intact skin. Use only when it is highly unlikely that the work being done will generate either high concentrations of vapors, gases, or particulates or splashes of material that will affect exposed skin. *Level C* - Recommended Personal Protective Equipment: Full facepiece, air-purifying canister equipped respirator. Chemical-resistant clothing (overalls and long-sleeved jacket; hooded one- or two- piece chemical splash suit; disposable chemical-resistant one-piece suit). Inner and outer chemical-resistant gloves. Chemical-resistant safety boots/shoes. Hard hat. Two-way radio communications. Optional Recommended Equipment: Coveralls. Long Cotton Underwear. Face Shield. Disposable Boot Covers. Escape Mask. Protection Provided: The same level of skin protection as Level B, but a lower level of respiratory protection. Conditions under Which Should Be Used: The atmospheric contaminants, liquid splashes, or other direct contact will not adversely effect any exposed skin. The types of air contaminants have been identified, concentrations measured, and a canister is available that can remove the contaminant. All criteria for the use of air-purifying respirators are met. Limiting Criteria: Atmospheric concentration of chemicals must not exceed IDLH levels. The atmosphere must contain at least 19.5 % oxygen, which is the minimum safe level. *Level D* - Recommended Personal Protective Equipment: Coveralls, Safety boots/shoes, safety glasses or chemical splash goggles, hard hat. Optional Recommended Equipment: Gloves, face shield, escape mask. Protection Provided: No respiratory protection and minimal skin protection. Conditions under Which Should Be Used: The atmosphere contains no known hazard. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals. Limiting Criteria: This level should not be worn in the Exclusion Zone of a hazardous work site. The atmosphere must contain at least 19.5 % oxygen, which is the minimum safe level.

Leukemia: cancer of the blood cells.

Limit Value (LV): The limit at or below which Member States of the European Community must set their environmental quality standards and emission standards. These limits are set by Community Directives.

Liquid: A fluid with a vapor pressure no higher than 40 psia.

Liquified Gas: A gas that has been converted to a liquid by pressure and/or cooling.

Liver Nodule: A small node, or aggregation of cells within the liver.

Local Alarm System: A combination of alarm components designed to detect a fire and to transmit an alarm on the immediate premises.

Looped Water Main: A water main arranged in a complete circuit so water will be supplied to a given point from more than one direction. Also called a grid system.

Lower Explosion Limit (LEL): The LEL is expressed as a percentage of the total volume of the air-fuel mixture; it is the lowest concentration of vapor fuel in air under which spontaneous combustion will occur. An example is gasoline. A mixture containing 1.5% gasoline vapor in air (concentration of air being 98.5% in this mixture) will spontaneously combust. The LEL in this example is 1.5% or simply 1.5. Below this concentration, the mixture is described as being too "lean"; or in other words, there is insufficient fuel for spontaneous combustion to occur.

Lymph: clear, yellow fluid found throughout the body.

Lymph Nodes: glands that produce lymph.

Lymphatic System: vessels that carry the lymph to the body.

M

Macrophages: A large phagocytic cell found in connective tissues, especially in areas of inflammation.

Malignancy: A cancerous growth. (A mass of cells showing both uncontrolled growth and the tendency to invade and destroy surrounding tissues).

Malignant: very injurious or deadly.

Mammary Tissue: milk-producing tissue of the breast.

Manometer: Instrument for measuring pressure; essentially a U-tube partially filled with a liquid (usually water, mercury, or a light oil), so constructed that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Maximum Allowable Concentration (MAC): Exposure concentration not to be exceeded under any circumstances.

Maximum Use Concentration (MUC): Also known as the Maximum Use Level or MUL. It is the maximum outside contaminant concentration a respirator can adequately protect against. The MUC can be calculated from the following relation: MUC = PF or FF x PEL (or other standard). The MUC is limited to a chemical cartridge's rated capacity.

Median Effective Concentration (EC_{50}): The concentration of toxicant or intensity of other stimulus which produces some selected response in one half of a test population.

Median Effective Dose (ED_{50}): The statistically derived single dose of a substance that can be expected to cause a defined nonlethal effect in 50% of a given population of organisms under a defined set of experimental conditions.

Median Lethal Concentration (LC_{50}): The concentration of a toxicant lethal to one half of a test population.

Median Lethal Dose (LD_{50}): The statistically derived single dose of a chemical that can be expected to cause death in 50% of a given population of organisms under a defined set of experimental conditions. This figure has often been used to classify and compare toxicity among chemicals but its value for this purpose is doubtful. One commonly used classification of this kind is as follows:

Category	LD_{50} Orally to Rat mg/kg body weight
Very toxic	<25
Toxic	>25 to 200
Harmful	>200 to 2000

Melting Point: The temperature at which a solid changes to a liquid.

Mesothelioma: A tumor of the mesothelium of the pleura, pericardium or peritoneum, arising as a result of the presence of asbestos bodies. A locally malignant spreading tumor diagnostic of exposure to asbestos.

Metabolic Activation: The biotransformation (q.v.) of relatively inert chemicals to biologically reactive metabolites.

Metabolism (Heat): Energy resulting from physical and chemical changes which are constantly occurring in the body. Term used for heat stress evaluation.

Methemoglobinemia: type of blood disease.

Microbar: A unit of pressure, commonly used in acoustics which equals 1 dyne per square centimeter or one newton. A reference point for the decibel, is 0.0002 dyne per square centimeter, or 20 Newtons/M^2.

Micron: A unit of length equal to 10^{-4} centimeter, approximately 1/25,000 of an inch.

Mists: Liquid particles generated by physical processes such as splashing, vaporization and condensation.

Mixed Function Oxidases: Oxidizing enzymes which are involved in the metabolism of many foreign compounds giving products of different toxicity from the parent compound.

Molecular Formula: A method of representing a molecule by a written formula, listing which atoms and how many of them are in the molecule, without showing how they are bonded to each other. **Monitor:** The measurement of the environmental factors which may adversely affect health.

"Mono-": The prefix that means one.

Monomer: A simple, small molecule that has the special capability of reacting with *itself* to form a giant molecule called a polymer.

Mucous Membrane: tissue lining of nose, mouth, esophagus, stomach, and intestine.

Multigeneration Study: A toxicity test in which at least three generations of the test organism are exposed to the chemical being assessed. Exposure is usually continuous.

Mutagen: Substance causing genes in an organism to mutate or change.

Mutagenic: Capable of producing a genetic change.

Mutagenic Agent: A chemical agent bringing changes in the hereditary makeup of the individual when applied to a living organism, resulting in progeny differing from the parent in some respect.

Mutagenesis: The production of mutations. Any chemical which causes mutations is said to be mutagenic. Some mutagenic chemicals are also carcinogenic. See *Carcinogenesis* .

Munant: an organism that has undergone a generic change.

Mutation: Any relatively stable heritable change in the genetic material.

N

Naphtha: Various volatile and often flammable liquid hydrocarbon mixtures used as solvents and diluents; consists mainly of hydrocarbons with higher boiling point than gasolines and lower boiling point than kerosene; principal component of chemical dispersants used prior to 1970.

Naphthenes: Class of hydrocarbons with similar physical

and chemical properties to alkanes; insoluble in water, generally boil at 10-20°C higher than corresponding carbon number alkanes.

Narcosis: Stupor or unconsciousness produced by chemical substances.

Nausea: upset stomach; feeling of need to vomit.

Necrosis: Death in a particular part of a living tissue; example: death of a certain area of a leaf.

"Neo-": A prefix given to an isomer of another compound. It exists in compounds that were named long ago and is used only when the compound it best known by its common name.

Neoplasm: Any new and morbid formation of tissue e.g. a malignancy.

Nephritis: inflammation of the kidneys.

Nephrotoxic: Harmful to the kidney.

Nephrotoxins: The term refers to a specific target organ characterization of effect. Nephrotoxins are chemicals which produce kidney damage. Signs and symptoms are edema and proteinuria. Examples are halogenated hydrocarbons and uranium.

Neurotoxins: The term refers to a specific target organ characterization of effect. Neurotoxins are chemicals which produce their primary toxic effects on the central nervous system. Signs and symptoms are narcosis, behavioral changes, and decrease in motor functions. Examples are mercury and carbon disulfide.

Nephrosis: kidney degeneration.

Neurogenic: pertaining to the nerves.

Neurologic: pertaining to the nervous system.

NFPA : National Fire Protection Association

NIOSH: Abbreviation for National Institute of Occupational Safety and Health.

Nitrophenols: Synthetic organic pesticides containing carbon, hydrogen, nitrogen, and oxygen: used as wood preservatives, fungicides, or disinfectants: affect liver and central nervous system in the human body.

Non-Target Organisms: Those organisms which are not the intended specific targets of a particular use of a pesticide.

No Observed Effect Level (NOEL): The maximum dose or ambient concentration which an organism can tolerate over a specific period of time without showing any adverse effect and above which adverse effects are detectable.

"Normal": The designation given to a straight-chain compound that has isomers. The designation in the molecular formula is an *"n-"* in front of the formula.

Nuisance Dust: Generally refers to innocuous dust, not recognized as the direct cause of a serious pathological condition.

O

Occupational Hygiene: The applied science concerned with the recognition, evaluation and control of chemicals, physical and biological factors arising in or from the workplace which may affect the health or well-being of those at work or in the community.

Ocular: Relating to the eye.

Olfactory: pertaining to the sense of smell.

Olefins: A synonym for the alkene series.

On Scene Commander (OSC): The overall coordinator of an oil spill response team, usually a representative of an oil company, a government official, or an independent oil spill cleanup contractor; responsible for on-site strategical decisions and actions throughout each phase of a cleanup operation and who maintains close liaison with the appropriate government agencies to obtain support and provide progress reports on each phase of the emergency response.

Oral Toxicity: How poisonous a pesticide is to an animal or person when taken by mouth.

Organelle: A structure with a specialized function which forms part of a cell.

Organic : Term used to designate chemicals that contain carbon. To date nearly one million organic compounds have been synthesized or isolated. Many occur in nature; others are produced by chemical synthesis.

Organic Peroxide: The term refers to an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Organic Vapor Analyzer (OVA): Hazard Monitored: Toxic concentrations of organic vapors. Application: This instrument is used to determine the relative concentrations of air contaminants. The information is used to establish levels of protection and other control measures such as site specific action levels. When equipped with the gas chromatograph option, it can be used for limited qualitative assessment of samples. Components: Survey probe with meter readout; self-contained hydrogen cylinder for detector; low and high audible alarm; range selector; lead-acid gel battery; gas select control; pressure gauges. Detection Method: Flame ionization. Operation: The sample is drawn by a pump to the detector where it is ionized (combusted). The electrons released are collected at an electrode which generates a current. The greater the current, the higher the concentration of contaminant. The instrument will detect only organic compounds. Readout: The meter can be read on the following ranges: 0-10, 0-100, 0-1000 ppm methane equivalent. Calibration: The

instrument is factory calibrated to methane. The calibration should be checked before and after use with a calibration check gas. Limitations: The instrument used in the survey mode in unknown atmospheres is strictly qualitative. Because the instrument is extremely sensitive to methane, it has limited application in areas where toxic vapors and gases are found with methane because the methane masks the other compounds. It is limited to about 8 hours of use due to hydrogen supply and battery life. Its use requires very high grade hydrogen: 99.95% pure. This instrument requires more training than other instruments when used in the gas chromatograph mode.

Organophosphate: Synthetic organic pesticides that contain carbon, hydrogen, and phosphorous; highly toxic to humans as they prevent proper transmission of nerve impulses.

ORM (Other Regulated Material): Under U.S. Department of Transportation regulations, an *Other Regulated Material* (ORM) is a material that: (a) May pose an unreasonable risk to health and safety or property when transported in commerce; and (b) Does not meet any of the definitions of the other hazard classes specified in subchapter C of the regulation; or (c) Has been reclassified an ORM (specifically or permissively).

ORM-A: This is a U.S. designation, where the reader should refer to 49 CFR 173.500. An ORM-A material is a material which has an anesthetic, irritating, noxious, toxic, or other similar property and which can cause extreme annoyance or discomfort to passengers and crew in the event of leakage during transportation. A list of the chemicals specified as ORM-A materials can be found in the regulation.

ORM-B: This is a U.S. designation, where the reader should refer to 49 CFR 173.500. An ORM-B material is a material (including a solid when wet with water) that is capable of causing significant damage to a transport vehicle from leakage during transportation. Materials meeting one or both of the following criteria are ORM-B designated materials: (a) A liquid substance that has a corrosion rate exceeding 0.250 inch per year on aluminum at a test temperature of 130 °F; and (b) Specifically designated by name in the Hazardous Materials Table found in 49 CFR 172.101.

ORM-C: This is a U.S. designation, where the reader should refer to 49 CFR 173.500. An ORM-C material is a material which has other inherent characteristics not described as an ORM-A or ORM-B but which make it unsuitable for shipment unless properly identified and prepared for transportation. Each ORM-C material is specifically named in the Hazardous Materials Table found in 49 CFR 172.101.

ORM-D: This is a U.S. designation, where the reader should refer to 49 CFR 173.500. An ORM-D material is a material such as a consumer commodity, which though otherwise subject to certain regulations, presents a limited hazard during transportation due to its form, quantity and packaging. They must be materials for which exceptions are provided in 49 CFR 172.101. A shipping description applicable to each ORM-D material or category can be found in the Hazardous Materials Table found in 49 CFR 172.101. In order to be transported under the proper shipping name of *consumer commodity*, a material must meet the that definition. It may be reclassified and offered for shipment as ORM-D material provided that an ORM-D exception is authorized in specific sections applicable to the material.

ORM-E: This is a U.S. designation, where the reader should refer to 49 CFR 173.500. An ORM-E is a material that is not included in any other hazard class, but is subject to the requirements of Title 49, Subchapter C. ORM-E materials include hazardous waste and substances as defined in 49 CFR 171.8.

OSHA: Abbreviation for Occupational Safety and Health Act.

OS & Y Valve: A type of outside screw and yoke valve used on piping or in pits connected to sprinkler systems. The position of the stem shows the valve to be either open or closed.

Osteroporosis: a condition in which bones become very fragile.

Osteosclerosis: hardening of bone tissue.

Ovarian: pertaining to the egg-forming organ in the female reproductive system.

Oxidation: The chemical combination of any substance with oxygen.

Oxidizer: The term refers to a chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Oxygen Deficiency: An atmosphere having less than the percentage of oxygen found in normal air. Normally, air contains about 21 per cent oxygen at sea level. When the oxygen concentration in air is reduced to approximately 16 per cent, many individuals become dizzy, experience a buzzing in the ears, and have a rapid heartbeat. OSHA indicates 19.5% as the lower limit of oxygen acceptable in industry.

Oxygen Meter: Hazard Monitored: Oxygen deficient atmospheres. Application: The instrument is used to determine atmospheric oxygen concentration. The information can be used to assess the presence of other asphyxiant, flammable or toxic gases/vapors. The

information is also considered in respirator selection. Components: Aspirator bulb or pump to draw sample, but also can be passive; meter readout with needle or LCD; audio and/or visual alarm or neither; NICAD or regular batteries; calibration adjustment. This instrument can be combined with a CGI and/or gas specific detection instrument such as a H_2S meter. Detection Method: Electrochemical cell. Operation: A sample of the atmosphere is drawn or allowed to diffuse into the detector. Oxygen in the sample reacts with the electrolyte n the cell generating a current. The higher the concentration, the greater the current. A potentiometer detects the increased current which is read on a meter needle or LCD. Readout: The instrument reads out as percent oxygen. Most instruments read from 0 to 25 % oxygen. Calibration : The instrument is easily calibrated to ambient oxygen in a clean atmosphere by adjusting a screw or knob. It should be calibrated at the same temperature and pressure it will be used in. Limitations : The instrument can be affected by temperature and pressure. Oxidizers can cause increased readings. Carbon dioxide can reduce instrument sensitivity.

P

Packing Group: This is a U.S. Department of Transportation designation that is assigned to a hazardous material in transport. The designation must appear by law on shipping papers and manifests. The Packing Group is designated by an upper case Roman Numeral **I**, **II**, or **III** depending on the degree of hazard. The designations are as follows : **I** refers to *Most Hazardous*; **II** refers to *Moderately Hazardous*; **III** refers to *Least Hazardous*. The reader should refer to Title 49, CFR, Section 172.101 (Hazardous Materials Table).

Pancreas: insulin producing gland.

Pancreatitis: inflammation of the pancreas.

Papilloma: type of tumor.

Paraffin Series: An older name given to the alkanes.

Parakeratosis: Imperfect formation of horn cells of the epidermis.

Parenchyma(-al): The specific or functional constituent of a gland or organ.

Partition Coefficient: A constant ratio that occurs when a heterogeneous system of two phases is in equilibrium; the ratio of concentrations (or strictly activities) of the same molecular species in the two phases is constant at constant temperature.

Pathogen: Any disease-producing organism.

PEA: Professional Environmental Auditor, a designation devised and trademarked by the author.

Pendent Sprinkler: An automatic sprinkler head designed for placement and operation with the head pointing downward from the piping.

Periorbital: area surrounding the eye socket.

Peripheral Nervous System: nervous system controlling the arms and legs.

Periphral neuritis: pertaining to the body cavity that surrounds all the abdominal organs.

Permeability: The property of soil or rock allowing passage of water through it; depends not only on the volume of openings and pores, but also on how these openings are connected to each other.

Peroxide: The hydrocarbon derivative with the general formula R-O-O-R'; also the name of the peroxide radical which has the structural formula -O-O-.

Personal Protective Clothing: Clothing and equipment such as coat, boots, pants, helmet, gloves, and breathing apparatus that shield the body from heat, smoke, fumes, and other harmful conditions.

Pesticides: Those chemicals used in agriculture to control the severity and incidence of pests and diseases which reduce agricultural yields; in addition, they have a number of non-agricultural uses.

pH: Means used to express the degree of acidity or alkalinity of a solution with neutrality indicated as 7.

Phagocytosis: The ingestion of micro-organisms, cells, and foreign particles by phagocytes; hence phagocytic *Macrophages*.

Pharmacodynamics: The study of the way in which xenobiotics exert their effects on living organisms. Synonym: toxicodynamics.

Pharmacokinetics: The study of the movement of xenobiotics within an organism. Such a study must consider absorption, distribution biotransformation, storage and excretion. Synonym: toxicokinetics.

Pharyngeal: pertaining to the pharynx.

Pharynx: sac surrounding the mouth, nose, and esophgus.

Phases of Fire: A degree of flame progression. Phase I, fire in incipient stage and beginning to grow. Phase II, free burning, flame propagation is at its greatest. Phase III, oxygen is deficient in the burn area, producing a smoldering phase.

Phenyl: The general name for the radical of benzene.

Pheromones: Chemicals produced by insects and other animals to communicate with other members of the same species; some are used to monitor insect populations; most pheromones used today are synthetic.

Phlebitis: inflammation of a vein.

Photoallergy: allergic response to a combination of a chemical and sunlight.

Photodegradable: Able to decompose through a chemical

reaction initiated by direct exposure to the sun's ultraviolet light.

Photosensitization: word used to describe either photoallergy or phototoxicity.

Phototoxicity: irritant response to a combination of a chemical and sunlight.

Physical Description: A brief summarization of the form of a substance, specifying whether it is solid, powder, flakes, crystals, liquid, gas, etc., accompanied by identification of color and odor where applicable.

Phytotoxic: Poisonous to plants.

Physiology: The science and study of the functions or actions of living organisms.

Pigmentation: coloration.

Piscicide: Pesticide used to control fish.

Placards: (1) Diamond-shaped markers 10-3/4" square required on a transporting vehicle such as a truck or tank car or a freight container 640 cu ft or larger. (2) Diamond-shaped sign required on outside of vehicles transporting radioactive materials displaying same standard warning terms and symbols as a label. (3) Paper forms of various designs used to identify RR cars requiring special attention (dangerous, explosives, etc.).

Plasma: fluid part of blood and lymph.

Pleural Thickening: thickening of tissue surrounding the lungs.

Pleurisy: inflammation ofthe lung cavity.

Pneumonia: infectious disease of the lungs that impairs breathing.

Pneumoconiosis: A chronic disease of the lungs resulting from the inhalation of various kinds of dusts. The pneumoconioses which include siderosis (iron oxide), silicosis (free silica), asbestosis (asbestos), etc., generally require a period of years for development.

Pneumonitis (Chemical): Inflammation of the lungs resulting from inhalation of chemical vapors and characterized by an outpouring of fluid in the lungs.

Potentiation: The increase in toxicity (usually considered an undesirable effect) of a pesticide when combined with one or more pesticides.

Poisonous Materials: Based on the definitions found in 49 CFR 173.325, poisonous materials are divided into three groups according to the degree of hazard in transportation: (a) Poison A; (b) Poison B; (c) Irritating Material. Following is a brief definition of each group. *Poisonous Materials (Poison A)* - Extremely dangerous poisons, Class A, are poisonous gases or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with the air is dangerous to life. *Poisonous Materials (Poison B)* - Class B poisons are those substances, liquid or solid (including pastes and semi-solids), other than Class A poisons or Irritating materials, which are known to be so toxic to man as to afford a hazard to health, or which, in the absence of adequate data on human toxicity, are presumed to be toxic to man because they fall within the categories, in tests specified by regulations, for oral toxicity, toxicity on inhalation, or toxicity by skin absorption when tested on laboratory animals. *Poisonous Materials (Irritating Materials)* - An Irritating Material is a liquid or solid substance which upon contact with fire or when exposed to air gives off dangerous or intensely irritating fumes, such as bromobenzyl cyanide, chloracetophenone, diphenylaminechlorarsine, and diphenylchlorarsine, but not including any Class A poisonous material.

Polychlorinated Biphenyls: A series of hazardous chemical compounds which have been manufactured for more than 40 years for such common purposes as electrical insulation and heating/cooling equipment. Now suspected to be carcinogens, PCBs have been disposed of in the air, on land and in water; recent surveys have detected the presence of PCBs in every part of the country, even those remote from PCB manufacturers.

Polymerization: The chemical reaction in which a special compound, called a monomer, combines with itself to form a long-chain molecule called a polymer.

Polymerize: The chemical reaction whereby a compound reacts with itself to form a polymer.

Polyneuropathy: disease of several peripheral nerves.

Positive Pressure Self-Contained Breathing Apparatus (SCBA): This apparatus provides a constant, positive pressure or flow within the facepiece, even when the wearer inhales deeply while doing strenuous or heavy work. In the U.S., only those apparatus certified by NIOSH and the Mine Safety and Health Administration in accordance with 30 CFR Part 11. It should be used in accordance with the requirements for respiratory protection specified in the OSHA Hazardous Waste Site Operations and Emergency Response Standard (29 CFR 1910.120) and/or the Fire Brigade Standard (29 CFR 1910.156). Chemical cartridge respirators or other filtering masks are not acceptable substitutes for positive pressure self-contained breathing apparatus. Demand-type SCBA does not meet the OSHA Fire Brigade Standard.

Post Indicator Valve (PIV): A post-type valve that provides a visual means of indicating "open" or "shut" position. It is found on the supply main of installed fire protection systems.

Potentiation: The effect of a chemical which does not itself have an adverse effect but which enhances the toxicity of another chemical.

ppm: Parts of vapor or gas or other contaminant per

million parts of air by volume.

Pre-action System: A type of automatic sprinkler system in which thermostatic devices are employed to charge the system with water before individual sprinkler heads are fused.

Predicted Environmental Concentration: The concentration in the environment of a chemical calculated from the available information on certain of its properties, its use and discharge patterns and the associated quantities.

Pre-fire Planning: The act of preparing to fight a fire in a particular building or group of buildings by advance planning of possible fire fighting operations.

Pressurized Gas: A gas that is still in the gaseous state, but under higher pressure than 14.7 psia.

Preventative Actions: Directions given by the Incident Commander at an emergency to prevent the problem from increasing.

Products-of-Combustion: Materials given off or released during the burning process.

Prolonged Exposure: More than a brief (or one-time) contact with a hazardous material such as radioactivity or a pesticide or the residue of that material.

Promoter (Carcinogenicity): An agent which increases tumor production by a chemical when applied after exposure to the chemical.

Proper Name: An agreed-upon system of naming organic compounds according the longest carbon chain in the compound.

Proportioner: A device for inducing the correct amount of agent into streams of water, especially for foam and wetting agents.

Proportioning: The occurrence of intermolecular collisions between oxygen and hydrocarbon molecules.

Proprietary System: A fire protection system that is owned and operated by the owner of the property.

Protection Factor (PF): The ratio of contaminant concentration outside of the respirator facepiece to that inside. It is taken as an indication of fit. PF values are established by manufacturers for specific types of respirators and are indicators only. Actual protection will depend on how a specific respirator fits a specific individual. Refer also to Fit Factor.

Protective Actions: Procedures taken during or after a hazardous materials incident for the protection of the general public from exposures occurring as a consequence of the incident.

Protective Materials: Refers to Chemical Protective Clothing such as suits and gloves. Following is a summary of the major materials used for chemical protective clothing (CPC). The reader will find specific recommendations and information on garments in Chapter 6. *Tyvek* - Product of DuPont. This is a spun-bonded nonwoven polyethylene fibers fabric. The Tyvek suit has reasonable wear, puncture and abrasion resistance. It provides excellent protection against particulate contaminants. It is inexpensive and suitable for disposable garments. *Nomex* - Product of DuPont. The material is comprised of an aromatic polyamide fiber. The material is noncombustible and is flame resistant up to 220 °C, and hence is used to provide the wearer with good thermal protection. Suits made from this material are very durable and are acid resistant. This material is used in firefighters' turnout gear and some fully encapsulating suits. *Polyethylene* - Used as a coating on polyolefin material such as Tyvek which increases the suit's resistance to acids, bases, and salts. Suits made from this material are considered good general purpose disposable products. *Saranax* - Made of Saran, a Dow Chemical product. This is usually coated on to Tyvek. The suit is a very good general purpose disposable product. It provides better overall protection than polyethylene and has excellent resistance to chlorinated hydrocarbons. *Polyvinyl Alcohol (PVA)* - This material resists degradation and permeation by aromatic and chlorinated hydrocarbons and petroleum compounds. The major drawback with this material is that it is water soluble and hence is limited to gloves. *Nitrile* - This material is also referred to as Buna-N, milled nitrile, nitril latex, NBR, and acrylonitrile. It resists degradation by petroleum compounds, alcohols, acids, and caustics. It is used extensively in boots and gloves, and is relatively inexpensive. *Polyvinyl Chloride (PVC)* - This material resists degradation by acids and caustics. It is used in boots, gloves, laboratory aprons, splash suits, and fully encapsulating suits. *Butyl Rubber* - This material resists degradation by many contaminants except halogenated hydrocarbons and petroleum compounds, which is a common deficiency of many protective materials. It is especially resistant to permeation by toxic vapors and gases. It is an expensive material used in boots, gloves, splash suits, laboratory aprons, and fully encapsulating suits. *Neoprene* - This material resists degradation by caustics, acids, and alcohols. I is used in boots, splash suits, and fully encapsulating suits. It is considered by many as a good all-around protective material. *Natural Rubber* - This material is a synthetic latex. It resists degradation by alcohols and caustics, and is used in boots and gloves. *Viton* - Product of DuPont. This is a member of the flouroelastomer family and is similar to Teflon in some respects. It has excellent resistance to degradation and permeability by aromatic and chlorinated hydrocarbons and petroleum compounds. It is very resistant to oxidizers. It is an extremely expensive material that is used in gloves

and fully encapsulating suits.
Psychometer: An instrument consisting of wet and dry bulb thermometers for measuring relative humidity.
Pulmonary Agents: The term refers to a specific target organ characterization of effect. These are agents which damage the lungs. Chemicals which irritate or damage the pulmonary tissue are categorized as pulmonary agents. Signs and symptoms include persistent coughing; tightness in chest; shortness of breadth. Examples are silica and asbestos.
Pulmonary Alveoli: Minute air-filled sacs in a vertebrate lung, thin walled and surrounded by blood-vessels.
Pulmonary Fibrosis: fibrous tissue forming in the lung.
Pyrolysis: The process of chemically decomposing an organic substance by heating in an oxygen-deficient atmosphere. High temperatures and closed chambers are used. Major products from pyrolysis of solid waste are water, carbon monoxide, and hydrogen. Some processes produce an oil-like liquid of undetermined chemical composition; gas may contain hydrocarbons and frequently there is process residue of a carbon char. All processes leave a residue of inorganic material. Gaseous products cannot be mixed with natural gas in principal distribution systems unless there is additional chemical processing. Applied to solid waste, pyrolysis has the features of effecting major volume reduction while producing storable fuels.
Pyrophoric: The term means a chemical that will ignite spontaneously in air at a temperature of 130 °F or below.
Pyrophoric Liquid: Any liquid that ignites spontaneously in dry or moist air at or below 130°F (54°C).

Q

Quantal Effect: An effect that either happens or does not happen, e.g. death. Synonym: all-or-none response.

R

RAD: Radiation Absorbed Dose; basic unit of absorbed dose of ionizing radiation; the absorption of 100 ergs of radiation energy per gram of absorbing material.
Radiant Temperature: The temperature resulting from the body absorbing radiant energy.
Radiation: The transfer of heat with no medium.
Radiation Authority: For radioactive materials, the Radiation Authority is usually a state agency or state designated official. The responsibilities of this authority include evaluating radiological hazard conditions during normal operations and during emergencies.
Radiation Heat: The transmission of heat through the medium of heat rays.
Radiation Illness: An acute organic disorder that follows exposure to relatively severe doses of ionizing radiation; characterized by nausea, vomiting, diarrhea, blood cell changes, and, in later stages, by hemorrhage and loss of hair.
Radiation Monitoring: Continuous or periodic determination of the amount of radiation present in a given area.
Radiation Saturation: A phenomenon in which a survey meter's capability to measure radiation levels is overwhelmed, causing the meter to incorrectly read "zero".
Radiation Sterilization: Use of radiation to cause a plant or animal to become incapable of reproduction; the use of radiation to kill all forms of life, especially bacteria, in food and surgical sutures.
Radical: An atom or group of atoms bound together chemically that has one or more unpaired electrons; it cannot exist in nature in that form, so it reacts very fast with another radical present, to form a new compound; also known as a "free" radical.
Radioactive Material: From 49 CFR 173.403, a radioactive material is any material having a specific activity greater than 0.002 microcuries per gram (μCi/g). Specifications and descriptions can be found in the regulations. The reader may also refer to the term *fissile material* in this glossary.
Radioactive Tracer: A small quantity of radioactive isotope used to follow biological, chemical or other processes by detection, determination or localization of the radioactivity.
Radioactive Wastes: Conventional materials that have been contaminated with radiation; not classified as hazardous and not covered by RCRA, they are specifically controlled by the U.S. Atomic Energy Act.
Radioactivity: Spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation.
Radioecology: Study of the effects of radiation on species of plants and animals in natural communities.
Radiopharmaceutical: A material containing radioisotopes used in medical diagnosis or therapy.
Rate-of-rise Alarm System: One of the systems installed for detecting fire by an abnormal rate of increase of heat; operates when a normal amount of air in a pneumatic tube expands rapidly when heated and exerts pressure on diaphragms.
Recommended Limit: A maximum concentration of a potentially toxic substance which is suggested to be safe. Such limits often have no statutory implications and in

which case a control or statutory guide level should not be exceeded.

Reducer Couplings: Couplings with a large and small connector for connecting hose couplings of two different sizes.

Registered Pesticide: A pesticide approved by the U.S. Environmental Protection Agency for use as stated on the label of the container.

Registry of Toxic Effects of Chemicals (RTEC): Volumes containing over 58,000 toxicity evaluations of specific chemicals and formulations.

Relative Biological Effectiveness (RBE): Factor used to compare the biological effectiveness of different types of ionizing radiation; inverse ratio of the amount of absorbed radiation required to produce a given effect to a standard radiation required to produce the same effect.

Relative Humidity: The ratio of the quantity of water vapor present in the air to the quantity which would saturate it at any specific temperature.

REM: Radiation Equivalent Man, the unit of dose equivalent; takes into account the effectiveness of different types of radiation.

Remote Alarm System: An alarm signaling system with a direct, privately owned circuit that goes to a fire department into privately owned receiving equipment.

Renal: Associated with the kidneys.

REP: Abbreviation for Registered Environmental Professional, a designation devised by the National Registry of Environmental Professionals.

Reproductive Effects: pertaining to birth defects,death of a developing baby prior to birth, inability to have children (both men and women), and so on.

Reproductive Toxicology (mammalian): The study of the effects of chemicals on the adult reproductive and neuroendocrine systems, the embryo, foetus, neonate and prepubertal mammal.

Reproductive Toxins: The term refers to a specific target organ characterization of effect. These are chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis). Signs and symptoms include birth defects; sterility. Examples are lead and DBCP.

Resonance: A phenomenon whereby a structure, to satisfy the rules of covalent bonding, should be fluctuating (resonating) back and forth between two alternate molecular structures, both of which are "correct" for the molecule. It is a way of explaining what cannot be explained using only the rules of covalent bonding.

Respirable (dust): Term used to indicate particulate matter which can be inhaled. Generally considered to be 5 microns or less in aerodynamic diameter.

Respirator: A face mask which filters out poisonous gases and particles from the air, enabling a person to breathe and work safely; used to protect the nose, mouth, and lungs from hazardous materials.

Respiratory Toxicity: How poisonous a pesticide is to an animal or person when breathed in through the lungs; an intake of any toxic substance through air passages into the lungs.

Ribonucleic Acid (RNA): A generic term for a group of nucleotide molecules, similar in composition to deoxyribonucleic acid (DNA), which perform a number of functions in programming the genetic code in cells. There are several types of RNA e.g. messenger RNA, ribosomal RNA, transfer RNA.

Risk (Toxic): The predicted or actual frequency of occurrence of an adverse effect of a chemical substance or mixture from a given exposure to humans or the environment.

Risk Assessment: The process of decision making applied to problems where there are a variety of possible outcomes and it is uncertain which event will happen.

Risk Evaluation: The determination of the significance of risk to those affected.

Risk Management: Judgements concerning the acceptability of risk.

Rodenticide: A pesticide used to control rodents.

Roentgen (R): The unit of radiation exposure in the air; units for quantities of X-ray or gamma radiation measured by detection and survey meters. Named after Wilhelm Roentgen, German scientist who discovered X-rays in 1895.

Rope Hose Tool: A piece of rope spliced to form a loop through the eye of a metal hook. Used for securing hose to ladders or other objects.

Rotameter: A flowmeter, consisting of a precision bored, tapered, transparent tube with a solid float inside.

S

Safety (Toxicological): Can be defined as the high probability that injury will not result from use of a substance under specific conditions of quantity and manner of use.

Salivary Glands: glands in the mouth that secrete saliva.

Sarcoma: type of cancerous tumor.

Saturated: A hydrocarbon possessing only single covalent bonds between carbon atoms.

Self-Accelerating Decomposition Temperature: The temperature above which the decomposition of an unstable material proceeds by itself independently of the external temperature.

Sensitizer: The term refers to a chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.
Sensitization: becoming allergic.
Shipping Papers: The shipping paper represents a document that contains vital information available that can help respond to a hazardous materials incident. The shipping paper contains information needed to identify the material(s) involved. This information can be used to initiate protective actions. The shipping paper contains the proper shipping name , the hazard class or division of the material(s), ID Number, Packing Group, and, when applicable, Reportable Quantity notation (RQ) (for use in reporting spill incidents). In addition, there must be available information that describes the hazards of the material and that can be used in the mitigation of an incident. This must be entered on or be with the shipping paper. Shipping papers are required for most hazardous materials in transportation.
Short Term Exposure Limit (STEL): The time weighted average (TWA) airborne concentration to which workers may be exposed for periods up to 15 minutes, with no more than 4 such excursions per day and at least 60 minutes between them.
Siamese: A hose appliance that has two or more female inlets and one male outlet; two or more inlets for one outlet.
SIC: Standard Industrial Code. Prepared by the United States Office of Management and Budget.
Silica Gel: A regenerative absorbent consisting of the amorphous silica. Used in dehydrating and in drying and as a catalyst carrier.
Silicosis: lung disease caused from inhaling silica.
Slopover: *see also Boilover.* Basically, the same principles that are responsible for a boilover are the cause of a "slopover". The fundamental difference is that in a slopover the reaction is from water that has entered the tank since the start of a fire. Usually this introduction is the result of the firefighters' activities as they attempt to extinguish the crude oil (or liquid of similar characteristics) fire. A slopover will occur at some moment after the heat wave has been formed - which may be from only a few minutes of burning - and water or foam is being applied to the liquid surface. Either the water from the hose streams or, after the bubbles collapse, the water in the foam will sink into the oil, contacting the heat wave, where it is converted to steam, and the agitation of the liquid surface spills some amount of oil over the tank rim. Historically, slopovers, although still exposing the firefighters to the danger of the escaping, burning oil, are not as violent as are boilovers. Regardless of the term used to describe the occurrence - that is, boilover, slopover, frothover, or whatever - the likelihood of some event that will cause the oil to cascade over the tank shell and down into the dike area is always present when crude oil burns.
Smoke: A mixture of gases, vapors, and aerosols formed from the incomplete combustion of carbonaceous materials.
Solid Stream: A hose stream that stays together as a solid mass, as opposed to a fog or spray.
Solution: Mixture in which the components lose their identities and are uniformly dispersed. All solutions are composed of a solvent (water or other fluid) and the substance dissolved called the "solute". Air is a solution of oxygen and nitrogen. A true solution is homogeneous as salt in water.
Solvent: A substance which dissolves other substances, most commonly water but often an organic compound.
Spanner Wrench: A tool used by firefighters for tightening or loosening couplings.
Specific Gravity: A measure of the weight of a material (liquid or solid) as related to the weight of an equal volume of water.
Specific Heat: The ratio between the amount of heat necessary to raise the temperature of a substance and the amount of heat necessary to raise the same weight of water the same number of degrees.
Spectrophotometer: An instrument used for comparing the relative intensities of the corresponding colors produced by chemical reactions.
Spontaneous Ignition: A material proceeding without constraint by internal impulse or outside energy to kindle or set fire; quick or slow oxidation or combustion brought about by chemical, electrical, biological (bacterial) or physical processes (vibration, pressure, friction) without assistance of extraneous sources of heat (flame, sparks, hot or glowing bodies).
Spontaneously Combustible: The process of increase in temperature of a material to a point of ignition without drawing heat from its surroundings.
Sprinkler Connection: A siamese connection used by the fire department for increasing the water supply and pressure to a sprinkler system.
Standard Temperature and Pressure: Measured volumes of gases are generally recalculated to 0° Centigrade and 760 mm pressure.
Stabilization: (1) Stage of an incident when the immediate problem or emergency has been controlled, contained, or extinguished. (2) Hazardous waste chemical treatment method by which a chemical reaction produces an insoluble form of the waste or incorporates the waste into a form

that is insoluble.

Standard Operating Procedures: Detailed instructions for implementation of emergency plans by the various response agencies.

Static Pressure: The potential pressure exerted in all directions by a fluid at rest. For a fluid in motion, it is measured in a direction normal (at right angles) to the direction of flow, thus it shows the tendency to burst or collapse the pipe. When added to velocity pressure, it gives total pressure.

STEL: *Short Term Exposure Limit* (STEL) refers to a safe level of exposure (see also TLV) from inhalation for a continuous period of time that is short (by OSHA standards either a 15 minutes or 5 minutes of continuous exposure). The concentration established by the STEL (usually in ppm) should not be exceeded during that period of exposure, and further, the time limit of continuous exposure should not be exceeded, else there is a health risk.

Straight Chain: The configuration of the molecule of a hydrocarbon when a carbon atom attaches itself to another carbon atom that has only one other carbon atom already attached to it.

Street Clothing and Work Uniforms: Garments, such as uniforms worn by police and emergency medical services personnel, provide little to no protection from the harmful effects of hazardous materials.

Structural Effect: The effect upon certain properties of an analogous series of compounds by *branching*. Properties such as boiling point, flash point, ignition temperature, and others change as branches are added to compounds, including isomers.

Structural Firefighters' Protective Clothing (SFPC):This category of clothing is usually referred to as *turnout* or *bunker gear*. This type of protective clothing is normally worn by firefighters during structural firefighting operations. It includes a helmet, coat, pants, boots, gloves, and a hood to cover parts of the head not protected by the helmet and facepiece. This clothing must be used with full-facepiece, positive-pressure, self-contained breathing apparatus (SCBA). This protective clothing should, at a minimum, meet the U.S. Department of Labor's Occupational Safety and Health Administration's (OSHA) Fire Brigades Standard (29 CFR 1910.156). Structural firefighters' protective clothing provides limited protection from heat. This clothing is not designed to provide adequate protection from harmful vapors or liquids that are encountered during most hazardous materials incidents.

Structural Formula: A drawing of the molecule, showing all the atoms of the molecule and how they are bonded to each other atom.

Structure-Activity Relationship (SAR): The correlation between molecular structure and biological activity. It is usually applied to observing the effect that the systematic structural modification of a particular chemical entity has on a defined biological end-point.

Subchronic Toxicity: The adverse effects occurring as a result of the repeated daily [oral] dosing of a chemical to experimental animals for part (not exceeding 10 %) of the life span. (Usually 1-3 months). Acute toxicity.

Substituted: A compound that has had one or more of its atoms removed and replaced by atoms of other elements in the molecule. A substituted hydrocarbon is a compound that has had a hydrogen atom removed and another atom substituted for it.

Superheating: Heating of a vapor, particularly saturated steam to a temperature much higher than the boiling point at the existing pressure; occurs in power plants to improve efficiency and to reduce condensation in the turbines.

Surface Active Agents: Chemicals which alter the forces of surface tension between adjacent molecules; generally decrease the surface tension of a fluid such as an oil, used to facilitate its dispersion throughout the water column.

Surfactant: An adjuvant which improves the emulsifying, dispersing, spreading, and wetting properties of a pesticide.

Synecology: The study of ecology dealing with interrelationships of living communities of organisms to each other and to the environment.

Synergism: Cooperative action of substances whose total effects is greater than the sum of their separate effects.

Synergistic Effect: An effect of two chemicals acting together which is greater than the simple sum of their effects when acting alone.

Synthesize: To make a molecule to duplicate a molecule made in nature.

Systemic: Spread throughout the body, affecting all body systems and organs, not localized in one spot or area.

T

Tare: A deduction of weight, made in allowance for the weight of a container or medium. The initial weight of a filter, for example.

Teratogenesis: Defects in embryonic and foetal development caused by a substance.

Teratogenic: capable of producing birth defects.

Test Animals: Laboratory animals exposed to pesticides so that toxicity and hazards can be determined.

Testicular Atrophy: wasting away of male reproductive organs.

Tetany: intermittent spasms.
"Tetra-": The prefix that means four.
Thermal Degradation: The term refers to the decomposition or degradation of a material due to exposure to heat or energy. Materials can be thermally degraded into three principal ways: anaerobic pyrolysis, oxidative pyrolysis ("smoldering"), and flaming combustion.
Thorium: A naturally radioactive element with atomic number 90 and, as found in nature, an atomic weight of approximately 232. The fertile thorium 232 isotope is abundant and can be transmitted to fissionable uranium 233 by neutron irradiation.
Threshold: The point where a physiological or toxicological effect begins to be produced by the smallest degree of stimulation.
Thrombosis: blood clot.
Thymus: organ that forms cells involved in the immune response.
Thyroid: hormone-producing gland inthe throat.
Time Weighted Average Concentration: Refers to concentrations of contaminants which have been weighted for the time duration of sample. A sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.
TLV: The TLV or *Threshold Limit Value* refers to a safe level of exposure by inhalation. The definition was established by the American Conference of Governmental Hygienists. There are several variations or criteria levels for the TLV. As an example, hydrogen sulfide has a TLV for s t o 5 ppm. Comparing this to the TLV-STEL of 400 ppm for carbon monoxide provides an indication of the need to be extremely careful when H_2S is suspected. Under OSHA Standards,
and particularly on MSDS (Material Safety Data Sheets) compounds are associated with a time weighted average (TWA) TLV, which is the allowable concentration for an 8-hour continuous exposure period. For firefighting purposes, the short-term exposure is likely more realistic.
Toxic: Poisonous; relating to or caused by toxin; able to cause injury by contact or systemic action to plants, animals or people.
Toxicant: Any substance which is potentially toxic.
Toxicity: A relative property of a chemical agent and refers to a harmful effect on some biologic mechanism and the condition under which this effect occurs.
Toxicology: The study of chemical substances which exert deleterious effects on living organisms, their chemistry in relation to their mode of action, antidotes, and physiological effects.
Toxin: A toxic organic substance produced by a living organism.
Transformation (neoplastic): The conversion of normal cells into tumor cells (see below). Frequently this is the result of a genetic change and the same term is used to describe the genetic modification of bacteria for biotechnological purposes.
Transplacental: across the placenta from mother to developing baby.
Transmutation: The changing of one element into another by a nuclear reaction or series of reactions. Example: the transmutation of uranium-238 into plutonium-239 by absorption of a neutron.
"Tri-": The prefix that means three.
Trohoc: An epidemiological study which starts with the outcome and looks backwards for the causes.
Tumor (neoplasm): A growth of tissue forming an abnormal mass. Cells of a **benign** tumor will not spread and cause cancer. Cells of a malignant tumor can spread through the body and cause cancer.
Tumorigenic: Causing tumor formation.

U

Ulceration: destroyed tissue.
Ultraviolet Radiation: The portion of the electromagnetic spectrum emitted by the sun adjacent to the violet end of the visible light range. Often called "black light", it is invisible to the human eye but when it falls on certain surfaces it causes them to fluoresce or emit visible light; responsible for the photo-oxidation of certain compounds including hydrocarbons.
Unit: A molecular fragment that repeats itself in a series.
Unsaturated: A hydrocarbon with at least one multiple bond between two carbon atoms somewhere in the molecule.
Unstable (Reactive): The term refers to a chemical which in the pure state, or as produced or transported , will vigorously polymerize , decompose, condense, or will become self-reactive under conditions of shocks, pressure, or temperature.
Upper Explosion Limit: The UEL is expressed as a percentage of the total volume of the air-fuel mixture; it is the highest concentration of vapor fuel in air under which spontaneous combustion will occur. An example is gasoline. A mixture containing 7.6% gasoline vapor in air (concentration of air being 92.4% in this mixture) will spontaneously combust. The UEL in this example is 7.6% or simply 7.6. Above this concentration, the mixture is described as being too "rich"; or in other words, there is too much fuel and not enough oxygen for spontaneous

combustion to occur.

Uranium: The basic raw material of nuclear energy, uranium is a radioactive element with the atomic number 92 and, as found in natural ores, an average atomic weight of approximately 238. The two principal natural isotopes are uranium 235 (0.7% of natural uranium) which is fissionable and uranium 238 (99.3% of natural uranium) which is fertile. Natural uranium also includes a minute amount of uranium 234.

Urinary System: kidney, bladder, and connecting tubes.

Urologic: pertaining to the urinary system.

USDA: Abbreviation for United States Department of Agriculture.

V

Vapor: The gaseous form of substances which are normally in the solid or liquid state and which can be changed to these states either by increasing the pressure or decreasing the temperature alone.

Vapor Control: Limiting the amount of vapor released from a pool of flammable or corrosive liquids is an operational concern. This technique requires the use of proper protective clothing, specialized equipment, appropriate chemical agents, and skilled personnel. Before engaging in vapor control, get advice from an authoritative source as to the proper tactics. There are several ways to minimize the amount of vapors escaping from pools of spilled liquids, such as special foams, adsorbing agents, absorbing agents, and neutralizing agents. To be effective, these vapor control methods must be selected for the specific material involved and performed in a manner that will mitigate, not worsen, the incident. Where specific materials are known, such as at manufacturing or storage facilities, it is desirable for the hazardous materials response team to arrange with the facility operators to select and stockpile these control agents in advance of a spill. In the field, first responders may not have the most effective vapor control agent for the material. They are likely to have only water and only one type of firefighting foam. Therefore, it is likely that water spray will be used. Because the water is being used to form a vapor seal, care must be taken not to churn or further spread the spill during application. Vapors that do not react with water may be directed away from the site using the air currents surrounding the water spray. Water spray has been used on large spills of some flammable materials in an attempt to reduce vapor concentration below the explosive limit. However, water sprayed into a confined area may actually increase the air concentration, possibly creating an explosive mixture of air and the flammable vapor. Before using water spray or other methods to safely control vapor emission or to suppress ignition, obtain trained technical advice, based on specific chemical name identification.

Vapor Density: A measurement of the weight of vapor compared to the weight of air.

Vapor Dispersion: The movement of vapor clouds in air due to turbulence, gravity spreading, and mixing.

Vaporization: The process of becoming a gas.

Vaporize: To evaporate; to form a gas and disappear into the air.

Vaporizer: A device for converting liquid to vapor by means other than atmospheric heat transfer.

Vapor Pressure: The pressure exerted by vapor molecules on the sides of a container, at equilibrium.

Vasoconstriction: narrowing of the blood vessels.

Venting Devices: A device that is designed to relieve excessive pressure from the vapor space of a container. To accomplish this, the device will be located on the tops of containers above the normal level of liquid of the full tank. Some vents are installed to allow for the venting of the tank during routine operations. Movement of liquid into or out of a container without the space above the liquid level having the ability to breathe will result in damage to the shell. Additional venting capacity is required to keep the internal pressures at a safe level during fire emergencies. The various types of venting devices in use include fusible plugs, spring-loaded relief valves, pop-up-type hatch covers, pressure/vacuum vents, and weighted caps.

Ventricular Fibrillation: rapid contractions of the ventricles of the heart.

Vomitus: Stomach contents that are regurgitated; matter which is vomited.

Vinyl: The general name for the radical of ethylene.

Virus: A disease-producing organism (pathogen) that needs living cells to grow and can cause disease in plants and animals including people; too small to be seen with a normal microscope.

Viscosity: The thickness of liquids; the degree to which or the ease with which a liquid flows; usually increases when temperature decreases. A liquid with a low viscosity will flow very rapidly and any spill of that liquid will create problems very quickly; a high viscosity liquid will not flow as easily and can therefore be controlled more readily should it spill.

Visible Radiation: The wavelengths of the electromagnetic spectrum between 10^{-4} cm to 10^{-5} cm.

Volatility: The tendency or ability of a liquid to vaporize. Such liquids as alcohol and gasoline, because of their well-known tendency to evaporate rapidly, are referred to as volatile liquids.

Volatilization: The changing of a liquid to a vapor.

W

Water Reactive: The term means a chemical that reacts with water to release a gas that is either flammable or poses a health hazard.

Water Reactive Materials: Water is sometimes used to flush spills and to reduce or direct vapors in spill situations. Some materials can react violently or even explosively with water. In these cases, consider letting the fire burn or leaving the spill alone until technical advice can be obtained. These materials require technical advice since

1. water getting inside a ruptured or leaking container may cause an explosion.
2. water may be needed to cool adjoining containers to prevent their rupturing (exploding) or further spread of the fires;
3. water may be effective in mitigating an incident involving a water-reactive material only if it can be applied at a sufficient "flooding" rate for an extended period; and
4. the products from the reaction with water may be more toxic, corrosive, or otherwise more undesirable than the product of the fire without water applied.

When responding to an incident involving water-reactive chemicals, take into account the existing conditions such as wind, precipitation, location and accessibility to the incident, as well as the availability of the agents to control the fire or spill. Because of the great number of variables, the decision to use water on fires or spills involving water-reactive materials should be made by an authoritative source. For example, a producer of the material, who can be contacted through the emergency response telephone number or CHEMTREC.

Water Solubility: A measure of the ability of a liquid to mix with water.

Weight Effect: The change produced in certain properties, including flash point, boiling point, and water solubility, as the molecular weight (calculated by adding the atomic weights of all the atoms in the molecule) of compounds in an analogous series is increased or decreased.

Wet-pipe Sprinkler System: An automatic sprinkler system in which the pipes are constantly filled with water under pressure.

Wet-standpipe System: A building standpipe system constantly filled with water. Sections of small diameter fire hose are connected to the standpipe system on each floor.

X

Xenobiotic: A chemical which is not a natural component of the living organism exposed to it. Synonyms: drug, foreign substance or compound, exogenous material.

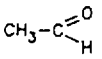
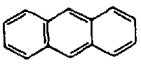
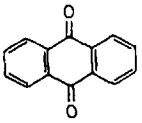
Xenobiotic Metabolism: The chemical transformation of compounds foreign to an organism by various enzymes present in that organism.

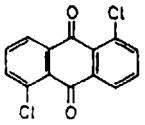
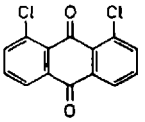
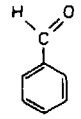
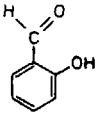
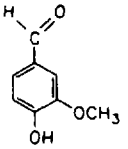
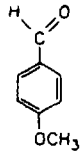
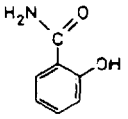
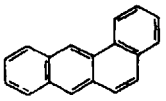
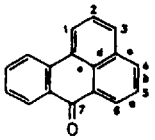
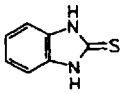
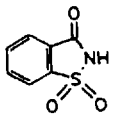
X-Ray: A penetrating form of electromagnetic radiation emitted either when the inner orbital electrons of an excited atom return to their normal state (these are characteristic X-rays), or when a metal target is bombarded with high speed electrons (bremsstrahlung).

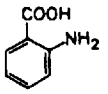
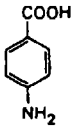
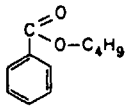
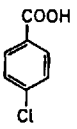
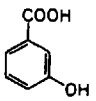
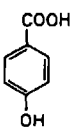
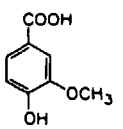
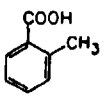
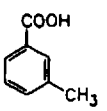
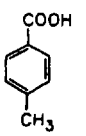
Appendix

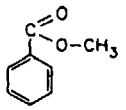
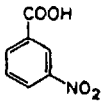
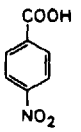
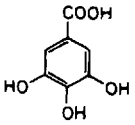
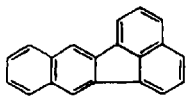
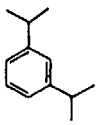
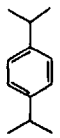
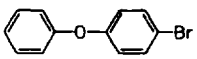
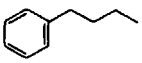
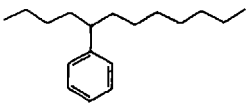
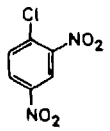
CHEMICAL STRUCTURES FOR SELECT CHEMICAL COMPOUNDS

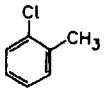
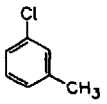
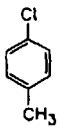
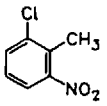
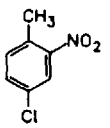
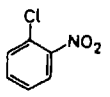
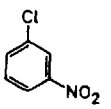
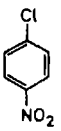
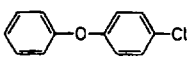
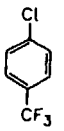
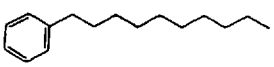
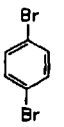
This appendix lists over 500 chemical compounds along with their structure and CAS number. This information is useful to readers in identifying compound structural information. An examination of the compound structural configuration is useful in assessing the stability or reactivity of a chemical, as well as potential toxic properties.

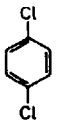
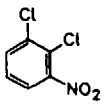
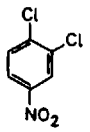
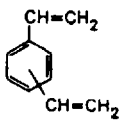
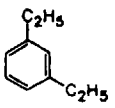
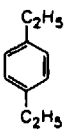
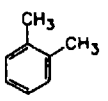
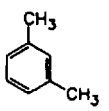
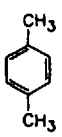
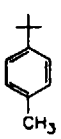
Chemical Name	Chemical Structure	CAS No.
Acenaphthylene		208-96-8
Acenaphthylene, 1,2-dihydro-		83-32-9
Acetaldehyde		75-07-0
Acetonitrile		75-05-8
Anthracene		120-12-7
9,10-Anthracenedione		84-65-1

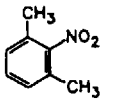
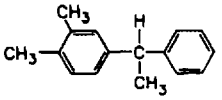
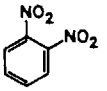
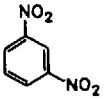
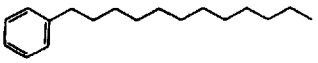
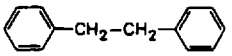
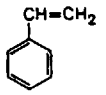
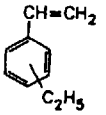
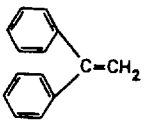
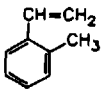
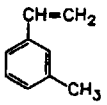
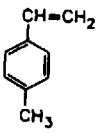
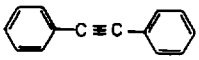
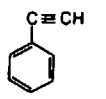
Chemical Name	Chemical Structure	CAS No.
9,10-Anthracenedione, 1,5-dichloro-		82-46-2
9,10-Anthracenedione, 1,8-dichloro-		82-43-9
2H-Azepin-2-one, hexahydro-		105-60-2
Benzaldehyde		100-52-7
Benzaldehyde, 2-hydroxy-		90-02-8
Benzaldehyde, 4-hydroxy-3-methoxy-		121-33-5
Benzaldehyde, 4-methoxy-		123-11-5
Benzamide, 2-hydroxy-		65-45-2
Benz[a]anthracene		56-55-3
7H-Benz[de]anthracen-7-one		82-05-3
2H-Benzimidazole-2-thione, 1,3-dihydro-		583-39-1
1,2-Benzimidazol-3(2H)-one, 1,1-dioxyde-		81-07-2

Chemical Name	Chemical Structure	CAS No.
Benzoic Acid		65-85-0
Benzoic Acid, 2-amino-		118-92-3
Benzoic Acid, 4-amino-		150-13-0
Benzoic Acid, butyl ester		136-60-7
Benzoic Acid, 2-chloro-		118-91-2
Benzoic Acid, 4-chloro-		74-11-3
Benzoic Acid, 2-hydroxy-		69-72-7
Benzoic Acid, 3-hydroxy-		99-06-9
Benzoic Acid, 4-hydroxy-		99-96-7
Benzoic Acid, 4-hydroxy-3-methoxy-		121-34-6
Benzoic Acid, 2-methyl-		118-90-1
Benzoic Acid, 3-methyl-		99-04-7
Benzoic Acid, 4-methyl-		99-94-5

Chemical Name	Chemical Structure	CAS No.
Benzoic Acid, methyl ester		93-58-3
Benzoic Acid, 3-nitro-		121-92-6
Benzoic Acid, 4-nitro-		62-23-7
Benzoic Acid, 3,4,5-trihydroxy-		149-91-7
Benzo[k]fluoranthene		207-08-9
Benzene		71-43-2
Benzene, 1,3-bis(1-methylethyl)-		99-62-7
Benzene, 1,4-bis(1-methylethyl)-		100-18-5
Benzene, 1-bromo-4-phenoxy		101-55-3
Benzene, butyl		104-51-8
Benzene, (1-butyloctyl)-		2719-63-3
Benzene, chloro-		108-90-7
Benzene, 1-chloro-2,4-dinitro-		97-00-7
Benzene, (chloromethyl)-		100-44-7

Chemical Name	Chemical Structure	CAS No.
Benzene, 1-chloro-2-methyl-		95-49-8
Benzene, 1-chloro-3-methyl-		108-41-8
Benzene, 1-chloro-4-methyl-		106-43-4
Benzene, 1-chloro-2-methyl-3-nitro-		83-42-1
Benzene, 4-chloro-1-methyl-2-nitro-		89-59-8
Benzene, 1-chloro-2-nitro-		88-73-3
Benzene, 1-chloro-3-nitro-		121-73-3
Benzene, 1-chloro-4-nitro-		100-00-5
Benzene, 1-chloro-4-phenoxy-		7005-72-3
Benzene, 1-chloro-4-(trifluoromethyl)-		98-56-6
Benzene, decyl-		104-72-3
Benzene, 1,4-dibromo-		106-37-6
Benzene, 1,2-dichloro-		95-50-1

Chemical Name	Chemical Structure	CAS No.
Benzene, 1,3-dichloro-		541-73-1
Benzene, 1,4-dichloro-		106-46-7
Benzene, 1,2-dichloro-3-nitro-		3209-22-1
Benzene, 1,2-dichloro-4-nitro-		99-54-7
Benzene, diethenyl-		1321-74-0
Benzene, 1,3-diethyl-		141-93-5
Benzene, 1,4-diethyl-		105-05-5
Benzene, 1,2-dimethyl-		95-47-6
Benzene, 1,3-dimethyl-		108-38-3
Benzene, 1,4-dimethyl-		106-42-3
Benzene, (1,1-dimethylethyl)-		98-06-6
Benzene, 1-(1,1-dimethylethyl)-4-methyl-		98-51-1

Chemical Name	Chemical Structure	CAS No.
Benzene, 1,3-dimethyl-2-nitro-		81-20-9
Benzene, 1,3-dimethyl-4-(1-phenylethyl)-		6196-95-8
Benzene, 1,2-dinitro-		528-29-0
Benzene, 1,3-dinitro-		99-65-0
Benzene, dodecyl-		123-01-3
Benzene, 1,1'-(1,2-ethanediyl)bis-		103-29-7
Benzene, ethenyl-		100-42-5
Benzene, ethenylethyl-		28106-30-1
Benzene, 1,1'-ethenylidenebis-		530-48-3
Benzene, 1-ethenyl-2-methyl		611-15-4
Benzene, 1-ethenyl-3-methyl		100-80-1
Benzene, 1-ethenyl-4-methyl		622-97-9
Benzene, 1,1'-(1,2-ethynediyl)bis-		501-65-5
Benzene, ethynyl-		536-74-3
Benzene, ethyl-		100-41-4

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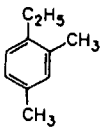
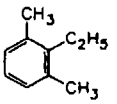
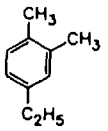
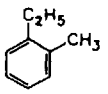
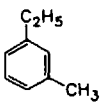
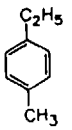
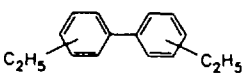
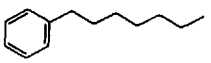
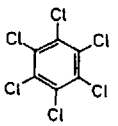
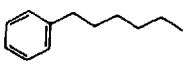
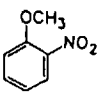
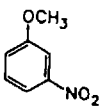
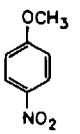
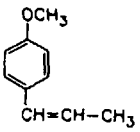
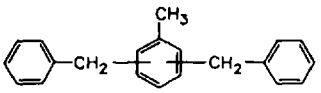
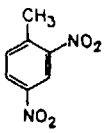
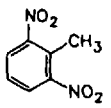
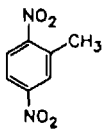
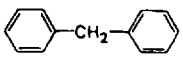
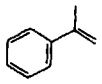
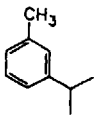
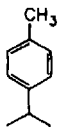
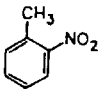
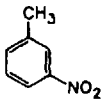
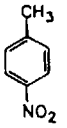
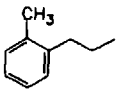
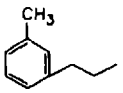
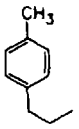
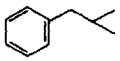
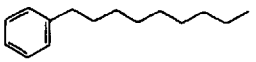
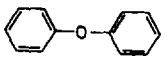
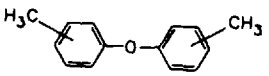
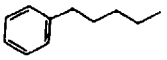
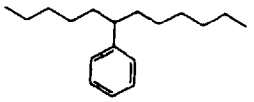
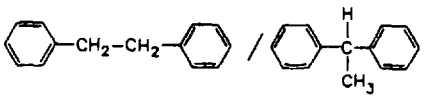
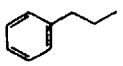
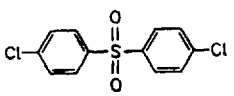
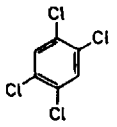
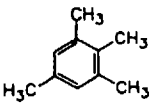
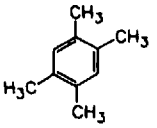
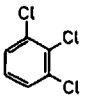
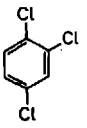
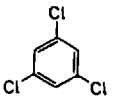
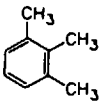
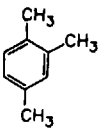
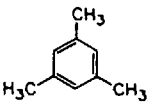
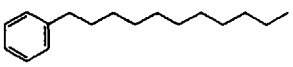
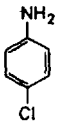
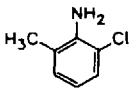
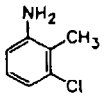
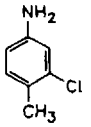
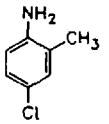
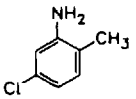
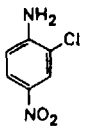
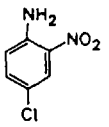
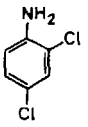
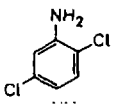
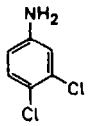
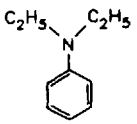
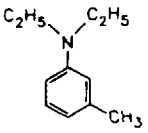
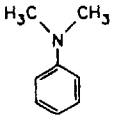
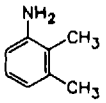
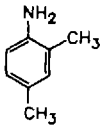
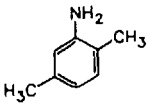
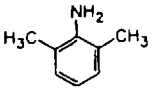
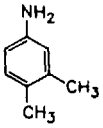
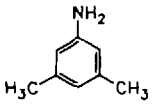
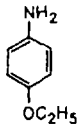
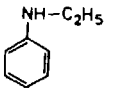
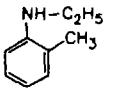
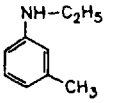
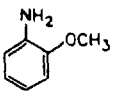
Benzene, 1-ethyl-2,4-dimethyl-		874-41-9
Benzene, 2-ethyl-1,3-dimethyl-		2870-04-4
Benzene, 4-ethyl-1,2-dimethyl-		934-80-5
Benzene, 1-ethyl-2-methyl-		611-14-3
Benzene, 1-ethyl-3-methyl-		620-14-4
Benzene, 1-ethyl-4-methyl-		622-96-8
Benzene, ethyl(phenylethyl)-		64800-83-5
Benzene, heptyl-		1078-71-3
Benzene, hexachloro-		118-74-1
Benzene, hexyl-		1077-16-3
Benzene, methoxy-		100-66-3
Benzene, 1-methoxy-2-nitro-		91-23-6
Benzene, 1-methoxy-3-nitro-		555-03-3
Benzene, 1-methoxy-4-nitro-		100-17-4

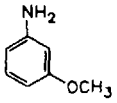
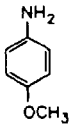
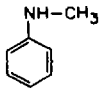
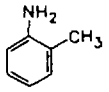
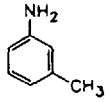
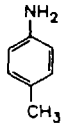
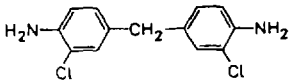
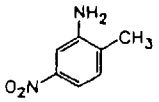
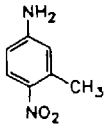
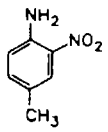
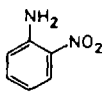
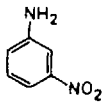
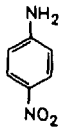
Chemical Name	Chemical Structure	CAS No.
Benzene, 1-methoxy-4-(1-propenyl)-		104-46-1
Benzene, methyl-		108-88-3
Benzene, methylbis(phenylmethyl)-		26898-17-9
Benzene, 1-methyl-2,4-dinitro-		121-14-2
Benzene, 2-methyl-1,3-dinitro-		606-20-2
Benzene, 2-methyl-1,4-dinitro-		619-15-8
Benzene, 1,1'-methylenebis-		101-81-5
Benzene, (1-methylethenyl)-		98-83-9
Benzene, (1-methylethyl)-		98-82-8
Benzene, methyl(1-methylethyl)-		25155-15-1
Benzene, 1-methyl-3-(1-methylethyl)-		535-77-3
Benzene, 1-methyl-4-(1-methylethyl)-		99-87-6
Benzene, 1-methyl-2-nitro-		88-72-2

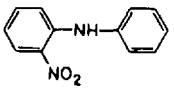
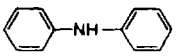
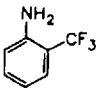
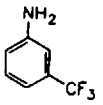
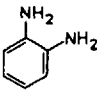
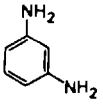
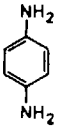
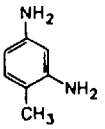
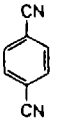
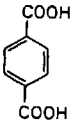
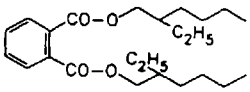
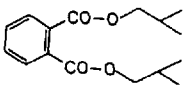
Chemical Name	Chemical Structure	CAS No.
Benzene, 1-methyl-3-nitro-		99-08-1
Benzene, 1-methyl-4-nitro-		99-99-0
Benzene, (1-methylpropyl)-		135-98-8
Benzene, 1-methyl-2-propyl-		1074-17-5
Benzene, 1-methyl-3-propyl-		1074-43-7
Benzene, 1-methyl-4-propyl-		1074-55-1
Benzene, (2-methylpropyl)-		538-93-2
Benzene, nitro-		98-95-3
Benzene, nonyl-		1081-77-2
Benzene, 1,1'-oxybis-		101-84-8
Benzene, 1,1'-oxybis[methyl-		28299-41-4
Benzene, pentyl-		538-68-1
Benzene, (1-pentylheptyl)-		2719-62-2
Benzene, (phenylethyl)-		38888-98-1
Benzene, propyl-		103-65-1
Benzene, 1,1'-sulfonylbis[4-chloro-		80-07-9

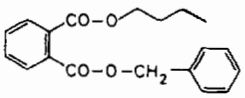
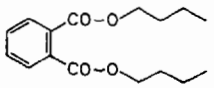
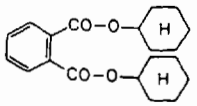
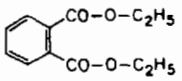
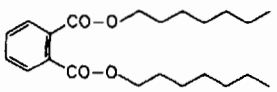
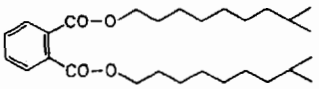
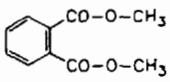
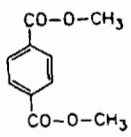
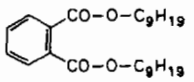
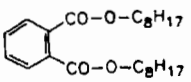
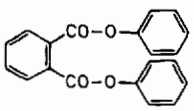
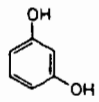
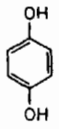
Chemical Name	Chemical Structure	CAS No.
Benzene, 1,2,4,5-tetrachloro-		95-94-3
Benzene, 1,2,3,5-tetramethyl-		527-53-7
Benzene, 1,2,4,5-tetramethyl-		95-93-2
Benzene, 1,2,3-trichloro-		87-61-6
Benzene, 1,2,4-trichloro-		120-82-1
Benzene, 1,3,5-trichloro-		180-70-3
Benzene, 1,2,3-trimethyl-		526-73-8
Benzene, 1,2,4-trimethyl-		95-63-6
Benzene, 1,3,5-trimethyl-		108-67-8
Benzene, undecyl-		6742-54-7
Benzenamine		62-53-3
Benzenamine, 2-chloro-		95-51-2
Benzenamine, 3-chloro-		108-42-9

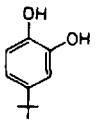
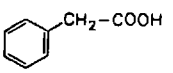
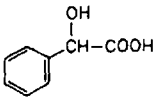
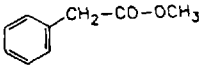
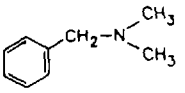
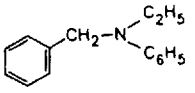
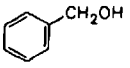
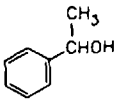
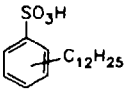
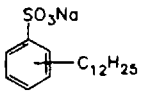
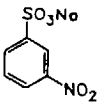
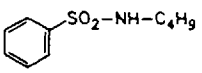
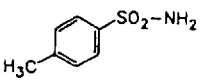
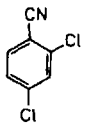
Chemical Name	Chemical Structure	CAS No.
Benzenamine, 4-chloro-		106-47-8
Benzenamine, 2-chloro-6-methyl-		87-63-8
Benzenamine, 3-chloro-2-methyl-		87-60-5
Benzenamine, 3-chloro-4-methyl-		95-74-9
Benzenamine, 4-chloro-2-methyl-		95-69-2
Benzenamine, 5-chloro-2-methyl-		95-79-4
Benzenamine, 2-chloro-4-nitro-		121-87-9
Benzenamine, 4-chloro-2-nitro-		89-63-4
Benzenamine, 2,4-dichloro-		554-00-7
Benzenamine, 2,5-dichloro-		95-82-9
Benzenamine, 3,4-dichloro-		95-76-1
Benzenamine, N,N-diethyl-		91-66-7

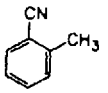
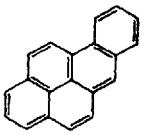
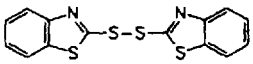
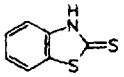
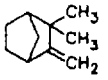
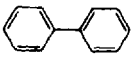
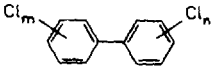
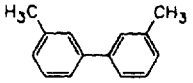
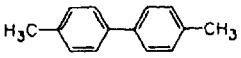
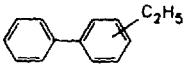
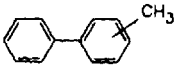
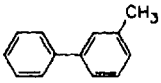
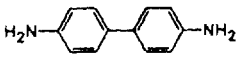
Chemical Name	Chemical Structure	CAS No.
Benzenamine, N,N-diethyl-3-methyl-		91-67-8
Benzenamine, N,N-dimethyl-		121-69-7
Benzenamine, 2,3-dimethyl-		87-59-2
Benzenamine, 2,4-dimethyl-		95-68-1
Benzenamine, 2,5-dimethyl-		95-78-3
Benzenamine, 2,6-dimethyl-		87-62-7
Benzenamine, 3,4-dimethyl-		95-64-7
Benzenamine, 3,5-dimethyl-		108-69-0
Benzenamine, 4-ethoxy-		156-43-4
Benzenamine, N-ethyl-		103-69-5
Benzenamine, N-ethyl-2-methyl-		94-68-8
Benzenamine, N-ethyl-3-methyl-		102-27-2
Benzenamine, 2-methoxy-		90-04-0

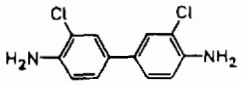
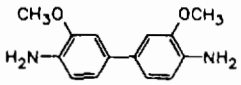
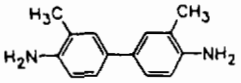
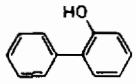
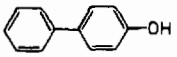
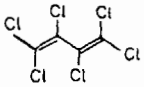
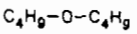
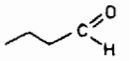
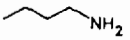
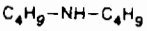
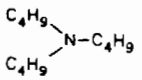
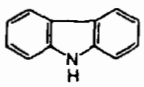
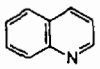
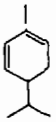
Chemical Name	Chemical Structure	CAS No.
Benzenamine, 3-methoxy-		536-90-3
Benzenamine, 4-methoxy-		104-94-9
Benzenamine, N-methyl-		100-61-8
Benzenamine, 2-methyl-		95-53-4
Benzenamine, 3-methyl-		108-44-1
Benzenamine, 4-methyl-		106-49-0
Benzenamine, 4,4'-methylenebis[2-chloro-		101-14-4
Benzenamine, 2-methyl-5-nitro-		99-55-8
Benzenamine, 3-methyl-4-nitro-		611-05-2
Benzenamine, 4-methyl-2-nitro-		89-62-3
Benzenamine, 2-nitro-		88-74-4
Benzenamine, 3-nitro-		99-09-2
Benzenamine, 4-nitro-		100-01-6

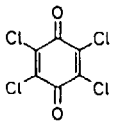
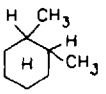
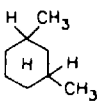
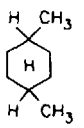
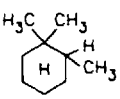
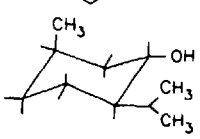
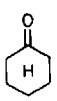
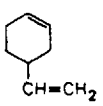
Chemical Name	Chemical Structure	CAS No.
Benzenamine, 2-nitro-N-phenyl-		119-75-5
Benzenamine, N-phenyl-		122-39-4
Benzenamine, 2-(trifluoromethyl)-		88-17-5
Benzenamine, 3-(trifluoromethyl)-		98-16-8
1,2-Benzenediamine		95-54-5
1,3-Benzenediamine		108-45-2
1,4-Benzenediamine		106-50-3
1,3-Benzenediamine, 4-methyl-		95-80-7
1,2-Benzenedicarbonitrile		91-15-6
1,3-Benzenedicarbonitrile		626-17-5
1,4-Benzenedicarbonitrile		623-26-7
1,4-Benzenedicarboxylic acid		100-21-0
1,2-Benzenedicarboxylic acid, bis(2-ethylhexyl) ester		117-81-7
1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester		84-69-5

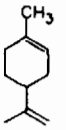
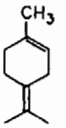
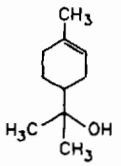
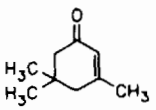
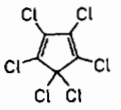
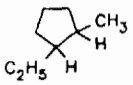
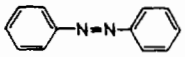
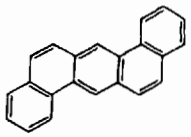
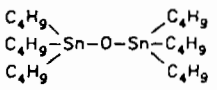
Chemical Name	Chemical Structure	CAS No.
1,2-Benzenedicarboxylic acid, butyl phenylmethyl ester		85-68-7
1,2-Benzenedicarboxylic acid, dibutyl ester		84-74-2
1,2-Benzenedicarboxylic acid, dicyclohexyl ester		84-61-7
1,2-Benzenedicarboxylic acid, diethyl ester		84-66-2
1,2-Benzenedicarboxylic acid, diheptyl ester		3648-21-3
1,2-Benzenedicarboxylic acid, diisodecyl ester		26761-40-0
1,2-Benzenedicarboxylic acid, dimethyl ester		131-11-3
1,4-Benzenedicarboxylic acid, dimethyl ester		120-61-6
1,2-Benzenedicarboxylic acid, dinonyl ester		84-76-4
1,2-Benzenedicarboxylic acid, dioctyl ester		117-84-0
1,2-Benzenedicarboxylic acid, diphenyl ester		84-62-8
1,2-Benzenediol		120-80-9
1,3-Benzenediol		108-46-3
1,4-Benzenediol		123-31-9

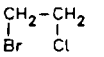
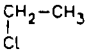
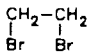
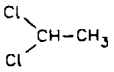
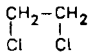
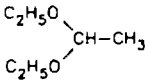
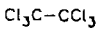
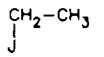
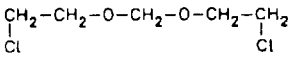
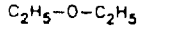
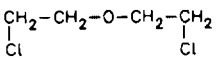
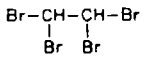
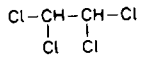
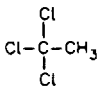
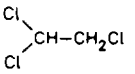
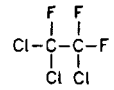
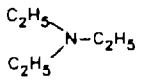
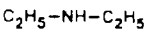
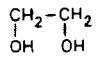
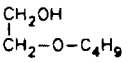
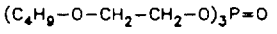
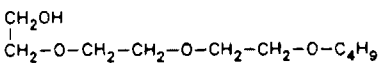
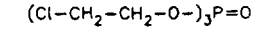
Chemical Name	Chemical Structure	CAS No.
1,2-Benzenediol, 4-(1,1-dimethylethyl)-		98-29-3
Benzeneacetic acid		103-82-2
Benzeneacetic acid, .alpha.-hydroxy-		90-64-2
Benzeneacetic acid, methyl ester		101-41-7
Benzenemethanamine, N,N-dimethyl-		103-83-3
Benzenemethanamine, N-ethyl-N-phenyl-		92-59-1
Benzenemethanol		100-51-6
Benzenemethanol, .alpha.-methyl-		98-85-1
Benzenesulfonic acid, dodecyl-		27176-87-0
Benzenesulfonic acid, dodecyl-, sodium salt		25155-30-0
Benzenesulfonic acid, 3-nitro-, sodium salt		127-68-4
Benzenesulfonamide, N-butyl-		3622-84-2
Benzenesulfonamide, 4-methyl-		70-55-3
Benzonitrile		100-47-0
Benzonitrile, 2,4-dichloro-		6574-98-7

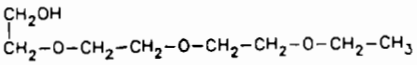
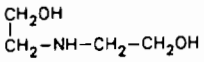
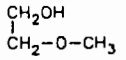
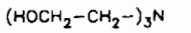
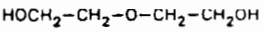
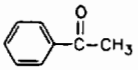
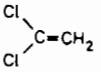
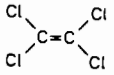
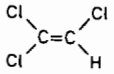
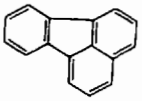
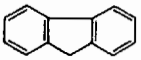
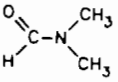
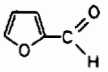
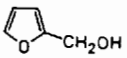
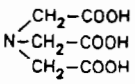
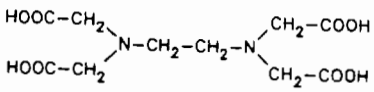
Chemical Name	Chemical Structure	CAS No.
Benzonitrile, 2-methyl-		529-19-1
Benzo[a]pyrene		50-32-8
Benzothiazole, 2,2'-dithiobis-		120-78-5
2(3H)-Benzothiazolethione		149-30-4
Bicyclo[2.2.1]hepta-2,5-diene		121-46-0
Bicyclo[2.2.1]heptane, 2,2-dimethyl-3-methylene-		79-92-5
Bicyclo[3.1.1]heptane, 6,6-dimethyl-2-methylene-		127-91-3
Bicyclo[3.1.1]heptane, 2,6,6-trimethyl-, didehydro deriv.		1330-16-1
Bicyclo[3.1.1]hept-2-ene, 2,6,6-trimethyl-		80-56-8
1,1'-Biphenyl		92-52-4
1,1'-Biphenyl, chlorinated		1336-36-3
1,1'-Biphenyl, 3,3'-dimethyl-		612-75-9
1,1'-Biphenyl, 4,4'-dimethyl-		613-33-2
1,1'-Biphenyl, ethyl-		40529-66-6
1,1'-Biphenyl, methyl-		28652-72-4
1,1'-Biphenyl, 3-methyl-		643-93-6
[1,1'-Biphenyl]-4,4'-diamine		92-87-5

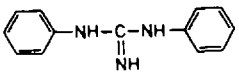
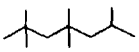
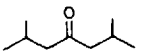
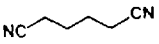
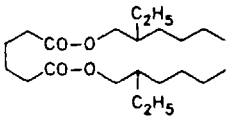
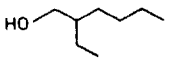
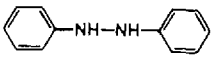
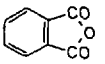
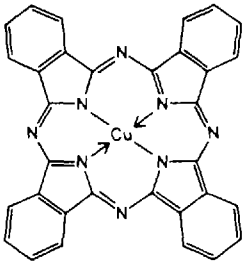
Chemical Name	Chemical Structure	CAS No.
[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dichloro-		91-94-1
[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethoxy-		119-90-4
[1,1'-Biphenyl]-4,4'-diamine, 3,3'-dimethyl-		119-93-7
[1,1'-Biphenyl]-2-ol		90-43-7
[1,1'-Biphenyl]-4-ol		92-69-3
1,3-Butadiene		106-99-0
1,3-Butadiene, 2-chloro-		126-99-8
1,3-Butadiene, 1,1,2,3,4,4-hexachloro-		87-68-3
1,3-Butadiene, 2-methyl-		78-79-5
Butane, 1-chloro-		109-69-3
Butane, 1,1'-oxybis-		142-96-1
Butanal		123-72-8
1-Butanamine		109-73-9
1-Butanamine, N-butyl-		11-92-2
1-Butanamine, N,N-dibutyl-		102-82-9
1-Butanol		71-36-3
2-Butanol		78-92-2
2-Butanol, 2-methyl-		75-85-4
2-Butanone		78-93-3
9H-Carbazole		86-74-8
Quinoline		91-22-5
1,3-Cyclohexadiene, 2-methyl-5-(1-methylethyl)-		99-83-2

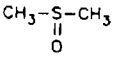
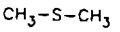
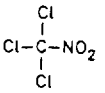
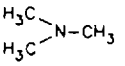
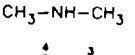
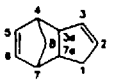
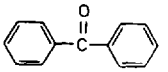
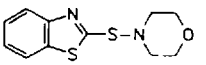
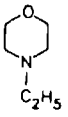
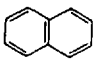
Chemical Name	Chemical Structure	CAS No.
2,5-Cyclohexadiene-1,4-dione, 2,3,5,6-tetrachloro-		118-75-2
Cyclohexane		110-82-7
Cyclohexane, chloro-		542-18-7
Cyclohexane,1,1-dimethyl-		590-66-9
Cyclohexane,1,2-dimethyl-		583-57-3
Cyclohexane,1,3-dimethyl-		591-21-9
Cyclohexane,1,4-dimethyl-		589-90-2
Cyclohexane, methyl-		108-87-2
Cyclohexane,1,1,2-tri methyl-		7094-26-0
Cyclohexanamine		108-91-8
Cyclohexanol, 5-methyl-2-(1-methyl)-, (1. alpha, beta, 5. alpha)-		89-78-1
Cyclohexanone		108-94-1
Cyclohexene		110-83-8
Cyclohexene, 4-ethenyl-		100-40-3

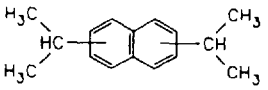
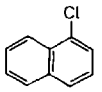
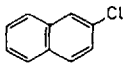
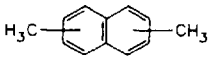
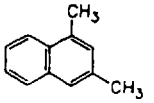
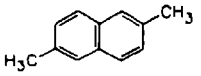
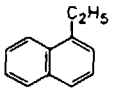
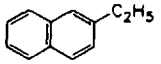
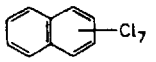
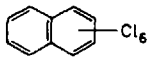
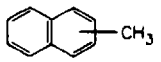
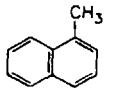
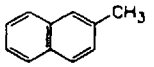
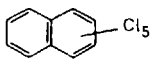
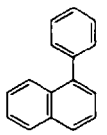
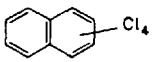
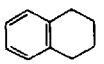
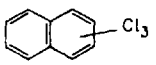
Chemical Name	Chemical Structure	CAS No.
Cyclohexene, 1-methyl-4-(1-methylethenyl)-		138-86-3
Cyclohexene, 1-methyl-4-(1-methylethylidene)-		586-62-9
3-Cyclohexene-1-methanol, .alpha., alpha.,4-trimethyl-		98-55-5
2-Cyclohexen-1-one 3,5,5-trimethyl-		78-59-1
1,5-Cyclooctadiene		111-78-4
1,3-Cyclopentadiene		542-92-7
1,3 Cyclopentadiene, 1,2,3,4,5,5-hexachloro-		77-47-4
Cyclopentane, 1-ethyl-2-methyl-, trans		930-90-5
Cyclopentene, 1-methyl-		693-89-0
1-Decanol	$C_{10}H_{21}OH$	112-30-1
Diazene, diphenyl-		103-33-3
Dibenz[a,h]antracene		53-70-3
1,4-Dioxane		123-91-1
Distannoxane, hexabutyl-		56-35-9
Dotriacontane	$C_{32}H_{66}$	544-85-4
Eicosane	$C_{20}H_{42}$	112-95-8
Ethane, bromo-		74-96-4

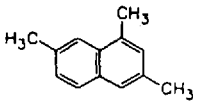
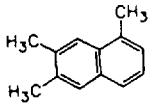
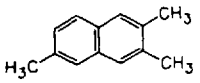
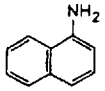
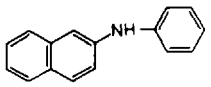
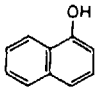
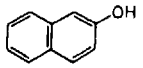
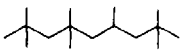
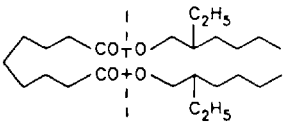
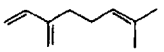
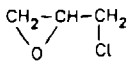
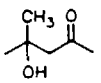
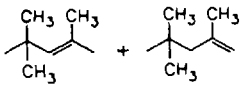
Chemical Name	Chemical Structure	CAS No.
Ethane, 1-bromo-2-chloro-		107-04-0
Ethane, chloro-		75-00-3
Ethane, 1,2-dibromo-		106-93-4
Ethane, 1,1-dichloro-		75-34-3
Ethane, 1,2-dichloro-		107-06-2
Ethane, 1,1-diethoxy-		105-57-7
Ethane, hexachloro-		67-72-1
Ethane, iodo-		75-03-6
Ethane, 1,1'-[methylenebis(oxy)]bis[chloro]-		111-91-1
Ethane, 1,1'-oxybis-		60-29-7
Ethane, 1,1'-oxybis[2-chloro-		11-44-4
Ethane, 1,1,2,2-tetrabromo-		79-27-6
Ethane, 1,1,2,2-tetrachloro-		79-34-5
Ethane, 1,1,1-trichloro-		71-55-6
Ethane, 1,1,2-trichloro-		79-00-5
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-		76-13-1
Ethanamine, N,N-diethyl-		121-44-8
Ethanamine, N-ethyl-		109-89-7
1,2-Ethanediol		107-21-1
Ethanol, 2-butoxy-		111-76-2
Ethanol, 2-butoxy-, phoshate(3:1)		78-51-3
Ethanol, 2-[2-(2-butoxyethoxy)ethoxy]-		143-22-6
Ethanol, 2-chloro-, phosphate(3:1)		115-96-8

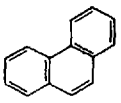
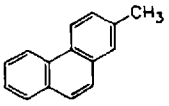
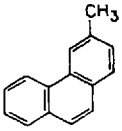
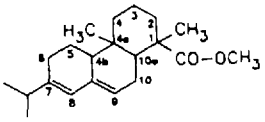
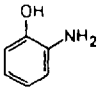
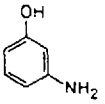
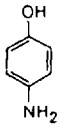
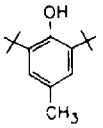
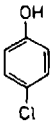
Chemical Name	Chemical Structure	CAS No.
Ethanol, 2-[2-(2-ethoxyethoxy)ethoxy]-		112-50-5
Ethanol, 2,2'-iminobis-		111-42-2
Ethanol, 2-methoxy-		109-86-4
Ethanol, 2,2',2''-nitrilotris-		102-71-6
Ethanol, 2,2'-oxybis-		111-46-6
Ethanone, 1-phenyl-		98-86-2
Ethene, bromo-		593-60-2
Ethene, chloro-		75-01-4
Ethene, 1,1-dichloro-		75-35-4
Ethene, 1,2-dichloro-		540-59-0
Ethene, tetrachloro-		127-18-4
Ethene, trichloro-		79-01-6
Fluoranthene		206-44-0
9H-Fluorene		86-73-7
Formaldehyde		50-00-0
Formamide, N,N-dimethyl-		68-12-2
Furan, tetrahydro-		109-99-9
2-Furancarboxaldehyde		98-01-1
2-Furanmethanol		98-00-0
Glycine, N,N-bis(carboxymethyl)-		139-13-9
Glycine, N,N'-1,2-ethanediylbis[N-(carboxymethyl)-		60-00-4

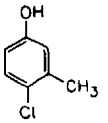
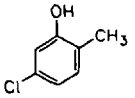
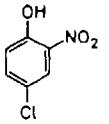
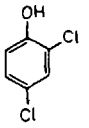
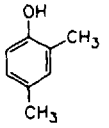
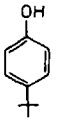
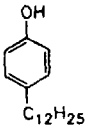
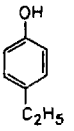
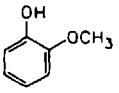
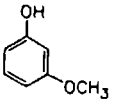
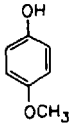
Chemical Name	Chemical Structure	CAS No.
Guanidine, N,N-diphenyl-		102-06-7
Heptane, 2,2,4,4,6-pentamethyl-		62199-62-6
4-Heptanone, 2,6-dimethyl-		108-83-8
Hexadecane	$C_{16}H_{34}$	544-76-3
Hexadinitrile		111-69-3
Hexanedioic acid, bis(2-ethylhexyl) ester		103-23-1
1-Hexanol, 2-ethyl-		104-76-7
Hydrazine, 1,2-diphenyl-		122-66-7
1H-Indene		95-13-6
1H-Indene, 2,3-dihydro-		496-11-7
1,3-Isobenzofurandione		85-44-9
Carbon disulfide	CS_2	75-15-0
Copper, [29H,31H-phthalocyaninato(2-)-N29,N30,N31,N32]-, (SP-4-1)-		147-14-8
Methane, bromo-	CH_3-Br	74-83-9
Methane, bromochloro-	$CH_2(Br)Cl$	74-97-5
Methane, bromodichloro-	$BrCHCl_2$	75-27-4
Methane, chloro-	CH_3-Cl	74-87-3
Methane, chlorotrifluoro-	CF_3Cl	75-72-9
Methane, dibromochloro-	$BrCHClBr$	124-48-1
Methane, dichloro-	CH_2Cl_2	75-09-2

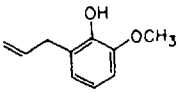
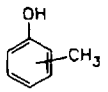
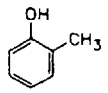
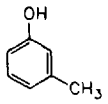
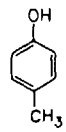
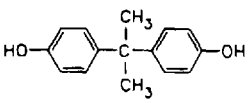
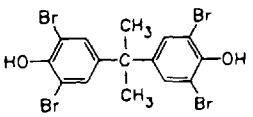
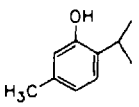
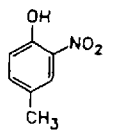
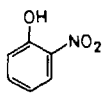
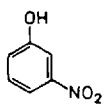
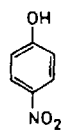
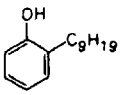
Chemical Name	Chemical Structure	CAS No.
Methane, dichlorodifluoro-		75-71-8
Methane, iodo-		74-88-4
Methane, nitro-		75-52-5
Methane, sulfinylbis-		67-68-5
Methane, tetrachloro-		56-23-5
Methane, thiobis-		75-18-3
Methane, tribromo-		75-25-2
Methane, trichloro-		67-66-3
Methane, trichlorofluoro-		75-69-4
Methane, trichloronitro-		76-06-2
Methanamine, N,N-dimethyl-		75-50-3
Methanamine, N-methyl-		124-40-3
4,7-Methano-1H-indene,3a,4,7,7a-tetrahydro-		77-73-6
Methanone, diphenyl-		119-61-9
Morpholine		110-91-8
Morpholine, 4-(2-benzothiazolythio)-		102-77-2
Morpholine, 4-ethyl-		100-74-3
Naphthalene		91-20-3

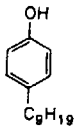
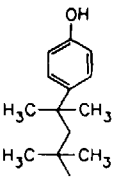
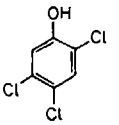
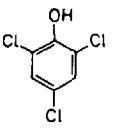
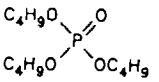
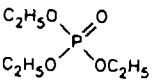
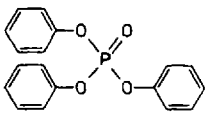
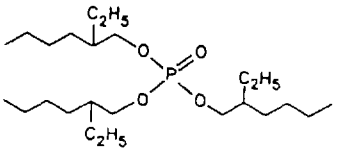
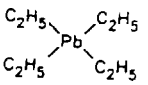
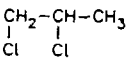
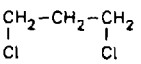
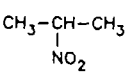
Chemical Name	Chemical Structure	CAS No.
Naphthalene, bis(1-methylethyl)-		38640-62-9
Naphthalene, 1-chloro-		90-13-1
Naphthalene, 2-chloro-		91-58-7
Naphthalene, dimethyl-		28804-88-8
Naphthalene, 1,3-dimethyl-		575-41-7
Naphthalene, 2,6-dimethyl-		581-42-0
Naphthalene, 1-ethyl-		1127-76-0
Naphthalene, 2-ethyl-		939-27-5
Naphthalene, heptachloro-		32241-08-0
Naphthalene, hexachloro-		1335-87-1
Naphthalene, methyl-		1321-94-4
Naphthalene, 1-methyl-		90-12-0
Naphthalene, 2-methyl-		91-57-6
Naphthalene, pentachloro-		1321-64-8
Naphthalene, 1-phenyl-		605-02-7
Naphthalene, tetrachloro-		1335-88-2
Naphthalene, 1,2,3,4-tetrahydro-		119-64-2
Naphthalene, trichloro-		1321-65-9

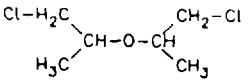
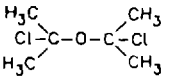
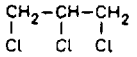
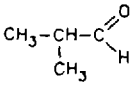
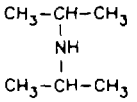
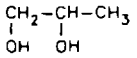
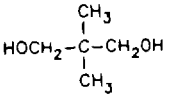
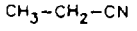
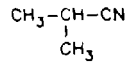
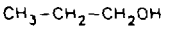
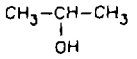
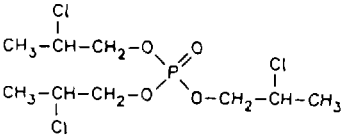
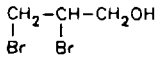
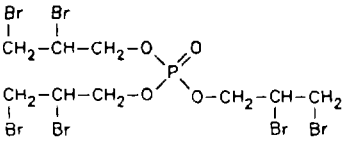
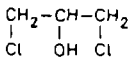
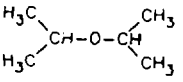
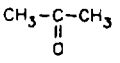
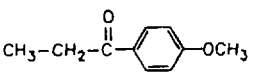
Chemical Name	Chemical Structure	CAS No.
Naphthalene, 1,3,7-trimethyl-		2131-38-6
Naphthalene, 1,6,7-trimethyl-		2245-38-7
Naphthalene, 2,3,6-trimethyl-		829-26-5
1-Naphthalenamine		134-32-7
2-Naphthalenamine, N-phenyl-		135-88-6
1-Naphthalenol		90-15-3
2-Naphthalenol		135-19-3
Nonane, 2,2,4,4,6,8,8-heptamethyl-		4390-04-9
Nonanedioic acid, bis(2-ethylhexyl) ester		103-24-2
Octadecane	$C_{18}H_{38}$	593-45-3
1,6-Octadiene, 7-methyl-3-methylene-		123-35-3
1-Octanol	$C_8H_{17}-OH$	111-87-5
Oxirane, (chloromethyl)-		106-89-8
1-Pentanol	$C_5H_{11}-OH$	71-41-0
2-Pentanone, 4-hydroxy-4-methyl-		123-42-2
2-Pentanone, 4-methyl-		108-10-1
Pentene, 2,4,4-trimethyl-		25167-70-8
3-Penten-2-one, 4-methyl-		141-79-7

Chemical Name	Chemical Structure	CAS No.
Phenanthrene		85-01-8
Phenanthrene, 2-methyl-		2531-84-2
Phenanthrene, 3-methyl-		832-71-3
1-Phenanthrenecarboxylic acid, 1,2,3,4,4a,4b,5,6,10,10a-decahydro-1,4a-dimethyl-7-(1-methylethyl)-, methyl ester[1R-(1-alpha, 4a-beta, 4b-alpha, 10a-alpha)]-		127-25-3
Phenol		108-95-2
Phenol, 2-amino-		95-55-6
Phenol, 3-amino-		591-27-5
Phenol, 4-amino-		123-30-8
Phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-		128-37-0
Phenol, 2-chloro-		95-57-8
Phenol, 3-chloro-		108-43-0
Phenol, 4-chloro-		106-48-9

Chemical Name	Chemical Structure	CAS No.
Phenol, 4-chloro-3-methyl-		59-50-7
Phenol, 5-chloro-2-methyl-		5306-98-9
Phenol, 4-chloro-2-nitro-		89-64-5
Phenol, 2,3-dichloro-		576-24-9
Phenol, 2,4-dichloro-		120-83-2
Phenol, 2,4-dimethyl-		105-67-9
Phenol, 4-(1,1-dimethylethyl)-		98-54-4
Phenol, 4-dodecyl-		104-43-8
Phenol, 4-ethyl-		123-07-9
Phenol, 2-methoxy-		90-05-1
Phenol, 3-methoxy-		150-19-6
Phenol, 4-methoxy-		150-76-5

Chemical Name	Chemical Structure	CAS No.
Phenol, 2-methoxy-6-(2-propenyl)-		579-60-2
Phenol, methyl-		1319-77-3
Phenol, 2-methyl-		95-48-7
Phenol, 3-methyl-		108-39-4
Phenol, 4-methyl-		106-44-5
Phenol, 4,4'-(1-methylethylidene)bis-		80-05-7
Phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromo-		79-94-7
Phenol, 5-methyl-2-(1-methylethyl)-		89-83-8
Phenol, 4-methyl-2-nitro-		119-33-5
Phenol, 2-nitro-		88-75-5
Phenol, 3-nitro-		554-84-7
Phenol, 4-nitro-		100-02-7
Phenol, 2-nonyl-		136-83-4

Chemical Name	Chemical Structure	CAS No.
Phenol, 4-nonyl-		104-40-5
Phenol, 4-(1,1,3,3-tetramethylbutyl)-		140-66-9
Phenol, 2,4,5-trichloro-		95-95-4
Phenol, 2,4,6-trichloro-		88-06-2
Phosphoric acid, tributyl ester		126-73-8
Phosphoric acid, triethyl ester		78-40-0
Phosphoric acid, triphenyl ester		115-86-6
Phosphoric acid, tris(2-ethylhexyl) ester		78-42-2
Piperidine		110-89-4
Plumbane, tetraethyl-		78-00-2
Propane, 1,2-dichloro-		78-87-5
Propane, 1,3-dichloro-		142-28-9
Propane, 2-nitro-		79-46-9

Chemical Name	Chemical Structure	CAS No.
Propane, 2,2'-oxybis[1-chloro-		108-60-1
Propane, 2,2'-oxybis[2-chloro-		39638-32-9
Propane, 1,2,3-trichloro-		96-18-4
Propanal, 2-methyl-		78-84-2
2-Propanamine, N-(1-methylethyl)-		108-18-9
1,2-Propanediol		57-55-6
1,3-Propanediol, 2,2-dimethyl-		126-30-7
Propanenitrile		107-12-0
Propanenitrile, 2-methyl-		78-82-0
1-Propanol		71-23-8
2-Propanol		67-63-0
1-Propanol, 2-chloro-, phosphate(3:1)		6145-73-9
1-Propanol, 2,3-dibromo-		96-13-9
1-Propanol, 2,3-dibromo-, phosphate(3:1)		126-72-7
2-Propanol, 1,3-dichloro-		96-23-1
2-Propanol, 1,1'-oxybis-		110-98-5
2-Propanone		67-64-1
1-Propanone, 1-(4-methoxyphenyl)-		12197-1

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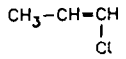
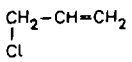
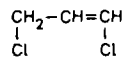
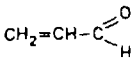
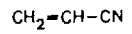
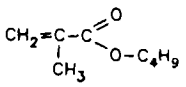
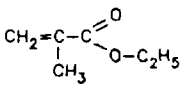
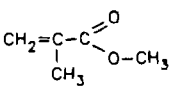
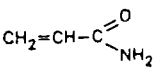
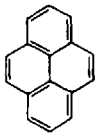
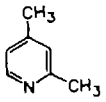
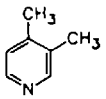
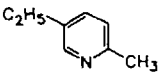
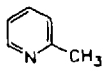
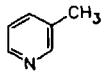
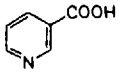
1-Propene, 1-chloro-		590-21-6
1-Propene, 3-chloro-		107-05-1
1-Propene, 1,3-dichloro-		542-75-6
2-Propenal		107-02-8
2-Propenenitrile		107-13-1
2-Propenoic acid, 2-methyl-, butyl ester		97-88-1
2-Propenoic acid, 2-methyl ethyl ester		97-63-2
2-Propenamide		80-62-6
Pyrene		79-06-1
Pyridine		129-00-0
Pyridine, 3-Chloro-		110-86-1
Pyridine, 3-chloro		626-60-8
Pyridine, 2,4-dimethyl-		108-47-4
Pyridine, 3,4-dimethyl-		583-58-4
Pyridine, 5-ethyl-2-methyl-		104-90-5
Pyridine, 2-methyl		109-06-8
Pyridine, 3-methyl		108-99-6
3-Pyridinecarboxylic acid		59-67-6

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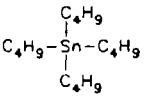
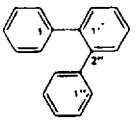
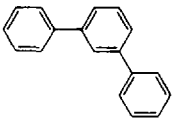
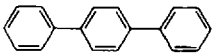
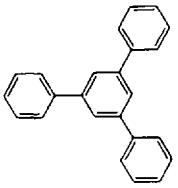
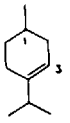
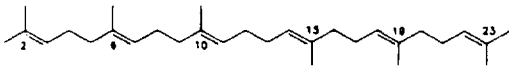
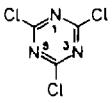
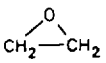
2-Pyrrolidinone, 1-methyl-		872-50-4
Stannane, tetrabutyl-		1461-25-2
1,1′: 2′,1″- Terphenyl		84-15-1
1,1′: 3′,1″- Terphenyl		92-06-8
1,1′: 4′,1″- Terphenyl		92-94-4
1,1′: 3′,1″- Terphenyl, 5′-phenyl-		612-71-5
Terpinene		8013-00-1
2,6,10,14,18,22-Tetracosahexaene, 2,6,10,15,19,23-hexamethyl-, (all-E)		111-02-4
Tetradecanoic acid	$C_{13}H_{27}COOH$	544-63-8
Tetratriocontane	$C_{34}H_{70}$	14167-59-0
Triophene, tetrahydro-, 1,1-dioxide		126-33-0
1,3,5-Triacine, 2,4,6-trichloro-		108-77-0
1,3,5-Trioxane		110-88-3
Paraffin waxes and Hydrocarbon waxes, chlorinated	$C_{10-20}H_nCl_m$	63449-39-8
Oxirane		75-21-8
Cadmium Oxide	CdO	1306-19-0

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