5

DEVELOPING RESPONSE TACTICS

5.1. INTRODUCTION

Previous chapters described the importance of assessing the hazards and identifying the potential credible incidents at the facility before any emergency. Chapter 4 provided guidance for determining a facility's overall emergency response strategy and approach. With this determined, specific tactical considerations can be given to particular hazards. This chapter discusses response tactics for primary industrial hazards such as fire, explosions, and hazardous materials release. A similar approach to developing tactics can be used for medical, rescue, and natural hazards.

To develop effective response tactics, the planner must assess and consider several general factors for each credible incident:

- **Processes**—pressure, temperature, chemical reactions.
- **Usage**—what form the material is in (solid, liquid, or gas), what quantities are involved.
- **Material Transfer**—the movement of materials throughout the system, including on-site tanker and rail car deliveries, loading and unloading fixed tanks, compressed gas, and pipelines.
- **Storage**—any materials needing isolation or segregation, including proper containment, with emphasis on compatibility and quantities.

With a complete understanding of the facility's credible incidents including the above factors, the planner can develop safe tactics and actions for mitigating an incident.

Tactics are the actions taken to achieve desired goals. They can be defensive (containing the problem from spreading and limiting the loss, but not eliminating it), offensive (aggressively attacking the problem at its source), or a combination of each (such as first containing the problem then moving in to mitigate). Emergency planners should determine whether the risk associated with a particular tactic is worth the potential benefit. History shows that without a plan for clear and effective tactics, emergency responders will face unnecessary risk. To lend credence to this statement, consider that 51% of all deaths that occur during rescue operations are those of the would-be rescuers. Many times these deaths result from an inadequate tactical plan.

The following incident demonstrates the effects of not having proper emergency response tactics and decisions:

> Three members of an industrial fire brigade and two other employees died during a fire at a warehouse in 1980. Automatic sprinklers protected the storage building, which measured 46 by 72 feet. The warehouse stored baled scrap paper approximately 15 feet high. Nearby welding and grinding operations started a fire, which was subsequently discovered by an employee who then notified the plant fire brigade.
>
> Arriving members of an industrial fire department found the building heavily charged with smoke and sprinklers operating at the ceiling. They entered the building with hose lines to find the seat of the fire. One crew of firefighters was approximately 12 feet inside the building when bales of paper fell, trapping two of them. Other firefighters and employees outside the building rushed in to assist. A second collapse trapped seven would-be rescuers. By the time the incident was over, two employees and three industrial firefighters were dead due to the collapsing bales and resulting suffocation. Seven other fire brigade members were injured in the incident.

This case illustrates why proper tactics are essential. If the responders had thought about their actions, they might have identified the problem of the paper bales collapsing under the weight of water. Effective planning will allow other life-saving factors to be considered.

The remainder of this chapter is divided into discussion of tactics for fire and for hazardous materials releases. Many of the tactical considerations discussed for one hazard may apply to others; however, some differences exist. As much as possible, an incident commander (IC) should follow common tactics consistently and consider differences as applicable.

5.2. PRINCIPLES OF RESPONDING TO FIRES

Several issues that planners need to consider when developing tactics for the identified credible fire scenarios include the capabilities of the facility's own fire response organization, and the integration between on-site fire brigades and off-site fire departments.

5.2.1. Plant Fire Response Organization

5.2.1.1. Fire-Fighting Brigade

The planner should first review the capability of the facility's fire brigade. The two most common types of brigades are an incipient fire brigade and an interior structural fire brigade, both described under OSHA regulations 29 CFR 1910.156 [2].

The key tactical difference between the two brigade types is that, operationally, an incipient brigade does not require personal protective clothing and it strictly adheres to extinguishing small incipient (beginning) stage fires by using portable fire extinguishers or hose lines no larger than 1.5 inches in diameter. The interior structural fire brigade uses approved fire-fighter protective clothing (bunker gear) and receives more extensive training in fire-fighting techniques, such as the use of extinguishing equipment including larger hose lines, foam, and other special extinguishing agents.

5.2.1.2. Equipment

Another issue affecting the development of fire response tactics is the on-site availability of personal protective equipment (PPE) including self-contained breathing apparatus (SCBA), bunker gear, gloves, boots, helmet, and other equipment, such as portable monitoring devices, fire apparatus, hoses, nozzles, foam, foam eductors, and nozzles. Chapter 7 provides an in-depth discussion of fire-fighting and personal protective equipment.

5.2.1.3. Personnel Availability

A major consideration is the number of trained personnel available at any time. For example, response brigade members must be able to leave their normal duty stations, such as boilers or intricate chemical processes, at all times. A sufficient number of fire brigade members are needed for response activities such as rescue, foam operations, securing utilities, stretching lines, forcible entry, ventilating, and protecting unaffected property and equipment.

5.2.2. Integration of On-Site Fire Brigades and Off-Site Departments

When contemplating using outside response agencies, planners should evaluate their response time, availability, capability to recognize and handle unusual hazards and critical processes, and ability to participate in drills.

Many issues can be resolved through pre-incident planning, integrated training, and periodic drills and exercises.

Planners should carefully determine and describe when help from outside fire departments is needed and how it is requested. There are many examples when delayed alarms contributed to large industrial fire losses. Using emergency action levels may help avoid unnecessary calls while ensuring prompt completion of necessary notifications. A version of the CCPS emergency action levels, discussed in Chapter 4, and modified for use in fires, can guide facility decision makers in determining when to call for outside assistance.

TABLE 5.1
Sample Fire Emergency Action Levels

Level	*Action*
Localized fire	Localized effect zone, limited to a single plant area (e.g., small fires, pump fires, trash fires). This could be handled by either an incipient fire brigade or a structural fire brigade.
Major fire	Medium effect zone, limited to site boundaries (e.g., major fire, chemical fire, small explosion). An incipient fire brigade **could not** handle this. This fire may be handled by a properly equipped and trained interior structural fire brigade with or without outside responders.
Catastrophic fire	Large effect zone, off-site effects on the surrounding community (e.g., major explosion, large chemical fire). This fire must be handled with all available trained personnel including site brigade and outside agencies.

5.2.3. Response Tactics

Emergency response, like most other activities, involves proper decision making followed by effective implementation, so advance planning is essential.

In general, making decisions in normal, day-to-day operational situations involves three main factors:

- **Quantity**: Resource limitations always exist (budget, personnel, logistics, information limitations, etc.),
- **Quality**: Making decisions under stress with limited information is difficult. People strive to make correct, effective, quality decisions, and
- **Time**: Every decision has deadlines (the time available to make a decision is compressed).

The impact of these decision factors—quantity, quality, and time—increase during emergencies. Proper planning prior to emergencies will help ensure that adequate resources are available when needed. Typically, relatively little time is available to make decisions, and the quality of the decision and its implementation can have a very serious effect on human safety and environmental protection.

5.2.3.1. Incident Pre-Plans

The term *pre-planning* describes the actual process of developing fire response tactics. A fire pre-plan provides emergency first responders an inventory of essential information necessary for developing tactical response plans at the outset of the emergency. Pre-plans can take many shapes and should be part of the facility's emergency response plan. They can cover different hazards including fire and chemical incidents (for example, choosing when fixed manual systems should be integrated).

Table 5.2 describes the information that can be included in a pre-plan.

TABLE 5.2
Sample Information for Pre-Plans

Information	*Description*
GENERAL	
Facility identification	Facility name (use common name)
Facility plot plan	Is it current?
Date	Date the information is gathered
Number of levels in structures	Number of floors from ground floor up (or height if more appropriate)
Structure dimensions	Estimate the overall size of building or open structure.
People in area during day and night	Typical number of people that can be found in the area during the day and night time. Any special needs people?
Included areas	Describe the area(s) that are associated with building/facility/area.
Sub levels	Number of below ground levels
Facility activity	What activities are taking place in the area?
STRUCTURE	
Construction type	What is the structure made of?
Exterior doors, type and number	What are outer doors made of, how many, and how do they work?
Elevators/lifts	State if structure has elevators and, if so, where.
Stairway location construction	State where stairs are located and what they are made of.
Interior wall construction	What are the walls inside structure made of?
Exits illuminated?	Are the exits illuminated and do they have back-up power (battery)?
Corridor widths/height	How wide are the corridors and aisles and how high are both?
PROCESS EQUIPMENT	
Tanks/vessels	Number of tanks/vessels and size in gallons
Tank/vessel construction	What is each tank/vessel made of, pressure rating, relief settings, insulation?
Contents	What product does it contain and quantity?
Marking system	What marking system is used on the tank (e.g., NFPA 704)?
Dikes and berms	What are the dikes and berms made of and how much product will it hold? Are there drains in the diked area? Can drains be shut?
Sprinklers	Sprinkled area?

Table continues on page 88.

TABLE 5.2
Sample Information for Pre-Plans (*continued*)

Information	*Description*
PROCESS EQUIPMENT (*continued*)	
Chemical shutoffs	Locations
Drainage description	Where will liquids running from the area go?
SUPPRESSION	
Foam system	Do tanks have foam or subsurface system?
Water monitor	Is tank area protected by water monitor system? Can foam be used in the system?
UTILITIES	
Heating type	What type of heat is used? What is the fuel source?
Electrical shutoff location	Where are the panel boxes or main shutoffs and what type breakers, fuses?
Gas shutoffs locations	If gas is used in the area, where are the shutoffs?
Water shutoffs locations	Where are the water shutoffs?
PROTECTION SYSTEMS	
Fire alarm type	Does the fire alarm sound only in the area or does it go off some where else?
Fire detection type	State type of alarm in area, if any.
Sprinkler type	Does system cover entire area or just sections?
Sprinkler wet or dry	Is the system wet or dry? What are the sprinkler heads rated for?
Sprinkler fire department connection	Where is the fire department connection for the sprinkler system? On the outside of any structure? Design pressure?
Portable extinguishers	Number and location
Portable extinguisher: type	State what types of extinguishers are maintained in area.
Standpipe fire department connection	Does the area have a standpipe system? If so where is it located and where is the fire department connection? Size and thread?
Standpipe hose diameter	Does the standpipe system have fire hose stations? If so, what size is the hose?
Standpipe wet or dry	Is the system wet or dry?
Nearest hydrant	Where is the nearest hydrant?
Secondary water source	Where would the secondary water source be found?
Other protection systems	List any other fire protection systems in area.

Information	Description
INSTRUMENTATION	
Inventory devices	Are there high-level alarms on tanks?
Leak detectors	Are there any leak detectors in the diked area or on tanks?
RESPONSE CONSIDERATIONS	
Chemicals in area	What chemicals are stored or used in the area?
Other "in-process" chemicals	What chemicals are produced during the process, if any?
Process description	Briefly describe the type of process taking place in area?
List of credible incidents	Taken from studies of what can go wrong.
Summary of hazards	Give a brief statement or overview of hazards in area.
Nearby hazards	List hazards that are nearby such as chemical storage, other processes taking place in building nearby.
Response considerations	Try to think of any information that a fire department or other emergency responders will need to know if a problem were to occur, such as any special mitigation techniques or actions, how would they get to the area, or whether they would need special tools.
Other comments	This area is for any additional information.

Developing a pre-plan provides an opportunity for plant emergency personnel and outside responders to meet, discuss, and evaluate each other's capabilities and limitations. To ensure effectiveness and to determine information accuracy, facilities should test a pre-plan by conducting real-time drills. As with all emergency planning documents, personnel must update a pre-plan, as the plant and its response capabilities change, or at least annually.

5.2.3.2. *Initial Assessment and Size-Up*

The first step in dealing with a fire or other incidents is the initial assessment and size-up, which is a phrase that describes the first responders' observations upon arrival at the scene. It deals with the first few critical minutes when understanding the situation is essential to determine the actions needed to contain and control the emergency safely. Responders should be sure to communicate with plant personnel to obtain information in order to size up, or evaluate the extent of an emergency and to help responders recognize the potentials for fire spread and the need for outside help.

During the first few minutes of a fire, response personnel must make several decisions, such as where to place the first hose line, who and when to evacuate, and to where. Responders must quickly make decisions based on available information, since the decisions made during the first few minutes may determine the outcome hours later.

A useful method, known as LOCATE (Figure 5.1), describes the issues responders need to consider during their initial assessment and size-up.

Life

Who is in jeopardy and what needs to be done to protect emergency responders, employees, and neighbors?

Occupancy

What is inside the buildings, tanks, pipes, and other s tructures?

Construction

What is the size, height, type of material (steel, aluminum. glass, etc.) used in the building?

Area

What activities are occurring in the immediate area and what affect do they have on the fire and vice versa? Do nearby chemical operations need protection?

Time

What tiem of day is it? What season and weather conditions are germane? How long has it been burning? How long before any corrective actions can be taken?

Exposure

What is exposed to the fire that needs protection, such as people, buidings, nearby areas, the environment (e.g., protection from contaminated fire water runoff)?

FIGURE 5.1. LOCATE. Note: The initial responders must consider several factors upon arrival at the scene. By applying LOCATE factors, responders can develop a good tactical plan. Another useful technique, DECIDE, is described in Section 5.3.2 on page 93.

5.2.3.3. *Managing the Incident*

As discussed previously, managing and decision-making during an emergency are obviously much different from normal operations because decisions must be made quickly without complete information. Well-trained first responders and a proper chain of command will allow for effectively managing the incident.

As a result of major wild land fires during the early 1970s, fire and other emergency services developed a management system, commonly referred to as the *incident command system* (ICS). The ICS creates a clear chain of command so that responders report to one supervisor. An ICS allows for an appropriate span of control enabling the incident commander (IC) to divide large operations into smaller, more manageable parts. The system enables the IC to develop a tailored response to each incident by using only necessary resources to bring the incident to a safe conclusion.

The ICS is a major component for controlling and mitigating any type of emergency. Chapter 11 provides a more fully developed explanation of the ICS.

5.2.3.4. *Response Priorities*

The tactical priorities for fire fighting should be as follows:

1. Safety of employees and the firefighters,
2. Preventing the fire from spreading,
3. Protecting the environment, and
4. Protecting the property itself.

The first priority is to protect the employees by evacuating or rescuing endangered people and by determining whether the area is safe for responders to enter; next, to choose a defensive plan to keep the fire from spreading. In taking an offensive approach, an IC must not forget the first priority—safety of people. The IC should also try to protect the environment from fire water runoff, smoke, and hazardous gases (e.g., can temporary dikes be built by responders? will fire water react with nearby chemicals?). An offensive plan can minimize the damage since crews will enter the area and extinguish the fire.

5.2.3.5. *Fire Suppression*

The basic strategy in firefighting is to contain and extinguish the fire. Although this strategy sounds quite simple, deciding where and how to cut off the spreading fire during heavy smoke conditions is not a simple decision. The possible need to rescue employees further complicates the operation. Some issues to consider during fire suppression include:

- **Communication**—Do proper communications exist between the IC and fire fighters during the response? Do fire fighters continually provide updates so that the IC can effectively evaluate the tactical plan?
- **Location and Extent**—Where is the seat of the fire and how far has it spread from the area of origin? Is the area safe to enter? Are water attack

lines large enough to control the fire? Are back-up lines in place to protect the attack crews? Can heavy fire streams protect exposures?

- **Apparatus and Equipment**—Is there adequate equipment, such as attack lines, water supply lines, and master stream devices to handle the incident? Are there tools to perform forced entry and ventilation? Is enough foam available to use in case of a flammable liquid fire? Is there proper equipment to apply foam? Is it the right type of foam to handle the problem—is it a hydrocarbon-based fire or a polar-solvent (alcohol) fire? Are apparatus and personnel correctly positioned?
- **Water**—How accessible are the water sources to the scene? Has the IC evaluated the water flow to determine whether there are adequate capacity and pressure on-site to meet the suppression needs? Is there a secondary water source? What areas can fire water run-off adversely affect? Is the weight of the water on the structure a concern? Are materials water reactive?
- **Fuel**—Shut off supply of fuel if possible.

5.3. HAZARDOUS MATERIALS

5.3.1. Hazardous Materials Response Regulations

While many of the tactical considerations discussed for fire fighting apply to hazardous material (Hazmat) situations, some differences exist. A primary consideration in developing a capability to respond to Hazmat situations is OSHA's Hazardous Waste Operations and Emergency Response regulation, 29 CFR 1910.120 [1], commonly referred to as HAZWOPER. This regulation is more encompassing and stringent in defining levels of response capabilities than OSHA's fire brigade regulation.

OSHA developed the HAZWOPER regulation to address an estimated 13,600 spills of hazardous chemicals that occur annually inside fixed industrial facilities. In terms of emergency response activities, it requires employers to have training, protective gear, cleanup equipment and supplies, and emergency plans in place before a spill occurs. It outlines duties and responsibilities of spill response teams in the private and public sector. The OSHA rule requires that all employees who will be responding to and/or working at chemical emergency incidents be provided with training. Specifically, OSHA designated five levels of response training based on duties during a Hazmat event:

- First Responder Awareness Level,
- First Responder Operations Level,
- Hazardous Materials Technician,
- Hazardous Materials Specialist, and
- On-Scene Incident Commander.

Table 5.3 summarizes the duties of each responder.

TABLE 5.3
Hazmat Responder Levels

Responder Level	*Duties*
First responders at the awareness level	Individuals who are likely to witness or discover a hazardous substance release who should be capable of initiating an emergency response sequence by notifying the proper authorities of the release.
First responders at the operations level	Respond in a defensive fashion without trying to stop the release. Their role is to protect nearby persons, property, and the environment from the effects of the spill, leak, fire, or explosion.
Hazardous materials technicians	Respond to incidents to stop the release. They assume a more offensive role than a responder at the operations level in that they plug, patch, or otherwise stop the release of a hazardous substance.
Hazardous materials specialists	Specialists require a more specific knowledge of the materials they must contain. The hazardous materials specialist would also act as the site liaison with federal, state, local, and other government authorities regarding incident scene activities.
On-scene incident commander	Assumes control of the incident scene and directs the activities of the emergency responders.

The first action at a hazardous material incident is establishing an incident command system (ICS) and the second is ensuring that a safety officer is at the scene, as mandated by HAZWOPER. The safety officer's role is to ensure the safety of the responders at the scene [3].

5.3.2. *Hazmat Initial Assessment and Size-Up*

As with fire situations, the LOCATE methodology can be used to perform an initial size-up for hazardous materials incidents.

Although the LOCATE stratagem is effective, another tool helpful in the initial size-up is DECIDE, as shown in Figure 5.2.

One key issue dealing with a hazardous material incident size-up is to identify the materials involved. Until the material is known, one cannot plan appropriate corrective actions. Whenever possible, the IC should talk to plant operating personnel to determine the material involved and to discern what caused the event to take place. Understanding the reasons for the incident can provide insight as to how the team can mitigate the problem. For example, if there was an explosion resulting in a number of damaged pipes, the likelihood of trying to patch the damaged pipes may be futile. With the cooperation and help of the plant operators, the IC should seek ways to stop open pipe leaks via remote shut-off, depressurization of sources, or shutting down operations.

Detect hazardous materials present

Estimate likely harm with or without intervention

Choose response objective

Identify action

Do best option

Evaluate progress

FIGURE 5.2. DECIDE.

5.3.3. Hazmat Reconnaissance

If the above issues cannot be answered upon initial arrival and after discussion with plant personnel, reconnaissance of the incident will be necessary using one of two primary reconnaissance methods. One approach involves having a two-person crew survey the incident from a safe distance (elevated and upwind distance ensuring that they will not come in contact with any of the materials) to determine what is taking place.

The second approach, although more dangerous, entails sending a minimum team of two responders directly into the incident area to assess conditions. With this approach, the reconnaissance team should use the highest level of chemical protective clothing (CPC). The IC should have back-up personnel in CPC ready to move in if there is a problem and set up an emergency route out of the area in case the initial entry route becomes blocked. The safety officer should also establish a decontamination (decon) area prior to entry.

5.3.4. *Work Zones*

Another important function during the initial size-up is establishing work zones. These zones clearly define work areas where certain actions can take place and particular personnel can work. These allow the emergency responders to effectively control the flow of equipment and to account for personnel moving in and out of the incident.

Determining work zone boundaries begins during the initial size-up, based on known incident hazards, weather conditions (especially wind direction), and location (keeping your work areas and personnel up-hill of the incident). In setting up work zones, ensure adequate room to work. It is easier to start off larger than needed and reduce the zones as necessary than to start off too small and have to pull back in a hurry and start over.

Three work zones, as represented in Figure 5.3, need to be set up for a hazardous material incident. These zones are:

- Hot zone
- Warm zone
- Cold zone

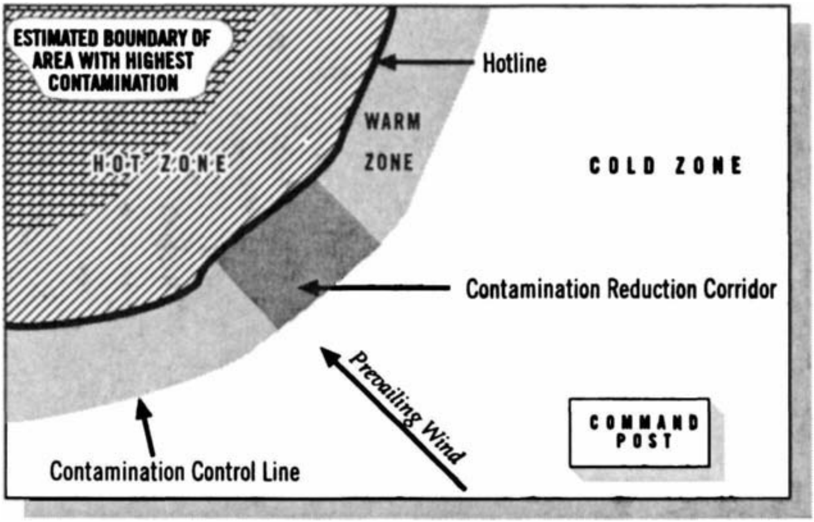

FIGURE 5.3. Work zones.

The hot zone, also referred to as the exclusionary zone, is the area where the incident is taking place. The size of this area will depend on the size of the release and what mitigation activities will occur. Only properly trained and equipped Hazmat personnel will work in this zone. The warm zone, an area encircling the hot zone, is also known as the decontamination or limited access zone. This is a buffer zone between the cold and the hot zones where decontamination will occur. Decontamination occurs in an area of the warm zone referred to as an access corridor. Only trained decontamination personnel and the safety officer can work in this zone.

Depending on the situation, the decon process can be as simple as using a pail of water with brushes, or an elaborate, multiple step process. The important concept is that decon is essential at each incident, and that the decon method employed must be appropriate and compatible with the materials involved.

The third work zone is the cold zone (also know as the support zone), which is the area for the command post and staging area. This zone must be secure and only response personnel and necessary advisors should be in this area.

5.3.5. Hazmat Tactical Action Plan

Once the initial size-up is complete and work zones in place, the IC then formulates a tactical action plan. This incorporates the information obtained during the size-up, any existing pre-plan, and any other information such as material safety data sheets (MSDS) information, manufacturer's information, or other reference materials on hand. This plan need not necessarily be written, but key actions taken should be documented.

The IC should consider the "what," "where," "when," and "who" in setting up an action plan. The "what" part deals with defining response objectives, determining the need to intervene in the situation, and evaluating the risk associated with that intervention (i.e., can the responders change the incident's outcome in a favorable way?).

"Where" deals with the location of all mitigation action such as decon set up, emergency exit routes, and staging areas.

The "when" element deals with the time frames: how much time there is before something needs to be done, and how long it will take to do.

The last element that forms the tactical plan is determining "who" will carry out the plan, including entry team, back-up team, decontamination team, and other support personnel. The action plan must address how many entry team people will be necessary to handle the problem. HAZWOPER states that a buddy system (entry and back-up teams with at least two people each) is necessary at hazardous material incidents. An equal number of people is advisable for the back-up team. The plan must also address the need for support personnel for decon, medical monitoring, and other areas.

5.3.6. Continual Reassessments

Once the action plan is complete, the IC must ensure that the responders are informed as to what they must do and how to do it, with the emphasis on safety. When all teams are briefed and ready, the IC can implement the plan. The IC must continually assess the plan's effectiveness and alter it if it does not work (again, briefing all involved before implementing the changes). Most importantly, a tactical plan rarely works without some modification. Therefore, the IC should never hesitate to reconsider tactics if necessary.

5.3.7. Termination

Once a hazardous material incident is under control, the IC can terminate the response and document the events. Documentation is important because it serves as a record of incident events and identifies the personnel involved. It also facilitates tracking any problems after the fact, such as medical concerns with response personnel, employees, and any environmental issues.

Only the IC can terminate an incident. This ensures that there will be an orderly dismissal of response personnel, makes collecting all documents and information regarding the incident easier, and allows the IC to debrief responders and any other involved personnel and to pass along any information regarding medical concerns or any other problems. Upon termination, the IC and other personnel must critique the response to determine what worked and did not work, and to determine if there is a need for any corrective actions. These records serve to meet certain regulatory requirements.

REFERENCES CITED

1. U.S. Department of Labor. 29 CFR Section 1910.120.
2. U.S. Department of Labor. 29 CFR Section 1910.156.
3. National Fire Protection Association. *Hazardous Materials Response Handbook*. Quincy, MA.

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10

TRAINING REQUIREMENTS

10.1. INTRODUCTION

If an emergency plan provides the framework for an emergency response program, then training is the foundation. Training translates analysis and planning into actual capabilities.

Each employee must know what their responsibilities are and how to execute them. This may range from actually shutting down process operations in a safe manner or calmly evacuating a building or area, to coordinating the activities of a highly trained fire-fighting or hazardous materials response team. Training requirements can be found in government regulations (OSHA, EPA, and DOT), and in industry standards or good practices such as those developed by the NFPA. This chapter describes emergency training identified in regulatory requirements and consensus standards, the primary emphasis of which pertains to safe and effective emergency response.

The best emergency training programs pay proper attention to adult learning techniques, are sensitive to challenges posed by language and literacy, and incorporate ample hands-on experience. Training should not be geared strictly to minimum hour requirements, but should strive for competency and demonstrated proficiency.

10.2. GENERAL REQUIREMENTS

Emergencies encompass fires, explosions, hazardous chemical releases, confined space rescues, and medical events. Training is essential to ensure that each employee is familiar with emergency procedures, with what is expected of them, and how they will work together as a team. Each employee's response will vary based on their job assignments and location at the time of the emergency. Training should be conducted at a level that is consistent with employee job functions and responsibilities. Training must be provided by competent individuals who are familiar with plant operations and emergency procedures. Attendance at training courses must be documented and used in a manner that ensures that those people requiring training will get their training and not "fall through the cracks." The training records should be easily retrievable for audits and inspections by regulatory agencies, as well as by internal management auditors. A management system is needed to verify effectiveness of training and to assure correction of any deficiencies found during drills.

10.2.1. OSHA Emergency Training Requirements

OSHA regulates emergency response training, as summarized in Table 10.1.

10.2.2. Basic Emergency Training

OSHA Standard 29 CFR 1910.38, "Employee Emergency Plans and Fire Prevention Plans" [6], covers training requirements for implementing an emergency plan. Emergency plan training should be given to personnel when the plan is initially developed, whenever the employee's responsibilities or designated actions under the plan change, and whenever the plan changes. At a minimum, personnel must know how they are to recognize hazards, the need to act, and what to do in accordance with the emergency plan. They need to know how to respond to plant emergency alarms.

TABLE 10.1
Pertinent OSHA Emergency Training Requirements

Regulation	*Subject*
29 CFR 1910.038 (a)	Emergency Action Planning
Appendix to Subpart E (Nonmandatory)-1	Evacuation Recommendations
29 CFR 1910.119	Process Safety Management
29 CFR 1910.120 (q)	HAZWOPER
29 CFR 1910.134 (e)(3), (f)	Respirator
29 CFR 1910.146	Confined Space
29 CFR 1910.156 (b),(c),(d)	Fire Brigade
29 CFR 1910.157	Fire Extinguishers
29 CFR 1910.158	Standpipe and Hose Systems
29 CFR 1910.159	Specify Fire Prevention Requirements under the Plan
29 CFR 1910.160 (b)	Fire System Safety
29 CFR 1910.164	Fire Detection Systems
29 CFR 1910.165 (b), (c), (d)	Employee Alarms

In addition to being familiar with the facility emergency plans, general personnel should also be familiar with the operation of portable fire extinguishers. Personnel who can quickly extinguish minor fires in the incipient stages without increasing their personal risk of injury can reduce or eliminate the risk of catastrophic events. OSHA Standard 29 CFR 1910.157 [17], "Portable Fire Extinguishers," requires initial and annual training for those personnel who may use these devices in their work area. The training must cover how to operate fire extinguishers and the hazards associated with incipient stage fire fighting. In facilities where additional fire-fighting equipment other than fire extinguishers is available, those personnel identified in the emergency plan as using the fire-fighting equipment should receive initial and refresher training.

Trained personnel are also required for inspecting, maintaining, operating, and repairing emergency response equipment. The following OSHA standards mandate the use of trained personnel for these activities:

- 29 CFR 1910.158 Standpipe and Hose Systems
- 29 CFR 1910.160 Fixed Extinguishing Systems, General
- 29 CFR 1910.164 Fire Detection Systems

10.2.2.1. Notification

The employer should explain to each employee the preferred means of reporting emergencies, such as telephone, public address systems, radio, or manual pull boxes. This requirement is found in OSHA's Employee Alarm Systems Standard (29 CFR 1910.165) [13]. Each employee should be familiar with the method designated to inform them of an emergency. This can occur through the use of sirens, warning bells, public address systems, telephones, or portable radios. If fixed extinguishing systems are present, personnel need to be aware of predischarge alarms to ensure that personnel have adequate time to evacuate the area. Posting notification instructions along with alarm signal descriptions throughout the plant is desirable.

10.2.2.2. Evacuation

Every employee must be trained on applicable evacuation procedures. A sufficient number of personnel should be identified and trained to assist in the safe and orderly emergency evacuation of personnel (e.g., evacuation captains). Training should be supplemented with site-specific evacuation drills to test the competence of the personnel in this area and provide a review of the procedures. A critique of the drill should be distributed to all involved personnel.

10.2.3. Operating Personnel

Operating personnel must be familiar with the emergency procedures associated with their specific operation. In an emergency, operating personnel may be called on to safely shut down a process, divert materials to a different vessel, or take other corrective measures to ensure the safety of people and property. OSHA Standard 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals" [7] was established to prevent or minimize the consequences of catastrophic releases of toxic, reactive, flammable, or explosive chemicals. This standard requires that operating personnel receive initial training on process-specific health and safety hazards, emergency operations, including shutdown, and safe work practices that apply to the employee's job assignments. Employers must provide refresher training to operating personnel every 3 years at a minimum, and more frequently as necessary.

10.2.3.1. Process-Specific Alarms and Notification

Notification of emergencies for operating personnel is similar to the notification requirements for general personnel discussed earlier, except that signals in the operating area may be more specific in location and type of emergency. Operating personnel must be familiar with the methods available to signal an emergency and how they will be informed of an emergency.

10.2.3.2. Shutdowns

Emergencies may necessitate shutting down equipment and processes as part of the emergency plan and prior to evacuation. Shutdown may result from an emergency affecting the immediate process or from emergencies occurring at other processes that are part of a larger system. Managers should establish operating procedures for the orderly and safe shutdown of process equipment, as well as immediate rapid shutdown procedures in life threatening situations. Operating personnel must be trained in these shutdown procedures to ensure an appropriate response to an emergency. The training should take the form of both classroom presentation and mock exercises that test personnel decision-making abilities and responsiveness under conditions that could be expected during an emergency.

Operating personnel must be aware of their roles and responsibilities during an evacuation. Operators need to know the criteria for determining whether to conduct an orderly shutdown and then to shelter in place, or evacuate. Similarly, they need to know the criteria for a rapid shutdown and shelter in place, or evacuate. PPE training is required to know proper protection if evacuation is required for either shutdown procedure.

10.3. EMERGENCY RESPONSE PERSONNEL

Emergency response personnel may be categorized into several areas based on their functions or their role within the plant. Responders who may require specialized training include:

- Fire-fighting personnel.
- Spill response personnel.

- Off-site contract and mutual aid responders.
- Emergency medical services/rescue personnel.
- Environmental/health/safety personnel.
- Specialist employees.
- Skilled support personnel.
- Media or public relations personnel.

10.3.1. General

Training for responders should begin with a program that describes the operations, processes, and raw materials used at the facility. Responders should be made aware of the hazards that are inherent to a process or operation as well as those hazards arising from an emergency. Process training should be given by a person who is familiar with the design and operation of the process or facility. Potential credible incidents and their affects, as developed in Chapters 3 and 4, should be used as a basis for the emergency training program. While some of this information may be transmitted through hazard communication standard training, responders will need to be trained to a greater level of detail. Initial responders may be required to make decisions concerning emergency response actions prior to the arrival of personnel with in-depth technical expertise on a given process or operation. For hazardous materials incidents, training at the first responder operations level is essential (discussed later in Section 10.3.3).

Emergency responders may find themselves threatened by exposures to chemical, physical, radiological, and biological hazards. OSHA has established standards to protect employees from harmful exposures that may result in illness, injury, or death.

10.3.1.1. Chemical Exposure

Chemical exposures are regulated by 29 CFR 1910.1000, "Air Contaminants" [14]. This standard establishes airborne concentrations of hazardous chemicals that may not be exceeded without the use of respiratory protection. Responders should be trained in these concentration limits, the use of respiratory protection, and air monitoring at hazardous materials incidents. Training requirements for respiratory protection are given in 29 CFR 1910.134 [9]. OSHA has also established chemical-specific standards for several hazardous materials listed in Subpart Z of 29 CFR 1910 that contain training requirements.

10.3.1.2. Confined Space Entry during Emergency

Physical hazards such as confined spaces are often encountered as part of an emergency response. Only trained and properly equipped responders may enter confined spaces that lack sufficient oxygen to sustain life or have concentrated chemical vapors that may be toxic or explosive. Training must be provided:

- Prior to assignment to confined space duties.
- Prior to any changes in confined space assignments.
- Whenever a change in confined space entry operations occurs that presents a hazard not covered in previous training.
- Whenever deviations from established confined space entry procedures occur. The emergency plan should state the emergency conditions in which this procedure need not be followed.

10.3.1.3. Rescue

Responder training should include recognizing a confined space, atmospheric hazards, physical hazards, and the employer's confined space entry program and procedures. Responders must be trained on appropriate rescue techniques and conduct simulated rescue exercises on an annual basis. Basic first-aid and CPR training is required for each member of the rescue team, and at least one member of the team must have current certification in first-aid and CPR. OSHA has established training requirements in 29 CFR 1910.146 "Permit Required Confined Space" [10].

10.3.1.4 Bloodborne Pathogens

Responders providing medical assistance to injured personnel may be exposed to biological hazards transmitted through blood. Bloodborne pathogens is the term used to describe pathogenic microorganisms present in human blood that cause disease in humans. Examples of bloodborne pathogens include hepatitis B (HBV) and human immunodeficiency virus (HIV). Responders must be trained at the time of initial assignment to a position that could result in such exposure, and annually thereafter. Additional training may be required in the event changes occur that affect a responder's exposure [15]. Training must include:

- An explanation of the bloodborne pathogen standard.
- Explanation of epidemiology and symptoms of bloodborne diseases.
- How bloodborne pathogens are transmitted.
- Explanation of employer's exposure control plan.
- Recognition of tasks that present a risk of exposure.
- How to prevent or reduce exposures through the use of engineering controls, work practices, and PPE.
- Selection, use, proper decontamination, and disposal of PPE.
- Information on the hepatitis B vaccine.
- Emergency procedures for incidents involving blood or other potential infectious agents.
- Reporting and follow-up procedures after an exposure incident.
- Explanation of appropriate warning labels, signs, etc.
- Emergency medical service personnel training:
  —ANSI/NFPA 473 contains specific requirements for EMS personnel responding to hazmat incidents.

Chapter 12 contains additional information regarding medical care and treatment that might be needed as a result of on-site emergency incidents.

10.3.1.5 Response Training Challenges

Hazard-specific response training is regulated under several different OSHA regulations. Hazardous materials response training is regulated under OSHA's HAZWOPER regulation (29 CFR 1910.120 q) [8], which requires providing certain levels of training. Fire fighting is governed under another OSHA standard (29 CFR 1910.156) [11]. Confined space rescue is governed by yet another OSHA regulation (29 CFR 1910.146) [10]. Medical emergency training is based on state requirements.

Aside from regulatory training requirements, responders must be continually trained on new equipment, response methodologies, and site hazards. Each hazard calls for using different types of equipment, and responders must be well trained and drilled in handling all the equipment. Because of the complexity of industrial technologies and of the regulations regarding emergency response, attention must be paid to management of the changes involved over even short periods of time.

10.3.2. Fire Brigade Training

OSHA Standard 29 CFR 1910.156 establishes requirements for fire brigades, industrial fire departments, and private or contractual fire departments. There are two levels of fire brigade recognized by OSHA: incipient fire brigades and interior structural fire brigades. Incipient fire brigades are trained to deal with the initial or beginning stage of a fire and can control such a fire using portable fire extinguishers, Class II standpipe, or small hose systems without the need for protective clothing or breathing apparatus. Interior structural fire brigades perform fire suppression activities or rescues in buildings involving fire beyond the incipient stage. OSHA requires that training be conducted frequently enough to ensure that fire brigade members can perform their functions in a safe manner, but annually at a minimum. For those members assigned to interior structural fire fighting, training should be conducted at least quarterly. The quality of the training must be similar to those well established fire training schools that are listed by OSHA in the Fire Brigade Standard. The training requirements of the OSHA standard are similar to NFPA 600 (Industrial Fire Brigades) [3], although the frequency and levels of training differ.

Among the first things that any fire fighter must learn are basic skills and knowledge, since without these, they will be unable to handle any fire situation. The basics deal with fire behavior and understanding the different energies that responders face. Examples are oxidation heat energy or the amount of heat generated by combustion, mechanical heat energy (frictional heat, friction sparks, and heat from compression), and electrical heat energy, including static, arcing, and resistance.

Responders must understand that fuels have various forms and physical properties that may require different tactics. Responders must understand how combustion occurs based on the fire tetrahedron. To extinguish fires, responders must be able to apply this knowledge so that the correct extinguishing agent will be used. (Please see Sections 10.3.3.1 and 10.3.3.2 on special training needed in the event of possible BLEVE or for chemical fires.)

Responders need to understand the phases of fire: incipient phase or starting point, the free burning phase where the fire begins to draw in oxygen, and the smoldering phase where the fire begins to smolder due to losing its air supply.

A dangerous backdraft situation can occur during or after the smoldering phase if ventilation is not performed properly. When improper ventilation occurs, the introduced air causes instantaneous combustion with explosive results.

Flashover, another serious fire fighting hazard, occurs when an excessive buildup of heat causes a simultaneous ignition of combustibles in an area.

Each fire fighting level carries a distinct set of training requirements. Incipient fire personnel need to be able to handle portable fire extinguishers and use 1-inch hose lines, and understand the four classes of fire (A, B, C, D) that each is appropriate for:

- Class A fires involve wood, paper, rubber, and plastic products.
- Class B fires involve flammable liquids, greases, and gases.
- Class C fires involve energized electrical equipment.
- Class D fires involve combustible metals.

Interior structural responders must learn the proper techniques in handling hose lines from 1½ inches to master stream devices and how to apply the fire streams to different situations. The more advanced fire-fighting units above incipient fire fighting need to train in areas such as ventilating, water supply, and other suppression systems. The use of self-contained breathing apparatus must be learned by each responder.

10.3.2.1. BLEVE

The acronym BLEVE stands for boiling liquid, expanding vapor explosion, which is a type of rapid phase transition in which a liquid contained above its atmospheric boiling point is rapidly depressurized, causing a nearly instantaneous transition from liquid to vapor with a corresponding energy release.

If a flammable or combustible liquid is contained in a vessel that fails in a BLEVE, a large fireball may result; however, it is not necessary for the liquid to be flammable or combustible to have a BLEVE occur.

In a BLEVE, the vessel catastrophically ruptures causing an explosion as the material in the vessel is rapidly released. The vessel may fail due to weakening of the vessel wall by flame impingement on the vapor space, failure at a seam or other weak point due to overpressure, or other failure scenario. As the vessel ruptures catastrophically, pressurized liquid is released and vaporizes instantaneously, rapidly mixing with air. If a flammable or combustible material is present and ignites, a large deflagration and/or fireball may occur as a large portion of the vessel contents may be released and combust in seconds. In the case of a common BLEVE scenario resulting from flame impingement on a vapor space, the ignition source for the fireball is present.

Such dangerous incidents have caused the deaths of emergency responders and others. The emergency responders' injuries and deaths were often due to the lack of knowledge and understanding of the physical dynamics that can occur for a vessel that BLEVEs. Responders first must learn to detect the type of situations that are subject to this type of incident. They need to understand the vessel construction and the stresses that are common with everyday use and those that may take place after the vessel has been exposed to outside energies such as fire or physical damage. Responders also need to understand the dynamics of the liquefied flammable products that are held in the pressurized vessel, including the physical characteristics of the product. Some examples are boiling point, vapor density, and flash point.

Responders need to recognize the signals and indicators associated with making a proper decision whether to respond to the incident or to withdraw to a safe area (i.e., fight or flight). A number of indicators can be used to help responders decide this; however, they are not always apparent. Several indicators that might indicate the need for responders to retreat include:

- Is there an increase in flame around the vessel or direct flame impingement in the vapor space? This condition should indicate that there may be imminent failure of the vessel since the fire is causing the product to boil allowing greater pressures to build up inside the vessel.
- Is there an increase in flame from the relief valve, which usually means pressure is building up?
- Has the smoke color changed, indicating that the situation is deteriorating further?
- Is there an increase in noise levels from the relief system? This can also be an indicator that pressure is increasing.
- Is noise coming from the vessel, such as popping or groaning sounds, that indicate stresses on the vessel?
- Has the tank itself shown any discoloration that may indicate a drop in product level or metal fatigue?

The responders need to be trained in what steps can be taken in controlling or preventing a BLEVE from occurring. One method of response is the rapid, massive cooling of the vessel. Another objective concerns eliminating the heat source from the area near the vessel, which is different from the tactic of cooling the vessel and is a separate action. An example is an aggressive foam attack on a spill fire to reduce the heat input to the vessel. Responders need to be trained to assess the adequacy of water supply necessary for use in both the vessel cooling and eliminating the heat source. They also need to be able to assess whether master stream devices can be put in service fast enough and to determine how long the flow rate will last without being interrupted.

Responders must understand the characteristics of a BLEVE to protect themselves and the public. They need to understand that the vessel failure can result in splitting, flattening, shattering, and rocketing pieces. If a flammable liquid is released, a ground flash can occur, which may be followed by a fireball that fans outward and upward. A BLEVE's severe thermal radiation can travel over hundreds of feet in all directions, and pieces of the vessel may be propelled outward up to ½ mile [1].

The final training requirement is to reinforce the idea that should responders encounter a potential BLEVE condition, then the best response option might be to pull back to a safe distance for their protection and allow the incident to continue.

10.3.2.2. Procedures for Chemical Fires

Training for fighting chemical fires requires supplemental training beyond normal fire-fighting operations. Hazardous material training becomes an important part of training for the fire fighters due to the intermixing of both hazards. The tactics change to meet the needs of the situation.

Basic chemistry becomes a vital part of understanding what is taking place with the products involved and how they will behave during fire situations. Examples include:

- Do the products float or sink when in contact with water?
- Will water react with the chemicals involved?
- What are the vapor pressures and boiling points of the products?
- Is the higher heat release potential of burning hydrocarbons present?

The physical characteristics of the chemicals become important to the responders to understand what is needed to control the fire. Other training information will deal with understanding the proper extinguishing media if water will not handle the problem, what extinguishing agent will work, and how. Can foam be used to smother the fire and stop vapor production? Can a combination of agents be used to handle the problem and will these agents be compatible with each other and the chemicals involved? What about the use of a water curtain or fog? Responders will need to be trained in containment procedures such as diking and berming.

Other issues the responders need to be trained in are the environmental concerns. Will the fire situation affect ground contamination or potable water supplies in the area. Will smoke affect on-site personnel and/or off-site communities?

10.3.3. Hazardous Materials Response Training

Responders to hazardous materials incidents risk injury, illness, or even death from exposure to toxic chemicals, biological agents, and physical hazards. Training can provide responders with the skills and knowledge necessary to recognize hazardous conditions, evaluate risk to personnel and the public, and implement control measures to reduce the risk to people, property, and the environment. The purpose of the training requirement is to give personnel the knowledge and skill to perform emergency response with a minimal risk to their health and safety, and the health and safety of others. The risks and level of exposure will vary with each response.

OSHA outlines training requirements for emergency response personnel who respond to an emergency based on NFPA 472. NFPA 472, "Professional Competence of Responders to Hazardous Materials Incidents" [2], provides guidance as to what information and skills a responder should have. Planners should recognize that NFPA codes are regularly updated.

OSHA HAZWOPER regulations (29 CFR 1910.120) require up to five levels of emergency response personnel, each with its own training and level of competence requirements:

- First responder awareness level.
- First responder operations level.
- Hazardous materials technician.
- Hazardous materials specialist.
- On-scene incident commander.

There are no minimum training time requirements at the first responder awareness level. OSHA does specify a minimum training time requirement of 8 hours for the operations level and at least 24 hours for hazmat technicians, hazmat specialists, and on-scene incident commanders. Personnel who are subject to the OSHA emergency response training requirements, including managers and supervisors, must receive annual refresher training. Employers can satisfy the annual refresher training requirement in many ways. Emergency response exercises may contribute toward meeting the annual refresher training requirements. Attendance at seminars emphasizing hands-on activities and critique of actual responses also are acceptable methods of satisfying the annual refresher training requirement.

First Responder Awareness Level. First responder awareness level responders are persons who are likely to witness or discover a hazardous substance release and to initiate an emergency response sequence by notifying the proper authorities. A security guard or police officer is an example of an awareness level responder. Awareness level responders are required to:

- Understand what hazardous materials are.
- Understand potential outcomes of emergencies involving hazardous materials.
- Recognize the presence of hazardous materials.
- Identify hazardous materials.
- Understand the role of the first responder at the awareness level.
- Recognize the need for additional resources.

- Restrict access to the emergency scene to authorized personnel and evacuate if necessary. The incident command system (ICS) should be implemented at this stage.

OSHA also states that awareness level responders should be familiar with the areas of safety, resources and planning, incident management, recognition of hazardous materials, classification, identification, and verification of hazardous materials, and hazard and risk assessment as they apply to their assignments.

First Responder Operational Level. First responder operational level responders are a part of the initial response to a release or potential release of hazardous substances. Their function is to mitigate the effects of a release without actually trying to stop the release. Operational level responders must have training and/or sufficient experience to demonstrate competency in:

- Basic hazard and risk assessment techniques.
- Selection and use of PPE.
- Basic hazardous materials terms.
- Basic control, containment, and/or confinement operations.
- Basic decontamination procedures.
- Expansion of the ICS.

Operational level responders should be familiar with the areas of safety, resources and planning, incident management, recognition of hazardous materials, classification, identification, and verification of hazardous materials, chemistry of hazardous materials, PPE, hazardous materials control, decontamination, and termination procedures as they apply to their assignments.

Hazardous Materials Technician. Hazardous materials technician (hazmat technician) responders may attempt to stop a release. Based on NFPA guidance and OSHA requirements, hazmat technician training is at least 24 hours in duration and sufficient to demonstrate competency in:

- Development of site safety plans.
- Implementing the employer's emergency action plan.
- Classifying, identifying, and verifying materials.
- Functioning within an assigned role in the ICS.
- Selecting and using specialized chemical PPE at Level A or Level B.
- Understanding hazard and risk assessment techniques.
- Implementing advanced control, containment, and/or confinement operations.
- Implementing decontamination procedures.
- Understanding termination procedures.
- Understanding basic chemical, biological, and radiological terminology and behavior.

The NFPA also states that hazmat technicians should be familiar with the areas of safety, resources and planning, incident management, recognition of hazardous materials, classification, identification, and verification of hazardous materials, chemistry of hazardous materials, hazard and risk assessment, PPE, hazardous materials control, decontamination, and termination procedures as they apply to their assignments.

Hazardous Materials Specialist. Hazardous materials specialist (hazmat specialist) responders respond with and provide support for hazmat technicians. Hazmat specialists must have more specific knowledge of substances than do hazmat technicians. Hazmat specialists may act as site liaison with government authorities concerning site activities. Hazmat specialists must have 24 hours of training—including first responder and hazmat technician training material—and sufficient experience to demonstrate competency in the following areas:

- Development of site safety plans.
- Classification, identification, and verification of materials.
- Functioning within an assigned role in the ICS.
- Selecting and using specialized chemical PPE to Level A.
- In-depth hazard and risk management techniques.
- Specialized control, containment, and/or confinement operations.
- Determination and implementation of decontamination procedures.
- Development and implementation of specialized decontamination procedures.
- Implementation of termination procedures.
- Chemical, radiological, biological, and toxicological terminology and behavior.

Hazmat specialists should be familiar with the areas of safety from the Hazmat team; resources and planning; incident management; classification, identification, and verification of hazardous materials; chemistry of hazardous materials; hazard and risk assessment; PPE; hazardous materials control; decontamination; and termination procedures as they apply to their plant site.

On-Scene Incident Commander. The on-scene incident commander (IC) assumes control of the emergency response incident scene. ICs coordinate the activities of all emergency responders and the communications between them. An IC should be a person with broad knowledge in managing emergency incidents. At a minimum, ICs must attend first responder operations level training, attend refresher training, and demonstrate additional competency in the following areas:

- Direction and coordination of all response activities;
- Implementation of an integrated emergency response plan;
- Notification and utilization of off-site resources;
- Directing resources in completion of the tasks;

- Providing management and technical oversight as well as logistical support;
- Coordinating transfer of information to the media and elected officials;
- Providing subsequent documentation on the incident;
- Providing guidance concerning state, local, and federal reporting requirements;
- Providing a critique of the incident and the response.

10.3.3.1. Understanding Hazard Symbols (NFPA 704)

NFPA 704 "Identification of the Fire Hazards of Materials" [4] was developed to protect personnel concerned with fires occurring in industrial locations or storage areas when the hazards of the material involved in a fire are not readily identified. This system provides information to emergency responders that can be used to determine whether evacuation is necessary or containment/control procedures can be implemented. The NFPA system uses health, flammability, and reactivity as categories for identifying the hazards of a material. Each category is assigned a number from zero to four. The number indicates the degree of severity of the hazard, with zero being no significant hazard and four indicating severe or extreme hazard. The symbol comprising the three hazard categories is a diamond made up of four smaller diamonds (see Figure 10.1). Each square is assigned a color and position using the following format:

- Blue (health hazard) found in the nine o'clock position.
- Red (flammability) found in the twelve o'clock position.
- Yellow (reactivity) found in the three o'clock position.

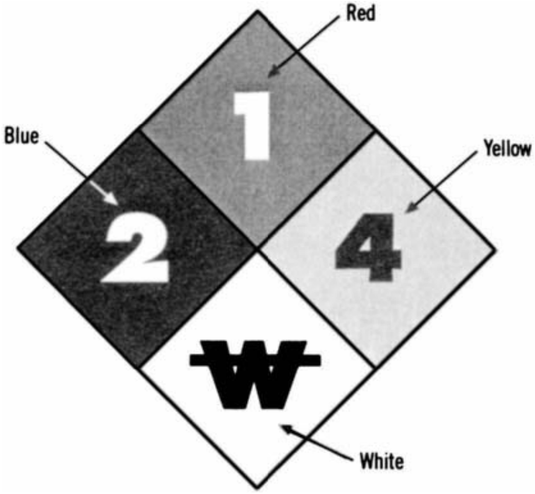
The fourth diamond is used for identifying any special hazards or requirements associated with the material. This special hazard area is located in the six o'clock position and has a white background.

Some facilities use the National Paint and Coatings Association's Hazardous Material Identification System (HMIS), which is very similar to the NFPA 704 System. HMIS provides a different format, provides information regarding PPE, provides health ratings based on normal industrial exposure (nonemergency conditions), and identifies chronic health hazards.

10.3.3.2. Foam Application

Chapter 7 discusses the technical aspects of emergency foam use, while this section discusses training needs. Responders need to understand that foam is effective in both vapor suppression of spills to prevent a fire or toxic hazard and in extinguishing a fire involving most all combustible and flammable liquids. Keys to success using foam include:

- Understanding the uses of foam and the need to use a foam concentrate that is rated for the specific type of fuel (i.e., hydrocarbon or polar solvent).
- Understanding proper operation of proportioning equipment and systems.



Color Code			
	BLUE	**Health Hazard (0 - 4)**	
	RED	**Flammability Hazard (0 - 4)**	
	YELLOW	**Reactivity Hazard (0 - 4)**	
	WHITE	**Special Hazards**	
		W	**Unusual Reactivity with Water**
		OX	**Oxidizing Properties**

FIGURE 10.1. Example of NFPA 704 hazard symbol.

- Understanding proper application techniques when applying foam manually that minimize lobbing or plunging the foam into the fuel.
- Understanding the concept of application densities and rates so that adequate foam will be applied to obtain the desired securement/extinguishment of the spill.

Although foam is effective in suppressing vapor, excluding air, and cooling, it must be recognized that it may not completely suppress vapors when used on products with high vapor pressures. It will, however, in these cases generally reduce the intensity of the fire/vapor production.

Responders should be familiar with the design, operation, and limitations of the foam proportioning equipment and systems in the plant. Fluroprotein foams generally require the use of air-aspirating foam nozzles for best performance. These nozzles, by increasing the expansion, produce a thicker foam with longer drain time; however, range and pattern variability are limited. AFFF foams do not require air-aspirating nozzles and can be applied using standard water fog nozzles with the resulting greater range and pattern variability. Additionally, AFFFs are approved for discharge through many standard-type water spray heads in deluge/sprinkler systems. Self-educting foam nozzle, in-line eductors, balanced pressure systems, bladder tank systems, subsurface systems using high back pressure foam eductors, and fixed water/foam systems should be included in the training program if present on-site.

Application techniques are an essential element of the training program to ensure that the foam is applied as gently as possible to the fuel surface. Lobbing foam exposes the foam longer to the thermal updraft of the fire, which results in increased destruction of the foam from dehydration and carryoff. Plunging the foam into the fuel destroys foam and agitates the fuel increasing vaporization. Foam should be applied by banking the foam steam off a fixed object in the fire area such as a dike wall, vessel support or skirt, or back wall of a tank and letting the foam flow onto the fuel surface. Although live fire training with foam is sometimes viewed as expensive, it is strongly encouraged to ensure that response personnel have the necessary skills to effectively and safely use the agent for maximum benefit in a real emergency.

If special foam concentrates designed for use on specific hazardous material products are provided, training should be provided. These hazmat foams may have specific limitations and require specialized proportioning equipment.

10.4. SUPPORT PERSONNEL

In-plant emergencies will generally involve other personnel who are not directly engaged in assessing or controlling an emergency, but are trained for technical, medical, logistical, and public relations support to emergency responders. Additionally, support personnel should have sufficient training to ensure that they do not put themselves or others at risk. This training will be function-specific in most cases, although general training on topics such as the plant evacuation and emergency plans must be provided to all personnel.

10.4.1. Media and Community Relations

Many companies increasingly train senior managers to deal with the media because they recognize the importance of conveying accurate information to the public and maintaining credibility in the community. There are countless examples of organizations not addressing media needs adequately, which contributed to inaccurate reporting. A plant that responds well to an incident and communicates this to the media effectively is far better off than a plant who may respond well, but does not communicate this fact well.

Training should cover:

- Simulated crisis communications exercises.
- Analysis in advance of likely questions and responses.

- The Do's and Don'ts of dealing with the media (please refer to Chapter 12, Table 12.1).

Plants should provide a media briefing center. Members of the media who are permitted to enter the plant during or after an emergency must receive training on plant hazard communication, PPE requirements, basic plant safety rules, and the emergency plan. Media personnel should sign a release of liability stating that they fully understand the information that has been covered and will abide by all safety rules that apply to the plant. Members of the media should be escorted by a plant representative who is fully trained and can assist the media in the event of an evacuation (see Chapter 8, Section 8.6.4).

10.4.2. Medical

In-plant emergencies may require the assistance of medical personnel. Medical personnel often include physicians, nurses, emergency medical technicians, paramedics, or advanced first aid personnel. All medical personnel must be trained in accordance with OSHA's Bloodborne Pathogen Standard. If the plan requires the medical personnel to enter exclusion zones or areas of contamination, they must first complete training and show competency at the level of first responder operational level. In cases where medical personnel do not have first responder operational level training, personnel in need of medical attention must be decontaminated and removed from the hot (exclusion) zone prior to medical attention being rendered. This will ensure that medical personnel are not being put at risk from exposure to chemical, physical, or biological hazards.

10.4.3. Specialist Employees

Members of the plant environmental staff, industrial hygienists, and engineering and operations staff are often required to provide technical advice and assistance. Their usual role is to evaluate the potential for impact on the environment and the community, provide information about the hazards, and make recommendations for mitigation of the hazards. In this case, these specialist employees will not generally be required to enter an exclusion zone. If specialist employees are required to enter an exclusion zone, they must first complete training and demonstrate competency based on the duties required. Specialist employees should receive the training provided to the general work force (such as hazard communication and emergency plans) at a minimum. Depending on their assignment under the emergency plan, specialist employees may also need training in using atmospheric monitoring instruments for use in fence line or neighborhood monitoring or dispersion modeling training.

10.4.4. Security

Security personnel who are likely to witness or discover a hazardous substance release, and to initiate an emergency response, must be trained to the first responder awareness level at a minimum. Security personnel may not enter exclusion zones or areas of contamination without first completing training and showing competency at the level of first responder operational level. Security personnel trained to provide first aid and CPR must be trained in accordance with OSHA's Bloodborne Pathogens standard. Security personnel must be trained and show competence in the area of implementing the emergency response plan. Plant security many times will be the first to be notified in the event an emergency occurs, and must follow procedures established for notification of the emergency response team and support personnel. In addition to periodic refresher training, the competence of security personnel to implement the emergency response plan should be tested through the use of field exercises and written examinations.

10.4.5. Skilled Support Personnel

Skilled support personnel are individuals who may be required to support the hazmat team in conducting response operations. For example, a heavy equipment operator might be needed to build an emergency ditch under certain circumstances. In this case, the incident commander or safety officer will need to brief the person on the hazards to be encountered, PPE, and how to protect themselves while assisting the hazmat team.

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13. OSHA Standard 29 CFR 1910.165, "Employee Alarm Systems."
14. OSHA Standard 29 CFR 1910.1000, "Air Contaminants."
15. OSHA Standard 29 CFR 1910.1030, "Bloodborne Pathogens."

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14

CLEANUP OF FACILITIES

14.1. INTRODUCTION

This chapter discusses considerations for cleaning facilities and equipment that were contaminated during an incident. Following an incident in which hazardous materials are released into the plant or into the environment, an important factor that should guide recovery and decontamination is time. If too much time lapses, ultimate cleanup cost might increase, if, for example, a hazardous material migrates further into the ground. Additionally, prompt attention should be given to cleanup of emergency response equipment that may have been contaminated during the response operation.

Based on potential consequence analysis (discussed in Chapter 3), facility and corporate management should estimate the scope of prevention and decontamination efforts necessary while conducting facility preplanning. Since this chapter discusses contamination that may travel beyond the boundaries of the facility, planning for response and cleanup of such off-site releases should be coordinated with appropriate regulatory agencies.

14.2. TYPES AND FORMS OF CONTAMINATION

Depending on the facility, several types and forms of contamination may be present following an incident. Preplanning and consequence analysis discussed earlier in this book can determine the types of contaminants and the forms of contamination that may be present following an incident. This information should provide estimates of the potential levels and extent of contamination on and off site. This information is useful in determining the resources necessary to provide a rapid response and recovery following an incident.

Table 14.1 illustrates some of the potential types and forms of contamination that may be present following an incident. Aside from the chemical involved, fire extinguishing agents might also pose a contamination problem. Each type and form of contamination possess unique characteristics and cleanup problems.

Other materials that ought to be removed after an emergency incident include any dead vegetation and building or equipment debris. Prompt removal of such materials has a beneficial impact on employee moral, community relations, and general image.

14.2.1. Chemical Contamination

During a major incident, chemicals can be released as a gas (or mist), liquid, or as a solid (or particulate). The physical form or state of the chemical and the method of release will determine the extent of contamination within the plant and in the environment. Key physical factors influencing the spread of material include solubility in water, freezing point, and vapor pressure. The hazard of a chemical release is related to the size of the release, the acute and chronic toxicity to humans, the toxicity to other biologic life forms (e.g., fish), and flammability or reactive considerations.

Many facilities and laboratories use radioactive nuclides for various purposes including antistatic devices, analytical instrumentation for level detection and density testing, or as part of other instruments. Additional information regarding radioactive contaminants is presented later in this chapter.

Older facilities may have asbestos insulation on piping or asbestos-containing construction materials. The asbestos fibers can be freed during an incident such as a fire or explosion and released as a particulate contaminant.

Good ventilation may readily dissipate a gas or vapor cloud released within a building; however, the gas or vapor may fill an entire room or compartment before dissipating. If this circumstance occurs, literally every surface within the room or

TABLE 14.1
Typical Types and Forms of Contaminants

	Potential Form of Contaminant		
Type of Contaminant	*Gas or Vapor or Mist*	*Liquid*	*Solid or Particulate*
Chemical	✔	✔	✔
Radioactive Material	✔	✔	✔
Pesticide		✔	✔
Heavy Metals		✔	✔
PCB		✔	
Asbestos			✔

compartment may be contaminated; however, the contamination will likely only be on the surface including the inside surfaces of ventilation systems. Depending on the configuration of the plant's ventilation system, contamination may be spread to other areas or to the environment. The extent and level of contamination depends on the duration of contact and other factors such as concentration, temperature, and how the contaminant reacts with the various materials contacted.

When released external to a building, a positively or neutrally buoyant gas or vapor cloud may dissipate rapidly with distance and may not deposit significant quantities of contaminants except near the point of release; however, a heavy gas or aerosol mist is more likely to be negatively buoyant and to remain in contact with the ground and may dissipate less rapidly. Hazardous materials released in association with a major fire may rise initially, leaving little or no contamination near the point of release. The plume may return to ground level at a distance from the point of release and deposit contamination. The facility management can use dispersion modeling systems to determine the extent of potential contamination under various release conditions. The plume footprint provides a good estimate of the area that may be affected by contamination (see Chapter 9).

Hazardous materials released as a liquid typically do not contaminate an area in the same manner as a gas or vapor. Liquids are more potent and problematic. Liquids can penetrate the cracks in a concrete floor, splash onto equipment and other surfaces, soak into soil or insulation, enter surface water bodies, or enter floor drains and sewers. Hazardous materials released as liquids may spread contamination to unexpected and remote locations. The hazardous material can penetrate into absorbent or porous materials such as insulation, drywall, concrete, painted surfaces, and soil. A liquid release entering a floor drain or sewer manhole can be carried to plant or public treatment facilities that may not be capable of removing or processing the contaminant. Potential issues include flammability and reactive hazards.

When released as a mist, the hazardous material can penetrate into absorbent or porous materials such as insulation, drywall, concrete, painted surfaces, and soil. Because of the relatively higher concentrations and duration of contact, liquids and mists will typically cause contamination at much higher levels than gases and vapors. Time is of much more concern with liquids because the contamination is inherently mobile following deposition and remains mobile for an indefinite period. Contamination that contacts soil may eventually reach ground water, and create an even more significant cleanup problem.

The accident at Dunsmuir, California in July 1991 demonstrates, in an extreme sense, the potential environmental damage waterborne contaminants can cause. A rail accident north of Dunsmuir released more than 10,000 gallons of a herbicide from a rail car into the Sacramento River. The water-soluble chemical killed fish and insect life along an almost 50-mile stretch of the river and some of the life in Lake Shasta. To illustrate the potential magnitude of this spill, the water supply for a large portion of northern California and the northern San Francisco bay area was at risk.

Hazardous materials may also be released as solids and particulates. The extent of contamination from solid materials is typically less significant than other forms, although the localized levels of contamination may be orders of magnitudes higher than either liquids or gases. Generally, the highest level of contamination will be closest to the point of release. Unlike deposition caused by mist, vapor or gases, most of the contamination associated with dust or particulates will deposit on horizontal surfaces. This form of contamination is easily disturbed and can be spread by physical contact, rain, wind, and the ventilation system. This form of contamination, in most cases, is also the easiest to remove.

14.2.2. Radioactive Contamination

Incidents involving radioactive materials present planners with a unique problem. Generally, the public has a higher concern for radioactive material releases than for chemical or other types of releases. This perceived higher risk exists and the public may demand that the planner go further to mitigate and clean up this type of release than would be expected for a chemical release with a similar level of risk (probability and consequence combined).

When radioactive substances are present, radioactive contamination may be possible. Important considerations include: are there radioactive sources nearby, where are they now, how can they be detected, and how to clean them up? A log of sources should be reviewed and checked after an event occurs where radioactive sources may have been damaged.

Except at nuclear power plants, hospitals, and major research facilities, radioactive materials are usually present only as sealed sources. A sealed source is a device that contains radioactivity, but the radioactivity is fixed in place inside the container. The radioactive material is usually incapable of being dispersed unless the container holding it is damaged under severe conditions. Radiography sources, instruments, check sources, and other sources found in the industrial setting are typically sealed sources. Unsealed sources are more fragile and more easily dispersed under conditions that may be present during low-grade incidents.

The planner must consider both sealed and unsealed sources when planning for decontamination. Special monitoring equipment must be obtained to detect and locate the radioactive contamination. Information regarding the type of radiation emitted is necessary to determine the appropriate response and cleanup methods.

When considering the cleanup options, the planner must consider worker safety and disposal regulations. Any facility having a source will have a designated radiation safety officer who should be consulted before cleanup. The radiation safety officer must have a record of all radioactive sources on the site detailing location, quantity, etc. For radioactive materials regulated under the Atomic Energy Act, the Nuclear Regulatory Commission (NRC) enforces regulations for worker exposure, transportation, and disposal. For radioactive sources not regulated by the NRC, such as radium, the U.S. EPA has prepared similar regulations concerning exposure, transportation, and disposal. The planner should consider the potential for worker exposure during the recovery and cleanup process.

14.3. PREVENTING THE SPREAD OF CONTAMINATION

Preventing the spread of contamination following an incident is just as important as preventing the contamination (incident) in the first place. Cleanup of hazardous waste or materials that will become hazardous wastes is regulated under the OSHA HAZWOPER (29 CFR 1910.120 q 11) program. Many of these prevention features should be considered in the initial design of the system.

Some common engineering and administrative methods used to prevent the spread of contamination within the plant are to:

- Install a high efficiency particulate filter on ventilation exhausts to remove particulates.
- Block ventilation dampers to shut off supply and exhaust ducting.
- Divert contaminated effluent or runoff to a holding tank or pond.
- Close floor and dike drains to prevent contaminants from entering drain system.
- Add sufficient secondary containment ponds with adequate capacity for the quantity of material being stored.
- Consider sealing concrete surfaces in the clean areas adjacent to the contaminated area with an impermeable coating such as epoxy to prevent contaminants from migrating into and through the concrete.
- Conduct a smoke survey of process, sanitary, and storm sewer systems to ensure all entrances and exits are identified.
- Consider weather effects on contaminant emissions.
- Install temporary detection equipment on new containment area.

14.4. DECONTAMINATION METHODS

Before entering the contaminated area to perform cleanup, appropriate work areas must be prepared. These areas are the same as those used during the emergency response phase and include the hot zone, warm zone, and cold zone.

The hot zone is the area being decontaminated. Only trained personnel wearing the required level of personal protective equipment and clothing should be allowed entry to the hot zone. A control or check point must be established and entry or exit strictly regulated. The size of this control corridor depends on the number of stations in the personnel decontamination procedure, general dimensions of work control zones, and amount of space available at the site. The warm zone is the area immediately surrounding the exclusion zone and provides a buffer between clean areas and the exclusion zone. If heavy equipment is needed in the exclusion zone, an additional entry point may be required to allow access of the equipment.

The cold zone is outside the contamination reduction zone. This clean, noncontaminated area serves as the command post and staging area for personnel and equipment. Strict access control must be maintained in the support zone as well. No samples, individuals, or equipment should leave the support zone without the approval of the safety officer.

14.4.1. Small-Scale Decontamination

Small-scale decontamination of facilities and equipment can generally be accomplished using ordinary cleaning and decontamination methods. Such methods include mops, brooms, soap and water, sponges, vacuum cleaners, etc. In some cases, specific decontamination solutions may be prepared to deal with contaminants possessing special qualities. As an example, water might not be appropriate to clean up water-reactive chemicals; however, it may be advantageous to use water to clean up chemicals that dissolve readily in water. Buckets, garden sprayers, scrub brushes, and sponges are commonly used to perform many small-scale decontamination activities. A child's wading pool, a stock tank, or an oversized galvanized wash tub can serve as a containment device for scrubbing, washing, and rinsing portable items such as hand tools, monitoring equipment, and SCBA. Bulldozers, trucks, fire apparatus, backhoes, and other heavy equipment can be difficult to decontaminate. The method generally used is to wash them with water or steam under high pressure and/or to scrub accessible parts with detergent–water solution.

Some characteristics of good decontamination solutions include:

1. The solution reacts with the contaminant to produce less harmful or harmless reaction products,
2. The contaminant dissolves in the solution, thereby removing the contaminant from the surface,
3. The solution neutralizes or renders harmless the contaminant, or
4. The solution possesses a combination of the above.

The decontaminating solution must also be compatible with the items being decontaminated. Frequently, more than one decontaminating solution is necessary to ensure complete decontamination.

14.4.2. Large-Scale Decontamination of Facilities

Large-scale decontamination is a two-phase operation. The first phase will remove or reduce the gross levels of contamination over large areas. This phase may consist of manually removing debris, scraping surfaces with a road grader, washing down floors with a fire hose, or using a vacuum sweeper to collect particulates. A round of sampling will be conducted after this gross decontamination to determine the next step. Typically, the second phase consists of localized small-scale decontamination as described earlier. In either case, provisions must be made to collect runoff and to dispose of debris and hazardous materials. Table 14.2 lists some decontamination methods for large-scale operations.

14.5. CONTRACTOR QUALIFICATIONS FOR CLEANUP

In many cases, cleanup after a large-scale incident with widespread contamination will entail the use of outside contractor support.

When seeking help from a contractor for cleanup operations, key qualifications to look for include:

- Knowledge/skills in the technologies needed for cleanup
- Appropriate equipment
- Adequate trained personnel, documentation of training of employees to be involved

TABLE 14.2
Large-Scale Decontamination Methods

Method	*Comments*
Water washing	Water must be collected and processed. Not good around electrical equipment or insulation. Ideal for paved areas, roofs, metal surfaces, and external walls. Should not be used on porous surfaces.
Vacuum	Exhaust from vacuum must be filtered. Applicable to open areas. As efficient as water washing for paved areas. Effective for porous and nonporous surfaces. Vacuum removes materials with little excess spillage.
Neutralization	Care should be taken to avoid uncontrolled reactions.
Absorption/ adsorption	Creates a disposal issue. Potential for reaction problems, if materials are incompatible.
Grading, scraping	Creates large quantities of material requiring disposal. Removes uncontaminated materials as well as contaminated materials. May create an airborne dust hazard.
Steam cleaning	Very effective for most nonporous surfaces and contaminants. Runoff must be collected for disposal.
CO_2 pellet blasting	Very effective for most nonporous surfaces and contaminants.
High pressure washing	Very effective for most nonporous surfaces and contaminants. Runoff must be collected for disposal.
Sand blasting/ abrasive	Effective for nonporous surfaces. Sand used becomes contaminated and requires disposal.

- Enforced safety and health policies to protect their employees
- Safety history—LTIs, OSHA violations
- Complete familiarity with and observance of the environmental regulations involved
- Financial responsibility

14.6. DETERMINING THE EFFECTIVENESS

Following each decontamination phase, samples are collected to verify the effectiveness. This sampling may be accomplished by swipe or wipe testing, collected of soil samples, collection of water samples, screening areas and equipment with survey meters, and visual inspection. Because decontamination is expensive and time consuming, decontamination efforts should include field monitoring and visual inspection as part of the criteria for ending the decontamination phase. In many instances, monitoring instruments can guide decontamination efforts by qualitatively identifying the extent of contamination. When the decontamination is complete, sampling activities will be continued to provide quantitative evidence that the cleanup was successful. Table 14.3 shows some of the various methods available to verify the effectiveness of cleanup and their limitations.

TABLE 14.3
Methods to Determine the Effectiveness of Cleanup Activities

Method	*Application*	*Results*	*Comments*
Soil samples	Chemical, radioactive, asbestos	Quantitative	Long lead time for results
Water sample	Chemical, radioactive	Quantitative	Long lead time for results
Swipe sample	Chemical, radioactive, asbestos	Quantitative	Long lead time for results
Organic vapor analyzer	Organic vapors	Quantitative	Immediate results, limited selectivity
Geiger mueller detector	Radiation (beta and gamma)	Quantitative	Immediate results
Colormetric	Chemical	Semiquantitative	Immediate results
Direct reading	Chemical	Semiquantitative	Immediate results
Scintillation detectors	Radiation (alpha and gamma)	Quantitative and quantitative	

Other field instruments and tools are available to test for various chemicals and characteristics such as pH. This equipment provides qualitative and semiquantitative results.

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PART B

PREPAREDNESS

3

IDENTIFICATION OF CREDIBLE INCIDENTS

3.1. INTRODUCTION

After prevention and mitigation measures are in place to prevent an emergency from developing, facilities must prepare for emergencies that may still occur due to unforeseen circumstances or a failure of prevention, mitigation, or management systems. The first step in the preparedness phase is to identify credible incidents. This step answers the question, "what potential incidents that could result in an emergency should we prepare for?" Identifying credible incidents is also an integral part of process hazard analysis, one of the twelve CCPS elements of chemical process safety management discussed in Chapter 1. Facilities that properly conduct a process hazard analysis may find a large number of potential incident scenarios. Where these incident scenarios have been developed, they may have been evaluated to prioritize the addition of safety features to significantly reduce risk. For emergency planning, the prioritization and selection of scenarios may differ due to a more focused interest in incidents that warrant emergency response.

In addition to identifying credible incidents, emergency planners should define the type and magnitude of consequences of selected incidents and determine which scenarios are most useful in emergency response planning. This chapter will:

- Define what constitutes a worst-case incident scenario;
- Discuss screening techniques for focusing on plant areas having the highest hazards in larger, more complex facilities;
- Describe the methods available to identify credible incidents;
- Describe criteria for selecting those incidents that are most useful in emergency planning; and
- Describe methods for assessing the consequences of these incidents.

3.2. DEFINING CREDIBLE INCIDENTS

Chemical process emergencies rarely involve a single event. Most often there are contributing causes and intermediate events, including the response of engineered safety features and human intervention. It is generally recognized that it is impossible to identify all possible causes, intermediate events and final consequences of potential incident scenarios. If all such factors were considered in complex process facilities, the number of potential incident scenarios resulting in the release of toxic and flammable chemicals, fire, and/or explosion would be too numerous to be useful in prevention and planning. The approach typically taken in process hazard analysis is to identify those scenarios that are considered most plausible. A typical scenario can represent a spectrum of outcomes, depending on the degree of failure and the range of possible intermediate detection and response events.

For example, consider a pump seal leak. This can range from a very small leak that immediately vaporizes to a leak of several gallons per minute of liquid that accumulates in a containment area. The strategy in the analysis is to represent this set of outcomes by a single scenario defined by the most severe consequence (and perhaps, lowest probability). This focuses the analysis on more serious potential outcomes.

In *Guidelines for Chemical Process Quantitative Risk Analysis* [5], three classes of incidents are defined:

- **Localized incident**—Localized effect zone, limited to a single plant area (e.g., pump fire, small toxic release).
- **Major incident**—Medium effect zone, limited to site boundaries (e.g., major fire, small explosion).
- **Catastrophic incident**—Large effect zone, off-site effects on the surrounding community (e.g., major explosion, large toxic release).

The catastrophic incidents represent the bounding set of incidents or largest effect incidents that can occur. They can be further divided into worst credible incident and worst possible incident, which are defined as follows:

- **Worst Possible Incident**—The highest consequence incident identified that is physically possible regardless of likelihood.
- **Worst Credible Incident**—The highest consequence incident identified that is considered plausible or reasonably believable.

Worst possible incident scenarios are the subject of the most concern and debate for emergency planning. With hazardous chemicals, it is easy to postulate a total and instantaneous loss of containment and release of all of the chemical inventory regardless of likelihood. Dispersion, fire, and explosion models can be used—and sometimes misused—to project an outcome of disturbing magnitude as measured in loss of life, property, and business viability. However, focusing prevention and preparedness programs only on this kind of incident would be a misapplication of resources.

Although they may be the easiest to postulate, worst possible incidents are generally extremely improbable events. This is particularly true for systems where good process safety management has been practiced from design through all phases of operation and maintenance. In high hazard cases, there are usually multiple layers of protection against the total loss of containment, including design safety factors, material selection, corrosion allowance, construction quality assurance, periodic inspection and testing, overpressure relief, instrumentation, and alarms. These and other management controls can result in a probability of total failure too low for the incident to be considered credible. If these incidents are not credible, then extensive efforts at prevention and preparedness may be counterproductive by diverting resources away from more likely and, hence, higher risk incidents.

Greater risk reduction can be achieved by focusing efforts on the worst credible incidents for emergency planning; however, a facility should also be aware of regulations that may affect the selection of scenarios. A summary of the approach to scenario selection by major federal and selected state regulations is provided in Table 3.1. While all current regulatory requirements must be considered for each location, the consensus of most risk management professionals and government authorities is that the worst credible incidents are more valuable in emergency planning [13] and considering worst possible incidents may divert attention and resources from higher risk scenarios. In addition, major incidents affecting nearby employees are even more important because they typically have a higher likelihood and, therefore, may have higher associated risk. Effective emergency response provides an additional layer of protection that can prevent propagation of the incident into a catastrophe.

Good examples of credible incident scenarios are those described in Table 3.1 for the Delaware EHS Risk Management Act regulations. Some examples of noncredible incidents include:

- Catastrophic failures of chlorine tank cars during unloading at a location meeting Chlorine Institute recommendations for separation from sources of fire and other protective measures [9]. Due to the exacting requirements of these vehicles, such catastrophic failures are practically nonexistent [19].
- Catastrophic vessel failure due to aircraft impact for sites that are more than 3 miles from an airport or outside the established flight paths [13].
- Catastrophic vessel failure due to meteorite impact.

Generally, if a postulated cause (i.e., vandalism) is effectively protected against (security system and/or site isolation), these causes may be bypassed in developing incident scenarios in favor of more likely causes.

3.3. SCREENING TECHNIQUES TO IDENTIFY FOCUS AREAS

In certain facilities, the number of chemicals stored and processed may be large. In major chemical manufacturing complexes, there can be many chemical process

TABLE 3.1
Summary of Regulatory Approaches to Scenario Selection

Regulation/Act	*Approach*
OSHA PSM, Evacuation Plan and HAZWOPER (29 CFR 1910.119, 1910.38a, and 1990.120)	The PSM rule refers to the use of several accepted Process Hazard Analysis techniques and does not specifically address whether noncredible scenarios should be considered. It does emphasize that the emergency action plan must include procedures for responding to smaller releases, presumably due to their higher likelihood and immediate impact in the work place. The emergency evacuation planning and HAZWOPER standards do not address the consideration of noncredible incidents.
California Risk Management and Prevention Program (Chapter 6.95 of Health and Safety Code)	This program is intended to address potential effects of accidental releases on the public, or outside the fence line effects, and require Risk Management and Prevention Programs where there is the potential for significant off-site effects. The regulations require modeling and consequence analysis for the largest potential release scenarios identified in hazard analysis. There are no specific rules requiring the inclusion of noncredible incidents at the state level. Only a few of the local enforcement authorities have requested the use of the Worst Possible Incident.
Delaware Extremely Hazardous Substances Risk Management Act (7 Delaware code, Chapter 77)	The act is intended to address potential effects of accidental releases on the public (i.e., outside the fence line effects) and to require Risk Management Programs where there is the potential for significant off-site effects. The regulations specifically define several approaches to calculating the "Potential Release Quantity" all of which indicate a philosophy of Worst Credible Incident defined above. These approaches include: • Catastrophic line failure (flow from both ends); • Catastrophic hose failure (flow from both ends); • Exposure of vessels and equipment to fire if material is flammable or if flammable or combustible substances are handled or stored nearby; • Venting of pressure relief valve at relief system design basis; and • Failure of mitigating systems such as flares, scrubbers, isolation valves, excess flow valves, cooling systems. Inherent in these approaches is the recognition that vessels which are properly designed in accordance with codes and standards and managed in accordance with the recommended elements of chemical process safety have an extremely low probability of instantaneous catastrophic failure.
New Jersey Toxic Catastrophe Prevention Act (NJAC Title 7—Chapter 31)	The purpose of this act is similar to that of the Delaware Act. The regulations require modeling and consequence analysis for the largest potential release scenarios identified in hazard analysis. There are no specific rules requiring the inclusion of noncredible incidents, but the facility must explain why any accident risk is not addressed. The regulations do require that emergency response team training include action plans for dealing with specific scenarios and that the drills be based on preplanned release criteria.
U.S. EPA Risk Management Programs for Chemical Accidental Release Prevention (58 FR 54190)	The purpose of these **October 1993** proposed regulations is similar to the above referenced state acts. EPA's initial proposal included the use of the "worst-case release" for emergency planning purposes. Worst-case release is defined as ". . .the loss of all of the regulated substance from the process in an accidental release that leads to the worst off-site consequences." This includes all material contained in different vessels. However, EPA also indicated that it "does not want facilities to focus solely on the worst-case release because other release scenarios are of concern, are generally more likely than a worst-case release scenario, and must be addressed in the prevention program." Furthermore, whereas this regulation requires the identification of "worst-case releases," it does **not** require emergency management plans for those noncredible incidents.

units covered in the emergency plan. In these cases it is impractical to identify credible incidents for all chemicals and all process areas regardless of hazard or risk before selecting those for use in emergency planning. An alternative approach used by many larger facilities is to first screen chemicals and/or processes to identify those with higher hazard. Incident identification would then focus on the higher hazard chemicals and processes.

Simple to more complex screening techniques are reviewed in the following sections. The use of these techniques is intended to reduce effort for incident identification. Their use is not essential and may be inappropriate for smaller facilities.

3.3.1. NFPA Fire Hazard Indices

The simplest and most widely used chemical hazard index is the National Fire Prevention Association (NFPA) *Identification of the Fire Hazards of Materials* [14]. This standard is widely used in industry for marking storage tanks and shipping containers and is specifically directed towards providing information to first responders. It is an indicator of the type and degree of hazard of materials in emergency situations.

Figure 3.1 illustrates the widely recognized NFPA diamond and provides a description of degree of hazard ratings. The actual numerical rating criteria are more complex and address the following:

- *Health Hazards*
  —Inhalation toxicity relative to saturated vapor concentration
  —Dermal toxicity
  —Oral toxicity
  —Eye and skin corrosivity
- *Flammability Hazards*
  —Flash point
  —Boiling point
  —Explosive/flammable dusts
  —Tendencies to readily ignite or burn rapidly
- *Reactivity Hazards*
  —Thermal or mechanical shock sensitivity
  —Self-reactive/explosive
  —Water-reactive/explosive
  —Exothermic reaction with exposure to heat, air, light or moisture

A complete description of the rating criteria is provided by NFPA [14]. The NFPA hazard ratings can be used to select those chemicals that may be most significant for emergency planning. Simple screening criteria could include one of the following using a sliding scale based on quantity of material:

THE NFPA 704 MARKING SYSTEM

THE NFPA 704 MARKING SYSTEM DISTINCTIVELY INDICATES THE PROPERTIES AND POTENTIAL DANGERS OF HAZARDOUS MATERIALS. THE FOLLOWING IS AN EXPLANATION OF THE MEANINGS OF THE QUADRANT NUMERICAL CODES

HEALTH (BLUE)

IN GENERAL HEALTH HAZARD IN FIREFIGHTING IS THAT OF A SINGLE EXPOSURE WHICH MAY VARY FROM A FEW SECONDS UP TO AN HOUR. THE PHYSICAL EXERTION DEMANDED IN FIREFIGHTING OR OTHER EMERGENCY CONDITIONS MAY BE EXPECTED TO INTENSIFY THE EFFECTS OF ANY EXPOSURE ONLY HAZARDS ARISING OUT OF AN INHERENT PROPERTY OF THE MATERIAL ARE CONSIDERED. THE FOLLOWING EXPLANATION IS BASED UPON PROTECTIVE EQUIPMENT NORMALLY USED BY FIREFIGHTERS:

4 MATERIALS TOO DANGEROUS TO HEALTH TO EXPOSE FIREFIGHTERS. A FEW WHIFFS OF THE VAPOR COULD CAUSE DEATH OR THE VAPOR OF LIQUID COULD BE FATAL ON PENETRATING THE FIREFIGHTER'S NORMAL FULL PROTECTIVE CLOTHING. THE NORMAL FULL-PROTECTIVE CLOTHING AND BREATHING APPARATUS AVAILABLE TO THE AVERAGE FIRE DEPARTMENT WILL NOT PROVIDE ADEQUATE PROTECTION AGAINST INHALATION OR SKIN CONTACT WITH THESE MATERIALS.

3 MATERIALS EXTREMELY HAZARDOUS TO HEALTH, BUT AREAS MAY BE ENTERED WITH EXTREME CARE. FULL-PROTECTIVE CLOTHING INCLUDING SELF-CONTAINED BREATHING APPARATUS, COAT PANT, GLOVES, BOOTS AND BANDS AROUND LEGS, ARMS AND WAIST SHOULD BE PROVIDED. NO SKIN SURFACE SHOULD BE EXPOSED.

2 MATERIALS HAZARDOUS TO HEALTH, BUT AREAS MAY BE ENTERED FREELY WITH FULL-FACE MASK AND SELF-CONTAINED BREATHING APPARATUS WHICH PROVIDES EYE PROTECTION.

1 MATERIALS ONLY SLIGHTLY HAZARDOUS TO HEALTH. IT MAY BE DESIRABLE TO WEAR SELF-CONTAINED BREATHING APPARATUS.

0 MATERIALS WHICH WOULD OFFER NO HAZARD BEYOND THAT OF ORDINARY COMBUSTIBLE MATERIAL UPON EXPOSURE UNDER FIRE CONDITIONS.

FLAMMABILITY (RED)

SUSCEPTIBILITY TO BURNING IS THE BASIS FOR ASSIGNING DEGREES WITHIN THIS CATEGORY. THE METHOD OF ATTACKING THE FIRE IS INFLUENCED BY THIS SUSCEPTIBILITY FACTOR.

4 VERY FLAMMABLE GASES OR VERY VOLATILE FLAMMABLE LIQUIDS. SHUT OFF FLOW AND KEEP COOLING WATER STREAMS ON EXPOSED TANKS OR CONTAINERS.

3 MATERIALS WHICH CAN BE IGNITED UNDER ALMOST ALL NORMAL TEMPERATURE CONDITIONS. WATER MAY BE INEFFECTIVE BECAUSE OF THE LOW FLASH POINT.

2 MATERIALS WHICH MUST BE MODERATELY HEATED BEFORE IGNITION WILL OCCUR. WATER SPRAY MUST BE USED TO EXTINGUISH THE FIRE BECAUSE THE MATERIAL CAN BE COOLED BELOW ITS FLASH POINT.

1 MATERIALS THAT MUST BE PREHEATED BEFORE IGNITION CAN OCCUR. WATER MAY CAUSE FROTHING IF IT GETS BELOW THE SURFACE OF THE LIQUID AND TURNS TO STEAM. HOWEVER, WATER FOG GENTLY APPLIED TO THE SURFACE WILL CAUSE A FROTHING WHICH WILL EXTINGUISH THE FIRE.

0 MATERIALS THAT WILL NOT BURN.

REACTIVITY (YELLOW)

THE ASSIGNMENT OF DEGREES IN THE REACTIVITY CATEGORY IS BASED UPON THE SUSCEPTIBILITY OF MATERIALS TO RELEASE ENERGY EITHER BY THEMSELVES OR IN COMBINATION WITH WATER. FIRE EXPOSURE WAS ONE OF THE FACTORS CONSIDERED ALONG WITH CONDITIONS OF SHOCK AND PRESSURE.

4 MATEIALS WHICH (IN THEMSELVES) ARE READILY CAPABLE OF DETONATION OR OF EXPLOSIVE DECOMPOSITION OR EXPLOSIVE REACTION AT NORMAL TEMPERATURES AND PRESSURES. INCLUDES MATERIALS WHICH ARE SENSITIVE TO MECHANICAL OR LOCALIZED THERMAL SHOCK. IF A CHEMICAL WITH THIS HAZARD RATING IS IN AN ADVANCED OR MASSIVE FIRE. THE AREA SHOULD BE EVACUATED.

3 MATERIALS WHICH (IN THEMSLVES) ARE CAPABLE OF DETONATION OR OF EXPLOSIVE DECOMPOSITION OR EXPLOSIVE REACTION BUT WHICH REQUIRE A STRONG INITIATING SOURCE OR WHICH MUST BE HEATED UNDER CONFINELMENT BEFORE INITIATION. INCLUDES MATERIALS WHICH ARE SENSITIVE TO THERMAL OR MECHANICAL SHOCK AT ELEVATED TEMPERATURES AND PRESSURES OF WHICH REAT EXPLOSIVELY WITH WATER WITHOUT REQUIRING HEAT OR CONFINEMENT. FIREFIGHTING SHOULD BE DONE FROM AN EXPLOSIVE-RESISTANT LOCATION.

2 MATERIALS WHICH (IN THEMSLVES) ARE NORMALLY UNSTABLE AND RAPIDLY UNDERGO VIOLENT CHEMICAL CHANGE BUT DO NOT DETONATE. INCLUDES MATERIALS WHICH CAN UNDERGO CHEMICAL CHANGE WITH RAPID RELEASE OF ENERGY AT NORMAL VIOLENT CHEMICAL CHANGE AT ELEVATED TEMPERATURES AND PRESSURES. ALSO INCLUDES THOSE MATERIALS WHICH MAY REACT VIOLENTLY WITH WATER OR WHICH MAY FORM POTENTIALLY EXPLOSIVE MIXTURES WITH WATER. IN ADVANCE OR MASSIVE FIRES, FIREFIGHTING SHOULD BE DONE FROM A SAFE DISTANCE OR FROM A PROTECTED LOCATION.

1 MATERIALS WHICH (IN THEMSELVES) ARE NORMALLY STABLE BUT WHICH MAY BECOME UNSTABLE AT ELEVATED TEMPERATURES AND PRESSURES OR WHICH MAY REACT WITH WATER WITH SOME RELEASE OF ENERGY BUT NOT VIOLENTLY. CAUTION MUST BE USED IN APPROACHING THE FIRE AND APPLYING WATER.

0 MATERIALS WHICH (IN THEMSELVES) ARE NORMALLY STABLE EVEN UNDER FIRE EXPOSURE CONDITIONS AND WHICH ARE NOT REACTIVE WITH WATER. NORMAL FIREFIGHTING PROCEDURES MAY BE USED.

SPECIAL INFORMATION (WHITE)

MATERIALS WHICH DEMONSTRATE UNUSUAL REACTIVITY WITH WATER SHALL BE IDENTIFIED WITH THE LETTER 'W' WITH A HORIZONTAL LINE THROUGH THE CENTER (W).

MATERIALS WHICH POSSESS OXIDIZING PROPERTIES SHALL BE IDENTIFIED BY THE LETTERS 'OX'.

MATERIALS POSSESSING RADIOACTIVITY HAZARDS SHALL BE IDENTIFIED BY THE STANDARD RADIOACTIVITY SYMBOL.

FIGURE 3.1 The NFPA 704 marking system.

- Selection of materials with a "4" rating for any hazard category.
- Selection of materials with a "3" or higher rating for any hazard category.

This may be the simplest screening strategy, but in its simplicity, does not account for the following factors:

- The quantity of material on-site.
- The conditions of temperature, pressure, etc. at the various points of use.
- Overall risk associated with the chemical based on process design, operations, and maintenance.
- Location of operations relative to high density population areas or especially sensitive locations (e.g., schools).

Some of these are addressed in other screening methods.

3.3.2. Toxicity/Mobility/Quantity Index

The Substance Hazard Index (SHI) has been the most widely used indicator of the potential consequences of toxic chemical release to develop threshold quantities for regulatory purposes. It is a combined measure of mobility (i.e., vapor pressure) and acute toxicity by the inhalation route. The SHI, a dimensionless ratio, is defined as follows:

$$\text{SHI} = \frac{\text{Equilibrium Vapor Concentration @ 20°C}}{\text{Acute Toxicity Concentration (ATC)}}$$

where equilibrium vapor concentration (ppm) = [vapor (or partial) pressure at 20°C/total atmospheric pressure] × 10^6. For gases, equilibrium vapor concentration is 1,000,000 ppm.

The ATC is defined (e.g., in the Delaware EHS Risk Management Act) as the lowest reported concentration in parts per million (ppm) that will cause death or permanent disability from a one-hour exposure. Potential sources of data for the ATC include the American Industrial Hygiene Association Emergency Response Planning Guideline-3 (ERPG-3), the NIOSH Immediately Dangerous to Life and Health (IDLH) concentration, and the LC_{lo} (the lowest concentration reported to be fatal to humans or animals). In the absence of this data for a chemical, one tenth of the LC_{50} has been used as an estimate of the LC_{lo}. Those toxic chemicals with the highest value for the release quantity multiplied by the SHI are likely to result in the most severe consequences and should be considered first for credible incident identification.

3.3.3. *Chemical Process Risk Indices*

Risk indices provide a relative ranking of risks that are used for screening and prioritization. A highly sophisticated screening technique is the use of process-based risk indices, which consider the actual process conditions of temperature, pressure, line and vessel size, and the chemical properties of toxicity and vapor pressure. The most widely used of such indices are the Dow Chemical Company Fire and Explosion Index [10] and Chemical Exposure Index [11].

The Fire and Explosion Index (F&EI) includes consideration of material characteristics (flash point and vapor pressure) at actual process conditions, general process hazards related to specific conditions (e.g., exothermic reaction, types of processing steps), and special hazards (e.g., temperature above flash and boiling points, in/and near flammable range). These are all considered using various weighting factors and summed to yield a numerical F&EI.

The Chemical Exposure Index (CEI) is based on the identification of the hypothetical leak of an inventory of hazardous toxic material. The largest release is based on process equipment sizing and process conditions using a standard set of assumptions for key types of piping and equipment. The release rate, airborne quantity, and American Industrial Hygiene Association (AIHA) Emergency Response Planning Guidelines (ERPG) values are used to calculate a numerical CEI and a hazard distance representing the distance where concentrations drop below ERPG concentrations. The F&EI and CEI are numerical indices that simplify the comparison of process chemicals and manufacturing units while considering actual process conditions, credible incidents, the extent of consequences, and (to some degree) overall risk.

3.4. TECHNIQUES FOR IDENTIFYING CREDIBLE INCIDENTS FOR EMERGENCY PLANNING

Having prioritized the hazards, a search is then needed to determine credible incidents presenting the most serious threats. Methods used to identify credible incidents for use in emergency planning vary from informal techniques to formal process hazard analysis. With experience, informal techniques can be effective. Formal techniques, while they also require experience in hazard analysis, are generally more thorough and incorporate formal methodologies for rational selection of emergency planning scenarios. If a facility has completed process hazard analyses for any of its hazardous processes, the emergency planner should first review the results of these studies to determine whether the consequences of identified failure events are suitable for emergency planning. If hazard analysis has not been conducted or did not adequately develop credible major incident scenarios for certain processes, one of the alternative techniques could be used for identifying credible incidents. These approaches are described in the following subsections.

3.4.1. Informal "Expert" Review

Informal reviews can be completed by a small team comprising individuals familiar with the plant design, operations, and maintenance of the process under study. At least one individual with expertise in risk management and emergency response should also be included. Information needed may include a plot plan with locations and quantities of major hazardous material storage, loading/unloading and use locations throughout the facility, process flow diagrams, and process operating conditions. Heat and material balances and piping and instrumentation diagrams (P&IDs) are also valuable references for the review. In addition, information necessary for the identification of hazards should be obtained and hazards should be identified, as discussed in Chapter 2. Next, incident histories summarizing incidents that occurred over the last several years should be carefully reviewed to determine if they are still likely events, given changes to the facility and any specific corrective measures taken in response to the incident investigation. Those incidents with a likelihood of occurrence should be considered. In addition, published incidents at similar facilities should be identified. Interviews with operators and a walk-through of the facility may also be of assistance in identifying less obvious problems, potential incidents, or unreported incidents that could have resulted in major consequences.

Once this information is obtained and reviewed by the team, a list can be generated identifying potential incidents. This may best be done in a brainstorming session where incident scenarios can be tested for credible causes and likely intermediate events that could affect the final outcome. The potential incidents can be generated by simply postulating a loss of containment of inventoried vessels and major pipelines in the facility. This can be augmented by the use of checklists of example incidents and causes. A brief list of generic sample incidents is presented in Table 3.2. A more extensive checklist of loss-of-containment causes has been published in *Guidelines for Chemical Process Quantitative Risk Analysis* [5, pp. 491–494]. Also, the group should explore hazards that may occur beyond simple loss of containment, such as those discussed in Chapter 2 (e.g., the special hazards of self-reactivity and mixture of coprocessed incompatible chemicals) and those that are related to process conditions, equipment, and chemistry.

The scenarios identified are sometimes limited and screened out early in the process of developing the list, retaining only those considered "worst credible" and "more likely major" incidents that may be most useful in emergency planning. In other cases, a more complete listing will be generated for reference and screened using techniques described later in this chapter to select those that may be most useful.

The results of this review are documented so they can be utilized for subsequent emergency planning steps and used as a resource if the activity is

TABLE 3.2
Selected Generic Causes of Loss-of-Containment Incidents

- Overpressuring a process or storage vessel due to loss of control of reactive materials or external heat input.
- Overfilling of a vessel or knock-out drum.
- Opening of a maintenance connection during operation.
- Leak at pump seals, valve stem packings, flange gaskets, etc.
- Excess vapor flow into a vent or vapor disposal system.
- Rupturing a tube in a heat exchanger.
- Fracture of a process vessel causing sudden release of the vessel contents.
- Line rupture in a process piping system.
- Failure of a vessel nozzle.
- Breaking off of a small-bore pipe (inches) such as an instrument connection or branch line.
- Inadvertently leaving a drain, sample or vent valve open.
- Internal/external explosion.

Adapted from *Guidelines for Chemical Process Quantitative Risk Analysis*. New York: AIChE, page 23.

repeated in the future. Documentation should include a summary of information sources, participants, methods, and the list of scenarios used in emergency planning.

3.4.2. Hazard Review to Support Emergency Planning

Hazard reviews can be conducted to support emergency planning. These reviews are typically conducted by a group of participants with a range of experience and expertise including engineering, hands-on operation, operations supervision, maintenance, emergency response, and a leader with experience in process hazard analysis. Such reviews may include the following elements:

- Process flow diagram review.
- Hazard identification.
- Site and industry-wide incident history.
- Identification of plausible scenarios regardless of history.

- Selection of a few scenarios for further assessment for each process area based on major or catastrophic effects and a consensus of greater likelihood.
- Analysis of causes, effects, likelihood, and severity, and identification of appropriate emergency response options and issues.

These reviews can be similar in structure to the process hazard analysis techniques (e.g., "what-if analysis" and "failure mode and effects analysis") described in *Guidelines for Hazard Evaluation Procedures* [6]. Since the focus is on incidents that can lead to injuries or major property loss (i.e., generation of major or catastrophic consequences), it is necessarily a less comprehensive review and the number of incident scenarios documented will be fewer than for other process hazard analysis studies.

The advantages of this formal process flow diagram-based review technique over the informal technique described in Section 3.4.1 include better identification of more complex potential process incidents and incorporation of a risk-ranking technique to determine scenarios with the highest risk. This risk ranking is particularly useful in prioritizing a usable number of scenarios for emergency planning for a facility that may contain numerous process units. It has the advantage of identifying emergency response approaches in conjunction with the development of the scenario. This leads to a clearer understanding of the potential incident and appropriate response techniques and precautions.

The results of the analysis are documented by a scribe in the same manner as a formal hazard analysis by distilling the comments of the participants into a summary. The analysis can be facilitated by using computer software to document and facilitate a group review of the results [6]. In addition, the documentation should include a summary of information sources, participants, and methods employed. Process hazard analysis computer software or standard word processing and spreadsheet software can be used to document the analysis.

3.4.3. Using Process Hazard Analysis to Support Emergency Planning

Process risk management is one of the twelve CCPS elements of chemical process safety management described in Chapter 1 [4]. Formal hazard evaluation is one of the key tools used to identify hazards, obtain a qualitative or relative ranking analysis of risk, and identify appropriate risk reduction measures. Hazard evaluation is considered the cornerstone of an overall process safety management program. Numerous techniques for conducting hazard evaluation are presented in the *Guidelines for Hazard Evaluation Procedures* [6]. These techniques vary in complexity, and it is best to use the simplest method that provides adequate information for the purpose at hand. In fact, it is not usually practical to start a hazard analysis at the complex end of the scale without first using one or more of the simpler analyses. These hazard analysis methods (roughly in order of complexity) include:

- Relative Ranking
- Safety Review
- Checklist Analysis
- Preliminary Hazard Analysis
- What-If Analysis (WIA)
- What-If/Checklist Analysis
- Hazard and Operability (HAZOP) study
- Failure Modes and Effects Analysis (FMEA)
- Event Tree Analysis (ETA)
- Fault Tree Analysis (FTA)

Those hazard analysis that are most often used to identify and evaluate defined incident scenarios include WIA, HAZOP, and FMEA. These methods use different techniques to identify "what can go wrong." Once questions are answered, the causes, consequences, and existing safeguards are identified. A ranking scheme is often used to assess the risk associated with each scenario to help determine whether additional risk reduction actions are warranted. Generally, the consequences should reflect what can occur without the existing safeguards or if the safeguards fail. When these analyses are completed according to the guidelines cited above, numerous potential incident scenarios are generated for quantitative risk assessment or emergency planning purposes. An example of the tabular results from these types of analyses is presented in Table 3.3.

Several of these techniques are primarily useful for hazard identification and are not generally used to identify potential incident scenarios (e.g., safety review, preliminary hazard analysis, relative ranking, checklist analysis). Others are generally used to examine incident scenarios in great detail using logic diagrams (FTA and ETA), often for the purpose of quantifying the probability of high-consequence events.

The emergency planner should carefully review previous hazard evaluation study results to ensure that they include fully developed scenarios of major incidents. These analyses are subjective, which may result in variations in the methods used, the degree to which specific scenarios are identified and developed, and the presentation of results. A well-developed scenario should include the nature of the hazard, process components involved, how it happens, rate of release (if applicable), and the potential ultimate outcomes such as the impacts of fire, explosion, or toxic gas exposure. The emergency planner should also check for the inclusion of obvious loss-of-containment scenarios for major system components and plant peripheral and support areas. An example of a potential omission could be failure to consider the incidents that could occur during the delivery of hazardous raw materials or the loading of hazardous products. If such information is lacking, one of the other techniques described previously should be used to identify scenarios and corrective action should be considered to improve the hazard evaluation program.

TABLE 3.3
Sample FMEA Results for the Routine Operation Phase

P&ID No: E-250
Revision: D
Meeting Date: 9/5/90

Team: Mr. Smart, Mr. Associate, Ms. Piper, Mr. Stedman, Mr. Volt (Anywhere VCM Plant)

Item No.	*Component*	*Failure Mode*	*Effects*	*Safeguards*	*Actions*
1	Flame scanner UVL-1B	No signal change False flameout signal	Loss of capability to initiate an incinerator shutdown upon loss of flame. Potential incinerator fire or explosion if flame extinguished. Inadvertent incinerator shutdown. Potential incinerator explosion if incinerator fuel not shut off.	Redundant UVL. Multiple incinerator interlocks (temperature, fuel, and air). Shutdown is alarmed. Operators verify shutdown actions. Double block and bleed valves in fuel lines. Three-way shutoff valve in vent line.	Verify the reliability of the UVLs.

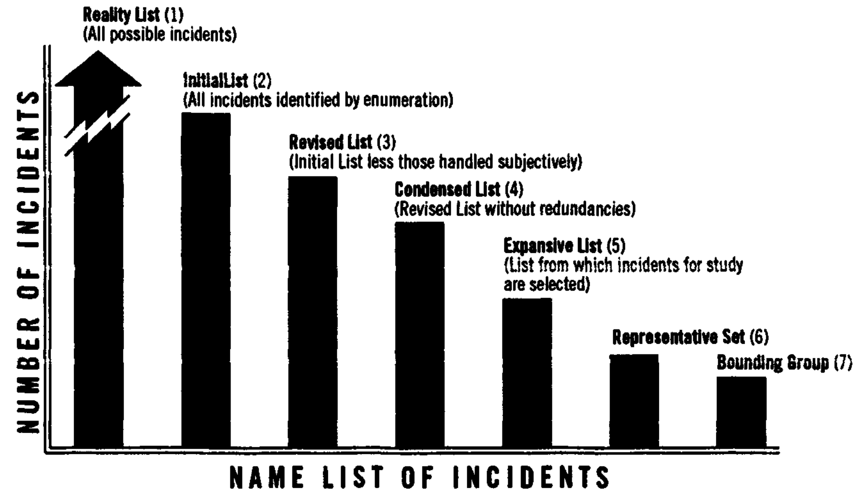
SOURCE: *Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples.* New York: AIChE, p. 333.

3.5. PRIORITIZING EMERGENCY PLANNING INCIDENTS FOR CONSEQUENCE ASSESSMENT

Once a list of potential incidents is developed, they can be screened to select a limited number of scenarios for more detailed consequence and impact analysis. As discussed earlier, the hazard evaluation or incident identification step narrows the set of all possible scenarios to a set of plausible incidents. These can be further screened to meet the objectives of emergency planning, which are to identify a group of incidents that are representative of:

- The various types of hazards.
- The upper boundaries of severity of consequences and ultimate impact.
- The upper boundaries of risk.

One representation of selecting incidents for use in quantitative analysis is presented in Figure 3.2. This figure shows the number of incidents from the



NOTES

(1) Approaches an infinite number of possible incidents of various sizes.

(2) Obtained by some form(s) of hazard analysis including check lists, "what ifs", etc.

(3) Removal of incidents with low consequences.

(4) Combine similar incidents, especially those with similar consequences.

(5) The list from which incidents will be selected for emergency planning study (or risk assessment). Based on the condensed list, it is obtained by grouping incidents into subsets where similar materials and/or release characteristics are involved.

(6) This is the list of representative subsets of incidents to be considered.

(7) The bounding group are incidents from the representative set that have the highest consequences.

FIGURE 3.2 Incident lists versus number of incidents. (Adapted from [5, p. 22]).

potentially infinite "reality list" to the "representative set" most appropriate for emergency planning.

A facility should rank potential incidents that are most important for emergency preparedness, based on the following three considerations:

- Incidents with only localized or minor effects (e.g., off-site odor) and occur over a short time with little potential for propagation into serious incidents are of less interest in emergency preparedness because there is little an emergency response organization can do to improve the outcome. If the likelihood of occurrence is sufficiently high to result in significant risk of employee exposure or injury, these incidents will still be identified and addressed in the hazard evaluation, plant personnel safety and industrial hygiene efforts.

- Major incidents likely to occur which may have already occurred within the life of the plant are most important in emergency planning because the organization may have to respond to these incidents. Furthermore, the ability to effectively respond to these incidents is especially critical in preventing their escalation into larger, major disasters or catastrophes.
- Worst credible incidents are high consequence catastrophic incidents with a very low likelihood or frequency of occurrence, but are plausible. These incidents must be seriously considered because, should they occur, they may exceed the resources of the on-site organization, test the limits of leadership and communications, and require supporting resources.

To select incidents for use in emergency planning, take the following steps:

1. Eliminate localized incidents that do not require mobilization of the emergency response team.
2. Consolidate redundant or very similar remaining incidents that have similar composition, inventories, discharge rates, discharge locations, and types of suitable emergency response actions.
3. Select one credible worst-case, higher-consequence incident and one higher likelihood major incident to represent each consolidated group.

This should leave the representative set of incidents that meet the objectives for emergency response planning. If the number of incidents in the representative set are too numerous to carry over into the consequence analysis stage, they can be further grouped and screened by consequence and/or risk. Screening can be performed based on best professional judgment, but the use of formal decision aids can produce a more objective result.

If numerous hazardous materials are present at the facility, it may be helpful to further group certain chemicals with similar chemical and hazard characteristics and those chemically compatible upon mixing. An example of this grouping is flammable liquids with relatively low acute toxicity. These groups of compounds may be best considered as a class for emergency planning, provided special hazards are not overlooked. This type of grouping, however, should be done with caution. Highly toxic and/or reactive materials, for example, should not be grouped with low toxicity flammable liquids.

Unless quantitative risk assessment has already been performed, screening by risk will generally involve an empirical semiquantitative risk ranking scheme. An example of a formal risk ranking scheme used for this purpose (as well as for hazard evaluation) is given in Tables 3.4 and 3.5 [18].

For each incident it is necessary to (1) estimate likelihood using approximate possibilities of failure of protective systems as well as likelihood of the initiating event and (2) estimate severity from consequences of the incident assuming failure of the protective systems. Incident modeling software is now readily available to

TABLE 3.4
Categories for Likelihood and Severity of Incident

Likelihood	*Category*	*Characteristics*
Frequent	a	Likely to occur frequently.
Probable	b	Will occur several times over life of process.
Occasional	c	Likely to occur during lifetime of process.
Remote	d	Unlikely but possible.
Improbable	e	Very unlikely.
Severity	*Category*	*Characteristics*
Catastrophic	I	Death or system loss.
Critical	II	Severe injury, severe occupational illness, or major system damage.
Marginal	III	Minor injury, minor occupational illness, or minor system damage.
Negligible	IV	Less than minor injury, occupational illness, or system damage.

aid in evaluating consequences; a number of simplified models for consequences are described in [5, Chap. 2]. By ranking into relative categories each of these factors, that is, likelihood and severity, as in Table 3.4, the resulting categories can be applied in Table 3.5 to provide a risk ranking index.

The actual risk criterion or action applied to each risk rank index (i.e., combination of likelihood and severity) is a matter of policy. An example of such a policy with guidelines is included in the suggested action(s) that might be taken for risk reduction (also shown in Table 3.5). Similarly, for purposes of emergency response planning, the risk ranking index can be used for prioritization of each incident of interest.

Further approaches on risk ranking are covered in the CCPS *Guidelines for Hazard Evaluation Procedures, Second Edition with Worked Examples* [6, p. 200].

It is not essential that all, or any, of these formal techniques be used for a particular facility. Facility needs and degrees of complexity vary widely. These techniques are offered to ensure the planner understands the range of selection techniques available to focus emergency planning efforts and is aware of the importance of defining and documenting the facility's selection criteria.

TABLE 3.5
Risk Ranking Index (RRI) Matrix[a] and Risk Reduction Response Guidelines

Risk Ranking Index (RRI) Matrix				
	Severity			
Likelihood	*I—Catastrophic*	*II—Critical*	*III—Marginal*	*IV—Negligible*
a—Frequent	RRI 1	RRI 1	RRI 1	RRI 3
b—Probable	RRI 1	RRI 1	RRI 2	RRI 3
c—Occasional	RRI 1	RRI 2	RRI 2	RRI 4
d—Remote	RRI 2	RRI 2	RRI 3	RRI 4
e—Improbable	RRI 3	RRI 3	RRI 3	RRI 4

Risk Reduction Response Guidelines	
RRI	*Decision Criteria*
1	Unacceptable
2	Undesirable
3	Acceptable with existing controls and protections and periodic review
4	Acceptable without review

[a] The shading and bold lines are suggested groupings of incidents within the matrix to indicate priorities for remediation (or preventive) actions consistent with the risk reduction response guidelines.

3.6. ASSESSING CONSEQUENCES AND IMPACTS

The consequences of incidents will generally include the release of flammable and/or toxic liquid and confined or overpressure explosions. Release of flammable or toxic liquid or gas will generally have one or more of the following potential general outcomes:

- Flash, evaporation, and/or aerosol formation.
- Toxic or flammable vapor dispersion.
- Fire.
- Explosion.

These general categories of outcomes do not, by themselves, provide sufficient information on the extent of the impacts on humans, the environment, and property that can occur. For example, to estimate the impact on humans of a toxic gas release, one must have information on dose response effects as a function of time (such as in Dow's Chemical Exposure Index [11]). Furthermore, there are numerous types of fires and explosions that may occur, each with different types of thermal behavior and overpressure effects. In these cases, specific outcomes will depend on the conditions of release, surrounding facilities, weather conditions, and the presence and location of potential sources of ignition. Consequence assessment is used to further characterize the potential outcomes of incidents, based on modeling thermodynamic, mass transfer, and energy transfer behavior. The results, expressed as concentration distributions, blast pressures, and heat fluxes, can then be compared to levels with known impacts on humans, the environment, and property.

3.6.1. Tools

This section provides a brief overview of consequence and impact effect modeling to assist in emergency planning. A range of models is available, from hand calculation techniques to screening level computer models to sophisticated computer models, that can account for a wide scope of material and environmental behaviors. Screening models are widely used in emergency management to obtain information on the approximate boundaries of the potential impact effects. More sophisticated models are available for use in certain incident release situations where many of the assumptions used in the simple models do not apply (e.g., dense gases). Chapter 9 further discusses the use and availability of models. In addition, treatment of more comprehensive consequence analysis is given in *Guidelines for Chemical Process Quantitative Risk Assessment* [5], and in *Guidelines for Use of Vapor Cloud Dispersion Models* [1], while a comprehensive overview is provided in *Loss Prevention in the Process Industries* [15].

3.6.1.1 Source and Dispersion Modeling

Source models are used to help quantify the rate of release; extent of flash and evaporation, based on the size of the breach of containment; conditions of the process; ground and atmospheric conditions; and properties of the material. Dispersion models then use the rates of vaporization from the source model, terrain characteristics, and meteorological conditions and properties of the material to predict the ground-level concentrations of the released chemical downwind from the source. Figure 3.3 depicts the various types of release modes and system models that can model a release of a volatile hazardous chemical under pressure from a breach of containment. Figure 3.4 illustrates several types of release modes.

There are reliable techniques for estimating release rates from loss of containment for discrete gas and liquid phases. Two-phase discharge can occur either from depressurization resulting in a boiling superheated liquid or if the breach in containment is near a gas–liquid interface. This case is more complex, however, and is usually more important for relief vent sizing and emission mitigation than for emergency planning purposes. It is important to note that the mass release

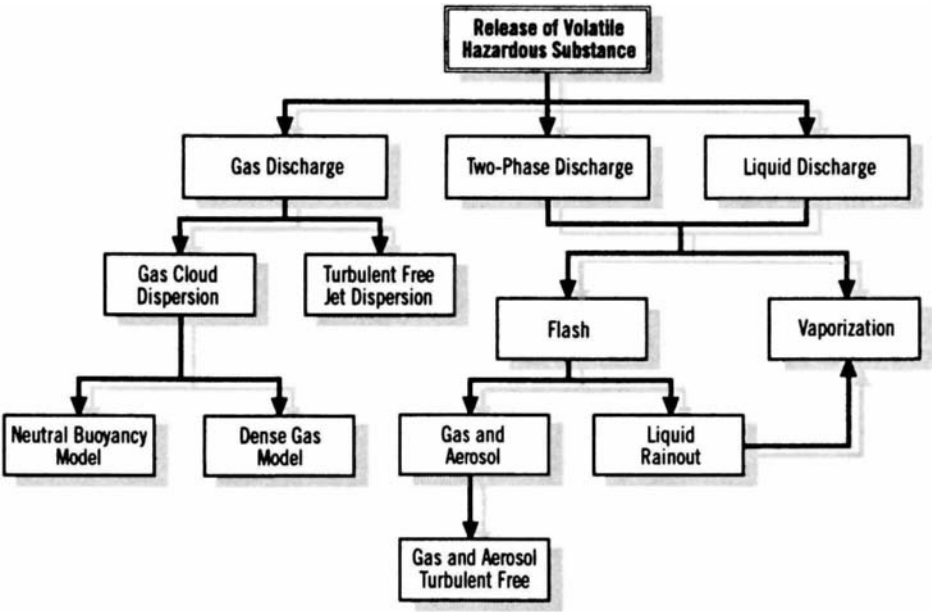
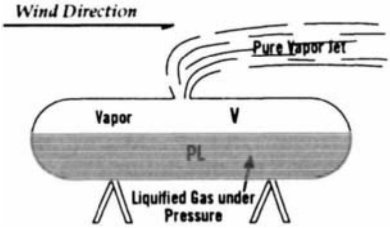


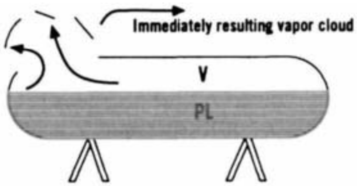
FIGURE 3.3 Logic diagram for discharge and dispersion models.

rate giving the highest consequences may not have been the release rate used to size the relief valve to protect against overpressure. Generally, at a given initial pressure and temperature, a liquid-only release will produce the more conservatively high mass release rate. When superheated liquids are released, boil-off will occur rapidly until the liquid is cooled to the boiling point. Continued heat input from the environment will result in additional vaporization. Under some conditions, however, the initial rate of boil-off may be so rapid that significant aerosol formation occurs, increasing the rate of release to the atmosphere. Models are available simulating these conditions, although those that address this phenomenon are more complex and based on relatively new research.

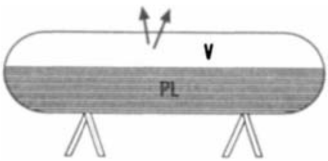
Atmospheric dispersion models are available for positively buoyant, neutrally buoyant, and negatively buoyant gases. Many of the simple and widely used screening models are Gaussian dispersion models that assume neutral buoyancy or gas with the same density as air. This may be adequate if its density is close to that of air or if its concentration is low enough in air that there is no effective density difference. Positively buoyant gases are less dense than air (e.g., methane) and negatively buoyant gases are more dense than air (e.g., butane and hydrogen fluoride). Normally neutrally or negatively buoyant gases may become positively buoyant because of higher temperatures or turbulence caused by fire. The greatest challenge in modeling for emergency planning is dense gases that do not readily disperse and may linger near the ground for longer time periods.



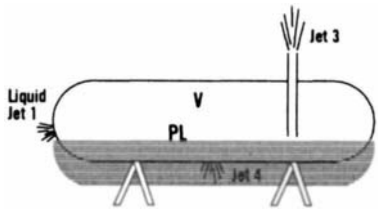
Small hole in vapor space-pressurized tank.



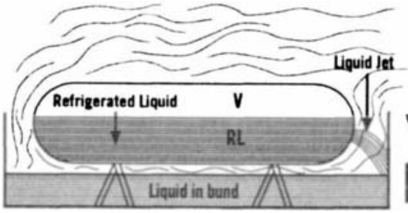
Catastrophic failure of pressurized tank.



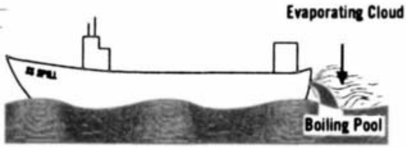
Intermediate hole in vapor space-pressurized tank.



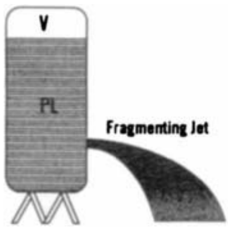
Escape of liquified gas from a pressurized tank.



Spillage of refrigerated liquid into bund.



Spillage of refrigerated liquid onto water.



High-velocity fragmenting jet from refrigerated containment.

NOTE: In most of these cases, the jet could be two phase (vapor plus entrained liquid aerosol).

FIGURE 3.4 Illustration of some conceivable release mechanisms.

Dispersion may be dramatically affected by the direction and velocity of the release and meteorological conditions, primarily wind velocity and stability class. For emergency planning, conservative conditions are generally assumed for all the major variables. The actual vapor clouds are expected to be much smaller than those estimated by these models.

Public domain computer programs for source and dispersion modeling for emergency planning purposes include the CAMEO ALOHA System (distributed by the National Safety Council on behalf of the National Oceanic and Atmospheric Administration) and ARCHIE (available from the Federal Emergency Management Agency). There are also proprietary systems available from private companies.

Dispersion models allow a relatively inexperienced user to estimate release rates and downwind concentrations. It is highly advisable, however, for the emergency planner to gain an understanding of the underlying theory and the limitations of these simplified models. Further discussion of the use of models for dispersion in emergency planning is presented in Chapter 9 of this guideline. For a thorough review of the methods of source and dispersion modeling, refer to *Guidelines for Use of Vapor Cloud Dispersion Models* and *Workbook of Test Cases for Vapor Cloud Sourced Dispersion Models* [1, 2]. These references also review some of the more sophisticated models available to estimate the rate of release and dispersion.

3.6.1.2 Explosion Modeling for Overpressure Area

There are several types of explosions that can occur in different situations, each with different characteristics and effects. These include:

- Physical explosions such as the rupture of a pressurized vessel, which can occur due to overpressure or premature equipment failure.
- Boiling liquid expanding vapor explosions (BLEVEs), which occur when a mass of pressurized liquid is suddenly released to the atmosphere due to failure of the vessel. This may occur due to flames impinging on a vessel. Ignition of the released material will result in a fireball if the material is flammable. However, it is not necessary for the liquid to be flammable to have a BLEVE.
- Unconfined vapor cloud explosions (UVCEs) and flash fires that occur when volatile flammable material is released to the atmosphere and disperses to a certain extent prior to being ignited. Generally, flash fires occur when a cloud containing less than one ton of material is ignited. UVCEs and associated pressure waves may occur when larger releases are ignited [5].
- Confined explosions that occur when explosive mixtures of dust or vapors and air ignite, or when other rapid exothermic reactions occur within a confined space, such as a pipe, vessel, or building. These are further categorized as deflagrations, which occur for slower flame velocities, and detonations, which occur for rapid flame velocities. Detonations result in

a shock wave with higher overpressure and are more damaging. Higher order dust or vapor explosions can be induced by partial confinement and/or mixing of the material.

Explosions are more likely to have serious effects close to the incident area. Explosions that can have wider effects are the UVCE and large inventory BLEVEs such as those which might result from a fire impinging on an LPG tank. The emergency planner should also consider secondary effects due to the presence of other equipment within these smaller high effect areas.

Numerous calculation methods and computer programs are available to model the effects of explosions, primarily shock wave overpressures. Other effects, such as missile generation, are more difficult to model but should still be considered in emergency planning.

Even simple computer packages require a basic knowledge of explosions to properly select the model and the appropriate physical and chemical parameters. The programs provide some warnings to reduce the potential for misuse, but there are ample opportunities to misapply models to materials for which the projected outcomes are not credible; therefore, the emergency planner should gain an understanding of the capabilities and limitations of these simplified models. For a thorough review of the methods of explosion modeling, refer to *Guidelines for Chemical Process Quantitative Risk Assessment* [5, pp. 105–123]. These references also review some of the more sophisticated hand calculation and computer models available to estimate the effects of explosions.

3.6.1.3 Fire or Thermal Effects Area Modeling

The previous section discussed the modeling of fireball and flash fires associated with the phenomena of BLEVEs and UVCEs. Two other common types of fires can be modeled. One is pool fires, which burn on the surface of flammable liquid pools, and jet fires, which occur when a jet of flammable liquid or gas escapes from its pressurized containment and ignites. The effects of liquid pool fires are more predictable, and models exist for both of these types of fires.

The effects of these types of fires tend to be localized. They are mainly of interest because emergency response teams typically will respond to such fires more frequently than explosions, and because these fires could have secondary effects if they impinge on neighboring tanks containing hazardous materials.

For a thorough review of the methods of fire effects modeling, refer to *Guidelines for Chemical Process Quantitative Risk Assessment* and the *Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs* [5, 7]. These books also review other hand calculation and computer models available to estimate the effects of fires.

3.6.2. Criteria for Defining Sensitive Areas

The models described in Section 3.5.1 project the incident consequences to the surrounding areas from concentrations of vapors, shock wave overpressures, and radiant heat flux. The final component necessary to interpret the potential end results are the critical levels producing specific adverse impacts in humans, the environment, and property. By coupling the projections of physical consequences at a distance with these impact criteria, the emergency planner can project zones of potential impact that will be useful in emergency planning.

3.6.2.1 Human Impacts

The presence of people either in the open or within buildings is critical in determining potential impact of a toxic, thermal, or overpressure release. Separate consideration for night or daytime events are frequently advisable because of the difference in population distribution.

3.6.2.1.1 Toxic Gas Effects. Human responses to toxics vary widely and, in many cases, little data are available on acute effect thresholds in humans especially for very short term exposures. A variety of threshold criteria, however, are used to indicate concentrations of toxic gases that can result in injury or death in humans. The most important criteria for emergency planning are those representing the lower threshold for life-threatening effects. As discussed in Section 3.3.2, the most widely used criteria are:

- American Industrial Hygiene Association Emergency Response Planning Guideline (ERPG).
- NIOSH Immediately Dangerous to Life and Health (IDLH) concentration.
- LC_{lo} (the lowest concentration reported to be fatal to humans or animals).
- One tenth of the LC_{50} as an estimate of the LC_{lo} in the absence of this data for a chemical.

The ERPG criteria are estimated concentrations below which target human impacts would not occur for a 60-minute exposure period. The ERPG criteria were developed for emergency planning and tend to give many considerations for the presence of sensitive individuals and scientific uncertainty. However, the number of chemicals for which ERPG values have been developed are limited. Figure 3.5 describes the ERPG criteria. Data applicable to ERPGs prepared by the Dow Chemical Company in its Chemical Exposure Index [11] and published by AIChE are reprinted as Appendix A.

Of the above criteria, the ERPG-2 is often useful for emergency planning because it represents a level below which, for a 1-hour exposure, most people can escape. This effect level is another important criterion for emergency planning. Emergency planners should be aware this approach may produce an extremely conservative projection of the true effect zone, particularly when other conservative modeling assumptions are considered. The criteria also do not account for the effects of sheltering or evacuation of the potentially exposed population, or other hazards, like asphyxiation. Other measures for life-threatening effects and less critical effects, such as odor, mild transient effects, or more serious short term

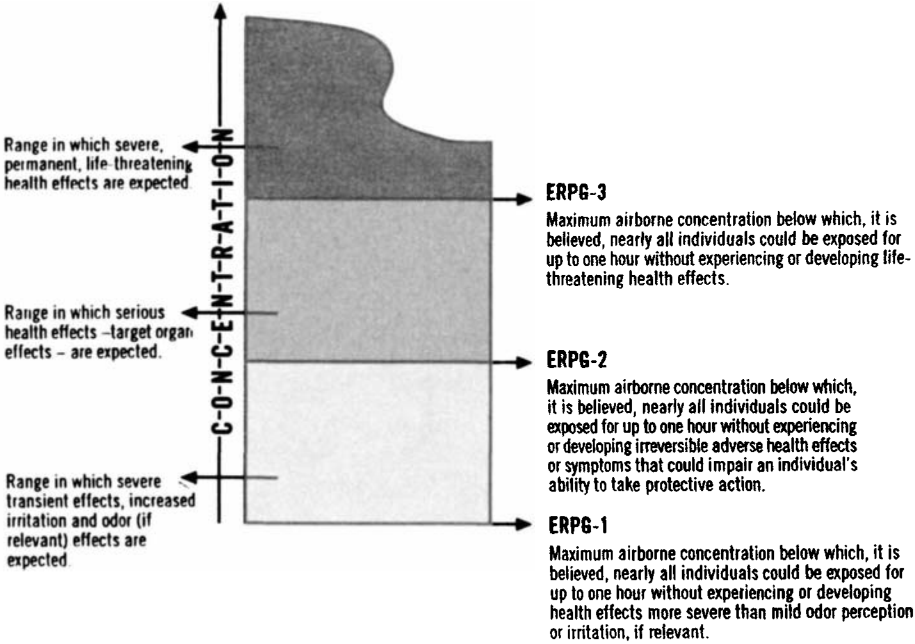


FIGURE 3.5 Emergency response planning guidelines. (Adapted from Organization Resource Counselors, Inc. 1987. *Development of Emergency Response Planning Guidelines for Air Contaminants.* Washington, D.C.)

effects, are available in the literature, including in *Guidelines for Safe Storage and Handling of High Toxic Hazard Materials* [3].

Once the acute toxicity criterion is selected for a particular chemical, many models allow for input of the value and for representation of the results for various multiples of this value.

3.6.2.1.2 Explosion Overpressure Effects. Explosion overpressures can cause extensive damage to structures and, by doing so, cause injury or death to occupants due to flying debris or collapse of the structure. Homes can be destroyed at overpressures ranging from 1 to 2 psi and can sustain serious damage at lower pressures [5]. Ninety percent of individuals outdoors may experience eardrum rupture between overpressures of 2.4 and 12.2 psi. Fatalities to humans outdoors due to overpressure (primarily from lung hemorrhage) may occur at overpressures greater than 15 psi, although such high overpressures rarely occur in chemical process explosions. Injuries and fatalities from impacts due to missiles (i.e., flying debris) can occur, but are more difficult to predict. Table 3.7 shows typical damage effects from blast or overpressure from an explosion.

Explosion models provide graphical results of overpressure using isobar maps or tabulated data for pressure at various distances. Some models include a presentation of the distances for various effects.

3.6.2.1.3 Fire Effects. The thermal radiation effects of fire are potential burn injury and death. These effects are a function of radiation intensity and time, as illustrated in Figure 3.6 and Table 3.6. Available computer models for fire generally provide the estimated radii where fatalities and lesser burns can occur. Fireballs resulting from BLEVEs can create intense thermal radiation over a wide area. Fire effects for other types of fires generally act over relatively short distances compared to the effects of toxic gas releases or explosions.

3.6.2.2 Environmental Impacts

Little data are available on the threshold values for short-term exposures effects of flora and fauna to toxic gases, fire, and explosion. It can be assumed that the types of responses for animals will be similar to those for humans, but the thresholds may vary widely. Plants and trees may react to relatively low concentrations of certain compounds by exhibiting discolored vegetation or by dropping leaves. In many cases, however, greater environmental impacts can result from the release of more persistent chemicals or materials that may settle on land or in water, rather than volatile chemicals that dissipate rapidly. This can occur under the following circumstances:

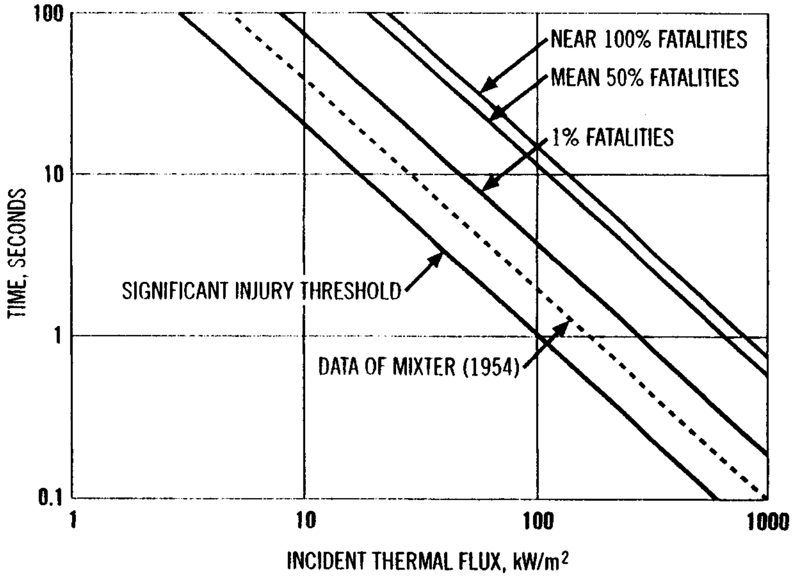


FIGURE 3.6 Serious injury/fatalities for thermal radiation. (Adapted from Mudan, K. S. 1984 "Thermal Radiation Hazards for Hydrocarbon Pool Fires." *Proc. Energy Combust. Sci.* 10(1), 59–80.)

TABLE 3.6
Effects of Thermal Radiation

Radiation Intensity (kW/m^2)	Observed Effect
37.5	Sufficient to cause damage to process equipment.
25	Minimum energy required to ignite wood at indefinitely long exposures (nonpiloted).
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing.
9.5	Pain threshold reached after 8 seconds; second degree burns after 20 seconds.
4	Sufficient to cause pain to personnel if unable to reach cover within 20 seconds; however blistering of the skin (second degree burns) is likely; 0% lethality.
1.6	Will cause no discomfort for long exposure.

SOURCE: *Guidelines for Chemical Process Quantitative Risk Analysis.* New York: AIChE.

- Spills of chemicals directly to the ground and/or waterways with potential for further migration to groundwater.
- Deposition of liquid, particulate, or multiphase material ejected from relief systems or explosions.
- Dispersion of hazardous solids (e.g., asbestos) due to a fire or explosion.
- Deposition of products of incomplete combustion of hazardous materials (e.g., dioxins from PCB transformer fires).

Once such deposition occurs, risks to humans and the environment may occur due to long-term exposures and chronic effects. Exposures may occur as a result of skin contact, ingestion of plants, and/or soil, inhalation of particulates, ingestion of contaminated surface or ground water, and propagation through the food chain. One well-known incident of this type was the incident in Seveso, Italy, which resulted in widespread deposition of dioxins (polychlorinated dibenzo dioxins and furans).

3.6.2.3 Property Effects

Property damage is typically most severe from fire and explosion. The largest number of incidents of property damage are from fire. Table 3.6 summarizes the effects of variouslevels of thermal radiation on property (and humans). Table 3.7 summarizes the effects of various explosion overpressure levels on property.

While it is less widely reported, property damage can also occur from corrosive gases and from released corrosive liquids, solids, or multiphase material.

TABLE 3.7
Damage Produced by Blast

Pressure (psig)	*Damage*
0.02	Annoying noise (137 dB if of low frequency 10–15 Hz).
0.03	Occasional breaking of large glass windows already under strain.
0.04	Loud noise (143 dB), sonic boom glass failure.
0.1	Breakage of small windows under strain.
0.15	Typical pressure for glass breakage.
0.3	"Safe distance" (probability 0.95 no serious damage beyond this value); projectile limit; some damage to house ceilings; 10% window glass broken.
0.4	Limited minor structural damage.
0.5–1.0	Large and small windows usually shattered; occasional damage to window frames.
0.7	Minor damage to house structures.
1.0	Partial demolition of houses, made uninhabitable.
1–2	Corrugated asbestos shattered; corrugated steel or aluminum panels, fastenings fail, followed by buckling; wood panels (standard housing) fastenings fail, panels blown in.
1.3	Steel frame of clad building slightly distorted.
2.0	Partial collapse of walls and roofs of houses.
2–3	Concrete or cinder block walls, not reinforced, shattered.
2.3	Lower limit of serious structural damage.
2.5	50% destruction of brickwork of houses.
3.0	Heavy machines (3000 lb) in industrial building suffered little damage; steel frame building distorted and pulled away from foundations.
3–4	Frameless, self-framing steel panel building demolished; rupture of oil storage tanks.
4.0	Cladding of light industrial buildings ruptured.
5.0	Wooden utility poles snapped; tall hydraulic press (40,000 lb) in building slightly damaged.
5–7	Nearly complete destruction of houses.
7.0	Loaded rail tank cars overturned.
7–8	Brick panels, 8–12 in. thick, not reinforced, fail by shearing or flexure.
9.0	Loaded train boxcars completely demolished.
10	Probable total destruction of buildings; heavy machines tools (7000 lb) moved and badly damaged, very heavy machine tools (12,000 lb) survived.
300	Limit of crater lip.

SOURCE: *Guidelines for Chemical Process Quantitative Risk Analysis.* New York: AIChE.

3.6.3. Unexpected Hazards

Occasionally unexpected hazards can have significant impacts in a hazardous material incident. One well-known example was the fire at a Sandoz facility in Switzerland used to store pesticides. The water used to extinguish the fire flowed into the Rhine River carrying with it significant quantities of pesticide. This incident affected the drinking water supplies in several countries as well as affecting the aquatic environment.

This incident demonstrates the need to review a plant's secondary containment structures and stormwater drainage systems to determine whether effective strategies to contain fire water runoff can be developed with existing facilities.

One hazard that may be unexpected is the potential for discharge of multiphase material from an emergency relief system. This possibility must be considered in the design of the relief system, or the sizing may be inadequate to relieve pressure during a fire or runaway reaction. It is often surprising to see that, after the first successful emergency relief occurs as planned, this two-phase material will be projected in the air and the nongaseous material will rain down to the ground over a large area. Depending on the characteristics of the material, it can represent an environmental threat (i.e., for material similar to that involved in the Seveso incident), result in exposure to or have other effects on the skin, or cause property damage due to adhesion or corrosive properties. In one such incident, a chlorinated organic intermediate rained over a wide area resulting in surface damage to the paint of several hundred automobiles belonging to both workers and the general public.

Another case where this hazard may be less obvious is a process configuration that allows storage tank liquid overfills to enter a common vent line also used to intermittently vent pressurized vessels. Any liquid entering the common line may be propelled by the high pressure vent gas and damage downstream equipment or be released to the environment. In one such incident, a liquid herbicide overflowed into a vent line and was subsequently discharged at high pressure and velocity and rained down on an adjacent livestock grazing pasture. The effects of the incident remained undiscovered until the cattle became ill and several died from feeding on the affected grass.

3.6.4. Other Effects

Other effects of emergency incidents that may be a consideration in emergency planning include:

- Odor
- Smoke/soot
- Visible plume
- Other particulates

Odor can have a beneficial effect if it becomes apparent before health effects occur. This can result in warnings to people to escape or seek shelter. In other cases odor can have negative effects where the threshold is significantly below the acute effects threshold. If odor is routinely emitted, people may become used to it or ignore it when a serious incident occurs. In other cases it may result in elevated public concern, even though there are no health effects, which can divert attention and resources from other emergency response needs. An example of this type of problem is mercaptans, which have extremely low odor thresholds. To compound the difficulty, mercaptans are often used as odorants for natural gas and can be mistaken for natural gas leaks.

Soot and smoke can result from incomplete combustion in many fires. Soot and smoke may contain harmful particulates and products of incomplete combustion, even when the fire is limited to ordinary combustible materials such as wood. Acute effects are typically limited to high exposures where respiratory irritation, impairment, or damage can result. In hazardous material fires, this may be compounded by the generation of toxic byproducts of incomplete combustion. Generally, information on such byproducts is not widely available in a comprehensive reference for a wide range of chemicals.

Any emergency that becomes publicized in surrounding communities can elicit a variety of perceptions including fear, concern for public health, and anger; therefore, it is necessary to consider the community in emergency planning, both to maintain good community relations and, in some cases, for assistance. Further guidance on relations with the community is provided in Chapter 8 of this book and by the Chemical Manufacturers Association in the *Community Awareness and Emergency Response* (CAER) *Code of Management Practices* [8].

3.7. CRITERIA FOR SELECTING INCIDENTS FOR EMERGENCY PLANNING

Once consequence assessment is finished, there may be a need to select additional incidents that will be used for action planning, tabletop exercises, and drills. This will depend on how many incidents were carried into the consequence assessment phase and whether the better definition of effects obtained from the assessments resulted in a change in perceived severity and risk. Any incidents no longer considered potentially severe can be deleted. If further reductions are needed, consider the minimum necessary to meet the key objectives of emergency planning discussed in Section 3.4, to identify a group of incidents that are representative of:

- The various types of hazards.
- The upper boundaries of severity of consequences.
- The upper boundaries of risk.

Generally, these will include up to ten types of incidents that reflect the range of hazards, strategies, equipment, technique, and scale of operations that will be encountered in the majority of incidents. Including a larger number of incidents may detract from the usability of the emergency plan, and the effectiveness of training and drills.

3.8. REVIEWING MITIGATION SYSTEMS

After consequence assessment is performed or reviewed for emergency planning for the first time, the improved understanding of the potential magnitude of effects often reinforces the need for maximizing the effectiveness of all levels of protection from prevention and mitigation through emergency response. If risk estimates have changed significantly with this improved understanding of potential incidents and their effects, risk estimates should be compared with facility risk policy. If it is believed that the risk is too high, consider refining the estimates through quantitative risk assessment or reducing risk by one or more of the following measures:

- Review prevention systems for adequacy and consider modification based on any new information.
- Review mitigation systems for adequacy and consider modification based on the new information.
- Review spill containment and runoff control systems for adequacy and consider modification based on the new information.

Despite the best intentions and preventive measures, it is also necessary to plan for emergency response. The identification of credible incidents and assessment of consequences provides a firm basis for proceeding with emergency planning.

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APPENDIX A: EMERGENCY PLANNING GUIDELINES: ERPGs/EEPGs

Material	*Molecular Weight*	*Boiling Point (°C)*	*ERPG-1 (mg/m³)*	*EPRG-1 (ppm)*	*ERPG-2 (mg/m³)*	*ERPG-2 (ppm)*	*ERPG-3 (mg/mg³)*	*ERPG-3 (ppm)*
Acetone cyanohydrin**	85.11	95			35	10		
Acrolein	56.06	52.5		0.1	1	0.5	7	3
Acrylic acid	72.06	141.4	6	2	147	50	2210	750
Acrylonitrile**	53.06	77.2			43	20		
Allyl chloride	76.53	44.8	9	3	125	40	939	300
Ammonia	17.03	–33.3	17	25	139	200	696	1000
Bromine	159.81	58.7	1	0.2	7	1	33	5
Butadiene	54.09	–4.41	22	10	111	50	11060	5000
n-butyl acrylate	128.17	147.5	0.26	0.05	131	25	1310	250
n-butylisocyanate	99.13	115.13	0.04	0.01	0.2	0.05	4	1
Carbon disulfide	76.14	46.3	3	1	156	50	1557	500
Carbon tetrachloride	153.82	76.8	126	20	629	100	4718	750
Chlorine	70.91	–34.05	3	1	9	3	58	20
Chlorine trifluoride	92.50	11.8	0.38	0.1	4	1	38	10
Chloroacetyl chloride	112.94	106	0.5	0.1	5	1	46	10
Chloroform**	119.38	61.7			488	100		
Chloropicrin	164.38	115.1		NA	1	0.2	20	3
Chlorosulfonic acid	116.52	152	2	0.4	10	2.1	30	6.3
Chlorotrifluoroethylene	116.47	–28.22	95	20	476	100	1429	300
Crotonaldehyde	70.09	102.4	6	2	29	10	143	50
Diketene	82.08	127.4	3	1	17	5	168	50
Dimethylamine	45.08	6.88	2	1	184	100	922	500
Epichlorohydrin	92.52	116.4	8	2	76	20	378	100
Ethyl chloride**	64.51	12.27			13192	5000		
Ethylene dichloride**	98.96	83.51			405	100		
Ethylene oxide	44.05	10.5		NA	90	50	901	500
Formaldehyde	30.03	–19.3	1	1	12	10	31	25
Hexachlorobutadiene	260.79	214.2	32	3	107	10	320	30
Hexafluoroacetone	166.02			NA	7	1	339	50
Hydrogen bromide**	80.91	–66.7			17	5		
Hydrogen chloride	36.46	–85.03	4	3	30	20	149	100
Hydrogen cyanide	27.03	25.07		NA	11	10	28	25
Hydrogen fluoride	20.01	19.9	4	5	16	20	41	50
Hydrogen sulfide	34.08	–60.4	0.14	0.1	42	30	139	100

Material	Molecular Weight	Boiling Point (°C)	ERPG-1 (mg/m^3)	EPRG-1 (ppm)	ERPG-2 (mg/m^3)	ERPG-2 (ppm)	ERPG-3 (mg/mg^3)	ERPG-3 (ppm)
2-isocyanatoethyl methacrylate	155.20	211.2		NA	1	0.1	6	1
Isobutyronitrile	69.11	103.6	28	10	141	50	565	200
Methacrylonitrile**	67.09	90.31			27	10		
Methanol	32.04	64.5	262	200	1310	1000	6551	5000
Methylamine	31.06	−6.32	13	10	127	100	635	500
Methyl chloride	50.49	−24.2		NA	826	400	2065	1000
Methyl iodide	141.94	−66.5	145	25	290	50	726	125
Methyl isocyanate	57.05	38.4	0.058	0.025	1	0.5	12	5
Methyl mercaptan	48.11	5.95	0.01	0.005	49	25	197	100
Perfluoroisobutylene	218.11			NA	1	0.1	3	0.3
Phenol	94.11	181.9	38	10	192	50	770	200
Phosgene	98.92	7.9		NA	1	0.2	4	1
Phosphorous pentoxide	141.94		5	1	25	4	100	17
Propylene oxide**	58.08	34.2			1188	500		
Styrene	104.15	145.2	213	50	1065	250	4259	1000
Sulfur dioxide	64.06	−10	1	0.3	8	3	39	15
Sulfuric acid (Sulfur trioxide)**	98.08		2	0.5	10	2.5	30	7.5
Sulfuryl fluroide**	102.06	−55.2			626	150		
Tetrafluoroethylene	100.02	−75.6	818	200	4090	1000	40902	10000
Titanium tetrachloride	189.69	217.45	5	1	20	3	100	13
Toluene diisocyanate**	174.16	252.8			1	0.2		
Trimethylamine	59.11	2.87		0.1	242	100	1209	500
Vinyl acetate	86.09	72.76	18	5	264	75	1760	500
Vinyl chloride**	62.50	−13.8			2556	1000		
Vinylidene chloride**	96.94	31.7			198	50		

NA = Not Appropriate — Reference Temperature 25°C

* = EEPG (Emergency Exposure Planning Guideline) is defined as the maximum airborne concentration of a material which, it is believed, nearly all individuals could tolerate for about one hour without incurring permanent health effects or symptoms which would interfere with their ability to take appropriate action.

** = Indicates EEPGs

To convert ERPG values from ppm to mg/m³, use the following equation:

$$ERPG\ (mg/m^3) = \left(\frac{ERPG(PPM)\ MW}{24.45}\right)$$

Source: From Reference [11].

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6

PHYSICAL FACILITIES AND SYSTEMS

6.1. INTRODUCTION

Certain emergency facilities and systems are vital to implementing emergency response strategies and tactics. Important physical facilities used by designated personnel to operate from or to stay in during emergencies include: shelters and safe havens, emergency operations centers, incident command posts, and a media information center. Systems are the equipment, tools, and mechanisms (such as sensors, radios, alarms, computers, and telephones) necessary for facility personnel to carry out their emergency duties.

This chapter reviews many important facilities and systems, including their use and design. The design of these facilities and systems, however, can change rapidly with the development of new technologies and methods. Planners should exercise caution when reviewing the design considerations contained herein and consider all new developments since the publication of this book.

6.2. FACILITIES

Designated personnel use certain physical facilities to operate from or to stay in during emergencies. Important facilities for the planner to consider incorporating into the response system include:

- Shelters and safe havens, used to house or protect people from the effects of the emergency.
- An emergency operations center (EOC), used by facility managers to coordinate and support emergency responder efforts.
- A command post (CP), used by the incident commander to operate from.

- Physical facilities used by persons performing the response, as well as the people affected by the emergency.
- Media center, used by the media and facility public relations personnel.

6.2.1. Short-Term Shelters and Safe Havens

There are generally two choices in planning for the protection of personnel following a toxic release: evacuation or shelter-in-place. Choosing the appropriate protection scheme depends on the type of release and other criteria as indicated in Table 6.1, which describes conditions that generally indicate the appropriate protective action.

Short-term shelters and safe havens provide refuge for people threatened by a toxic substance release when evacuation is not viable. The concept of sheltering people when an evacuation would cause or threaten greater harm is known as "shelter-in-place." In this book, this concept applies to protecting on-site personnel only. There are two types of facilities used to achieve protection-in-place: shelters and safe havens. Shelters afford less protection than safe havens.

A shelter is, by definition, a building or facility that affords protection. Sheltering in the context of emergency response refers to the act of directing persons to remain inside buildings. Shelters provide passive protection for inhabitants when ventilation is off and all windows and other openings are closed. While not necessarily designed to prevent infiltration of contaminated air, most buildings inherently provide a degree of safety. Also, a shelter might be the interior portion of an administration building. This may be used if the release scenario precludes evacuation. Personnel may also use shelters following an evacuation of an isolated area of the facility merely to provide some comfort and protection from the elements.

TABLE 6.1
Example Criteria for Determining Best Protective Action

In-Place Protection	*Evacuation*
Total or one-time release of product from containment.	Prolonged release of a large amount of product.
Vapor cloud moves rapidly and dissipates.	Possibility of further container failure.
Weather conditions promote rapid dissipation of vapors.	Shelter is inadequate for protection.
The release is readily controllable.	Sustained fire with possibly toxic fumes.
No explosive or flammable vapors exist.	Weather conditions preclude rapid dissipation of vapors.

Conversely, engineers purposely design safe havens to provide protection against air inflow once ventilation is shut off (either manually or automatically). Safe havens are usually airtight rooms containing a supply of breathing air such as supplied from bottled compressed air. Often, control rooms are designed as safe havens to enable operators to safely shut down critical systems during an emergency.

6.2.1.1. *Selection and Design*

Planners should select safe havens based on the need for personnel to work relatively unencumbered for a certain time without effect from the external environment. Some control rooms might need to withstand an infiltration of toxic vapors if an orderly shutdown is necessary to prevent a larger problem from occurring. The *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires* [2] covers criteria for protecting control rooms from toxic vapors and other hazards. Another consideration for selecting a safe haven concerns personnel who likely could not evacuate safely due to distance to a shelter or the lack of alternate evacuation routes.

Planners should select short-term shelters for other employees based on adequate size, relative distance from likely incident areas, and being out of the prevalent wind patterns. The shelter should not be so far away that personnel cannot reach it in a timely manner. Before designating a building as a short-term shelter, planners should consider a number of design features, including:

- Structurally sound with no obvious holes, cracks, voids, or other structural weaknesses that may allow hazardous gases to penetrate into the interior unencumbered,
- Adequate seals on doors and windows, and
- Ventilation control/shutoff.

Short-term shelters and safe havens are not intended for long-term occupancy. If long-term sheltering facilities are necessary, plans and designs must provide for a safe supply of indoor air and other support systems (based on the number of people and volume of air).

6.2.1.2. *Use*

Planners should develop procedures for effectively utilizing short-term shelters and safe havens. These procedures would cover:

- Title of the person(s) responsible for determining the need for shelters.
- A reliable means of alerting people to move to shelters, and communicating with them during the emergency.
- How to mark the shelters and havens.
- A means of accounting for persons once they are in shelters or havens.

6.2.2. Emergency Operations Center (EOC)

An EOC is an area where designated personnel coordinate information, develop strategies for addressing the media and government agencies, handle logistical support for the response team, and perform other management functions. A centralized facility allows emergency managers and staff to contend with incident issues more effectively. This section summarizes the features and characteristics of an effective facility EOC.

6.2.2.1. Location of the EOC

The EOC should be spacious enough to safely accommodate 5–15 people for extended periods of time. While it is desirable to have a dedicated room, the typical EOC in an industrial facility is a conference room that can be readily converted for use during an emergency. The advantages of using a conference room are:

- Generally large size.
- General availability of office equipment (copiers, telephones) and information display systems (overhead projectors, white boards) nearby.
- Availability of bathrooms.
- Availability of nearby offices for private conversations.
- Proximity to most managers' offices.

The size of the conference room is not the only criteria for locating the EOC. Obviously, do not locate the EOC too close to any process that might have an incident. Also, potential weather emergencies may affect EOC siting. If the plant is in an area where hurricanes could be a problem, an EOC location should not be on an outside wall or on the first floor because of problems with high winds or flooding.

Ideally, there should be an alternate EOC identically supplied and equipped elsewhere in the facility, should the primary EOC become unusable. To determine the alternate location, plant personnel should analyze the facility to identify an area that would not be seriously affected by the same incident that prevents use of the primary EOC. For example, if a process using chlorine is of concern and the primary EOC is to the south of the process, the alternate EOC's ideal location is in the opposite direction north of the process.

6.2.2.2. Equipping the EOC

People using the EOC will require access to key facility documents and normal office equipment. Table 6.2 contains a list of typical EOC supplies and equipment for consideration.

The EOC must be able to support all the equipment and supplies specified in Table 6.2, either directly inside or next to the EOC. Place large or noisy items such as the photocopying machine or the fax machine near, but not inside the EOC.

TABLE 6.2
Suggested EOC Supplies and Equipment

SUPPLIES
• Emergency plan
• Emergency checklists for managers
• Telephone directories for the plant, corporate headquarters, neighboring plants, government agencies
• Maps and diagrams of plant, buildings, processes, utilities, pipelines, sewers, etc.
• Public information materials
• Material safety data sheets (MSDS)
• Writing materials (pens, paper, notebooks, log books, etc.)
• Flip chart and/or white board
• Coffee and other refreshments
• Message logs
EQUIPMENT
• Emergency power supply systems
• Plant telephones, power failure telephones, cellular telephones
• Two-way radios and backup battery packs and chargers
• Tape recorder
• Emergency management computer system including any dispersion modeling system
• Fax machine
• AM/FM radio
• Photocopying capabilities
• Television, video cassette recorder, hookup to security cameras
• Tables and chairs
• Clock
• Bathrooms (nearby)
• Weather station
• Overhead projector
• Radio scanner
• Personal computer

Many plants have security systems with strategically located video cameras throughout the facility. If wired into the EOC, these could be useful in keeping managers abreast of activities in the field.

6.2.2.3. Design of the Emergency Operations Center

The planner should determine the layout of the EOC in conjunction with the managers who will use it. Figure 6.1 depicts a typical EOC layout.

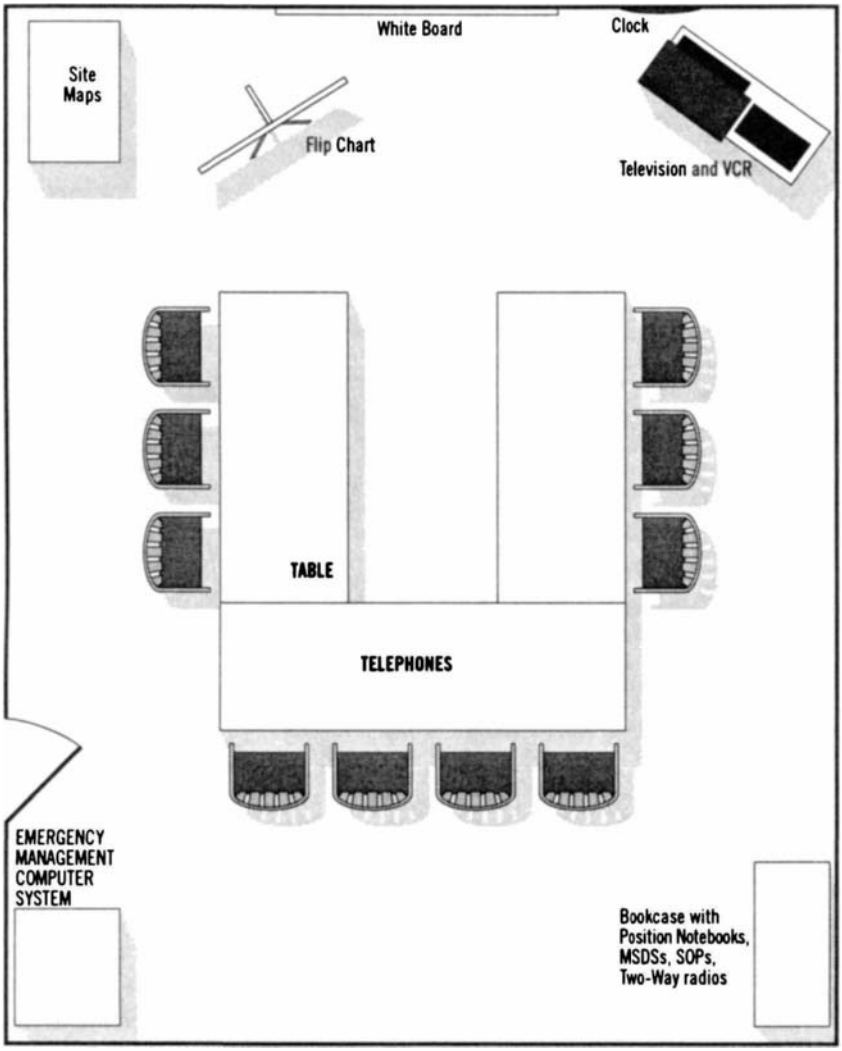


FIGURE 6.1. Typical emergency operations center layout.

An EOC should, at a minimum, meet the requirements for a shelter as specified in Section 6.1.1. The EOC should have the same ventilation, emergency alerting systems, fire protection, and emergency power supply systems as a shelter. All considerations about the design should also meet the specifications in NFPA's 101 Life Safety Code [3]. An EOC should have an emergency power supply system following the specifications contained in Section 6.3.7. Finally, the design criteria should address operations during severe weather.

6.2.3. *Incident Scene Areas*

Response operations require several working areas, including an incident command post, staging area, and entry points for community responders.

6.2.3.1. *Command Post*

The incident commander (IC) manages the incident by assessing it, devising tactical plans, directing resources, monitoring progress, assuring safe practices, and communicating with the managers at the EOC when developing overall incident strategy. The command post (CP) is where the IC and staff work and is the center of tactical management of the incident. The CP may be as simple as the front seat of a pick-up truck or as elaborate as a full-size bus, command platform, or series of trailers and modular vehicles. They all share a number of the same desirable characteristics, including but not limited to:

- Mobility in order to be located at a vantage point to manage tactical forces, and, if possible, safely view the incident itself.
- Safely located, protected from the incident hazard. (Its mobility allows for relocation if the weather changes or the scope of the incident changes.)
- Accessible to operating crews, but able to be secured from non-response personnel.
- Protected from the elements.
- Communication capability: radios, cellular telephone, fax, modem, ideally with secure channels.
- Reference sources: hard copy, on-board database, modem.
- Clear markings, a green light or flag (command staff should also wear identifying clothing, such as vests).
- Sufficient power to operate (with back-up source).
- Incident recording capability, such as 35-mm and instant print camera, video, voice recorder.
- Emergency equipment on hand, including monitoring equipment, binoculars, etc.

6.2.3.2. *Staging Areas*

"Staging areas" refers to the concept of assembling resources (people and equipment) before committing them to an incident assignment. This concept allows the IC to have resources available near the scene before their assignment. Staging areas may be pre-designated or they may be incident specific, identified by the IC. They should be close enough to the incident to allow for a maximum 5-minute

PHOTO 6. Incident Command Post Vehicle.

PHOTO 7. Interior of Incident Command Post Vehicle Showing Support System Equipment.

response, but not so close as to interfere with operating forces or be next to the CP. The staging area should be clearly identified and its location communicated to responders.

6.2.3.3. Community Agency Entry Points

Facility responders should coordinate the response from off-site forces, which starts with their entry through designated gates to the site. The entry site may be predesignated and marked accordingly (and the subject of previous training), or it may be incident-specific. As in the case of staging areas, all designations and instructions must be clear. Assigning a liaison officer to meet with off-site forces and direct community agency response will lessen the possibility for missed communications. Sufficient space is necessary for assembling whatever resources respond from off-site.

6.2.4. Media Information Center (MIC)

An incident of any significance will likely gain the attention of the media. By paying careful attention to the media's needs, a plant may avoid a public relations failure. Without proper planning, the media can disrupt emergency operations, distract management from other essential duties, and possibly endanger themselves and others if allowed to move throughout the plant uncontrolled. Dealing with the media can be easier and less disruptive if a media information center (MIC) is designated. An MIC is a safe and comfortable area where public relations personnel can provide the media with the information they need and where the media can work. (Chapter 8 discusses media interaction during emergency.)

Since the media will have basic questions concerning the layout and operations of the facility, public relations personnel can prepare media information packages that address anticipated questions and place these packages in the MIC. As with the EOC, there needs to be an alternate MIC identified and stocked with the appropriate supplies. Failure to have an adequately supplied MIC can result in a poor impression to the media that may carry on to the public.

The MIC is the focal point for relaying information about an emergency to the public through the media. When the media representatives feel confident with the information they receive, the reports/articles about the incident are typically more accurate. If there are off-site consequences from the incident, the MIC is a central point for the media to obtain information and relay it to the general public.

6.2.4.1. Location of a Media Information Center

Planners should review hazard assessments before identifying the site for the MIC. Most plants have large training or conference rooms (preferably not near the room housing the EOC) capable of holding the media representatives during an emergency. Even a cafeteria can double as an MIC during an emergency. The following are important considerations in selecting the MIC location:

- Is the MIC outside the operational area of the plant?
- Can the media get to the MIC without going near operational areas?
- Is the MIC far away from emergency responders and other key personnel for their safety and protection?
- Will reporters be safely away from the entrance/exit of emergency response vehicles?
- Is the MIC away from any processes that could be involved in an emergency?

Figure 6.2 depicts potential MIC locations within a typical plant. Either an administration building or the training center may be ideal because they are readily accessible, yet usually segregated from production areas and likely emergency response areas.

TABLE 6.3
List of MIC Suggested Supplies and Equipment

SUPPLIES
• Flip chart and/or white board
• Site plot plan
• Descriptions (MSDSs) of the chemicals/solvents involved in the emergency
• Public information materials, including background information on the plant, sample press releases, official stationary, etc.
• Podium with plant name and logo
• Boards for mounting displays or charts
• Office supplies—paper, pens, stapler, tape, etc.
• Copies of each news release
EQUIPMENT
• Telephones—Outside lines for use of the press for modems and voice
• Telephones—Inside lines for use of plant staff
• Electrical outlets for media use
• Microphone and public address system
• Overhead projector
• Photocopying machine
• Television, video cassette recorder
• Tape recorder
• AM/FM radio
• Tables and chairs for media
• Emergency power supply systems
• Clock
• Nearby bathrooms
• Fax machine

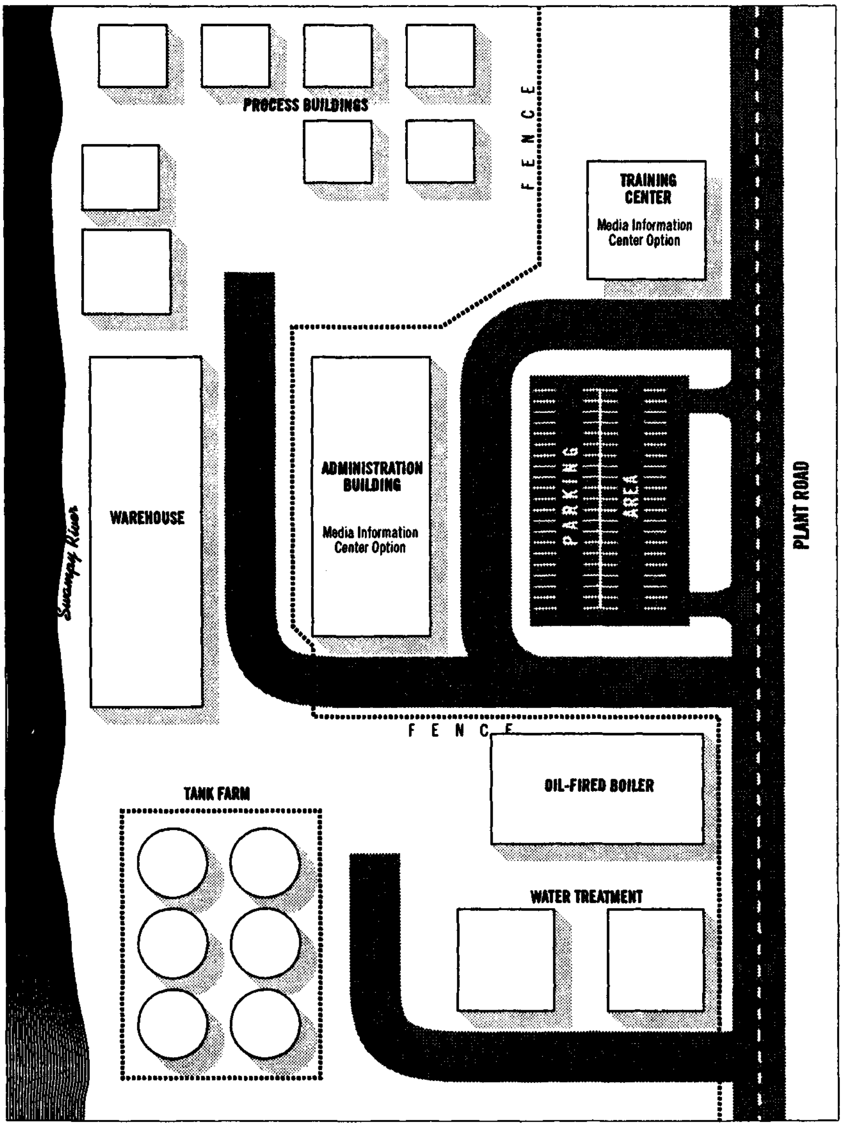
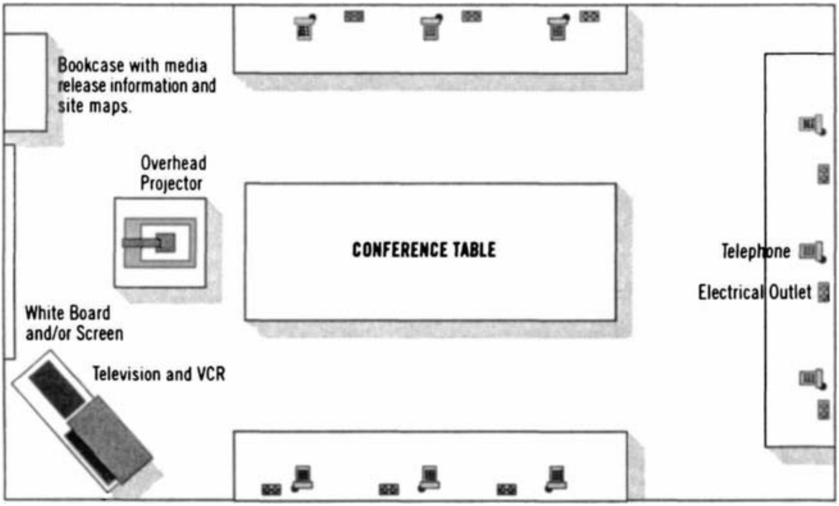
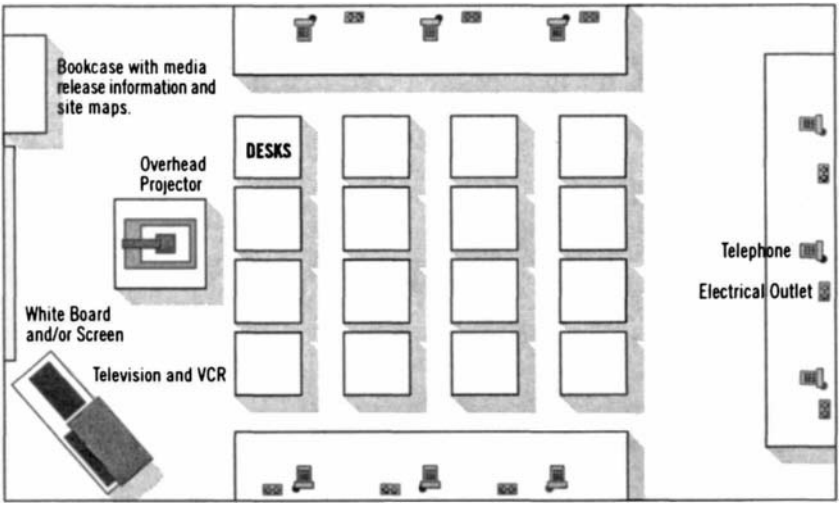


FIGURE 6.2. Example media information center locations.



CONFERENCE ROOM ARRANGEMENT



CONFERENCE ROOM ARRANGEMENT

FIGURE 6.3. Media information center sample layout.

6.2.4.2. Design of MIC

The MIC design is very similar to that of the EOC. It should have ventilation, emergency power supply systems, and other features similar to a shelter. Table 6.3 indicates typical supplies and equipment for the MIC.

The MIC layout should be agreeable to all inhabitants and comfortable for extended time periods. Figure 6.3 depicts a typical MIC layout, although the media spokesperson can arrange the materials as desired.

6.2.5. Control Rooms

A control room houses the primary process control system. For the emergency planning purposes, a process control room needs to:

- Withstand an initial incident in a process.
- Allow operators to safely shut down or control the process.
- Contain personal protective equipment that allows operators to leave the area when necessary.

The control room must conform to applicable industry building standards and local codes concerning its placement and design. The key emergency planning design criteria include:

- HVAC systems.
- Emergency power supply systems for process operation and shutdown.
- Emergency process shutdown.

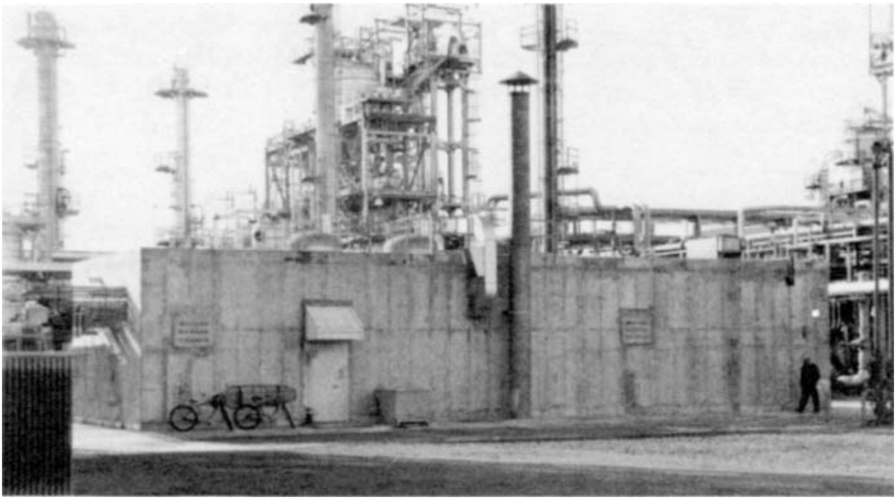


PHOTO 8. Reinforced Control Room Building in Operating Area'

- Emergency communications into the control room and out of the control room (especially with the command post) with either power failure phones or radios.
- Wiring of local alarm systems into the control room.
- Overpressure protection, where applicable.

Control rooms also can be sources of communications for emergency assistance and can be focal points for emergency notification. *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires* provides additional control room design information [2].

6.2.6. Medical Support Facilities

A critical response function is treating injuries caused by the emergency. These injuries may include thermal burns, chemical exposure, skeletal injuries, an aggravation of an existing medical condition, or a combination of all. These injuries may range in number and scope from few severely injured persons to a large number of varied and complicated injuries. Some people may need immediate, life-saving attention, while others may need less intensive intervention. All might need some degree of decontamination. Chapters 8, 11, and 12 discusses this in greater detail.

In many industrial facilities, the source of day-to-day treatment of medical emergencies and routine physical examinations is the clinic, first-aid room, or nurses office. In a chemical emergency, while it may be the first place thought of for medical care, some of the characteristics that make this the ideal location for daily medical affairs causes it to be unsuitable for medical support in an incident. For example, these first aid rooms are generally small, located within other administrative offices, and may lack the ability to process and decontaminate large numbers of exposed persons; however, these first-aid clinics may well serve as a base of operations in a large-scale incident or be used as a triage center for a small number of critical patients.

6.2.6.1. Coordination with Local Medical Community

An on-site, on-duty emergency medical service (EMS) professional, fire brigade members, the security force, or off-site responders generally provide primary emergency medical services. Because all patients will be transported, a close working relationship with the local medical community is essential. EMS providers must interact with the nearby hospitals, walk-in clinics, and specialized medical care and trauma centers. Duties, responsibilities, medical and command authority, and patient routings are among the many issues to address before an incident.

The facility must work with off-site response organizations to establish a smooth working relationship. The facility should provide site-specific information about the type of chemicals and processes used, likely injuries, specific treatment protocols and supplies, and response routes. MSDSs should be readily available for medical personnel.

Planners and hospital personnel should review the capabilities of area hospitals including total beds, their ability to treat chemical injuries, decontamination facilities, and any specialized capabilities. Hospitals should identify the amount of specialized supplies necessary for any specific chemical injuries, such as calcium gluconate, cyanide antidotes, and eye treatments.

6.2.6.2. *Airlift Requirements*

The use of air medical evacuation (medivac) by helicopters has become a widely used practice. Medivac is a life-saving operation that can bring a critically injured person very quickly to an advanced trauma center for treatment.

Medivac units have some requirements and procedures under which they operate. Most medivac units will not transport chemically injured victims if doubt exists as to contamination; therefore, facilities must plan to thoroughly decontaminate a patient. Most helicopters require very modest areas to approach and land; at a minimum, helicopters need a 100-foot diameter area with approaches completely clear of wires, trees, or other structures or obstructions. Ground transport units must use extreme caution when approaching the helicopter; specific training on helicopter operations is recommended. Planners should identify and mark at least one primary and several secondary landing zones.

Planners should review issues relating to landing zones, transport protocols, operating with air crews, patient transfers, terminology with the medivac crews, and training.

6.2.6.3. *Mass Casualty and Decontamination*

Planning for emergencies must include the possibility of mass casualties and the potential of large numbers of patients requiring decontamination. By definition, a mass casualty incident is one in which the number and severity of injuries exceeds resources, thus requiring an assessment of injuries and a priority for treatment and transport. The strain on the system precludes treating and transporting all patients at once. Delaying care depends on the severity of injuries, total numbers of patients, and the ability of the system to provide care. The facility must assess the possibility for a mass casualty incident and develop contingencies based on the anticipated number and severity of injuries, and the heath care system available to treat those injuries. Response protocols, supplies, locations of triage and treatment areas, hospital routing, and communications must all be addressed.

The possibility of large-scale chemical exposure exists at many industrial facilities; therefore, planners should develop decontamination equipment and procedures. Existing safety showers may be used, supported by portable facilities, keeping in mind the need to control runoff water. Planners should identify the need for and stockpile decontamination solutions and fresh clothing for those requiring it. Planners should develop a method of accounting for all persons who have been through the decontamination system and for securing personal items.

6.2.7. Adequate Water Supplies

Having a sufficient water supply is very important to emergency response. Specific industrial applications will vary as to the processes involved, chemicals used, oxidation potential, rate of heat production, and other factors that will result in fire flows of up to and exceeding 12,000 gallons per minute (gpm).

Major factors affecting water demand include:

- Deluge and sprinkler system demand.
- Automatic and manual foam system demand.
- Hose stream and monitor appliance demands.

6.2.7.1. Alternate Sources

In addition to the normal water supply sources, planners should identify alternate water sources to assure water delivery in an emergency if the primary source is unavailable. Some of the more common sources of alternate water supply include on-site storage tanks, cooling tower basins, clarifiers, and cisterns. Other alternatives might include lakes, ponds, reservoirs, and portable basins. All of these sources share some common care and maintenance issues, and they should be protected against earthquakes, freezing, flood damage, drought, and silt build-up. In the case of storage tanks, mechanical components should be inspected and regularly maintained. Planners should pay close attention to the required fire flow and duration when planning for alternate sources of water supply.

6.2.7.2. Access and Connecting to Alternate Sources

All alternate water sources must have clear access for a fire vehicle to take draft from the source. These factors include hard surface road or platform capable of supporting heavy (20 tons) vehicles within 10 feet of the source. The lift from the surface of the water should not exceed 10 feet.

If the source is an above-ground tank with head pressure, access must include space for the fire pumper to connect to the supply coupling from the tank. If the alternate source includes a stationary pump, drafting is less important than fire pump maintenance and the ability of the fire pumper to connect to it. All of the mentioned connections should be clearly marked, and parking or other obstructions should not be allowed for at least 25 feet in all directions.

There should be a definite procedure for connecting into alternate sources, and a shutdown and disconnect procedure to assure proper operation in the future. Using "dry" hydrants and floating strainers in the case of static sources may also be indicated.

6.3. SYSTEMS

Technology will continue to change and provide newer systems for dealing with all phases of emergency management. Systems typically refer to electronic devices or tools that facilitate collecting information, modeling data, and transmitting information. Most systems provide a great resource in emergency planning and response. Systems used by untrained personnel or that are fed erroneous data will hurt the emergency planning and response process. Erroneous data fed to systems can lead to disastrous results or seriously injure an employee.

Consider the consequences of assuming the wind direction in the event of a gas leak. If the assumption is wrong (i.e., assuming the wind is coming from the east when in reality it is to the east), dangerous plumes will cover unprotected areas.

The following example depicts the ramification of overconfidence in an alarm or alerting system:

> A pulp and paper mill uses a hazardous material in its paper bleaching process. All mill employees are aware that the detection alarms and sirens are in place, and, when an alarm sounds, mill employees first look at the wind sock on top of the bleach plant to see in what direction to run. During the installation of the detection alarms however, the installers accidentally did not hook up the detection alarms on the first floor of the bleach plant to the control room or the overall plant siren.
>
> One day, a flange splits and the hazardous material releases within the building. The heavier than air vapors sink to the first floor. An operator riding a man-lift down to the first floor does not hear an alarm and is overcome by the vapors when stepping off the lift.

The above example demonstrates the need for fully testing and exercising emergency systems following installation, and on a regular basis thereafter.

6.3.1. Detection/Early Warning Systems

Many devices are available to provide warning of potentially harmful conditions in processes, storage, and transportation. These include, but are not limited to, level alarms, temperature alarms, overspeed indicators, and many other devices that serve as a warning of a potential problem. Water flow and sprinkler alarms are also a means of detecting fire, with the supposition that a flow of water to the sprinkler system indicates a fire.

Hazardous materials detectors are available to sense the release or accumulation of various harmful gases. These units may be portable or permanently installed. Combustible gas indicators detect only levels of potentially flammable or explosive gases and do not identify specific gases. Other types can sense only those specific gases preset or programmed in them. These are useful, however, when the facility has a number of target products that require detection. Typical of these are oxygen, chlorine, carbon monoxide, hydrogen sulfide, and sulfur dioxide.

Table 6.4 indicates the techniques used for detecting a number of hazardous gases.

TABLE 6.4
Evaluation of Gas Sensing Methods[a]

Principle	Parameter[b]			Sample System	Typical sensitivities[c]				
	Sensi-tivity	Selec-tivity	Respond Speed		0.01 ppm	0.1 ppm	1 ppm	10 ppm	100 ppm
OPTICAL									
Infrared absorption	6	9	6	Yes/No				CO	VC, SO_2, $COCl_2$
Ultraviolet absorption	7	6	6	Yes/No	Hg				
Fluorescence	8	8	6	Yes					
Flame emission	8	6	6	Yes	P	S			
Chemiluminescence	8	8	6	Yes	O_3	NO_x			
Colorimetry	6	8	3	Yes		$COCl_2$	Cl_2	SO_2, H_2S	
Laser	7	8	9	No		HC, $COCl_2$			
ELECTROCHEMICAL									
Conductimetry	6	4	6	Yes		HCl	SO_2, Cl_2		
Galvanometry	8	5	4	Yes		H_2S, $COCl_2$	HCN, NO_2		
Coulometry	6	6	4	Yes		SO_2, NO_2		CO	
Polarography	6	6	6	Yes			H_2S, NO_2	NO	CO
Potentiometry	6	4	8	Yes		F–	Cl–, S=		
IONIZATION									
Hydrogen flame	9	5	8	Yes			=C=		
Photoionization	8	2	8	Yes			>10 eV		
Aerosol ion current absorption	8	4	6	Yes			HF, F_2, Cl_2		
CHROMATOGRAPHIC									
Gas chromatograph	9	9	2	Yes			HC		
THERMAL									
Conductivity	3	2	6	Yes				HC	
Catalytic combustion	8	7	9	No				HC	
Semiconductor	9	2	9	No			HC		

[a]Reference CCPS *Guidelines for Vapor Release Mitigation*, AICHE, 1988 [1, p. 80].
[b]Numbers represent ratings from very poor (0) to very good (10).
[c]VC = vinyl chloride; HC = hydrocarbons

6.3.2. *Communications System Design*

Communications within the plant, to off-site agencies, and between responders are all important and required for a coordinated and effective response effort. For emergency planning purposes, two distinct communications groups exist: telephone services and radio services. With the growth in radio technology, cellular communications, and the linking of telephones and radios, communications possibilities have expanded and will continue to expand. Personnel need training in the disciplines and correct use of communications equipment.

6.3.2.1. Direct Phone Lines and PBX

Local telephone companies provide direct phone lines. The local telephone company is responsible for providing the power for the phone signals and acts as the primary switching center for the phones. Private branch exchanges (PBX) are a switching center within the plant. The plant or a contractor normally maintains the on-site PBX. Table 6.5 shows the differences between the two phone systems and their features related to emergency planning.

The trend in business and industry is to use PBX systems for day-to-day telephones. PBX systems offer many features that are useful for emergency response, including the ability to perform conference calls, broadcast calls, and other features. Management should control access to the PBX room since communications are vital.

There also should be access from the plant to alternate telephone exchanges in case the primary exchange becomes overloaded. In the event of high winds or other hazards that could affect telephone wires, the plant should arrange for priority restoration. Cellular telephones are particularly useful for their mobility. Cellular telephones allow the emergency responders to telephone the EOC, any

TABLE 6.5
Direct Phone Lines versus PBX Phones

Direct Phone Line	*PBX Phones*
Power from off-site source	Relies on plant power—normally, less reliable than the telephone company
No programmed phones required	Usually requires phones to be programmed for an outlet/extension
Limited flexibility for conference calls, site wide broadcasts, etc.	Very flexible—quick and easy conference calls, all phone broadcasts
Easily compatible with devices such as fax machines and modems	Usually require special analog-to-digital cards on each extension to allow the use of fax machines or modems

off-site responders, and any persons reachable by conventional telephone. Finally, satellite telephone services are available, albeit relatively expensive.

6.3.2.2. Radio

Many facility emergency teams use traditional radio systems capable of communicating on-site, but with a limited range off-site. New technologies exist to further enhance communication, such as trunking and repeater.

Radio trunking systems are now available that behave like a telephone trunking system; the system routes calls and provides electronic features such as call waiting, paging, etc. The benefits of trunking systems (usually in the 800 or 900 megahertz range) include:

- Increased capacity of communications on a limited number of frequencies.
- Direct tie-ins to telephone systems.
- Secure conversations between interested parties (limited to the two transceivers).
- Encrypting signals.

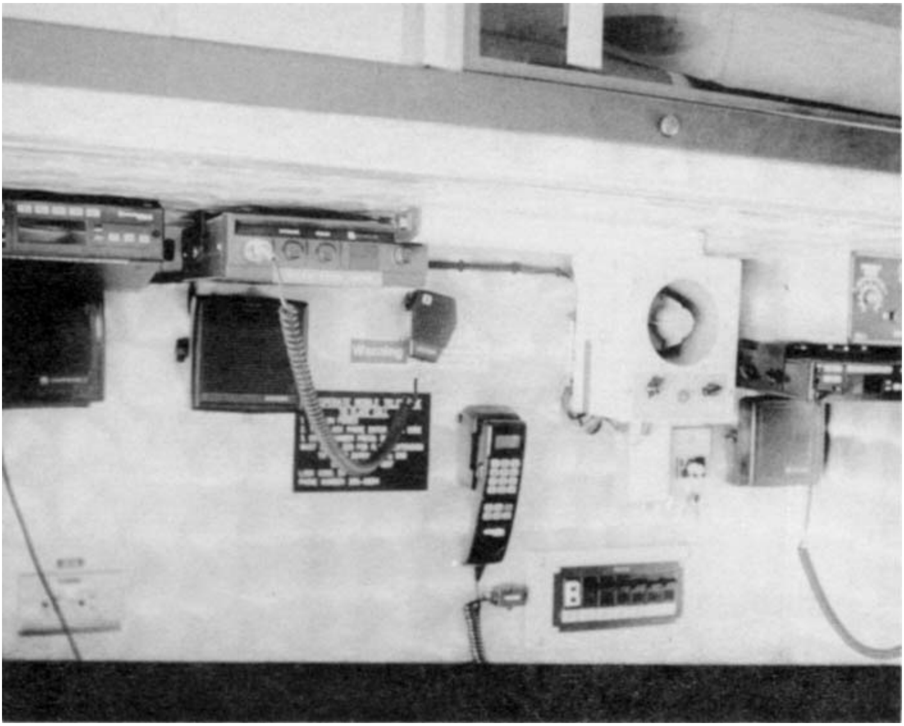


PHOTO 9. Emergency Communication Equipment in a Command Post Vehicle.

Trunking systems can also dynamically group radios and broadcasting messages to select groups of users on an "as needed" basis. The disadvantage of radio trunking systems is the cost, and few facilities are willing to add a trunking system solely for emergency management purposes.

Finally, personnel must be trained to use radios properly. In contrast to telephones, they provide only "one way" communication. Users must be taught to be concise with their information, to indicate the end of their message, to listen for the response to their communication, and to identify themselves.

Communications with off-site agencies can be critical, and there are many ways to connect an off-site agency with a plant. Table 6.6 indicates the different methods, their advantages, and disadvantages of connecting off-site community response agencies with a plant.

Due to the wide variety of communications systems available, radio systems are not always compatible. The lack of compatibility can lead to frustration for responders. Ideally, off-site and on-site responders should be able to communicate by direct radio communications with the flip of a switch.

Another problem concerns the security of radio communications. Many people now have radio scanners and can listen to sensitive communications unless the radios used have scramblers.

TABLE 6.6
Off-Site Communications Options

Option	*Advantage*	*Disadvantage*
Give the agency a plant radio with an emergency channel used by the plant.	Gives the off-site agency easy access to the plant. Cost for the plant is number of radios given to different agencies.	Limits the accessibility of radio communications to/from the agency. Extra hardware that requires maintenance for the agency.
Install the frequencies of emergency channels on plant and off-site agencies.	Gives the off-site agency easy access to the plant. Gives each party the ability to flip a switch to gain access to the other's frequency.	Potentially high initial cost of installation. Each radio needs to be altered to accept the new frequency. Some radios may not have room for another channel.
Have an agency representative at the EOC.	No cost. Facilitates communications.	Adds additional personnel to sometimes crowded and noisy EOC.
Do nothing—provide no means of communication.	No cost initially.	Limits the ability of off-site agencies to actively participate in a coordinated response effort.

Plants should have enough extra batteries and rapid recharging capabilities to ensure use during extended emergencies.

6.3.3. *Community and Site Alerting and Notification Systems*

Community and site alerting and notification systems require the cooperative planning between plant and off-site officials to effectively use the systems. When a plant has a potential to affect off-site areas, local officials and plant personnel must be able to receive clear and concise information about the incident so they know what to do immediately.

Community and site personnel must be able to receive messages about all types of hazards. The system should have a capability to indicate the nature of the hazard, identify the necessary response, and direct the public in their actions. Possible uses of an alerting system include:

- A release at the nearby chemical plant occurred, and the public should stay inside their houses or they should evacuate.
- Tornado warnings.
- A release of chemical product into the river taints the community's water supply and all water consumption must cease.

Where a community does not have a system, the plant should consider putting one in. For a site alerting system, the system should have the following features:

- Everyone can hear it.
- Anyone can see it (e.g., strobe lights).
- It can provide a general alarm or coded signals.
- It can provide PA messages.

These examples do not provide all the possible uses, but rather they illustrate the variety of situations that alerting systems need to address.

Notification technologies have advanced in recent years, but many plants still use old systems. While the costs of the newer systems are significant, the certainty of notification is more reliable than the older systems.

Systems and methods that have been available for the past few decades provide basic alerting, but do not confirm if notification was successful. These include sirens and alarms, door-to-door notification, loudspeakers, public address systems, and television and radio broadcasts. Each system entails advantages and disadvantages. Many methods require extensive time to implement (for example, it is very time consuming to relay evacuation notices door-to-door in sparsely populated areas).

Frequently, response agencies use these systems in tandem to complete the notification. For example, when a community siren sounds, the Emergency Broadcast System (EBS) will subsequently broadcast a message over radio and television. The only traditional method that confirms receipt of the emergency message is door-to-door notification.

Technology-based systems can include computer telephone dialing systems, tone-alert systems, and cable television override systems. The computer telephone dialing systems can have the call receiver enter codes if they received the message. (This requires that people have touch-tone phones.) Tone-activated systems are radio receivers located in the homes around a plant and activated by a special radio transmission, indicating a problem at the plant. These systems can be expensive to initiate and maintain, but are useful when used in conjunction with other methods to notify a broad range of persons.

Redundant systems are important in case of power failures, other failure, or routine maintenance. Having spare batteries and repeaters or power generators helps overcome basic system failure problems. Backup systems are also important. Backups to tone-alerts systems are door-to-door notification, sirens, EBS messages, etc. The backup to sirens and EBS messages is door-to-door notification. A backup to on-site sirens or PA systems can be telephoning the area monitor in all areas of the plant who, in turn, passes along notification to nearby employees.

6.3.4. Computer Systems for Emergency Management

An emergency management computer system organizes the information necessary for managing all phases of emergencies. The typical system should incorporate all relevant databases such as chemical information, emergency plans and procedures, resource databases, and technical references. Typically, these systems are available for IBM-PC compatible or Apple Macintosh computers. The system should preferably be part of an intercompany local area network (LAN) or wide area network (WAN) so the information is available to personnel responsible for emergency response, that is, those manning the incident command post (ICP) and/or the emergency operations center (EOC).

6.3.4.1. Design Criteria

An emergency management computer information system should track emergency equipment inventories, contain site maps, connect to a dispersion modeling program, and store emergency procedures. An enhanced system would integrate with the overall process safety management, maintenance, purchasing, personnel, processes, and all other facility activities. There are a number of commercially available systems.

The emergency management information system can also be connected to alarms, sensors, and a real-time meteorological data gathering system. The weather data can be very crucial in an emergency.

Linking all or some of these features will allow an operator to gather all relevant information at one single terminal. For example, in the event of a pipeline rupture, an operator can use a computer system to:

- See where the leak is.
- See the schematic of the piping.

- Determine the last maintenance performed on the pipe.
- Locate the nearest storm drain or process drain to the rupture.
- Check the warehouse for the number of absorbent booms capable of containing the spill.
- Model the consequences of the release.
- Display a facility map showing distances to toxic and/or flammable concentrations.
- Identify cleanup contractors.
- Display the material safety data sheet for the released material.
- Display the plant's hazardous material spill procedure.

6.3.4.2. *Limitations*

Emergency management computer systems have two primary limitations: maintenance and updating, and power during emergencies. Information systems are only as good as the information contained, and these systems require updating. An inventory system of emergency supplies can be difficult to keep up to date. Often there is inadequate staff to update information used only during an emergency. Also, these systems should only be used by persons with adequate training.

For information to be available at the time of an emergency, the system must be operational in all types of situations, including power failures, hurricanes, etc. Protecting the computer system is essential, and underscores the importance of emergency power supply system discussed in Section 6.3.7.

6.3.5. Site Maps and Diagrams for Emergency Management

Maps and diagrams locating vital response information are an integral tool in preparing for and responding to an incident. Site maps will be able to provide most of the plant features at the time of an incident. For example, locating the hazardous materials storage and process areas allows responders to identify potential subsequent problems (e.g., secondary exposures, utility problems). Maps of utilities, sewers, firewater systems, etc. are also important to identify positive or negative impacts of the emergency on these systems.

Maps could be stored in emergency response vehicles, off-site response vehicles, the EOC, and the media information center. Maps intended for field use could be laminated for use in all weather.

For emergency planning purposes, only one site map is necessary. Individual features listed in the following sections are easily added in layers above the basic site map. These maps are best computer generated for quick and easy changes and quick production. Ideally, maps should be part of the plant's computer-aided design system. Individuals who constantly update the plant engineering documents and drawings are usually best able to update the maps used for emergency response. In the absence of a drawing department, several desktop computer packages that run on a variety of hardware platforms are available to produce excellent quality maps. These packages are available for most computer platforms.

Maps for emergency plans should not be too complex. The scale and level of detail are best left to the discretion of the drafters and the responders. The symbols used could follow the conventions of NFPA 170 [6] or corporate standards. NFPA 170 is ideal because of its common use by fire and rescue departments in fire pre-planning.

Plants frequently undergo change (such as the contents of tanks, the routing of wiring, and the routes of pipe), and it is important to try to keep them up to date on site maps. Regular updates and document tracking will help ensure the quality of the information within the maps. Plant personnel must perform document tracking to ensure that responders have the latest version of facility maps.

Site maps provide responders and management with an overview of the incident scene and identify vulnerable processes, facilities, and utilities. The incident commander can use the maps to track response personnel, efforts in areas, and other incident-specific information.

Typical contents of a site map suitable for emergency response programs are listed in Table 6.7.

6.3.6. *Emergency Power Systems*

Emergency power supply systems (EPSS) are critical to enable a facility to maintain its many critical systems (e.g., telephones, radios, HVAC, process control, notification systems, alarm systems) during a power outage. Every critical facility and emergency management system should have an EPSS for temporary power. Emergency power can be generated by a battery rack, an internal combustion engine attached to a generator, or a separate feed of energy from another electrical source. Combustion engines connected to generators are considered emergency power supplies, whereas battery racks are considered stored energy systems. NFPA has a standard for each type of system:

- *NFPA 110, Emergency and Standby Power Systems* [4].
- *NFPA 111, Stored Electrical Energy Emergency and Standby Power Systems* [5].

When designing an EPSS for an emergency facility or system, designers should review these standards and local codes.

In choosing the type of system that will be adequate to meet the needs of each facility, planners should consider the following questions:

- How quickly does emergency power need to be supplied after the loss of main electrical power? For some duties, an uninterruptible power source (UPS) may be warranted. An example might be controlling exothermic chemical reactions in progress.

TABLE 6.7
Suggested Content of Site Maps and Diagrams for Emergency Response

GENERAL LAYOUT	UTILITY SERVICE
• Materials Storage Area	• Fire Water Mains
—Tanks	—Hydrants
—Warehouses	—Monitors
—Drum Lots	—Foam Stations
—Rail Car Sidings	• Water Mains
• Process Areas	—Process
—Equipment	—Cooling
—Racks/Buildings	—Potable
—Control Rooms	• Steam Mains
—Laboratories	• Other Heating/Cooling Fluid Mains
• Service Areas	• Gas Services
—Offices	—Nitrogen
—Laboratories	—Air
—Powerhouse	• Electric Power Distribution
—Emergency Garage	—Mainlines
—Dispensary	—Switchboxes
• Access	—Transformers
—Site Road	• Sewers Lines
—Exists/Entrances	—Storm
—Site Roads	—Chemical Waste
—Docks	—Sanitary
	—Sumps/Cross Connects
PROCESS TRANSFERS	—Lift Station
• Major Process Piping	—Oil/Water Separators
—Load/Unload Materials	—pH/Flammable Gas Monitor Station
—Storage Area Process Area	
• Pumps	**OFF-SITE FEATURES**
• Block Valves	• Direction and distance to sensitive occupied locations
• Conveyors	—Schools, Hospitals, Prisons
	—Homes
	—Tunnels, Bridges, Highways

- What is the estimated minimum number of hours the emergency power must be supplied before refueling or recharging?
- Could the failure of electrical power result in loss of life or serious injury?
- What is the expected location of the EPSS?
- How much load is expected to be carried by the EPSS?
- Is the plant located in an area with the potential for severe inclement weather or seismic activity that would result in prolonged power outages?

In answering the above questions, a planner should determine the NFPA type, class, and level. NFPA 110 provides pertinent information on the identifiers. Once the planner determines these and the other requirements, vendors can provide the necessary technical support to choose the best type of EPSS for the given facility application.

Installing an EPSS at each facility is expensive and can incur a costly and tedious maintenance schedule. Having too few EPSSs can limit the amount of maintenance, but can leave key facilities powerless if a primary EPSS falters when power fails. These systems must be tested frequently to ensure reliability.

6.3.7. Weather Stations

Weather stations help planners evaluate weather for uses in dispersion models and tracking meteorological trends. A weather station should be constructed of stainless steel parts or other corrosion-resistant materials. The station should be located in an area away from structures or other obstructions that would interfere with its operation. More than one weather station is ideal to duplicate the analysis of the conditions for a detailed analysis of plant conditions. The stations should ideally have continuous data loggers for the retrieval of information and analysis of information.

Weather stations are limited in the conditions they measure. The station measures the condition at only one point in the plant. Thus, more stations located at strategic points elsewhere in the plant will help determine facility-wide conditions and show how on-site processes can affect the conditions. During an emergency, the weather station may require an EPSS.

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12

SUPPORT FUNCTIONS, SYSTEMS, AND FACILITIES

12.1. INTRODUCTION

This chapter discusses planning considerations for essential support functions, systems, and facilities needed during and subsequent to an on-site emergency. Incidents that require activation of on-site emergency response organizations rely on these activities to provide basic organizational and logistical support. These activities are necessary to marshal resources for effective response, collect information and respond to public inquiry, provide emergency medical care, and report to government agencies. The scope of these support activities includes communicating with external agencies, dealing with the news media, maintaining site security, coordinating assistance from external response agencies, and recalling off-shift personnel and expert technical assistance. Planning these support activities before an incident can substantially improve emergency response performance.

12.2. FUNCTIONS

12.2.1. Internal Management and Technical Support

Corporate and local managers have an important role in preparing emergency plans, procedures, and protocols. Management has responsibility for carrying out these protocols and procedures during emergencies to protect people at the facility and the public, as well as to limit damage. Additionally, management is concerned with reducing the adverse impact on the corporate public image and on financial damage, including lost production and possible fines.

Technical support consists of personnel within the organization and outside emergency response groups. Technical support personnel within the organization include engineers, chemists, operators, maintenance personnel, and managers having special knowledge of process operations, emergency systems, building plans and equipment layout, and hazardous materials present. A technical support team consisting of these experts or others with similar qualifications will provide the Incident Commander with a pool of knowledge to draw on during emergencies. Technical support team members should be placed on the recall list with designated alternates in the event team members are directly involved with the emergency or are not available.

The emergency action plan identifies the emergency response organization and responsibilities of specific personnel at the facility. While the emergency response team (ERT) is dealing with the incident, management personnel should be staffing the Emergency Operations Center (EOC) and other parts of the support structure. The following lists some activities that can be assigned to management personnel:

- Begin recall of essential personnel starting with key emergency response team members and support personnel.
- Contact mutual-aid or outside-aid organizations as requested by the incident commander.
- Provide logistical support by contacting emergency equipment and material vendors to obtain additional equipment and supplies as necessary.
- Maintain personnel accountability and identify missing individuals.
- Set up and establish communications, including backup and alternative systems.
- Notify families and personnel.
- Communicate with and begin preparing reports for government agencies (such as the LEPC and other local emergency response organizations) and the news media.
- Start collecting information necessary for incident investigation, press release, government reporting, and legal.

Suggestions of specific managerial functions for typical plant positions follow. Each plant is different and these functions must be written for plant-specific personnel capabilities.

12.2.1.1. Plant Manager

The plant manager typically would have responsibility for the following items. Some or all of the items may be delegated to subordinates, particularly in larger facilities. Many facilities assign a senior manager as an EOC coordinator to oversee emergency management activities.

- Ensuring implementation of the plant's emergency plan.
- Providing evacuation decisions.
- Providing command and control over plantwide resources in responding to and recovering from an incident.

- Reviewing and approving the release of any information to the press or public.
- Approving formal or informal emergency response mutual aid agreements with any governmental, community, or industry group.
- Ensuring the availability of adequate resources, staffing and backup staff to support emergency management activities.
- Monitoring the effectiveness of response activities during emergencies and following all appropriate procedures.
- Ensuring continued compliance with the provisions of the company's policy on emergency management.
- Ensuring that government reporting is completed.
- Preparing and submitting emergency-related reports to management as required.
- Ensuring proper cleanup.
- Communicating with community leaders.
- Terminating an emergency ("all clear").

12.2.1.2. Production Managers/Superintendents

The plant's production managers and superintendents, particularly those whose operations are affected by the emergency, provide technical advice to the incident commander about the process or processes under way in the area of the incident. Specific duties might include:

- Providing technical advice and contacting specific individuals for unique details of the incident site.
- Determining the location, size, dollar value, and potential damage to facilities and equipment.
- After the initial incident is under control, providing assistance in determining potential loss of revenue, effect on customers, effect on employees, and estimating how long the affected area will be out of production.
- Evaluating the effects of the incident on the system and neighboring units.

12.2.1.3. Purchasing

The purchasing manager can be responsible for establishing the system necessary to ensure adequate resource support during an incident. Specific duties might include:

- Developing provisions to replenish supplies during an incident, such as establishing purchasing agreements with vendors of emergency supplies, prior to an emergency.
- Obtaining additional emergency supplies during an emergency.
- Assisting in recovery operations.
- Maintaining a list of approved cleanup contractors.
- Notifying suppliers/vendors of the possible need to delay deliveries.

12.2.1.4. Human Resources Department

The Human Resources Department might have responsibility for:

- Assisting in recalling employees.
- Implementing personnel accountability procedures.
- Implementing employee assistance programs following emergencies.
- Initiating appropriate family notifications as required.
- Maintaining current displays and status boards in EOC during emergencies.

12.2.1.5. Safety and Health Manager

The safety and health manager might be responsible for determining the effect of the emergency on the health and safety of employees, contractors, visitors, guests, and the surrounding community; ensuring proper accounting of all personnel following evacuation; and following up all incidents to determine corrective actions in emergency procedures and training. Many facilities assign the safety and health manager as the EOC coordinator.

Specific duties might include:

- Maintaining EOC equipment and supplies in a constant state of readiness.
- Notifying OSHA, as required by law and regulation with the Legal Department's consent.
- Assisting in the conduct of postemergency investigations.
- Ensuring implementation of corrective actions or revisions to procedures and training to protect employees, contractors, visitors, and guests.

12.2.1.6. Public Relations Manager

The public relations manager might be responsible for all media contacts during and after an incident. Specific duties might include:

- Preparing press releases and obtaining approval for their release.
- Handling requests for interviews, information, and photo opportunities.
- Preparing and conducting press briefings.
- Obtaining correct and pertinent information from other managers.
- Briefing the corporate officials, as necessary.
- Establishing and maintaining contacts with the local news media.
- Training other managers to serve as spokespersons.

12.2.1.7. Environmental Manager

The environmental manager might be responsible for determining the on-site and off-site environmental consequences of the incident. Specific duties might include:

- Determining the environmental effects of the emergency.
- Providing pertinent environmental information to the IC or directly for use in communicating to off-site response organizations (fire, police, etc.)

about the type of emergency, off-site consequences, need for assistance, etc.
- Notifying government environmental agencies as required by regulation.
- Assisting in conducting of postemergency investigations.
- Coordinating environmental monitoring activities.
- Coordinating cleanup activities.

12.2.2. Security

Site security is responsible for maintaining the integrity of the facility boundaries during an emergency. However, the security forces should not interfere with emergency activities. Key plant personnel should possess recognition that allows easy recognition by the security force.

Simultaneously, the security force will need to control access to the incident scene for safety reasons. The presence of news media and nonessential personnel will add to the confusion and complicate the incident. The media should be directed and escorted to the designated media center for information concerning the incident. Nonessential personnel should be directed to report to their supervisors.

Typically, the security force will be responsible for initiating the emergency plan and providing some first responder duties. Security personnel may also direct traffic, provide crowd control, guide incoming emergency response vehicles to the command post or staging area, help in communications activities, and provide other assistance to the emergency response team. These activities should be planned well before an emergency. Training and equipment should be provided for security personnel appropriate to their anticipated functions.

Security might be responsible for coordinating the security activities such as maintaining site control, assisting in the accounting of personnel during evacuation, and assisting in incident investigation as required. Specific duties might include:

- Implementing notifications.
- Communicating emergency information, including personnel accountability messages.
- Site and incident scene traffic and crowd control.
- Protection of the incident scene following the emergency.

12.2.3. Legal

The legal department has duties before, during, and after an incident. Before an incident, management should resolve legal issues surrounding mutual-aid or outside-aid agreements. During and after the incident, legal questions concerning liability for damage to private property, personal injury, and environmental release may arise. Information gathering should begin when practical following the initiation of the incident. The information gathering should be directed toward obtaining complete factual data and avoiding conjecture.

The Legal Department will usually provide consultation to other managers to ensure that actions being taken in response to incident and informational releases about the incident do not incur further liability. Specific duties might include:

- Consulting with other managers (environmental, safety and health, etc.) to ensure their response activities are legally appropriate and that contact with governmental agencies are within proper legal framework.
- Maintaining liaison with the appropriate local, state, and federal agencies in conjunction with other managers and keeping these agencies apprised of current situations.
- Ensuring adherence to all applicable regulations during an emergency and completion of all required government notifications.
- If appropriate, in conjunction with the environmental manager and safety and health manager, working with the public relations manager to set up and conduct a briefing for government officials or the media.
- Assisting in the investigation.

12.2.4. Outside Technical Support

Outside organizations may provide technical assistance to facilities experiencing an emergency involving hazardous materials. The response of these groups may include advice from technical experts and/or a physical response of emergency teams. Some of these organizations include:

- CHEMTREC, Chemical Transportation Emergency Center, a support center provided by the Chemical Manufacturers Association, deals with hazardous materials transportation emergencies.
- U.S. Coast Guard, the National Response Center (NRC), and National Response Team provide assistance for emergencies involving spills on waterways.
- U.S. EPA Regional Response Teams—U.S. EPA provides technical advice teams to deal with regional emergencies.
- The Chlorine Institute's CHLOREP program provides response teams from member companies in various geographical areas. The Chlorine Institute can be contacted regarding specific details of the team's capabilities before an emergency. During an emergency, these teams can be requested for support through CHEMTREC (1-800-424-9000).
- Poison control centers and the Center for Disease Control may also be contacted for information dealing with the treatment of chemical exposure.

The emergency plan should list the telephone numbers of these and other organizations and the protocol for who is authorized to place the call. Personnel contacting these agencies should do so only when directed by the plant incident commander and should possess the technical expertise necessary to understand the information obtained from these organizations. The current *Fire Protection Handbook* [1], published by the National Fire Protection Association, contains a listing of government and private organizations providing technical assistance and emergency response functions.

12.2.5. Reporting Requirements

A release of hazardous materials usually triggers certain reporting requirements besides those required for immediate response to end the incident. The plan should identify specific reporting requirements so that personnel can obtain information and data necessary for these reports.

The Emergency Planning and Community Right-to-Know Act of 1986 contains four specific provisions for preplanning, the public's "right-to-know," and release reporting:

1. Facilities with *extremely hazardous substances* (EHS) present greater than threshold quantities must participate in the planning process with Local Emergency Planning Committees (LEPC).
2. Facilities must report a release of specific hazardous substances greater than a defined reportable quantity to the LEPC and the State Emergency Response Commission.
3. SARA requires facilities to prepare and submit detailed information including material safety data sheets (MSDSs) to the state, the LEPC, and the fire department with jurisdiction.
4. SARA-defined toxic release reporting (federal and state) requirements for manufacturing facilities. Each state's State Emergency Response Commission must define specific requirements for their state.

SARA requires annual reporting for any hazardous chemical requiring an MSDS under the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard. Reporting is based on the presence of hazardous chemicals, quantity present, and possible exemptions. The annual report must consist of information requested by either the Tier I (mandatory) or Tier II (optional) form. The Tier II form requests more specific information concerning chemicals and hazards than Tier I.

Reporting requirements for chemical releases fall into several categories, and more than one report may be required for the same release. Under SARA, reporting under Title III is required following a release of an extremely hazardous substance (EHS) above the reportable quantity (RQ). CERCLA (i.e., Superfund) assigns RQs to certain chemicals. State reporting may also be required. CERCLA hazardous substances require reporting to the National Response Center (NRC) when the amount released is greater than the CERCLA RQ. The complete listing of CERCLA hazardous substances and corresponding RQs is contained in 40 CFR Part 302. Annual reporting for emissions or releases of SARA Section 313 Toxic Chemicals must be made as part of the community's right-to-know. If the release affects persons only at the facility, SARA reporting may not be required; however, CERCLA reporting may still be required.

Under SARA, a facility releasing more than a RQ must immediately notify the LEPC and State Emergency Response Commission. A written report to both agencies must follow this verbal notification as soon as practical following the event. The immediate notification must include the following information:

- The chemical name and quantity released.
- The release location, time, and duration.
- EHS status of the chemical, known or anticipated health risks, and necessary medical attention.
- Release status and media affected (air, water, etc.).
- Any applicable precautions for the public.
- Spokesperson identity for the facility and the telephone number for further information.

RCRA Hazardous Wastes are not included in SARA reporting but may require other reporting for permitting purposes. Much of the information required for RCRA can be used to support reporting and documentation for SARA. Management should refer to 40 CFR Part 261 and other RCRA-related regulations for additional information.

12.2.6. Public Relations

The media's ability to broadcast directly from the incident scene creates the need for developing a public relations plan. Information provided to the media must be accurate, but should not cause undue public concern or alarm from the civilian population. Workers at the facility should direct all inquiries for information to the designated facility spokesperson.

The emergency plan should establish a policy that provides guidance for answering anticipated questions and designates a single facility spokesperson responsible for information release. Alternates should be designated for times when this person is not available.

The following questions and issues can be expected from the news media and the general public:

- What is the nature of the incident?
- Were any toxic or hazardous chemicals released and how much was released?
- What is the status of the emergency? How long will the emergency last?
- What precautions should be taken by the public?

- How many injuries? What is the nature of the injuries? What is the identity of the injured persons?
- A facility description and the activities involved in the incident.

Responsible management authority must approve these and other responses. Approving a news release is necessary to ensure factual correctness and to prevent the unnecessary release of trade secret information. The legal department may also wish to review any information released and suggest changes as required.

Using a single facility spokesperson helps ensure the release of consistent, error-free information. This individual should develop the information releases provided to outside agencies as part of the reporting requirements for the facility. Additionally, the spokesperson should be familiar with the technical and legal issues surrounding an incident. The spokesperson should coordinate with local government spokespersons to ensure consistency in reporting incident information to the public. This bulletin should contain answers to questions identified and approved during preplanning and other questions specific to the particular incident.

To avoid hindering emergency response at the scene and for the safety of media personnel, media personnel should be escorted to the media information center.

12.3. SYSTEMS

12.3.1. Mutual Aid

A mutual aid program with other nearby companies and emergency response agencies allows for sharing resources and helping one another during an emergency. Mutual aid refers to agreements to share emergency resources such as equipment, information, personnel, and possible financial assistance during emergencies. This program requires much coordination and liability issues must be addressed, but it can be very beneficial for small firms with limited resources or larger firms with high hazard potential.

If any mutual aid agreements (written or verbal) exist, they should be attached to the emergency plan or incorporated by reference.

Attorneys should review all mutual aid agreements so that all liabilities and compensation methods and rates are known and approved of in advance. Cost and other conditions, should not be so prohibitive that member facilities would fail to use the resources available to it under this program. Mutual-aid agreements should define the following additional items:

- Command responsibility and incident management system.
- Insurance requirements.
- Communications and terminology.
- Standard Operating Procedures.

TABLE 12.1
Media Interaction Do's and Don'ts

Do's	*Don'ts*
Obtain accurate information and be completely honest.	Try to fool the reporters and the public.
Decide what you want to say, and check to be sure you have the appropriate information.	Believe you know it all.
Review subjects you do not want to address.	Figure you can wing it.
Prepare for likely questions.	Expect that you can evade all tough questions.
Organize information into key points and key messages.	Memorize standard answers.
Practice.	Rely on your glibness.
Critique practice sessions and revise your approach as needed. Use nontechnical people as your audience.	Rehearse until all spontaneity is lost.
Assume that everything is on the record.	Seek to go off the record.
Review with reporters topics you cannot comment on (if appropriate and if decided in advance).	Insist that reporter not raise any embarrassing topics.
Offer to obtain additional information for the reporters, so you can gauge their interests.	Demand to know in advance which questions they will ask.
Stress your interest in getting accurate information for reporters.	Threaten lawsuits or withdrawal of ads.
Be cordial.	Crack jokes.
Be professional.	Try to butter up reporters with compliments.
Be honest and accurate. Your credibility depends on it.	Lie.
Stick to your key points.	Improvise.
Lead. Take charge.	React passively, or be overly aggressive or rude.
Raise your key messages.	Dwell on negative allegations.
Offer to find out information you don't have if a question is raised about it.	Guess, because if you are wrong, your credibility will be shot.
Explain the subject.	Use jargon.
Stress the facts.	Discuss hypothetical questions.
Explain the context.	Assume the facts speak for themselves.
Be forthcoming.	Decide to reveal something that is confidential without considering its implications.
Give a reason if you can't talk about a subject.	Dismiss a question with "no comment."
State your points emphatically.	Ask reporters for their opinions.

Do's	*Don'ts*
Correct big mistakes by stating that you didn't give an adequate answer and you would like a chance to clear up the confusion.	Demand that a botched answer not be used.
Remember the media are interested in "What?, When?, Where?, Who?, How? and Why?"	Be afraid to say that you don't have the answers to Who?, How?, or Why? at the present time.
Stress any heroic efforts by individual employees.	Stress any individual errors or negligence.
Emphasize what is being done to correct problems.	Estimate monetary damages, costs to the company, insurance coverage, or level of interference with company activities.
State your conclusions first, to get your main points across, then back them up with facts.	Let your message get lost in a morass of detail.
Have available information relating to company processes, raw materials, and chemical intermediates.	Hesitate to refuse to give proprietary information.
Try to be as open with the media as possible.	Give one reporter exclusive information.
After the Q & A:	
Remember, what you say is still on the record.	Assume the interview/conference is over.
Remember, it's all on the record.	Insist that some comment now be put "off the record."
Be careful around microphones and tape recorders.	Assume that a microphone is off.
Correct any mistakes you made in the Q&A.	Let sleeping dogs lie and not correct any mistakes.
Volunteer to get additional information reporters need.	Refuse to talk any further with reporters.
Tell reporters to telephone if they have any questions about something you said.	Ask, "How did I do?"
Volunteer to be available if a reporter wants to go over it with you.	Ask a reporter to show you a copy of the story before publication or broadcast so you can correct it.
Call reporters if stories appear that are inaccurate, and politely point out what is wrong.	Call the reporter's boss to complain without first speaking to the reporter.

- Equipment requirements.
- Alarm response requirements.

Good examples of mutual-aid organizations are the Channel Industries Mutual Aid Association in Houston and the Kanawa Valley Mutual Aid organization in West Virginia.

12.3.2. Communications System Operation

Emergency communications systems must be able to operate under extreme conditions, including loss of site power, foul weather, fire, and chemical release. Communications systems relying on land lines, such as telephones and loudspeaker systems, are subject to damage by these events and rendered inoperable. The facility communications system must be capable of notifying emergency response team members and fire brigade members that an incident has occurred. The notification should provide members with information concerning the level of hazard and location. If the plant announcing system is unreliable during emergencies, facility management may need to consider providing pagers to the emergency response team and other plant personnel. Consideration for one redundant and one backup system is important.

Using a two-way radio is the preferred communication method during emergencies. Two-way radios should be available to fire brigade members, emergency response team members, and in all emergency response vehicles. Additional two-way radios and spare batteries should be stocked in the EOC. The facility should arrange for two or more frequencies to provide flexibility and backup. The communications system must also be compatible with the communications used by mutual-aid companies and EMS personnel (common frequency, ability to share radios, etc.). All frequencies assigned should be for emergency purposes only and unique to the facility.

Standard terminology and communication protocols must be adopted that are consistent with any mutual-aid agreements. Standardized communications procedures allow easy information transmission and provide the incident commander with a rapid means to notify emergency response teams of changing situations or strategy and increased hazard levels. The standard operating procedure will allow transition from a relatively small incident to a major incident without major changes.

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4

CONCEPTUAL APPROACH TO EMERGENCY RESPONSE

4.1. INTRODUCTION

Previous chapters discussed the process for recognizing the presence of hazardous materials and identifying credible incidents. Developing credible incident scenarios helps focus efforts on formulating strategies to deal with emergency situations. The incident scenarios allow managers to:

- Identify the types of equipment needed,
- Determine what personnel expertise and resources are needed to mitigate the incident, and
- Develop appropriate response strategies.

As discussed in Chapter 3, planners should first review the credible incidents and discern the consequences and impacts a facility could face during each incident. Then the planners should decide how to best utilize internal resources and available outside support organizations, such as public safety agencies or neighboring facilities.

Once planners understand the capabilities and resources available, they should develop an overall strategy for responding to credible incidents. This is important because a facility might not have adequate capabilities and resources to safely respond to certain credible incidents, and therefore planners must devise alternative strategies. Alternatives may include expanding the staff, upgrading equipment, using sister plants, utilizing public safety agencies or contractors, forming mutual aid associations with neighboring facilities, or any combination thereof.

Depending on the strategy selected for responding to credible incidents, organizing personnel and dividing responsibilities require good judgment at this early stage of emergency planning. For example, if a plant chooses to rely only on internal resources for response, planners must determine which employees would respond to emergencies, who would support their efforts, and who would address other nonroutine issues. A multiplant site must also decide whether to develop a site-wide response group or individual response groups for each plant, with overall site coordination.

Planners should consider regulatory requirements in developing strategies and equipment requirements. Depending on the approach chosen, government regulations may mandate that certain equipment and capabilities be in place.

The concepts presented in this chapter are important to new facilities developing new plans, as well as for plants that are reevaluating an emergency program. An existing facility may undergo change (downsizing or expansion), and the impact on emergency programs, strategies, and capabilities must be reviewed.

In summary, this chapter will describe:

- Evaluating facility resources and capabilities,
- Determining ways to obtain additional resource and capabilities,
- Devising strategies for responding to credible incidents, including organizational and managerial issues,
- Assessing regulatory issues that affect overall concepts to emergency response, and
- Understanding the impact of change on emergency response strategies.

4.2. CAPABILITY AND RESOURCE ASSESSMENT

Knowing the magnitude of problems caused by credible incidents will help determine the types of resources needed to ensure effective emergency response. Understanding the capabilities of available resources will also help planners select the most feasible response strategy and organization. Resources that may be necessary for emergency response may be different from resources that are currently available, so assessing current resources and capabilities is essential. Resources include people, emergency facilities, equipment, and supplies, while capabilities include the personnel expertise, experience, and training.

Planners should assess resources and capabilities in relation to expected hazards. For example, if acid is used on-site, neutralizers will be needed. If the facility is in a floodplain, questions concerning the availability of pumps and sandbags would be appropriate. Planners should ask similar questions regarding the community emergency response capabilities and resources, if needed.

Organizations with an emergency preparedness program in place might already have an equipment inventory. If not, one should be developed. Planners should review the inventory to determine whether any additional equipment is necessary, and note the condition of existing equipment.

4.2.1. Trained Personnel

Knowing how many people are available to respond to an emergency is essential in developing equipment lists. In evaluating personnel resources, determine the availability of key personnel on all shifts, including weekends. Day shifts may have enough operational and maintenance personnel to staff a response team; off-shifts may have insufficient staffing levels to meet optimal response team numbers. A good call-in system might overcome this problem. Also, the addition of automated, fixed mitigation systems (e.g., deluge system, monitors, etc.) can reduce the demand for personnel or increase the effectiveness of personnel.

Management must provide personnel with initial training to respond to hazards, as well as refresher training and practice exercises. The cost of training includes instructor fees, student pay (often at an overtime rate), classroom facilities, simulation equipment, and related administrative costs.

The physical fitness and medical condition of personnel is also important to consider. Knowing whether staff members are physically capable of safely responding to expected hazards is not only appropriate, but also required by many regulations. This chapter introduces the regulatory requirements covering medical, equipment, and training requirements for personnel responding to emergencies.

In addition to a trained response team, a trained support and management staff is also necessary. Managers typically need training in regulatory reporting requirements, media relations, and facility response procedures. Administrative staff are also required for supporting managers. Chapter 8 further discusses managers' roles in emergency response, whereas Chapter 10 covers training in greater detail.

4.2.2. On-Site Response Equipment

Most plants will have one or more of the following categories of hazards: fire, hazardous materials release, medical incidents, natural hazards, or technical rescue (e.g., confined space, high-elevation). Upon reviewing the credible incidents, one should be able to determine the general categories of response equipment that might be necessary. Consider one or more of the following equipment categories:

- **Fire Fighting Equipment** (depending on fire brigade level: turnout gear, hose lines, nozzles, SCBA, portable fire extinguisher, apparatus, etc.),
- **Hazardous Materials Release Equipment** (release control tools, detection equipment, containment equipment, decontamination equipment, meteorological instruments, etc.),
- **Personal Protective Equipment** (clothing, suits, respiratory protection, gloves, boots, etc.),
- **Communications Equipment** (two way radios, pagers, priority frequencies, telephone, fax equipment, etc.),
- **Medical Equipment** (neck collars, stretchers, ambulance, backboards, first aid kit, oxygen, etc.), and
- **Rescue Equipment** (pulley system, harnesses, life lines, air lines, etc.).
- **Information** (reference books, process documentation, response plans, material inventories, incident analysis and reporting checklists, etc.).

Based on the credible incidents and hazards of all areas of the plant, planners can establish their own list of required equipment. Chapter 7 provides important equipment information for preparing the resource needs. In putting the list together, consider:

- Weather conditions that might affect response equipment or procedures,
- Personal protective equipment that allows workers to perform necessary tasks and does not unnecessarily restrict movement or cause fatigue,
- Compatibility of response equipment with material exposure, and
- Special incident needs.

Once this list is complete, planners can compare it to what is available throughout the plant. A report documenting available quantities of equipment, the nature and impact of any potential deficiency, and recommended corrective action can be addressed. All equipment will need proper storage locations that are secure and accessible. Regular inspection to ensure readiness is important.

4.2.3. Response Equipment Available Off-Site

A plant need not obtain all requisite equipment to meet every conceivable requirement because neighboring facilities or public safety agencies may have the necessary equipment. Equipment inventories should complement other internal and external resources whenever practical. If the equipment is readily available from outside sources, it may be wise to use the money available for other purposes.

In reviewing the resources and capabilities of the community public safety agencies, planners should check with key agencies to determine what their capabilities are. The local emergency planning committee (LEPC), city or town manager's office, fire department, or emergency management agency would typically have an emergency operation plan that should list overall capabilities and possibly contain detailed equipment lists. After reviewing this information, planners should meet with individual department heads or their designees to confirm the information. The age of the equipment and whether the equipment is appropriate to handle the facility's special needs are also important to review. A review is also needed to assure that on or off-site personnel are trained and capable of using the equipment. For example, if the facility stores chlorine, does the community's fire department or hazardous materials response unit possess and have capability in the use of an appropriate chlorine leak repair kit?

The planner should confirm that the resources specified in community plans is properly maintained and that emergency responders have the necessary training to use the equipment.

4.2.4. Facilities

Chapter 6 provides important criteria that are useful in evaluating facilities needed to support emergency operations. Typical facilities and systems that are useful for response operations include:

- Short-term shelters and safe-havens
- Emergency operations center (EOC)
- Incident command post
- Media information center
- Control rooms
- Medical support facilities
- Adequate water supplies
- Detection/early warning systems
- Communication systems
- Community and facility alerting systems
- Real-time modeling system
- Computer systems for emergency management
- Site and utility maps and drawings
- Emergency power systems
- Meteorological instruments

Planners should evaluate these resources and prepare their own requirements list, considering the criteria outlined in Chapter 6. An example of evaluating resources applied to medical support facilities might include:

- Does the plant have medical facilities available and, if so, what are its capabilities and limitations?
- Can the local hospital handle mass casualty incidents, chemical exposure injuries, burns, and other possible injuries?
- Is there a local trauma center that can better handle such emergencies?
- Are medical airlift capabilities available in the area; if so, what advance modification agreements are necessary?
- Are ambulance and emergency medical services personnel familiar with the plant's layout and hazards?
- Have arrangements been made with local hospitals, as well as distant specialized medical facilities (e.g., burn or trauma centers), for providing treatment for chemical exposures, burns, and other medical emergencies?
- Are there any anticipated special chemical treatment needs?

Planners can employ the same thought process and questioning for other facilities and systems [5].

4.2.5. Specialized Supplies and Contractors

As mentioned in Section 4.2.3, managers should consider external technical and emergency response resources to supplement in-house resources and expertise. Sources of external support might include:

- Other company resources
- Neighboring facilities (mutual aid)
- Local emergency services

- Local medical facilities
- Private contractors
- Monitoring and analytical companies

4.2.5.1 Other Company Resources

Depending on the size of the company, there may be other resources within the company that can help resolve a problem or challenge confronting the plant. Some companies have regional offices or multiple plants in an area that could support individual facilities in case of emergency. Expert staff might be readily available to support operations, such as a public relations specialist or an experienced engineer.

4.2.5.2 Neighboring Facilities (Mutual Aid)

Many sites pool their resources with other companies to maximize the benefit of every available dollar. Many examples of neighboring facilities teaming to form ***mutual aid*** organizations exist. In this arrangement, plants compare notes on what they need to respond to their hazards. Often, one organization can purchase expensive, but rarely used, equipment and share it with others in time of need. The other organizations would reciprocate by buying other necessary equipment. In this arrangement, all equipment should be compatible and personnel cross-trained to use it.

In forming a mutual aid organization, it is important to establish clear procedures for requesting equipment; requirements for cleaning, repairing, or replacing used or damaged equipment; and any costs involved. The company attorney should review legal considerations and limitation of liability.

A description of the organization and activities of the Sabine Neches Chiefs Association, a mutual aid group consisting of over 40 major industrial plants, several municipalities, and other public agencies, appears in [3] along with two graphic case studies. (See Appendix A, Chapter 7 and Appendix A, Chapter 11 of this Guideline for information supplied by the (Houston) Channel Industry Mutual Aid group.)

4.2.5.3 Local Emergency Services

As with neighboring facilities, local emergency service organizations might possess needed equipment and supplies such as earth movers or structural timber. While community resources vary from location to location, it is important to work out arrangements for using and sharing available resources in a manner that meets the facility and the community needs.

4.2.5.4 Local and Regional Medical Facilities

Planners should inform local and regional medical servers about the facility's hazards, and communicate potential medical needs in order to help them prepare for an emergency. Also, they should determine whether hospitals have the appropriate facilities and equipment to treat potential injuries.

4.2.5.5 Private Contractors

Establishing agreements with hazardous materials response and cleanup contractors to supplement in-house resources may be desirable, especially if large hazardous materials spills are a possibility. Contractors must possess the capability to respond in a timely manner, and deal with the company's unique hazard potentials. For example, if the credible incident scenarios depict a complex response (a spill into a rapidly flowing river or coastal area), planners should ensure that the contractor (or combination of contractors) can handle such a response. Contractors should routinely train their employees at least to government standards, and preferably more stringent standards such as NFPA standards for industrial fire brigades or hazardous materials responders [4, 5]. Reviewing contractor equipment inventory and verifying via visual inspection is also prudent. The contractor's response time following initial notification should be adequate to meet company needs. The contractor should participate in company training sessions and emergency exercises, and the participation of the contractor should be documented. The planner should obtain references and talk to the contractor's clients to determine their satisfaction with the contractor's service.

The plant's attorney should develop a contract before an emergency. The attorney can determine whether the contractor possesses the correct type and level of insurance. Planners should obtain the contractor's telephone number along with the telephone number of the president and key officers, in case the emergency number for some reason is unreachable.

4.2.5.6 Monitoring and Analytical Companies

While facility personnel likely can identify a spilled material quickly, there may be occasions when a released material is unknown; therefore, having analytical or industrial hygiene monitoring services available might be advantageous. Analytical services might also help determine contamination levels or confirm the adequacy of cleanup. A company should choose a laboratory capable of meeting facility needs, including proper analytical capabilities and emergency service.

4.3. DETERMINE CONCEPT OF EMERGENCY OPERATIONS

The planner should now understand the capabilities and limitations of the organization to handle potential emergencies, and the availability of external support. The planner can now begin developing an overall strategy and structure for how the plant will respond to emergencies. The term often used to describe this strategy is the concept of emergency operations, which states the overall strategy for responding to credible incidents and how people and organizations will interact during an emergency.

A good method for mapping out the emergency operations is to use a simple flow chart to identify the major activities that must take place from the moment an emergency arises. By developing and refining this flow chart, planners will end up with a graphic illustration of the concept of operations. The flow chart will help identify the management system for use in time of emergency and to identify deficiencies or gaps in logic. It will also help determine what types of response forces are necessary. By reviewing this flow chart against various credible incident scenarios, a plant can determine whether on-site staff can handle likely events or whether external resources are sufficient or necessary. Figure 4.1 is an example of such a flow chart.

4.3.1. *Effective Use of Inside and Outside Response*

An important element in defining a concept of emergency operations is to determine whether a plant will use internal personnel to respond to credible incidents, rely on external forces, or use a combination of each. A careful assessment of available options to deal with response to credible incidents is prudent, since each contains its own set of costs and benefits.

4.3.1.1 Internal Response Capability

Plants have wide latitude in determining how they will respond to on-site emergencies. Government regulations do not generally mandate particular capabilities to handle fire and hazardous materials emergencies. Some organizations choose to protect their employees solely by having proper prevention and evacuation plans in place, thereby leaving actual response to community emergency services agencies; however, it is often in a plant's best interest to have a response capability to minimize damage and loss. Many companies, at the very least, try to contain an emergency until outside agencies respond.

If a company chooses to respond to emergencies, complying with regulations is not just essential; it is a part of doing business. These regulations cover evacuation, fire brigades, hazardous materials response teams, confined space rescuers, and medical responders. These regulations generally apply to training, equipment, and other administrative matters affecting personnel and how they operate.

4.3.1.2 External Response Capability

Developing an internal response capability entails cost and other important considerations such as training, adequate manpower, and equipment. Using external agencies to respond to credible incidents is often a viable alternative, but a careful appraisal of this option is advisable.

One approach is to take a brief look at on-site and off-site emergency response capabilities, then decide based on a thorough review and methodical decision-making approach.

As discussed in the next few pages, a simple decision analysis technique exists to determine the best option for a plant's response approach. It begins with identifying the various options for staffing and training a response organization.

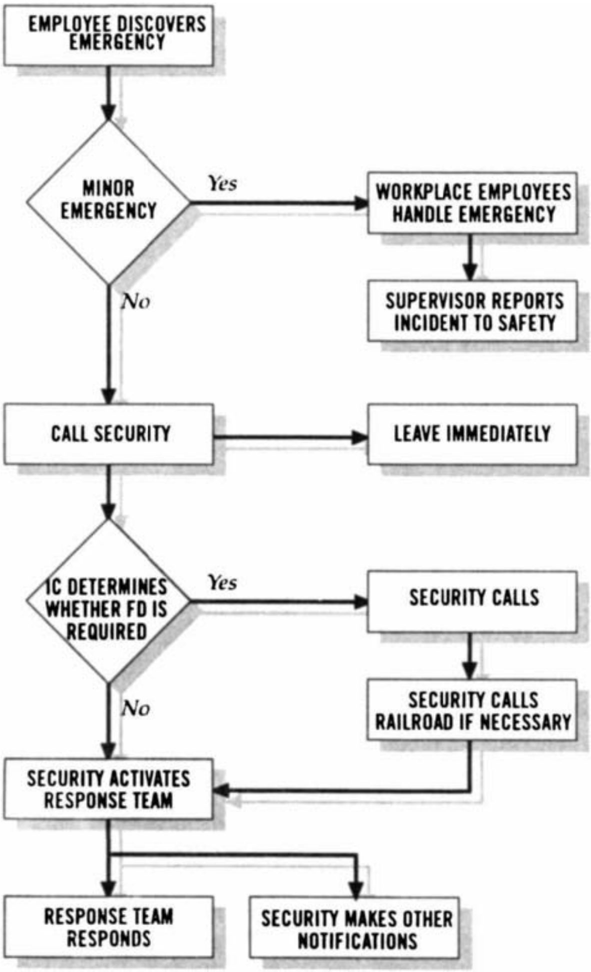

FIGURE 4.1. Sample flow chart (notification process).

Depending on local conditions, there might be several options available to management, such as:

- Plant personnel only
- Immediate community only
- Community and plant
- County response units or mutual aid units
- Private contractors.

4.3.1.3 Simple Decision Analysis Technique

An organization can then identify important factors for evaluating the various response options and weigh these factors to reflect their relative importance in the decision. Several categories of factors for judging the relative benefits of each alternative include:

- Response effectiveness,
- Management issues, and
- Cost considerations.

Tables 4.1 through 4.3 describe these factors. Table 4.4 provides an example of how this methodology compared three different options.

A plant can use these factors to evaluate each response alternative. One can assign a relative weight, on a scale of 1 to 5, to each factor depending on management priorities. Then the planner can rank each alternative on a scale of 1 to 5, with 5 being most favorable to the plant and 1 being least favorable to the plant. Multiplying the rank by each factor's weight yields a score. Adding up all scores yields a number that may be useful in ranking alternatives. The higher the score, the more advantageous the alternative.

This method allows plants to methodically evaluate the strengths and weaknesses of various response approaches, and communicate recommendations to management.

TABLE 4.1
Response Effectiveness Evaluation Factors

Factor	*Explanation*
Response time	Rapid and safe response to an incident is essential to effective mitigation. The sooner forces mobilize and respond to the scene, the greater the chance of containing the incident.
Existing on-duty personnel	Are there enough trained people on duty at the plant who are available to respond to an incident? What is the minimum number of people necessary for credible incident response?
Existing qualifications/ training	Consider the availability of qualified and trained personnel in existing organizations. Using an existing response team, if available, is sensible.
Site-specific knowledge	Effective responders must have good sound knowledge of the materials involved and familiarity with the area in order to ensure effectiveness.
Existing off-duty personnel	If a plant's on-duty staff is insufficient, then access to off-duty personnel must fill this gap.
Availability of response	There are times when a response unit might be unable to respond because of other emergencies. What needs to be done if this happens?
Existing equipment	Some organizations may already own Hazmat response equipment.

TABLE 4.2
Management Issues and Factors

Factor	*Explanation*
Control of plant during emergencies	Some managers have a concern about losing control of their facility to public safety officials during emergencies. Many have built highly qualified teams to help avoid this potential. Public safety officials generally don't want to shut down facilities. They usually won't do so as long as the facility has an effective emergency response program in place and a trustworthy relationship established.
Ongoing commitment	Regardless of the option chosen, an emergency response program requires ongoing commitment and attention, including personnel training and equipment maintenance.
Community relations	There are some community relations considerations. For example, will a company gain much credit for helping improve a community response agency? Will a company gain even more credit by taking care of its own problems without using community resources?
Ongoing management/ administration	Depending on the option chosen, a degree of administrative oversight is necessary. Not establishing an on-site team at a plant will require less administration.

TABLE 4.3
Cost Evaluation Factors

Factor	*Explanation*
Cost of equipment	What are the equipment costs for each alternative?
Cost of training	What are the training costs for each alternative?
Ongoing medical surveillance	What are the costs and administrative burdens to maintain ongoing medical surveillance programs for each alternative?
Refresher training cost	What are the costs and administrative requirements to provide annual refresher training programs for each alternative?
Equipment maintenance costs	What are the costs and administrative burdens to maintain equipment for each alternative?

While the above example primarily compares the use of external resources with in-house resources, it can also compare using a facility-wide response organization versus establishing response teams in each plant unit. Some plants establish small response teams that ensure a rapid response and familiarity with the process unit. Plants with limited personnel levels in each unit, however, may not find this to be a viable option.

TABLE 4.4
Example Evaluation of Response Options

	Factor*	R	R	R	R	R	R	R	M	M	M	M	M	C	C	C	C	C		
		Response Time	Existing On-Duty	Existing Qualifications	Site Specific	Existing Off-Duty	Availability of Response	Existing Equipment	Control of Plant	Ongoing Commitment	Community Relations	Management/Administration	Dual Use	Cost of Equipment	Cost of Training	Ongoing Medical Program	Refresher Training	Equipment Maintenance	Score	Percent
Options**	Weight	5	5	4	4	3	3	3	3	3	2	2	1	3	2	1	1	1		
Option 1	Rating	5	5	1	4	3	5	2	4	5	4	4	1	1	2	2	3	3		
	Score	25	25	4	16	9	15	6	12	15	8	8	1	3	4	2	3	3	159	69%
	%	100%	100%	20%	80%	60%	100%	40%	80%	100%	80%	80%	20%	20%	40%	40%	60%	60%		
Option 2	Rating	3	2	2	1	3	2	2	1	1	2	5	4	2	3	5	4	5		
	Score	15	10	8	4	9	6	6	3	3	4	10	4	6	6	5	4	5	108	47%
	%	60%	40%	40%	20%	60%	40%	40%	20%	20%	40%	100%	80%	40%	60%	100%	80%	100%		
Option 3	Rating	4	2	3	2.5	3	3	3	2.5	2	3	5	4	3	4	5	4	5		
	Score	20	10	12	10	9	9	9	7.5	6	6	10	4	9	8	5	4	5	143.5	62%
	%	80%	40%	60%	50%	60%	60%	60%	50%	40%	60%	100%	80%	60%	80%	100%	80%	100%		
Average	Rating	4	3	2	2	3	3	3	2	2	4	4	4	2	3	4	3	4		
Average	Score	20	17	9	10	10	10	8	7	7	8	9	4	6	5	4	3	4		
Average	%	81%	69%	47%	49%	69%	66%	53%	46%	47%	76%	87%	73%	43%	54%	74%	69%	89%		

*Factors R: Response Effectiveness
M: Management Issues
C: Cost Factors

** Some Sample Options might be: Option 1, Plant only; Option 2, Community only; Option 3, Combination of 1 & 2.

4.3.2. *Organizing for Credible Incident*

Once the plant completes the evaluation of various response options and determines a general concept of emergency operations, another important task is to assign emergency responsibilities and develop an organizational structure for emergency operations since it will probably be different from the normal plant organization.

A simple method for determining responsibilities is to develop a matrix listing plant individuals and departments on one axis, and required emergency functions along the other. Through brainstorming and management review, select who will have primary and secondary responsibilities for each emergency function. When making such assignments, remember to consider the experience, expertise, and availability of personnel to accomplish each function. For example, site security and crowd control are the logical responsibilities of security guards; yet, if only two security guards are on duty during off-shifts, they likely cannot carry out these functions without additional support. Matrix responsibilities should be set as much as possible on position skill requirements rather than personal skill attributes to deal with changes in site personnel. Once responsibilities are assigned, the planner can develop an emergency organizational chart. The planner should review the chart and responsibility matrix with management and staff to ensure that everyone understands their responsibilities and authority. A sample responsibility matrix is shown as Figure 4.2. Some specific suggestions for emergency roles are presented in Table 8.2 of Chapter 8 on Developing a Workable Plan.

4.3.3. *Classification of Emergencies*

Emergency classification systems are useful to establish the magnitude of an emergency. In doing so, planners assign increasing resources to each level of event. As the emergency grows in magnitude, the classification would change and the level of response would increase.

A good example is the nuclear industry, which uses emergency classification systems effectively. It uses four levels called:

- Unusual event
- Alert
- Site area emergency
- General emergency.

Nuclear plant operators receive training on what level to declare based on certain plant conditions or events that may occur When they declare a certain level, all plant employees and government emergency agencies follow a specific procedure for that action level. For example, upon the declaration of an unusual event, a specific plant employee knows that he must notify certain federal, state, and local officials according to the plan. The benefit of using emergency classifi-

FUNCTION	POSITION				
	Operations Manager	Safety Manager	Engineering	Environmental Manager	Security
Assist in prevention measures, provide technical advice to incident commander during emergencies.					
Determine government notifications, provide advice on preventing environmental impacts, communicate with government environmental officials, assist in environmental sampling efforts.					
Assist in tracking expenditures and damage assessment. Assist other managers.					
Provide victim assistance, coordinate with corporate insurance, finance, or risk management officals. Serves as interface with hospital.					
Assist general managers in determining notification requirements. Review press releases prior to issuance.					
Provide staff for emergency teams, provide technical advice on incident mitigation measures, assist in prevention activities, evaluate damage following an incident, participate in incident investigation.					
Coordinate media relations, prepare press releases.					
Assist in obtaining necessary logistic (backup supplies and equipment) to support emergency operations.					
Provide advice to incident commander, provide MSDS and other information to hospitals and physicians, make notification to OSHA or state agencies as required.					
Provide assistance to managers, notify customers of potential delivery disruptions following an emergency.					
Secure the facility and incident scene during and following an emergency, make notifications, prevent interference of onlookers and media with essential operations.					
Maintain or shut down operations as necessary to ensure safety.					

FIGURE 4.2. Sample responsibility chart.

NOTE: Various positions and their possible emergency roles are shown in Table 8.2 of Chapter 8.

cation levels is that the response is better organized and manageable. It also ensures the application of only those resources necessary to cope with the emergency.

While the Nuclear Regulatory Commission defines these action levels for nuclear power plants, there are no required action levels for most other types of industrial facilities.

Other industries, therefore, can choose whether to use the concept and have flexibility in identifying and defining these action levels. Some organizations may find the use of an emergency classification system unwieldy or unnecessary. Others find it a useful way to organize and write appropriate emergency response procedures. *Guidelines for Chemical Process Quantitative Risk Analysis* [1], defines three classes or levels of events:

- **Localized Incident**—Localized effect zone, limited to a single plant area,
- **Major Incident**—Medium effect zone, limited to site boundaries, and
- **Catastrophic Incident**—Large effect zone, off-site effects on the surrounding community.

Plant Guidelines for Technical Management of Chemical Process Safety [2, p. 98] contains another example of a plant emergency procedures manual that states how the plant will respond, given different classification levels.

4.4. REGULATORY CONSIDERATIONS

In formulating a conceptual approach to emergency response, planners must consider many regulations. The two federal agencies that most affect plant emergency planning are the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA). Over the years, OSHA has taken a leading role in promulgating in-plant emergency planning that affects workers, while the EPA regulated planning to alleviate the impact of plant emergencies on the environment and community.

Table 4.5 identifies many of the OSHA emergency planning requirements for consideration in developing a conceptual framework for emergency response. Later, as detailed plans and procedures develop, planners should closely consider these and other regulations.

Of the regulations listed in Table 4.5, 1910.38; 1910.120; and 1910.156 are of primary concern in developing the conceptual framework.

Several EPA regulations affect many organizations including: written site plan, spill prevention control and countermeasure provisions, hazardous waste contingency planning requirements, various reporting requirements, and Title III of the Superfund Amendments and Reauthorization Act. As of this writing, EPA is promulgating risk management planning regulations that include extensive emergency planning requirements affecting nearly 140,000 facilities that produce, store, or use certain hazardous chemicals. The site response strategy must be coordinated with that mandated by EPA regulations.

The Coast Guard also requires certain reporting and emergency planning that may affect in-plant emergency plans, especially for facilities located near navigable waters. Keep in mind that federal regulations change with time, as do agency interpretations, so seek appropriate counsel regarding current regulations, and also consider state and local regulations that may affect a plant's approach to emergency planning.

TABLE 4.5
OSHA Regulations Affecting Plant Emergency Organizations and Planning

Regulation	*Subject*
29 CFR 1910.38 (a)	Emergency action planning
Nonmandatory appendix to Subpart E	Evacuation recommendations
29 CFR 1910.120 (q)	HAZWOPER
29 CFR 1910.134 (e)(3), (f)	Respirator
29 CFR 1910.147	Lockout/tagout
29 CFR 1910.156	Fire brigade
29 CFR 1910.157	Fire extinguishers
29 CFR 1910.158	Standpipe and Hose Systems
29 CFR 1910.159	Specify fire prevention requirements under the plan
29 CFR 1910.160 (b)	Fire system safety
29 CFR 1910.164	Fire detection systems
29 CFR 1910.165 (b, c, d)	Employee alarms
29 CFR 1910.169	Confined space rescue
29 CFR 1910.1030	Bloodborne pathogens

4.5. THE EFFECT OF CHANGE ON EMERGENCY PREPAREDNESS

One final consideration for plants reviewing their approach to emergency planning concerns the management of change. Companies have improved productivity and efficiency, which resulted in reduced staffing. Often, these changes can affect how companies respond to emergencies. Reviewing the conceptual framework for emergency response is important following changes in personnel. For example, one particular company had an interior structural fire brigade in the 1970s, but then suffered years of budget cutbacks that eliminated the training and equipment necessary to support the original mission. The company should reevaluate its emergency response strategy.

Changes in manufacturing processes should also trigger a review of a plant's approach to emergency response. Major process changes, such as a production expansion, may result in an organization having too little response capability or, in rare cases, having too much response capability.

Finally, emergencies can and often do occur during maintenance turn-arounds or during a major capital expansion. Most companies establish emergency systems for normal operations, but these may be inadequate when plants undergo major or even minor expansion or turn-arounds. Personnel responsible for emergency response must review their response strategies before temporary or long-term maintenance and construction projects.

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9

USING MODELING FOR EMERGENCY PLANNING

9.1. INTRODUCTION

After identifying credible incident scenarios, discussed in Chapter 3, accidental release modeling techniques can be used to assess the consequences. Accidental release modeling is useful for estimating the potential consequence or area of impact of hazardous material releases, fire, thermal radiation, and blast. *It enables the emergency planner to prioritize many different potential release scenarios by determining the magnitude of potential consequences and to develop improved emergency plans to deal with incidents.*

The following subsections discuss incident consequence estimation for emergency planning, use of models for developing response plans, utilizing the appropriate models, and real-time emergency response modeling systems.

9.2. CONSEQUENCE ANALYSIS

Consequence analysis is a tool that is used to determine the potential area of impact posed by potential incidents at manufacturing facilities that store and handle hazardous substances. It allows managers and operators of such facilities to plan for emergencies and make prudent risk-reduction decisions. The chemical and petrochemical industries have initiated extensive systems (Responsible Care, CAER, API RP-750, etc.) to ensure the safe operation of all facilities. In the United States, the Emergency Planning and Community Right-to-Know Act (EPCRA) establishes emergency planning requirements for hazardous substances for facilities that store/use large quantities of hazardous substances. This act includes a requirement for establishing Local Emergency Planning Committees (LEPC), and plans or procedures to respond to emergencies. Sound hazard assessments help develop response tactics in case of an accidental release. With updated information and appropriate systems in place, predicted consequences or impact areas from hazardous releases can be quickly communicated to emergency responders (e.g., plant emergency response teams, fire department, HAZMAT team).

Manufacturing facilities must conduct consequence analyses (called hazard assessment in some regulations) to comply with current legal requirements of the Occupational Safety and Health Administration's (OSHA) Process Safety Management (PSM) rule (29 CFR 1910.119) that deals with on-site worker exposure. Additionally, the EPA is developing Risk Management Planning (RMP) regulations (40 CFR Part 68) that address off-site consequences and risk. States such as California, New Jersey, and Delaware also have regulations that require estimation of the consequences of accidental releases. Modeling is a valuable tool to assist with these assessments.

Consequence analysis evaluates the potential areas of impact of an accidental release, the results of which are expressed in terms of the distance from the incident of toxic concentrations, overpressure, or thermal flux. Planners (or other appropriately trained personnel) can use accidental release models to identify those geographic areas that may be vulnerable to adverse effects on human health and/or property damage. The distribution of the effect being estimated or isopleth contours identify the vulnerable (or hazard) zones for each credible incident scenario analyzed. The estimate can also provide identification of:

- The population exposed.
- On-site facilities where effects might occur.
- Essential off-site services such as hospitals, police and fire stations, bridges, tunnels, emergency response centers, and communication facilities that lie within the vulnerable zones and whose operations may be impaired.
- Sensitive receptors, such as churches, schools, day-care centers, and retirement homes that may be impacted by a release.

The accidental release models used for consequence analysis provide results of the atmospheric dispersion of chemicals following an accidental (inadvertent or unanticipated) release. The concentration levels of concern are typically those that potentially can cause acute harm to human beings. The extent of vulnerable zones (i.e., dispersion modeling results) is based on estimates of the quantity/rate of hazardous material released, meteorological conditions, nature of the local terrain, and the concentration level of concern.

In case of release of a toxic gas, the impact area or consequence is estimated as the downwind plume area whose extent is defined by a gas concentration. The concentration level of concern for acute toxicity is typically based on Emergency Response Planning Guidelines (ERPG) concentrations currently under development by the American Industrial Hygiene Association (AIHA). In cases where ERPG-3 and ERPG-2 concentrations are unavailable, other criteria may be used. Please refer to Chapter 3 for further description of the ERPG system.

The Chemical Manufacturers Association (CMA) recommends the following hierarchy [4]:

Onset of Irreversible or Serious Health Effects

Priority	*Guideline*	*Description*	*Source*
1	ERPG-2	Emergency Response Planning Guideline	American Industrial Hygiene Association
2	SPEGL	Short-Term Public Emergency Guidance Level	National Research Council
3	STEL	Short-Term Exposure Level	American Conference of Governmental Industrial Hygienists (ACGIH)
4	TLV–C	Threshold Limit Value–Ceiling	ACGIH
5	EEGL	Emergency Exposure Guidance Level (1-hour exposure limit)	National Research **Council**
6	3x Occupational Guideline–TWA		
	3x TLV–TWA	Threshold Limit Value–Time Weighted Average	ACGIH
	3x WEEL–TWA	Workplace Environmental Exposure Level	ACGIH
	3x PEL–TWA	Permissible Exposure Limit	OSHA
	3x REL–TWA	Recommended Exposure Limit	National Institute for Occupational Safety and Health

Onset of Life-Threatening Effects

Priority	*Guideline*	*Description*	*Source*
1	ERPG-3	Emergency Response Planning Guideline	American Industrial Hygiene Association
2	1-hr LC_{50}/30	LC_{50} divided by 30	U.S. Environmental Protection Agency

In case of the release of a flammable material, the impact area is estimated from the extent of overpressure in the event of an explosion or the extent of thermal flux in the event of a fire. In either situation, the area of impact is more likely to be characterized as a circle centered on the ignition source and is less affected by weather conditions than is a toxic gas cloud. For flammable/explosive materials, criteria such as the lower flammable limit (LFL) or a fraction of the LFL are used to determine vulnerable zones. In case of a fire, the vulnerable zone is defined by a thermal radiation level where escape within a short period of time will prevent burn injuries. The appropriate criterion for assessing explosion/blast damage is an overpressure level that causes minor structural damage with possible injuries and/or a level that causes injuries to people in the open. The CMA recommends the following criteria [4]:

- *Explosions:*
  —Peak overpressure of 1.0 psig—threshold of partial demolition of houses.
  —Peak overpressure of 2.3 psig—threshold of ear drum rupture and lower limit of serious structural damage.
- *Pool/Jet Fires:* Radiation heat flux of 4 kW/m^2—based on a 90-second maximum exposure; threshold of second-degree burn based on a 90-second exposure.
- *Fireballs:* Radiation heat flux of 5 kW/m^2—threshold of second-degree burn based on a 60-second exposure.
- *Flash Fires:* One-half the Lower Flammable Limit (½ LFL[1]) for the substance—estimate of flame and heat radiation envelope that could seriously impact public safety and health resulting from a flash fire.

9.3. USING MODELS FOR DEVELOPING EMERGENCY RESPONSE PLANS

9.3.1. *Input Data Needs*

The first step in hazard assessment is properly defining the release scenarios, a discussion of which is provided in Chapter 3. For any given scenario, many source and environmental parameters have to be defined in order to properly predict the way a chemical release is dispersed in the atmosphere.

Required source information includes: composition (species and phase); total mass in storage; thermodynamic properties of the released material (pressure, temperature, enthalpy); and geometry of the leak or spill. Ambient environmental conditions of interest are temperature, wind speed, atmospheric stability, ground temperature, and relative humidity.

The source term used in dispersion calculations is also determined by the type of release—liquid, gas, multiphase, or aerosol; and its duration—continuous, instantaneous, or transient. Some of the possible source scenarios are:

- Release from a pipe or vessel.
- Release from a pressure relief device (relief valve or rupture disk).

1 *Note:* A fraction of LFL is used to determine the size of a potentially flammable gas cloud since the mixture is nonuniform in concentration and a pocket above the LFL may encounter an ignition source.

- Evaporation from a pool or from the soil.
- High-velocity (jet) release.
- Vessel failure.

Based on the source term, there are several possible dispersion mechanisms, which depend on plume/cloud density (heavier-than-air, neutral, or lighter-than-air), source momentum, and atmospheric turbulence. Density effects include plume rise or fall (positive or negative buoyancy), gravity slumping in ground-level heavier-than-air releases, and stable density stratification in ground-level clouds. Source momentum enhances mixing in elevated jets, and mixing and surface interactions in ground-level flow. Wind transports a plume/cloud, and atmospheric turbulence disperses it. The appropriate models to use to account for these phenomena are discussed in Section 9.4.

9.3.2. *Interpretation of Results*

If consequences are represented by the distance to concentration levels of concern, then concentration isopleths may be drawn on maps of a facility and the surrounding area. Since wind direction is not usually known ahead of time, the plume footprint should be rotated about the release point to show the circle of possible area that could be impacted. A generalized concept is shown as Figure 9.1.

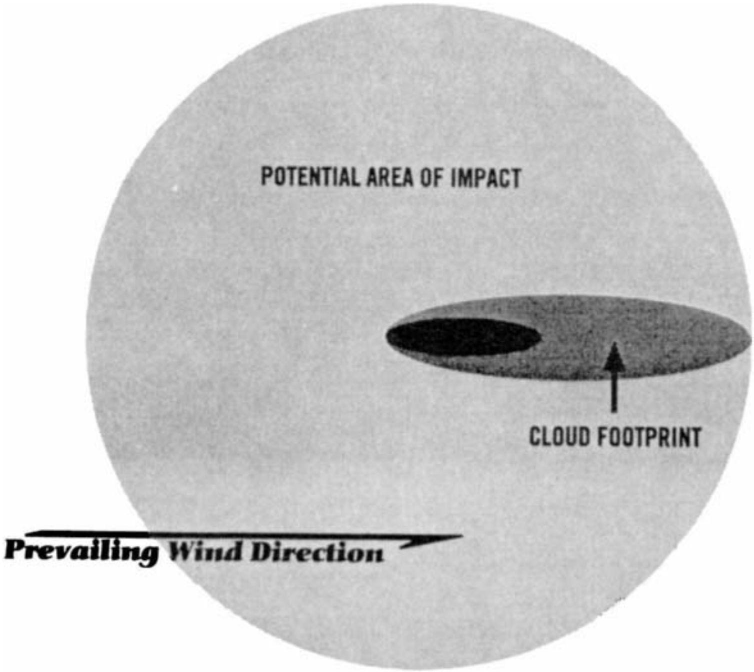

FIGURE 9.1. Vapor cloud plume footprint.

Other types of potential consequences include:

- Biological response as a function of concentration and exposure time.
- Distance at which the flammability limit is exceeded (can result in light-back of a plume from an ignition point to the leak source).
- Thermal radiation effects from fires or jet flames.
- The effects on people or on the surroundings of the pressure impacts of vapor cloud explosions.
- Oxygen displacement and the potential for asphyxiation.
- Visibility limitations within a pollutant cloud.
- Temperature extremes resulting from cryogenic liquid spills, flashing flows, hot fluid releases, or chemical reactions.
- Entrainment of released material into inlet ducts for surrounding process equipment and ventilation systems.
- The thrust and expansion force from high pressure and flashing liquid releases.
- Injury due to projectiles.

The consequence analysis results indicate potential hazards; however, if one wants to determine the risk associated with a particular scenario, a risk assessment must be performed. Risk assessments are typically much more comprehensive that a hazard assessment, and take into account the frequency at which different scenarios occur. Information about risk assessments can be found in the CCPS *Guidelines for Chemical Process Quantitative Risk Analysis* [2].

9.4. UTILIZING APPROPRIATE MODELS

Several models are available in both the public and private domain for performing a consequence analysis. The different types of models and their capabilities are discussed in the AIChE/CCPS volume entitled *Guidelines for Use of Vapor Cloud Dispersion Models* [3], which will be revised by 1996, and in the U.S. EPA's *Guidance on the Application of Refined Dispersion Models for Hazardous/Toxic Air Releases* [5]; however, the choice of a model is not simple and depends on the types of scenarios being modeled. Simple Gaussian dispersion models are useful for modeling releases whose density is equal to or lighter than air (neutrally or positively buoyant). If the gas is denser than air or the released vapor is dense because of the presence of aerosols, modeling the release and dispersion becomes more complicated. Several models have algorithms for estimating the nature of the source term, including the physical state (liquid, gas, or combination), liquid fraction, temperature, and release rate or quantity.

Many models have been developed for the release and dispersion of a dense gas. Among those in the public domain are DEGADIS, HGSYSTEM, SLAB, and ALOHA. Proprietary models include FOCUS, TRACE, SUPERCHEMS, and PHAST. The Annual Guide to Environmental Software published in *Pollution*

Engineering [1] has an extensive list of available models. Consult *Guidelines for Use of Vapor Cloud Dispersion Models* to understand the modeling of dense gas effects and to select the correct model for any given application.

Computer models are extremely valuable for developing emergency plans. By analyzing the appropriate scenarios ahead of time, the results can be kept in a readily available location for use during a real emergency.

9.5. REAL-TIME EMERGENCY RESPONSE MODELING SYSTEMS

Incorporating consequence analyses results in emergency plans is extremely important, as indicated previously; however, if a facility believes it is necessary to account for the variation in wind speed, wind direction, and transient nature of releases, there are real-time emergency response modeling systems available. Such systems may help a facility in the following ways:

- Plan and prepare for emergencies.
- Aid in training personnel to respond to emergencies quickly and safely.
- Respond rapidly to actual emergency situations (if the actual scenario has already been modeled).
- Communicate and coordinate emergency activities with community emergency responders.
- Judge whether shelters would be safe during an emergency.

Examples of real-time emergency response systems that are commercially available are SAFER, MIDAS, ALOHA and EIS-CHARM. These modeling systems are typically connected to meteorological towers and other sensors to obtain real-time data and evaluate predefined scenarios. They can be set up to activate alarms in case of an emergency. The results can also be displayed on video screens throughout a facility. Information about these systems can be found in the Annual Guide to Environmental Software. As with other accidental release models, emergency response systems are most valuable when used as planning tools for hypothetical releases. For real time incidents critical input data such as release rate are usually difficult to obtain and, therefore, limit the accuracy of the output information.

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3. AIChE/CCPS. 1987. *Guidelines for Use of Vapor Cloud Dispersion Models.* New York: AIChE.

4. Mayhew, Joe J., Letters on *Risk Management Programs for Chemical Accidental Release Prevention*, Chemical Manufacturers Association to Environmental Protection Agency, February 16, 1994.
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PART C

RESPONSE

11

KEY RESPONSE FUNCTIONS

This chapter identifies the critical emergency response decisions and their implementation. It defines the incident command system (ICS), identifies how to implement the ICS, and discusses key tactics required to mitigate the incident and carry out decontamination.

11.1. INCIDENT COMMAND SYSTEM

11.1.1. Definition

The incident command system (ICS) is a field application of management principles to emergency situations. The ICS assigns various duties and responsibilities, roles, and triggering actions to implement various levels of the ICS. The model ICS ensures that the lines of authority and communication are direct and clearly defined. Figure 11.1 presents a sample for the functional components of a plant ICS.

The ICS should be modular and capable of expanding or contracting depending on the size or complexity of the incident. Incident commanders must maintain an effective span of control so that ideally, no more than seven personnel or functions report to one supervisor.

An effective ICS is also dependent on ensuring unity of command; that is, each person reports to one supervisor. All activities at the incident scene are the responsibility of the incident commander until delegated.

The use of a field or mobile command post (CP), described in Chapter 7, is part of an ICS. The CP must be clearly identified and visible. It should be located close enough to the incident as to offer command and control, but must not be located close enough to place it in physical jeopardy or cause interference with tactical operations.

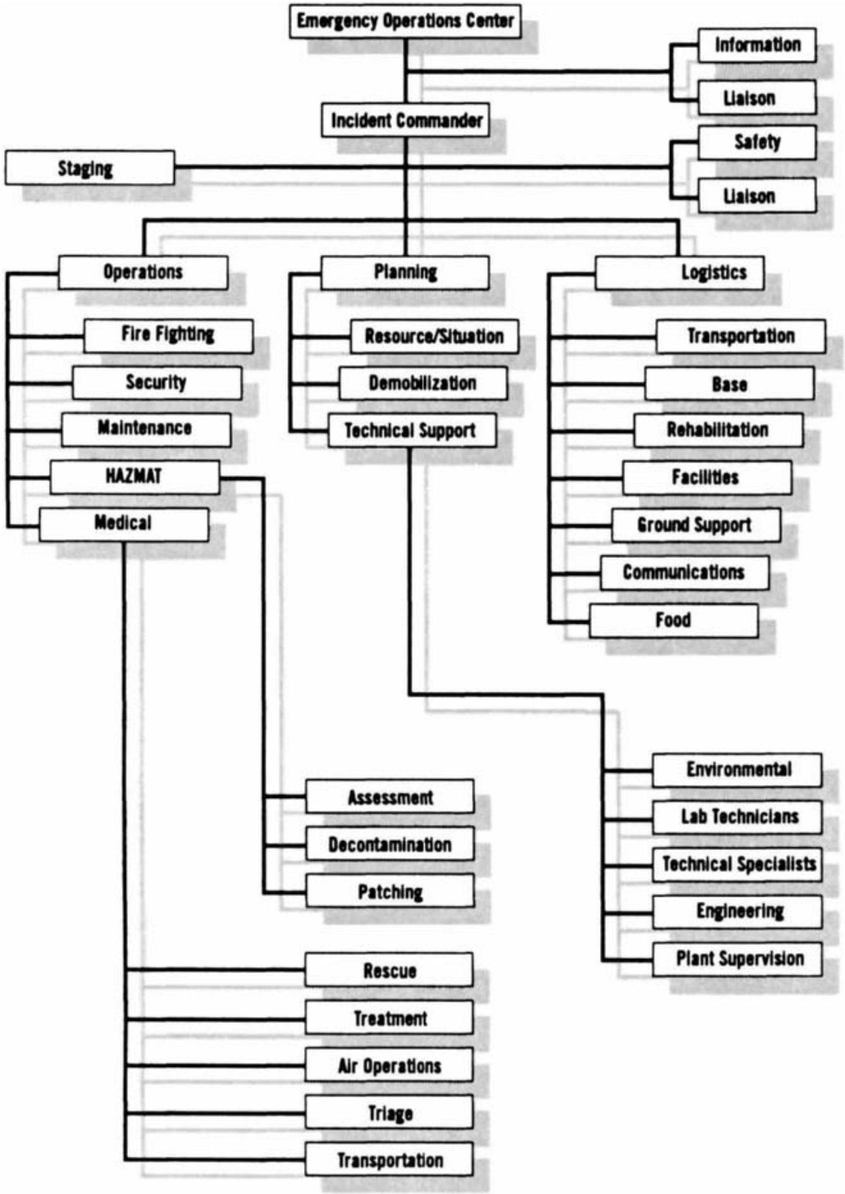

FIGURE 11.1. Sample incident command system plan.

The ICS should be capable of being applied to the full range of emergency incidents. The ICS should provide for common communications and terminology to allow for multijurisdictional, multiagency response.

Appendix A of this chapter is the ICS Worksheet used by Channel Industries Mutual Aid (CIMA) for the quick evaluation of an incident.

11.1.2. Characteristics of an ICS

An effective ICS consists of the following characteristics and advantages:

- *Modular Expansion:* The management system is expanded or contracted to meet the needs or requirements of the incident.
- *Manageable Span of Control:* As the incident expands in size, scope, or complexity, the span of control is kept manageable by expanding the command system.
- *Common Terminology and Communications:* All response personnel, including multidivisional, multiagency, and multijurisdictional entities, all use the same terminology to refer to action levels, command positions, and related strategy and tactics. Common communication channels and terminology are also an integral part of ICS.
- *Unity of Command:* All tasks are assigned (or preassigned). Personnel are aware of who their supervisor is and any changes to their status. The reporting and communication lines are accordingly clear and direct.
- *Economy of Resources:* The command and control of resources by the assigned supervisors help ensure that all necessary tasks will be done and no task will be overlooked. Closer accountability of resources ensures that the jobs will be completed safely and with the minimum amount of effort or forces required.
- *Safety of Operations:* By maintaining closer supervisory control, operating personnel will be more closely accountable to their ICS supervisors. Personnel will be more closely monitored to ensure their safety and well-being.
- *Common Command Post:* A well-marked command post from which the IC operates.
- *Consolidated Action Plan:* By planning for multiagency response, the ICS brings all responders to the same common management structure. Strategy is then developed and implemented as a joint operation from one ICS with command, control, coordination, and communication level not possible without ICS.

11.1.3. Considerations for ICS

In planning for the management of emergency response, a number of critical considerations are needed in the development of the ICS, including:

- The ICS should be developed to offer coverage for all shift periods regardless of whether the facility is a full 24-hour operation. The ICS should be an extension, as much as possible, of routine operations applied to emergency requirements. The ICS must be realistic, based on the actual capability of available personnel, both in numbers and qualifications.
- The roles, duties, and responsibilities of command positions should be clearly identified and understood by all participants. Action levels and the accompanying activities must be well-defined and practiced by key members.
- The ICS should be routinely implemented on all incidents to instill familiarity and confidence in the system. Weak areas or procedures needing modification can also be identified and corrected by the constant use of ICS.
- Predeveloped incident action checklists should be used to ensure complete coverage of vital response aspects and ensure consistency in response (see Appendix A to this chapter, page 281).
- All ICS command positions should be position-specific and not person-specific. Particular persons may not be able to respond when the incident occurs.
- All responders should be trained in the implementation and operation of the ICS. Command positions should be at least three deep in trained backup personnel. If this coverage is not possible, alternative responses or duties must be considered.
- Identifying and assigning a site safety officer. The duties of the site safety officer are to control and account for entrance and exit of emergency responders in the incident hot area. The site safety officer will also determine the PPE requirements and ensure that all responder activities are safe.

11.2. STRATEGY DEVELOPMENT

A major function of the ICS is to assign the responsibility and accountability for developing and implementing a strategy and coordinating resources to effectively manage an emergency incident. The strategy will generally be either offensive (characterized by aggressive tactics aimed at quick mitigation of the incident) or defensive (characterized by protective measures aimed at protection of exposures and containment). The incident commander (IC) should determine the strategy based on preincident assessments and planning, real-time conditions obtained through size-up and reconnaissance activities, and available resources at the time of the incident.

Objectives should be identified that are necessary to accomplish the strategy, which will then become the action plan. Tactics, those specific tasks necessary to accomplish the objectives, can then be identified and assigned to resources as they are available.

The tactics employed must be based on incident-specific assessments and the IC's overall strategic goal. Tactics available include immediate withdrawal and isolation of the affected area, total or limited evacuation (on-site and off-site), protection-in-place, active intervention of an offensive or defensive nature, or a combination of all the above.

11.2.1. Assessment and Decision Making

Strategic decisions should be based on preincident evaluation of the hazard and information from the actual incident. This incident information is gained from a number of sources. They range from qualitative observations to quantitative readings obtained from monitoring devices. The list of information sources during the incident includes:

- Knowledge of operators and area supervisors.
- Observations of witnesses or those involved in the situation, such as:
  —Any unusual behavior of chemicals or processes.
  —Unusual smoke, flames, or other visible signs of reaction.
- Data obtained from fixed monitoring systems, portable direct-reading instruments, or other information obtained from reconnaissance by response teams.
- Knowledge of the chemicals involved (preplan reference).
- Reconnaissance of the incident scene.

11.2.1.1. Identify Chemical/Hazard

As incident data become available, the IC needs to discern and consider the following:

- Type and characteristics of materials involved, such as flash point, flammable range, specific gravity, vapor density, vapor pressure, pH, solubility, reactivity, incompatibilities, products of combustion, and neutralizing agents.
- Amount of product available for release, reaction, combustion, or other danger.
- Condition of the containment system, such as current pressure and temperature (especially if abnormal), amount and type of vessel damage, any reactions underway, and consequence of a release.
- The level of active or passive control systems in place and ability to transfer, treat, or neutralize.

11.2.1.2. Identify Critical Areas

The IC must consider the area that could be affected by a hazardous materials release. By using consequence modeling system or exposure level guidelines, the IC can estimate an impact area. Within that area, the IC must identify:

- *Human Exposure Considerations:*
  —Will material migrate off-site?
  —Who could be exposed to the chemical?
  —What will the exposure effect be?
  —How far away will the IDLH, STEL, or ERPG level reach?
  —How quickly will these dangerous exposure levels be reached?
- *On-Site Critical Systems Considerations:*
  —Are any critical control areas within the danger area?
  —Are there systems that must remain in place (or at least undergo an orderly shutdown) to prevent even greater potential damage?
- *Environmental Considerations:*
  —Bodies of water.
  —Sensitive land areas.
  —Wildlife preserves.
  —Fisheries.
  —Other environmentally sensitive areas.
- *Property:*
  —On-site property (such as equipment, operating systems, railcars, tank wagons, raw materials, finished product, inventory, or buildings).
  —Off-site property.
- *Critical Off-Site Systems:*
  —Major transportation systems that may be affected by the incident.
  —Utilities such as water, power generation, or communications that may be affected by the incident.
- *Response Team Work Areas:*
  —Command post.
  —Staging areas.
  —Routes for incoming assistance.

11.2.1.3 Establish Control Areas

Strategic planning for each incident, based on incident-specific conditions, must consider control areas such as command post, staging areas, work zones, and possible evacuation assembly areas. While many of these areas are likely identified during the preplanning stage, allowance for incident-specific variables must be made.

The IC needs to determine the "hot" zone or exclusionary zone, which is the area of maximum hazard and may be entered only by those properly protected against the particular hazard. Only those with a specific mission and purpose should be allowed to enter the hot zone. All persons entering this (and other) zones must do so under the control of the site safety officer and IC. All entries will be made using a buddy system with back-up personnel to assist in case of emergency.

The hot zone will be supported by the contamination reduction zone (CRZ) or "warm" or "decon" area. This warm zone serves as a buffer against the transfer of harmful products from the "hot" zone. Again, only those properly protected and with a specific purpose should be permitted to enter the "warm" zone.

The "cold" or support zone is designated for the Incident Command post and other vital support personnel and functions. No protective clothing is required in this area. The cold zone is still considered a restricted area and unauthorized personnel should not be permitted entry to this area.

The size, location, and extent of the zones will depend on the type of release or incident, nature of contaminants, weather, terrain, topography, and other factors. Real-time observations, instrument readings, and various reference documents can aid in determining the size and dimensions of the control zones. The Department of Transportation's (DOT) *Emergency Response Guidebook* [2], CHRIS [1], ERPGs, MSDSs, and other resources can aid in determining harm levels and data to assist in establishing the zones.

Other control areas may consist of on-site and off-site protective action areas such as evacuation assembly areas or shelters. The facility emergency plan should contain decision-making criteria regarding whether to evacuate or to protect-in-place. The persons vested with the authority to initiate protective actions must be well-trained as to their duties and the means to reach their decisions. Specific triggering actions and the authority to modify or expand the protective action must ultimately rest with the IC. The IC must decide early which protective action is necessary, if any. This decision should be based on preincident planning supported or modified by incident-specific conditions. Also, if the release has the potential to migrate off-site, the IC or designee should communicate with local emergency response officials.

11.2.1.4. Ensure Protective Actions Are Taken

An ICS, with its management structure and enhanced control and communications, facilitates accomplishing protective actions. The delegation, action checklists, and the feedback loop of the ICS prompts the follow-up to ensure that protective actions have been taken. Continuous feedback from response personnel enables the IC to maintain command and control. Updates are especially critical when interacting with off-site officials who may be implementing evacuation or protection-in-place directions.

11.2.2. Evaluate Additional Resources Needs

Another important action in the early stages of any incident is estimating the potential breadth of the incident and the need for additional resources. An ICS can facilitate both the rapid escalation and deescalation of the response effort by controlling the requests for more personnel, equipment, or specialized apparatus. Response activities are labor intensive and obtaining additional trained responders, along with appropriate PPE, is important.

11.3. DETERMINE MITIGATION TACTICS

The IC should determine actions necessary to mitigate the event. This may include offensive actions, defensive actions, or merely cleanup activities. For example, hazardous material incidents might entail using responders to apply extinguishing agents, active leak control devices, passive control devices, absorbents, neutralization agents, heavy equipment, and other safety and control mechanisms.

11.3.1. Evaluate Need for Off-Site Warnings

The IC must determine the need for off-site warning based on the possible migration of incident effects to off-site areas. These areas can be identified through preincident modeling, references such as the DOT's *Emergency Response Guidebook* and AIHA's ERPG, and real-time conditions. The obligation to warn the public typically rests with community officials. The obligation of the facility IC is to recommend to off-site officials when a public warning might be appropriate.

Depending on the locale, community emergency response officials might use stationary warning systems or have police or fire/rescue vehicles provide warning using their public address systems.

11.4. IMPLEMENT TACTICAL PLAN AND EVALUATE

Once the plan is determined, the IC will inform the site safety officer and response team members of the details of the action plan and any other important information. The IC will then implement operations.

The IC will not deviate from the plan without advising all concerned. The responders will don appropriate PPE (selected by the IC or site safety officer) and prepare to execute the IC's plan. For hazardous materials events, someone other than the individual wearing the PPE will ensure that the suit is taped/sealed properly and no contaminants will be able to enter the suit. A qualified backup team will also prepare for operations. The backup team will follow the same procedures as the entry team and will be on "standby" to enter the hot zone. If the first entry team cannot finish the necessary work before coming out of the hot zone, the backup team may function as the second entry team. A decontamination area must be operational before anyone enters the hot zone. Additionally, someone on the ICS team should control the entry personnel.

Whenever a team is working in the hot zone, there needs to be a fully prepared backup team standing by to enter the hot zone. As team members prepare, the site safety officer or designee will take and record their vital signs. The IC and site safety officer will review communication protocols between the entry teams.

The team may use two-way intrinsically safe radios, hand signals (see Table 11.1), or other appropriate methods for communicating during response activities.

TABLE 11.1
Example Response Team Hand Signals

Signal	*Definition*
Hands clutching throat	Out of air/cannot breath
Hands on top of head	Need assistance
Thumbs up	OK/I am all right/I understand
Thumbs down	No/negative
Arms waving upright	Send backup support
Grip partners wrist	Exit area immediately

Entry team personnel will enter the zone and work as a unit. If it becomes necessary for one person to leave, the entire unit will leave. When the site safety officer advises that it is time to leave the area, the entry team will leave immediately. This can be through direct contact with the site safety officer or IC. The decon team must be prepared for possible emergency decontamination if the entry team encounters unexpected problems.

As the team is making its way out of the hot zone, they will report as much information as possible to the command post. All information is vital, especially if it is necessary for another team to enter the hot zone to complete the assignment.

The IC will regularly evaluate progress to verify that the chosen plan is working. If no progress is being made after a reasonable amount of time, then it may be necessary to gather all personnel and discuss alternatives.

11.5. RESPONSE TEAM DECONTAMINATION

This section focuses on decontamination issues for responders to a hazardous materials incident. The areas of decontamination and treatment of those nonresponse team personnel contaminated in the incident prior to team arrival, as well as the protection of responders and their equipment, will be discussed.

Decontamination is best defined as the process of removing harmful products from personnel, protective clothing, and equipment in order to prevent the spread of hazardous materials and lessen the possibility of exposure to dangerous chemicals. Decontamination is a systematic removal or reduction of a contaminating agent. The definition of decontamination will be limited to emergency response considerations and not to restoration or cleanup efforts after the emergency is over (which is covered in Chapter 14).

This chapter differentiates between the two types of decontamination actions commonly implemented during an incident. The first of these is "gross" or emergency decontamination. Gross decontamination includes actions taken to treat individuals (injured responders or other incident victims) who may have been exposed in the initial release or other incipient phases of the incident and control the spread of harmful properties from the initial hot zone.

The prime characteristic of gross or emergency decontamination is the speed of decontamination initiation. This rapid action must be combined with a thoroughness to prevent further injury to the victim and to minimize the spread of hazardous materials.

Gross decontamination is also the first step in assessing the condition of persons exposed to harmful chemicals. Treating life-threatening injuries must accompany gross decontamination and both are often integrated into one life-saving action. While life-threatening injuries must be treated immediately, decontamination may be a major part of the initial emergency medical intervention. Responders should inform medical personnel that only a gross decontamination has been implemented. Treatment of secondary, non–life-threatening injuries may be delayed until after a more thorough decontamination.

Technical decontamination for responders is a more thorough activity taken to minimize the transfer of harmful products encountered by response teams in the hazmat incident. Speed is secondary to thoroughness and complete decontamination efforts. Characteristics of technical decontamination include multiple wash/rinse stations, maximum segregation, and zone security.

11.5.1. Types of Contamination

The types of contamination parallel the states of matter:

- *Solid:* Contamination by solid material ranges from small aerosol particles suspended in smoke to larger dust-type materials. Larger, irregular deposits may be the result of explosions or pressure releases. Solid contamination may include nuisance dust to harmful asbestos fibers. Toxins may range from materials with long-term latent effects such as asbestos to acutely toxic pesticides. Flammable solids may even be air or water reactive complicating decontamination efforts.
- *Liquid:* This form of contamination may range from gross splashes of harmful materials to fine spray and mists in smoke or releases. Liquid contamination is especially difficult to decontaminate because the liquid spreads easily to cracks and remote exposed areas. Liquid contamination may dry, leaving little visible evidence of contamination.
- *Gas:* Gaseous contamination may be in the form of a direct release or may accompany one of the other forms of contamination. Even pure gaseous contact may leave residual product or harmful by-products. Chlorine and ammonia are two prime examples of this. Each may react with moisture and impurities, thereby leaving dilute solutions of corrosive and irritating material.

11.5.2. Prevention of Contamination

The first line of defense is the prevention of the contamination. Site security, management of sites, location of zones, efficient work practices, and common sense in avoiding contact with harmful materials are the basis for contamination prevention.

The control zones should be located uphill and upwind from the potential contaminant. Every effort must be made to avoid direct contact with harmful areas. Mechanical devices, remote control apparatus, or the use of in-place control systems should be considered before placing persons in possible contact with harmful chemicals. Personnel should avoid working in plume or spray areas. Zones should be closely managed to control personnel from entering the area.

11.5.3. Decontamination Methods

Responders can use any number of effective, safe, and accepted decontamination methods. In choosing a decontamination method, response managers must consider the situation, chemicals involved, extent of contamination, location, weather, and number of persons to be decontaminated. The following is a list of some of the most commonly used methods of decontamination:

- *Dilution:* The use of water, mild detergents, and rinse solutions to cleanse and dilute the contaminated material. Wash solutions may include detergents, tincture of green soaps, or other mild liquid soaps. Rinse solutions may include mild basic solutions of trisodium phosphate (TSP) or sodium bicarbonate. *Note:* a compendium of wash/rinse solutions is available from the Agency for Substance and Toxic Disease Registry (ASTDR). Runoff water and wash/rinse solutions should be impounded and held for neutralization on-site or disposed of as hazardous waste.
- *Disposal:* The use of disposable garments, tools, and appliances in the hot zone should be considered. As personnel exit the contaminated areas, clothing and other items are deposited in suitable containers for later disposal as hazardous waste. The use of multilayer composite protective clothing permits the use of garments with a high protection level, yet inexpensive enough to be considered routinely disposable.
- *Physical Removal:* The use of brushes to brush away or a vacuum to take up material that may be water or air reactive. The larger particles should be removed in such a way followed by flooding amounts of water and detergent.
- *Neutralization:* Neutralization is not typically applied directly on humans and its use should be confined to garments and equipment. Soda ash, sodium bicarbonate, crushed limestone, TSP, vinegar, citric acid, household bleach, calcium hypochlorite, and mineral oils are some of the more commonly used neutralization materials. A specific neutralizer, calcium gluconate, is used in case of skin contact with HF.

- *Adsorption:* The adsorption by materials that take up the contamination by directly causing the harmful products to adhere to the surface of the adsorbent. The adsorbent is then disposed of or the contaminant is removed from it.
- *Physical Removal/Isolation:* Physical removal/isolation entails the total isolation and impoundment of a site and/or equipment. Contaminated materials may then be treated on-site or disposed of permanently in place.

11.5.4. Determining Effectiveness

The effectiveness of decontamination may be determined in several ways. The first of these is close visual observation of the condition of chemical protective gear as crews clear the decontamination area. Gross exposures should be avoided, but in those cases where this contact is inevitable, close scrutiny of the decontamination effort is in order.

The runoff water, wash, and rinse solutions can be field-tested and monitored for the presence of known toxins. The pH levels of runoff can also be quickly and accurately tested. In the cases of radiation exposure and contamination, the detectors for the specific type of radiation involved can be used. Definitive testing can be performed by laboratory analysis of runoff water and decontamination gear. All tests and monitoring results must be documented as to time, place, circumstances of test, and results.

11.5.5. Planning for Decontamination

As with all other aspects of emergency response to chemical incidents, preplanning is vital to the safe and effective implementation of decontamination. While all incidents differ and present a variety of challenges, a number of factors can be planned for, including:

- *Decontamination Locations:* Places in the facility that have accessibility to a sustained flow of water (either from safety showers or hose lines) can be identified. The ideal location combines large water flow capacity with the ability to impound runoff for treatment or disposal. If a stationary catchment is not possible, a large, clear area for the placement of portable pools and impoundment basins is required. A location out of the main areas of travel is desirable. Proposed decontamination locations should not be in or near areas of likely incident release impact areas.

  Shelter from the extremes of weather is also desirable. Provisions for the security of valuables and personal effects is also a requirement for field and emergency decontamination.
- *Decon Equipment:* An array of equipment and supplies should be stockpiled for the purposes of decontamination, including:
  - Small-diameter hoses for the delivery of water for decon pools and for use as scrub and rinse. Care must be taken to prevent excessive pressure

and volume so as not to injure persons or overtax the impoundment capability.

—Hand-held, adjustable nozzles such as the type used for lawn and gardening watering that permits a fine spray and adjustments of stream and configuration.

—Portable sprayers for the direct application of soap or rinse solutions.

—Fine bristle brushes and sponges for scrubbing and further rinsing.

—Prepackaged mixtures of wash and rinse solutions measured for proper dilution with the intended application device.

—Pools, basins, or other impoundment means.

—Portable showers.

—Portable tents, modesty screens, or other shelter devices.

—Disposable clothing such as Tyvek® or cotton coveralls.

As with all other aspects of planning for emergencies, decontamination needs may be assessed according to the type and amount of chemicals used in a facility factored against the number of possible patients and locations available to decon, triage, and treat them.

11.6. MEDICAL DECONTAMINATION/TRIAGE/TREATMENT

During an incident involving hazardous materials, medical emergencies may arise due to injuries resulting from physical trauma, chemical contamination, burns, and other causes. Emergency medical response must be prompt and effective, but should not place the responders or patients at additional risk. The level of planning and response should be consistent with the potential human consequences. Analysis of the consequences of the most severe events postulated by the credible incident scenarios may provide information in determining the potential for personal injury.

During incident preplanning for facilities, potential locations for a decontamination and triage area should be selected and identified. A minimum of two locations should be selected to account for varying wind conditions. The decontamination and triage area, called the contamination reduction zone (CRZ), should be inside a potential warm zone if possible. The area should be in a warm zone location protected from activities at the incident scene. The locations selected should be based at a minimum on the following three criteria:

1. The location should be upwind to avoid exposure to chemical fumes, vapors, and smoke.
2. The location should be uphill to avoid runoff from fire-fighting water and chemical spills.
3. The location should be accessible to emergency vehicles.

Planners should identify the nearest medical facility capable of treating the level of chemical exposure and trauma anticipated. The local hospital and government health authorities should participate in training the emergency room (ER) personnel and emergency medical services (EMS) personnel. This training program should include using MSDSs and identification of the properties of the hazardous materials that may be involved, medical treatment protocols for exposure, decontamination techniques, contamination control techniques, appropriate level of protection (LOP) for ER and EMS personnel, drills and exercises to field-test procedures, and procurement of resources necessary to meet expected ER and EMS needs.

Facilities can anticipate three categories of patients during an incident involving hazardous chemicals:

1. Patients with physical trauma who are not contaminated.
2. Patients with minor or no physical trauma, but who are chemically contaminated.
3. Patients who are severely injured and chemically contaminated.

EMS personnel should treat all patients as chemically contaminated unless positive evidence is provided to the contrary. Experienced ER or EMS personnel should triage all victims (assign treatment priorities).

Triage is a method for rapid assessment of emergency care priorities. Triage is more difficult during incidents involving chemical exposure. The rapid initial patient assessment will identify those patients requiring life-sustaining measures and identify the injuries or problems of each patient and the extent of chemical contamination or exposure. Besides the initial assessment, EMS personnel should frequently reassess patients waiting for care. Depending on the chemical involved and method of exposure, the condition of the victim may become worse without quick and proper treatment. EMS personnel should obtain the identity of the chemicals involved in the incident, the chemicals' physical properties, and the symptoms of varying levels of exposure.

Triage at the scene of a chemical spill must be performed along with decontamination of patients. In all cases, life-saving measures should take precedence over decontamination unless decontamination is necessary to protect the patient or EMS personnel. The minimum level of decontamination (gross decontamination) necessary before treatment or transport is removal of the patient's clothing (redress with disposable coverall, Tyvek coveralls, or blankets) and any obvious contamination. Full decontamination of the patient should begin when the patient is in a stable condition. EMS personnel at the scene are responsible for these judgment calls.

Decontamination must be performed as quickly as possible. Once the patient is in a safe location and gross decontamination has been completed, detailed decontamination can begin as described below:

Step 1: Ensure appropriate PPE is available and worn by EMS personnel before entering the incident scene. Remove patient from area of highest contamination.

Step 2: Remove the patient's clothing and personal effects and place them in a plastic bag labeled with the patient's name. Redress patient with PPE or blankets.

Step 3: Remove any visible contamination. Wash patient with a mild soap solution and rinse with warm water (if available) or other decontamination solutions as appropriate. Responders should contain runoff. Typically, wash and rinse are performed twice.

Step 4: Apply other appropriate antidote or ointments as directed by responsible medical supervision.

NFPA 473 [3] identifies several protocols or procedures for patient decontamination that require site-specific development to guide decontamination. These guidelines include the following:

- Determining the potential for spread of contamination and the need for and potential extent of decontamination.
- Selection of personal protective clothing and identification of decontamination protocols appropriate to the chemicals that may be involved.
- Protocols/procedures for treatment and decontamination of patients who require immediate care and/or transport due to the severity of their injuries.

Management, with the assistance of proper medical authority, is responsible for determining the signs, symptoms, and proper emergency medical care for potential exposure to chemicals. Management is also responsible for developing and carrying out of a program to control biological hazards. This program includes a means to protect response personnel from disease through contact with blood and bodily fluids.

11.7. USING DISPERSION MODELING DURING EMERGENCIES

As indicated in Chapter 9, industry and emergency response agencies typically use dispersion modeling systems to determine vulnerability zones within and outside a facility before an emergency occurs. Dispersion modeling identifies the plume that hazardous materials, if released, could travel based on known chemical data and expected weather patterns. These models help planners understand areas that could be effected and allow them to determine what actions to take if a release occurs. Many facilities incorporate this information into their facility's emergency plan, which can later be used by responders in developing tactical action plans during an emergency. Some facilities print various plume scenarios onto transparencies that allows responders to overlay the plume on a map.

Some computerized dispersion modeling programs allow responders to input meteorological data and estimated release data into the computer during the actual emergency. While this capability can be advantageous, it must be remembered that modeling is only a tool, and its misuse can result in grave consequences. Some modeling systems are very complex while others are very basic, but all require information that is sometimes difficult to obtain (e.g., actual release data). Some programs have inherent limitations that both the operator and the IC must understand. For example, some systems do not model heavier than air vapors very well, while others may not take into account the effects of topography and structures on the plume. All modeling information should be used along with all other available facts in determining appropriate actions such as evacuation or sheltering in-place.

The principal use of dispersion modeling during an emergency is to determine the likely direction the release may travel and the concentrations throughout the plume during various times. One problem with modeling is that weather data at the incident scene may be quite different from a point 200 yards away. Another problem is that actual release information might not be known, thereby resulting in an under- or overestimation of the plume.

11.8. TERMINATION

Both good managerial practice and federal regulation indicate that emergency incidents be brought to a safe, orderly, and organized conclusion. OSHA's HAZWOPER regulation (29 CFR 1910.120 q) [4] specifies the termination requirements. The IC conducts the termination activity in three phases:

- On-site debriefing.
- Critique.
- Critique (after-action) report.

The IC conducts an on-site debriefing once the incident is under control, but before releasing responders. The debriefing includes a number of very important action items:

- It provides a reminder that the signs and symptoms of exposures to the various materials involved should accompany a site safety officer's check of all responders' well-being. The need for critical incident stress debriefing should also be addressed at this time.
- It identifies any immediate equipment repairs, replacement, resupply and other equipment care and maintenance issues. If not already assigned, responsibility for completion of said tasks must be assigned.
- It identifies any serious operational problems and assigns them for immediate follow-up action.
- It identifies contact persons for follow-up activity before responders leave the area.

A formal critique meeting should be held to discuss the incident and how it was handled. This activity should take place as soon as practical after the incident. Findings should be published as to lessons learned and reinforced. Critiques must be conducted on an impartial basis with the focus being on constructive improvement for health and safety.

Critique reports on the incident should include positive as well as negative aspects of the activity. Again, this must be done in an impartial and professional manner with the emphasis on the positive and how responders can improve for the future.

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APPENDIX A. CHANNEL INDUSTRIES MUTUAL AID ICS WORKSHEET

IMMEDIATE CONCERNS
[ ] Personnel Accounted For
[ ] Product(s) Involved ______________________
[ ] MSDS or Other Hazard Information In-Hand

TACTICAL PRIORITIES
1. Rescue
2. Fire Control
3. Property Conservation

MULTIPLE CASUALTY
[ ] No. of Victims
[ ] Assign Medical Division
[ ] Request Ambulances (BLS/ALS)
[ ] Lifeflight Standby/Response (Assign Air Operations Division/LZ)
[ ] Obtain Bulk Supplies (Trauma, Backboards, O_2 Cylinders)
[ ] Heavy Equipment
[ ] Request Ambulances

First 10 Victims	3 ALS	4 BLS
For Each Additional 10	2 ALS	3 BLS

VAPOR RELEASE
[ ] Personnel Exposures Downwind
[ ] Traffic Isolated
[ ] Notification of Exposed (Municipal EOC, CIMA, CAER Line, News Media)
[ ] CAER ALERT (Level 1,2,3)
[ ] Nuisance, Shelter in Place, Evacuate
[ ] Mitigation of Release (Water Spray, Plug, Block In)
[ ] Downwind Monitoring

N
↑

Wind Direction
N
W E
S

PROCESS FIRE
[ ] Equipment Involved (Pump, Furnace, Piperack, etc.)
[ ] Process Liaison
[ ] Exposures Protected
[ ] Fixed Fire Prot. Activated (Deluges, Monitors, Foam Systems)
[ ] Process Isolated
[ ] Radiation/Asbestos Hazards
[ ] Structural Stability
[ ] Power Isolated
[ ] Drainage Control
[ ] Hydrocarbons Floating on Water
[ ] Runoff Hazardous to Personnel
[ ] Fire Pump Status/Header Pressure

TANK FIRE
[ ] Tank Type ______________ Tank Dia. ____________
[ ] Tank Levels
[ ] Process Liaison
[ ] Exposures Protected
[ ] Fixed Fire Prt. Activated (Deluge, Monitor, Foam, Halon, CO_2)
[ ] Tank N_2 Inerted
[ ] Tank Static (No Pump-In or Pump-Out)
[ ] Drainage Control
[ ] Fire Pump Status/Header Pressure
[ ] Min. Foam Application Rate ______
[ ] Min. Conc. for 65 Minutes ______
[ ] Foam Coordination

GLOSSARY

Absorption: A process in which one material actually penetrates the inner structure of another, i.e., poisoning through direct skin contact.

Accident: An undesirable, unplanned combination of events or circumstances that lead to physical harm to people or damages to property. Usually the result of contact with a source of energy above the threshold limit of the body or structure.

Active System: A system in which failures are immediately evident during normal operation.

Acute Effect: An adverse effect on a human or animal body, with severe symptoms developing rapidly and coming quickly to a crisis. See also, "Chronic."

Acute Hazard: The potential for injury or damage to occur as a result of an instantaneous or short duration exposure to the effects of an undesirable event (e.g., an explosion with the potential for causing damage and injury).

Acute Toxicity: The adverse (acute) effects resulting from a single dose or exposure to a substance.

Adsorption: A process in which one substance is attracted to and held on the surface of another.

Atmospheric Stability: A measure of the degree of atmospheric turbulence commonly defined in terms of the vertical temperature gradient. In neutral stability the gradient is equivalent to the Adiabatic Lapse Rate (ALR). Stable atmospheric conditions refer to a gradient less than the ALR (ultimately to a temperature inversion), and unstable conditions to a gradient greater than the ALR.

Auto-Ignition Temperature: The auto-ignition temperature of a substance, whether solid, liquid, or gaseous, is the minimum temperature required to initiate or cause self-sustained combustion, in air, with no other source of ignition.

Boiling-Liquid-Expanding-Vapor Explosion (BLEVE): A type of rapid phase transition in which a liquid contained above its atmospheric boiling point is rapidly depressurized, causing a nearly instantaneous transition from liquid to vapor with a corresponding energy release. A BLEVE is often accompanied by a large fireball if a flammable liquid is involved, since an external fire impinging on the vapor space of a pressure vessel is a common BLEVE scenario. However, it is not necessary for the liquid to be flammable to have a BLEVE occur.

Bounding Group (of incidents): A small number of incidents selected to bracket the spectrum of possible incidents, which may include those catastrophic incidents sometimes referred to as the Worst Credible Incident and Worst Possible Incident.

C.A.S. Number: Chemical Abstracts Service Number: used to identify specific chemicals.

Catalyst: A substance that modifies a chemical reaction (makes it faster or slower).

Catastrophic: A loss of extraordinary magnitude resulting in physical harm to people, and damage and destruction to property, and/or to the environment.

Catastrophic Incident: An incident with an outcome effect zone that extends off site into the surrounding community.

Chemtrec: Chemical Transportation Emergency Center; a national center established by the Chemical Manufacturers Association in Washington, D.C in 1970, to relay pertinent information concerning specific chemicals.

Chronic Effect: An adverse effect on a human or animal body, with symptoms which develop slowly over a long period of time. Also, see "Acute."

Chronic Toxicity: Adverse (chronic) effects resulting from repeated doses of or exposures to a substance over a relatively prolonged period of time.

Cold Zone: Contains the command post and other support functions as are deemed necessary to control the incident. This is also referred to as the clean zone or support zone in other documents.

Combustible: A term used to classify certain liquids that will burn, on the basis of flash points. The National Fire Protection Association (NFPA) defines "combustible liquids" as having a flash point of 100°F (37.8°C) or higher. See also, "Flammable."

Common Cause Failure (CCF): The failure of more than one component, item, or system due to the same cause.

Concentration: The relative amount of a substance when combined or mixed with other substances. Examples: 2 ppm Xylene in air, or a 50% caustic solution.

Condensed Phase Explosion: An explosion that occurs when the material is present in the form of a liquid or solid.

Confined Explosion: An explosion of fuel-oxidant mixture inside a closed system (e.g., vessel or building).

Confined Space: A space that is large enough and so configured that an employee can bodily enter and perform assigned work; has limited or restricted means for entry and exit; and is not designed for continuous human occupancy (OSHA 29 CFR 1910.146).

Consequence: The direct result of a hazardous event, usually expressed in safety assessments in terms of the magnitude of the area over which these impacts occur.

Consequence Analysis: The analysis of the expected effects of incident outcome cases independent of frequency or probability.

Continuous Release: Emissions that are long in duration compared with the travel time (time for cloud to reach location of interest) or averaging or sampling time.

Control Zone: The designation of areas at a hazardous materials incident based upon safety and the degree of hazard. Many terms are used to describe the zones involved in a hazardous materials incident. These zones shall be defined as the hot, warm, and cold zones.

Corrosive: As defined by DOT, a corrosive material is a liquid or solid that causes visible destruction or irreversible changes in human tissue at the site of contact on. In the case of leakage from its packaging, a liquid that has a severe corrosion rate on steel.

CPQRA: The acronym for Chemical Process Quantitative Risk Analysis. It is the process of hazard identification followed by numerical evaluation of incident consequences and frequencies, and their combination into an overall measure of risk when applied to the chemical process industry. It is particularly applied to episodic events. It differs from, but is related to, a Probabilistic Risk Assessment (PRA), a quantitative tool used in the nuclear industry.

Decomposition: Breakdown of a material or substance (by heat, chemical reaction, electrolysis, decay, or other processes) into parts or element or simpler compounds.

Decontamination: (Contamination Reduction). The physical and/or chemical process of reducing the level and preventing the spread of contamination from persons and equipment used at a hazardous materials incident.

Deflagration: The chemical reaction of a substance in which the reaction front advances into the unreacted substance at less than sonic velocity. Where a blast wave is produced that has the potential to cause damage, the term explosive deflagration may be used.

Dense Gas: A gas with density exceeding that of air at ambient temperature.

Dermal: Used on or applied to the skin.

Dermal Toxicity: Adverse effects resulting from skin exposure to a substance. Also referred to as "Cutaneous toxicity."

Detonation: A release of energy caused by the extremely rapid chemical reaction of a substance in which the reaction front advances into the unreacted substance at greater than sonic velocity.

Domino Effects: The triggering of secondary events, such as toxic releases, by a primary event, such as an explosion, such that the result is an increase in consequences or area of an effect zone. Generally only considered when a significant escalation of the original incident results.

Dow Fire and Explosion Index(F&EI): A method (developed by Dow Chemical Company) for ranking the relative fire and explosion risk associated with a process. Analysts calculate various hazard and explosion indexes using material characteristics and process data.

Effect Models: Models that predict effects of incident outcomes usually with respect to human injury or fatality or property damage.

Emergency and First Aid Procedures: Actions that should be taken at the time of a hazard exposure before trained medical personnel arrive.

Emergency Exposure Guideline Limits (EEPG): Maximum concentration levels that provide guidance in advance planning for management of emergencies. Developed by the National Academy of Sciences (NAS).

Emergency Response Personnel: Any persons engaged in the response to emergencies, including firemen, police, civil defense/emergency management officials, sheriffs, military, manufacturing, and transportation industry personnel.

Emergency Response Planning Guidelines (ERPG): A system of guidelines being prepared by an industry task force of which ERPG-2 is the (ERPG) maximum airborne concentration below which, it is believed, nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible, adverse, or other serious health effects or symptoms that could impair an individual's ability to take protective action (similar to EEGLs).

Emergency Trip Button: A hard-wired push button that, when pushed, will maintain the trip position and place selected final control elements in a safety position.

Entrainment: The suspension of liquid as an aerosol in the atmospheric dispersion of a two-phase release or the aspiration of air into a jet discharge.

Epidemiology: The study of the configuration, distribution, and determinants of health and its disorders. (*Patty's Industrial Hygiene and Toxicology,* Volume 1: *General Principals,* 3rd Edition, G. Clayton, 1978.)

Event Tree: A logic model that graphically portrays the combinations of events and circumstances in an accident sequence.

Exclusion Zone: The area where contamination does or could occur. Workers may not enter the exclusion zone without appropriate personal protective equipment. (*Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities*, NIOSH/OSHA/USCG/EPA, 1985.)

Exothermic: A chemical reaction characterized by the evolution of heat.

Explosions: A release of energy that causes a pressure discontinuity or blast wave.

Extremely Hazardous Substance (EHS): Any chemical listed in 40 CFR Part 355 Appendix A or B. Roughly 360 chemicals are on this list. The U.S. EPA has determined that the chemicals on this list are extremely hazardous to the public when released during a spill or other emergency. The U.S. EPA has taken the physical, chemical, and toxic properties of the chemicals into consideration.

Failure Mode and Effects Analysis (FMEA): A hazard identification technique in which all known failure modes of components or features of a system are considered in turn and undesired outcomes are noted.

Fault Tree Analysis (FTA): A logic model that graphically portrays the combinations of failures that can lead to a particular main failure or accident of interest (Top Event).

Fireball: The atmospheric burning of a fuel-air cloud in which the energy is mostly emitted in the form of radiant heat. The inner core of the fuel release consists of almost pure fuel whereas the outer layer in which ignition first occurs is a flammable fuel-air mixture. As buoyancy forces of the hot gases begin to dominate, the burning cloud rises and becomes more spherical in shape.

Firepoint: The lowest temperature at which a liquid will produce sufficient vapor to flash near its surface and continue to burn, usually 10 to 30°C higher than the flash point.

Flammable: A "Flammable Liquid" is defined by NFPA as a liquid with a flash point below 100°F (37.8°C).

Flammable (Explosive) Range: The range of a gas or vapor concentration in air that will burn or explode if an ignition source is present. Limiting concentrations are commonly called the "lower flammable limit" (LFL/LEL) and the "upper flammable limit" (UFL/UEL). Below the lower flammable limit, the mixture is too lean to burn and above the upper flammable limit is too rich to burn.

Flash Fire: The combustion of a flammable vapor and air mixture in which flame passes through that mixture at less than sonic velocity, such that negligible damaging overpressure is generated.

Flash Point: The lowest temperature at which vapors above a liquid will ignite. There are several flash point test methods, and flash points may vary for the same material depending on the method used. Consequently, the test method is indicated when the flash point is given (150°PMCC, 200°TCC, etc.). A closed cup type test is used most frequently for regulatory purposes. Flash point test methods:

Cleveland Open Cup (OC)
Pensky Martens Closed Cup (PMCC)

Setaflash Closed Tester (SETA)
Tag Closed Cup (TCC)
Tag Open Cup (TOC)

Foam: A stable aggregation of small bubbles which flow freely over a burning liquid surface and form a coherent blanket which seals combustible vapors and thereby extinguishes the fire (OSHA 29 CFR 1910.155).

Forensic Engineering: The art and science of professional practice of those qualified to serve as engineering experts in matters before a court of law or in arbitration proceedings.

Frequency: The number of occurrences per unit time at which observed events occur or are predicted to occur.

Hazard: An inherent chemical or physical characteristic that has the potential for causing harm to people, property, or the environment. In this document it is the combination of a hazardous material, an operating environment, and certain unplanned events that could result in an accident.

Hazardous Material (HAZMAT): A substance (gas, liquid, or solid) capable of creating harm to people, property, and the environment.

Hazardous Materials Response Team: A group of trained response personnel operating under an emergency response plan and appropriate standard operating procedures to control or otherwise minimize or eliminate the hazards to people, property, or the environment from a released hazardous material.

Hazardous Waste: Any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are nondegradable or persistent in nature or because they can be biologically magnified or because they can be lethal or because they may otherwise cause or tend to cause detrimental cumulative effects (CFR, Title 40, part 261).

Hazard and Operability Study (HAZOP): A hazard evaluation method used to identify deviations from the intention of process design and what their causes and consequences may be. This is done systematically by applying suitable guide words.

This is a systematic detailed review technique for both batch or continuous plants which can be applied to new or existing processes to identify hazards.

HAZWOPER: Hazardous Waste Operations and Emergency Response Standard issued by OSHA which contain requirements for worker health and safety at hazardous waste sites, hazardous waste treatment, storage, and disposal facilities, and emergency responses to hazardous materials incidents.

Heat of Reaction: The net difference in heat of formation of all reactants and of all products. The reaction is exothermic if heat is released by the reaction, and endothermic if heat is required for the reaction.

Hot Zone: Area immediately surrounding a hazardous material incident/release, which extends far enough to prevent adverse effects to personnel outside the zone. This zone is also referred to as the exclusion zone or restricted zone.

Immediately Dangerous to Life and Health (IDLH): Maximum airborne contaminant concentrations from which one could escape with 30 minutes without any escape impairing symptoms or any irreversible health effects. Developed by the National Institute for Occupational Safety and Health (NIOSH).

Impact: The ultimate potential result of a hazardous event, expressed, depending on the particular application, in terms of injuries, fatalities, environmental or property damage, business interruption, etc.

Incident Command System (ICS): An organized system of responsibilities and standard operating procedures used to manage and direct emergency operations.

Incident Commander: The person responsible for overall management of a hazardous material incident.

Incipient Fire: A fire in the initial or beginning stage which can be controlled or extinguished without the need for protective clothing or breathing apparatus (OSHA 29 CFR 1910.155).

Inherently Safe System: A system which remains in a non-hazardous situation after the occurrence of non-acceptable deviations from normal operating conditions.

Injury: Physical harm or damage to a person resulting from traumatic contact between the body and an outside agency or exposure to environmental factors.

Instantaneous or Puff Release: Emissions that are *short* in duration compared with the travel time (time for cloud to reach location of interest) or sampling (or averaging) time.

Isopleth: A plot of specific locations (in the three spatial coordinates: x, y, z) downwind from the release source bounded by a concentration of interest (e.g., fixed by toxic load or flammable concentration).

Jet Discharge: The release of a vapor and/or liquid at sufficient pressure such that significant air entrainment results.

Jet Fire: Flame type resulting from combustion of discharge from pressurized release of gas and/or liquid.

Mitigation System: Equipment and/or procedures designed to interfere with incident propagation and/or reduce incident consequences.

LC50 (Lethal Concentration 50): The concentration of a material in air which, on the basis of laboratory tests, is expected to kill 50% of a group of test animals when administered as a single exposure (usually 1 or 4 hours). The LC50 is expressed as parts of material per million parts of air, by volume (ppm) for gases and vapors, or as micrograms of material per liter of air (g/L) or milligrams of material per cubic meter of air (mg/m^3) for dusts and mists, as well as for gases and vapors.

LD50 (Lethal Dose 50): A single dose of a material which on the basis of laboratory tests is expected to kill 50% of a group of test animals. The LD50 dose is usually expressed as milligrams or grams of material per kilogram of animal body weight (mg/kg or g/kg).

LFL: Lower Flammable Limit of a vapor or gas; the lowest concentration (lowest percentage of the substance in air) that will produce a flash of fire when an ignition source (heat, arc, or flame) is present. See also, UFL.

Major Incident: An incident whose effect zone, while significant, is still limited to site boundaries (e.g., major fire, spill).

Mutual Aid (Mutual Aid Agreement): Mutual Aid and Mutual Aid Agreements are terms used to describe cooperative emergency response efforts between industrial, governmental, and community emergency response organizations. These agreements may include equipment, personnel, or other resources supplied by one group to another when an emergency condition arises that cannot be effectively controlled without outside assistance.

National Response Center (NRC): The Federal notification center for pollution incidents in the U.S. Located at U.S. Coast Guard Headquarters in Washington, DC. The NRC relays to appropriate regional authorities for response actions. Spills are reported to this center.

National Response Team (NRT): A group composed of representatives of primary and advisory federal response agencies. The NRT is responsible for planning and response activities for pollution emergencies at the national level.

pH: The measurement of the hydrogen ion concentration in solution. Acidic or basic corrosives are compared with one another by their ability to dissociate in solution. Those that form the greatest number of hydrogen ions are the strongest acids, while those that form the most hyroxide ions are the most potent bases. Strong acids have low pH values; strong bases have high pH values. The scale range is 0-14.

Poison, Class A: A DOT term for extremely dangerous poisons, that is, poisonous gases or liquids of such nature that a very small amount of the gas, or vapor of the liquid, mixed with air is dangerous to life. Some examples: phosgene, cyanogen, hydrocyanic acid, nitrogen peroxide.

Poison, Class B: A DOT term for liquid, solid, paste, or semisolid substances, other than Class A poisons or irritating materials, which are known (or presumed on the basis of animal tests) to be so toxic to man as to afford a hazard to health during transportation.

Pool Fire: The combustion of material evaporating from a layer of liquid at the base of the fire.

Positively Buoyant Gas: A gas with density less than that of air at ambient temperature.

Preventive Maintenance: Inspection or testing conducted on equipment to detect impending or minor failures and restoring the proper condition of the equipment.

Primary Event: A basic independent event for which frequency can be obtained from experience or test.

Probability: The expression for the likelihood of occurrence of an event or an event sequence during an interval of time or the likelihood of the success or failure of an event on test or on demand. By definition probability must be expressed as a number ranging from 0 to 1.

Process Hazard Analysis: An organized effort to identify and evaluate hazards associated with chemical processes and operations to enable their control. This review normally involves the use of qualitative techniques to identify and assess the significance of hazards. Conclusions and appropriate recommendations are developed. Occasionally, quantitative methods are used to help prioritized risk reduction.

Process Safety: A discipline that focuses on the prevention of fires, explosions, and accidental chemical releases at chemical process facilities. Excludes classic worker health and safety issues involving working surfaces, ladders, protective equipment, etc.

Process Safety Management: A program or activity involving the application of management principles and analytical techniques to ensure the safety of chemical process facilities. Sometimes called process hazard management.

Propagating Factors: Human, process, and environmental actions and influences that contribute to guiding, sustaining, continuing, transmitting, spreading, and extending the sequence of events following the initiating event.

Protective System: Systems which function to prevent or mitigate the occurrence of an incident (e.g., pressure relief values, shutdown interlocks).

Public Emergency Exposure Limit (PEEL): The maximum concentration in air of a toxic material to which the public might be exposed without significant adverse impacts in the event of an accident.

Quenching: Severe cooling of the reaction system in a short time (almost instantaneously) by dilution. This condition "freezes" the status of a process and prevents further reaction.

Radioactivity: Ability of the material to emit particles and energy rays as a result of nuclear decay.

Reaction: The process in which chemicals/materials (reactants) are converted to other chemicals/materials (products). Types of reactions are often named individually e.g. oxidations (= oxidation reactions), decompositions (= decomposition reactions), brominations (= reactions with Bromine).

Respiratory System: The breathing system, including the lungs and air passages (trachea or "windpipe", larynx, mouth, and nose) to the air outside the body, and the associated nervous and circulatory supply.

Risk: A measure of potential economic loss or human injury in terms of the probability of the loss or injury occurring and the magnitude of the loss or injury if it occurs.

Roentgen: The international unit of measure of ionizing radiation as x-rays or gamma rays; equal to the quantity of radiation that will produce in .001293 grams of dry air at 0 degrees C and 750 mm of mercury pressure, ions carrying one electrostatic unit of electricity of either sign.

Runaway: A thermally unstable reaction system which shows an accelerating increase of temperature and reaction rate. The runaway can finally result in an explosion. Three stages can be distinguished: a first stage in which the temperature increases slowly and almost no gases are generated, a second stage in which gas generation starts to occur, and thermal gradients may occur depending on the rate of agitation and on the physical properties of the reaction system, and a third stage in which a fast increase of temperature mostly coincides with fast reaction and/or decomposition rates, temperature gradients in the system are most likely, and the pressure increases severely.

Safety: The expectation that a system does not, under defined conditions, lead to a state in which human life, economics or environment are endangered.

Safety Layer: A system or subsystem that is considered adequate to protect against a specific hazard. The safety layer:

- Is totally independent of any other protective layers.
- May be an administrative procedure.
- Cannot be compromised by the failure of another safety layer.
- May be a noncontrol alternative (i.e., chemical, mechanical).
- Must have acceptable reliability.
- Must be approved according to company policy and procedures.
- May require diverse hardware and software packages.
- Must meet proper equipment classification.

Sealed Source: A radioactive source that contains a radioactive material in a fixed form inside a container.

Sheltering: Physical protection (such as an enclosed building) against the outcome of an incident.

Short Term Exposure Limit (STEL) Value: The concentration to which workers can be exposed continuously for a short period of time without suffering from (1) irritation, (2) chronic or irreversible tissue damage, or (3) narcosis of sufficient degree to increase the likelihood of accidental injury, provided the daily TWA is not exceeded.

Short-term Public Emergency Guidance Levels (SPEGLs): For exposures whose occurrence is expected to be rare in the lifetime of any one individual, the

60-minute exposure concentration that reflects an acceptance of the statistical likelihood of a non-incapacitating reversible effect in an exposed population, while avoiding significant decrements in performance. Developed by the National Academy of Science (NAS).

Source Term: The estimation, based on the release specification, of the actual cloud conditions of temperature, aerosol content, density, size, velocity and mass to be input into the dispersion model.

Standpipe: Hose connection for use by fire departments or a hose system used by trained employees to fight incipient fires (OSHA 29 CFR 1910.155).

STEL: Short Term Exposure Limit; ACGIH terminology. See also, "TLV-STEL."

Thermally Unstable: Chemicals and materials which decompose, degrade or react at ordinary temperatures and times.

Threshold Limit Value Ceiling (TLV-C): The concentration in air that should not be exceeded during any part of the working exposure. Ceiling limits may supplement other limits or stand alone. Developed by the American Conference of Governmental and Industrial Hygienists (ACGIH).

Threshold Limit Value-Short-Term Exposure Limit (TLV-STEL): A 15-minute, time-weighted average concentration to which workers may be exposed up to four times per day with at least 60 minutes between successive exposures with no ill effect if the TLV-TWA (see below) is not exceeded. The limit supplements the TLV-TWA where there are recognized acute effects from a substance with toxic effects that result primarily from chronic exposures. Developed by the ACGIH.

Threshold Limit Value/Time Weighted Average (TLV/TWA): Concentration of a material to which an average healthy person may be repeatedly exposed for 8 hours each day, 40 hours per week, without suffering adverse health effects.

Top Event: The unwanted event or incident at the "top" of a fault tree that is traced downward to more basic failures using logic gates to determine its causes and likelihood.

Toxic Dose: The combination of concentration and time for inhalation of a toxic gas that produces a specific harmful effect.

UFL: Upper Flammable Limit of a vapor or gas; the highest concentration (highest percentage of the substance in air) that will produce a flash of fire when an ignition source (heat, arc, or flame) is present.

Uninterruptible Power Supply (UPS): A power supply that employs automatic switching of main power supply from primary to secondary (usually battery and/or diesel generator) upon failure of the primary. A type of power supply that can provide electrical power even when line power is lost.

UVCE (Unconfined Vapor Cloud Explosion): Explosive oxidation of a vapor cloud in a non-confined space (i.e. not in vessels, buildings, etc.). Vapor cloud explosions in densely packed plant areas (pipe lanes, units, etc.) may show accelerations in flame speeds and intensification of blast.

Vapor Density: The weight of a vapor or gas compared to the weight of an equal volume of air; an expression of the density of the vapor or gas. Materials lighter than air have vapor densities less than 1.0 (example: acetylene, methane, hydrogen). Materials heavier than air (examples: propane, hydrogen sulfide, ethane, butane, chlorine, sulfur dioxide) have vapor densities greater then 1.0.

Vapor Pressure: The pressure exerted by a saturated vapor above its own liquid in a closed container.

Venting: Emergency flow of vessel contents out of the vessel. The pressure is reduced by venting, thus, avoiding a failure of the vessel by over-pressurization. The vent flow can be a one phase or a multi-phase flow, each of which results in different flow and pressure characteristics.

Wind Rose: A plan view diagram that shows the percentage of time the wind is blowing in a particular direction.

Workplace Environmental Exposure Levels (WEELs): Similar to TLVs, but for materials not addressed by ACGIH or OSHA. Developed by the American Industrial Hygiene Association (AIHA).

Worst Credible Incident: The most severe incident, considering only incident outcomes and their consequences, of all identified incidents and their outcomes, that is considered plausible or reasonably believable.

Worst Possible Incident: The most severe incident, considering only incident outcomes and their consequences of all identified incidents and their outcomes.

7

RESPONSE EQUIPMENT AND SUPPLIES

7.1. INTRODUCTION

This chapter discusses the equipment and supplies needed to respond to on-site emergencies. A highly trained plant emergency response team cannot mitigate an incident without adequate equipment and supplies, such as extinguishing agents, personal protective equipment, or spill clean-up equipment. Furthermore, choosing the wrong equipment could lead to serious injuries to site personnel, responders, and possibly the public.

Plants must obtain necessary equipment and supplies and maintain and replenish them. Without regular inspections, maintenance, and replenishment, a response team will quickly become inoperable as a result of deficient resources.

7.2. FIRE APPARATUS

Planners should consider acquiring fire apparatus, even though the cost of buying and maintaining it may appear significant. When the initial cost is amortized over the expected life of the vehicle, the cost per year for the mobile response capability that apparatus provides usually is cost effective. This is particularly true when the expected life of emergency vehicles is 10 to 20 years depending on design, use, and care. The types of apparatus include engines (water and/or foam), aerials or ladder towers, rescue vehicles, ambulances, portable pumps, large flow monitor trucks, foam tankers, initial attack trucks, command vehicles, and hazardous material vehicles.

The decision of whether a particular type of apparatus is necessary is based on:

- The type and extent of fixed fire protection systems that exist (e.g., water spray/sprinkler systems, foam systems, standpipes, fire proofing).

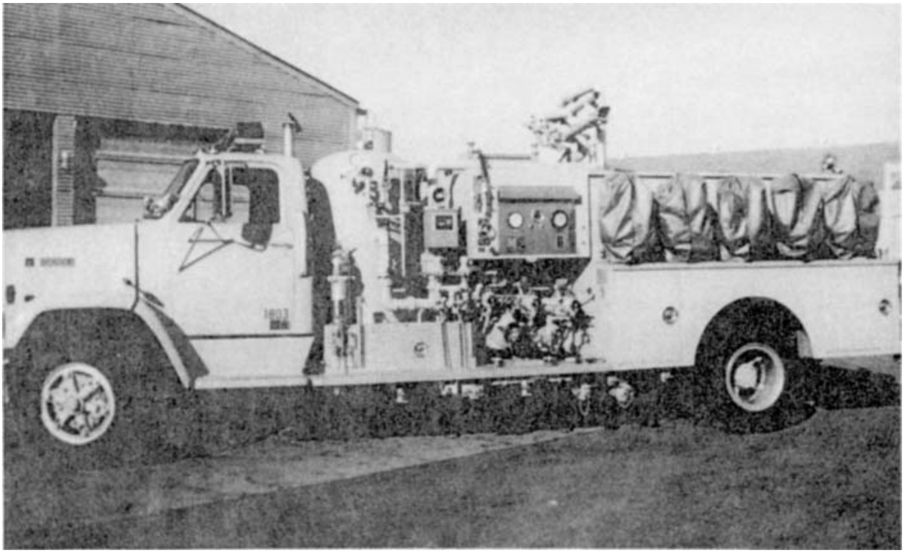

PHOTO 10. Industrial Fire Truck with Foam Capability.

- The fire water system flow and pressure design.
- The capabilities of the plant's response team.
- The size of the facility.
- The capabilities of outside agencies to respond to a plant emergency (type equipment, response time, time that equipment can remain committed on site).
- Costs for maintenance, operation, and training.

Even in facilities with extensive fixed fire protection systems, emergency response crews must respond to complete securement of emergency situations. Response vehicles provide immediate response with many essential tools and equipment needed such as SCBA, protective clothing, meters, extra air cylinders, etc. Smaller facilities can many times use a crew cab pickup with storage boxes for both emergency response and plant general purposes. A small foam concentrate tank, a monitor with self-educating foam nozzle and a few sections of supply hose can provide a very economical but hard-hitting initial attack vehicle for flammable liquid spill fires or vapor suppression.

Facilities with large storage tanks may determine that portable diesel-driven fire pumps, large diameter supply hose, and large flow (greater than 2000 gpm) portable monitors may be the most cost effective to provide the necessary foam application rates needed for fire extinguishment.

It is noteworthy that fire results in more plant closings than any other hazard and that 70–80% of building and construction codes apply to fire safety [2].

7.3. EXTINGUISHING AGENTS

Even if the extent of fire hazard in a credible event scenario is minimal, some type of fire extinguishing agent will usually be necessary. Moreover, extinguishing agents should be available to prevent or guard against fire spreading throughout the plant. With the vast number and variety of flammable materials used in modern industrial processes, assembling an adequate inventory of efficient and compatible extinguishing agents is a significant part of the emergency planning process.

Planners must consider the compatibility of the extinguishing tool with other agents and fuels and have facilities stockpile suitable materials in sufficient quantities to control fires. In addition to considering the types of fuels available, planners must identify the safest and most efficient application method.

Training must be sufficient for all personnel to recognize the proper agent, know how to properly apply the agent, and understand all safe operating procedures including when to evacuate. All extinguishing agents and systems should be subject to a rigorous inspection and repair program.

Before discussing extinguishing agents, it is important that the reader briefly recall the four classes of fires:

- *Class A:* paper, wood, plastics or similar items
- *Class B:* flammable and combustible liquids
- *Class C:* energized electrical systems and equipment
- *Class D:* combustible metals

7.3.1. Water

Water is still the most widely used extinguishing agent because of its many advantages. Water is widely available, inexpensive, and requires no special technical equipment to move and apply it. Water extinguishes fire by absorbing heat from the surface of a burning material more rapidly than the heat is being produced. The surface of the burning material then cools below the temperature necessary to give off vapors that are combustible.

Water's effectiveness may depend on its application:

- Straight, solid water stream for reach and penetration with less heat transfer.
- Spray patterns for more finely divided droplets for greater heat absorption.

Water may also smother a fire by expelling oxygen if sufficient steam is generated in an enclosed area. Water can extinguish fires by agitation and emulsification of heavier viscous flammable liquids, or by dilution in some water-soluble flammable liquids. Class A fires such as wood, paper, or other simple fibrous fuels lend themselves much more readily to water's extinguishing capabilities.

Manufacturers can use various additives to modify water's characteristics. Among these are antifreeze solutions, compounds to lessen the surface tension for better penetration, and thickeners to increase the viscosity and resist runoff [2].

For all of its favorable attributes, water has some critical drawbacks:

- Water conducts electricity at dangerous rates in solid streams or in areas of pooled runoff.
- Water is unsuitable for extinguishing flammable gases.
- Water can cause steam explosions when applied to a material having a boiling point higher than that for water.
- Water adds to runoff and can spread a fire instead of controlling it,
- Water runoff may cause environmental problem(s).
- Water is highly reactive with a number of materials such as combustible metals and some oxidizers, acids, and alkalis.
- Water may be ineffective on flammable liquid fires and may spread the fire to other areas.

Even if water is not used to directly extinguish a fire, it can be used to soak the area around a fire to protect response personnel and products against the exposure to radiant heat. Water may be applied by stationary sprinklers, portable hand extinguishers, hand-directed hose streams, mobile vehicle-mounted deluge appliances, or stationary master streams.

7.3.2. Foams

Fire-fighting foam solutions combine water's good characteristics (availability and heat absorption), with the blanketing and smothering effects of a thick foam. Fire-fighting foam contains a mix of water and gas-filled (usually air) bubbles formulated to float on the surface of flammable liquids. This resulting blanket excludes air from the fuel, absorbs heat, and forms a vaporproof seal.

Foam is produced by mixing a concentrated reagent solution with water and aerating using an air-aspirating nozzle at predetermined proportions, depending on the type and application of the foam. Several types of foam exist, differentiated by their expansion ratio (defined in Section 7.3.2.1) and the type of reagent solution used as concentrate. Different expansion rates and concentrates are used depending on the intended hazard and the desired extinguishing characteristics. Each type has its own criteria, benefits, and considerations.

Foam has some drawbacks and several important considerations. For full effectiveness, foam must hold together in a cohesive blanket and resist the effects of high vapor pressure fuels, fuels that are miscible, water reactives, and those liquid fires where the surface temperature may exceed the boiling point of water. It is difficult to extinguish three-dimensional and free-flowing fuel fires (such as multisurface and those involving sustained or pressurized flow of burning product) using foam. In these situations, control is best achieved by stopping the fuel at its source. Also, responders must remember that foam conducts electricity better than water.

TABLE 7.1
Foam Expansion Ratios

Expansion Ratio	*Description*
Low expansion with a ratio of up to 20 : 1.	These foams are used to extinguish the common flammable liquid spill, tank, or vehicle fires by the use of a cooling and smothering blanket. Aeration is accomplished at the nozzle by means of an aspirator. The foam solution may be introduced at the nozzle by means of an eductor or at the water source by means of pump-mounted proportioning equipment.
Medium expansion with a ratio from 20 to 200 : 1.	The higher expansion rate is accomplished by injection of more air at the nozzle. This type is more effective in restrictive spaces, inaccessible areas, and deep-seated combustibles subject to smoldering.
High expansion with a ratio of up to 1000 : 1.	This type of foam is generally made with a blower or fan and is used with great effect on closed spaces such as aircraft hangars, ship holds, and basements or other confined areas of buildings. This foam acts as a barrier to heat movement and excludes oxygen. Steam displacement also occurs. Extreme care must be exercised when persons operate in the foam areas. This type of foam is not resistant to areas of extreme thermal updraft or even moderate ambient wind conditions.

7.3.2.1 Expansion Ratios

Foam can be categorized by its expansion ratios—the ratio of final foam volume to the original foam solution before adding air. The NFPA *Fire Protection Handbook* lists three foam expansion ratios, and is summarized in Table 7.1 [2].

7.3.2.2 Types of Concentrates

Fluoroprotein Foams. Fluoroprotein foams are used for Class B hydrocarbon type fires (e.g., gasoline, JP5). They consist of natural solids and additives formulated in a 3–6% solution in water to give the foam blanket high water retention, elasticity, and resistance to impact. Fluoroprotein foams have several good characteristics including:

- Good heat resistance,
- Holding ability,
- Vapor suppressor (check with manufacturer for effectiveness),
- High viscosity,
- Anti–burn-back characteristics, and
- Resistance to breakdown by most fuels.

Synthetic agents may be added to the protein polymers creating a fluorinated protein foam that has better resistance to the pickup of fuel by the foam bubble. This property is particularly useful in subsurface injections or direct nozzle applications into fuel areas.

Alcohol or polar solvents, such as ketones, ethers, acetone, or several water soluble chemicals, will break down the foam blanket. Fluoroprotein foams are not recommended where polar solvents may be encountered unless specifically rated for polar solvents.

Aqueous Film-Forming Foam (AFFF). Aqueous film-forming foams are good for Class B fires and are made from fluorinated synthetic hydrocarbons that are similar to protein foams but with a water solution on the surface of the flammable liquid. Concentrations in water range generally from 3 to 6%. AFFFs have lower viscosity, faster application, and quicker ***knockdown*** than fluorprotein foams, and form a vapor seal that resists burn back. The floating film has a self-sealing ability that makes it resistant to impact damage. High heat levels and aromatics can reduce effectiveness of AFFFs. AFFFs may be used on Class A fires because of their lower viscosity and higher penetration ability. AFFFs can also be used with good effect for rapid knockdown and vapor sealing in conjunction with dry chemical systems.

Each foam's manufacturer can recommend the appropriate nozzle for proper application. While responders can apply AFFF with ordinary nozzles, the foam blanket will break down quicker and will need to be replenished sooner and more often.

Alcohol/Polar Solvent-Resistant Foams. Ketones, ethers, acetone, and other water soluble chemicals break down the ordinary foams by draining the water out of the foam bubble and effectively destroying the foam blanket. Alcohol/polar solvent-resistant foaming agents that resemble AFFF have been developed to resist the effects of water soluble and miscible chemicals on foam. Even the small amount of alcohol (up to 10%) found in the gasohol fuel blend can affect the blanketing properties of ordinary foams.

7.3.3. Dry Chemicals

Dry chemical extinguishing agents consist of finely divided agents that are applied using hand extinguishers, hand-held hose lines, or fixed systems. The agent may consist of sodium bicarbonate, potassium bicarbonate, monoammonium phosphate, potassium chloride, or other materials depending on formulation and intended use. Various additives and mixes increase flow and water resistance while reducing caking and storage problems.

Dry chemicals are particularly suited for flammable liquid fires and rapidly extinguish the flames. The dry chemical particles interfere with the chain reaction and give it rapid extinguishing properties. A multipurpose dry chemical agent (monoammonium phosphate) is effective on Class A, B, and C fires. All types of dry chemical agents are electrically nonconductive and may be used safely on Class C fires.

Dry chemicals effectively extinguish fire, but since they do not cool surfaces, materials can reignite. A safety consideration is the potential mixing of incompatible components of dry chemicals in storage or in a container. Some types are alkaline (carbonates), whereas others are acidic (monoammonium phosphate), and mixing them must be avoided.

7.3.4. Dry Powders

The term "dry powder" generally refers to the various formulations of finely divided powders developed to control fires in Class D combustible metals, such as magnesium, sodium, potassium, aluminum, and others. Several formulations of extinguishing agents exist including powdered graphite, sodium chloride, graphitized foundry coke, dry sand, and copper powder. All form some type of coating or crust around the burning material. Responders apply it using a hand extinguisher or shoveling it by hand. In most cases, the fire smothers under the coating of the extinguishing agent. A problem with dry powder and its extinguishing capabilities is that the range and type of combustible metals it can be used on are very limited. For example, Lith-X® is effective and safe only on lithium metal fires in the range of 3 to 8 feet. Met-L-X® is effective and safe on a selected group of metals but should not be used on lithium fires. The maximum distance that dry powders extinguishers are effective is about 10 feet.

7.3.5. Halon

The term Halon refers to a group of halogenated hydrocarbon chemicals in which one or more of the hydrogen atoms have been replaced with a member of the halogen series. These Halon agents are nonflammable and are thus suitable as extinguishing agents. Halogenated hydrocarbons such as methyl bromide have been in use with great effectiveness since the turn of the century but their toxic properties have come under increasing scrutiny over the years.

Halons extinguish fire by breaking the molecular chain reaction that releases oxygen and hydrogen atoms and other radicals to become available for the combustion process. This action is not entirely understood but the effect is very clear. Halon will rapidly and completely extinguish Class B fires and quickly knockdown surface Class A fires. It can control deep-seated Class A fires with complete extinguishment following a heavier application of the agent. Halons can be used to control explosive atmospheres. Halons are nonconductive to electricity and, because they leave no residue, are ideal for rooms containing computers, electronics equipment, and other areas highly susceptible to fire. The agent is discharged from hand extinguishers, or by stationary systems that usually are designed to flood an entire area.

While Halon agents have always spawned toxicity concerns, the modern Halons have generated considerable controversy. Research continues but there is agreement that the Halon's decomposition and combustion byproducts can be toxic to humans. In the presence of high heat, Halon will decompose into toxic chemicals capable of causing respiratory damage. Responders should always use breathing apparatus when using Halon agent in closed areas.

All Halon agents have been identified as stratospheric ozone depleting agents. International environmental agreements call for stopping production of Halons by the year 1996. Research is underway to develop substitute compounds.

7.3.6. Carbon Dioxide

Carbon dioxide (CO_2) is well suited for flammable liquids fires and areas sensitive to residue or damage by extinguishing agents. Its nonconductive properties, penetration by the gas, and blanketing also indicate application to electrical equipment, machinery, and motors.

CO_2 is a noncombustible, self-pressurized extinguishing agent that spreads over the surface of burning flammable liquids and blankets all parts of the burning area. It extinguishes chiefly by smothering the burning area with an inert gas and diluting the level of oxygen needed for combustion. The snow vaporizes to leave no residue. CO_2 is stored as a liquid, but is expelled as a gas under pressure by hand extinguishers, stationary flooding, or direct application systems, hose lines, or vehicle-mounted nozzles.

CO_2 is a relatively clean extinguishing agent that leaves no residue. It will knock down large flammable liquid fires and, because of its heavier than air properties, it can penetrate into inaccessible areas. It will not spread fire (as water runoff might) nor conduct electricity. As a flooding or inerting agent, it may prevent explosion or buildup of flammable vapors in isolated areas.

Carbon dioxide is nontoxic, but will inert an atmosphere and create an asphyxiation hazard. Care should be taken in using portable extinguishers in small areas. Flooding systems must be equipped with pre-discharge alarms to allow for escape by persons in the area.

Carbon dioxide may knock down the fire, but it does not adequately cool hot spots. Once the CO_2 dissipates, reignition is likely if the combustible mixture still exists. Other CO_2 limitations include:

- Limited extent of spread (under 20 feet).
- Reactive with some flammable metals.
- Damaging to skin; it may cause burns because of its low temperature.
- Potential static electrical buildup around ungrounded nozzles, which could cause an ignition in an explosive atmosphere.
- Relatively low extinguishing ratings for size and materials as compared to other agents (limited Class B ratings).
- Limited effectiveness outdoors where àir currents disturb the blanketing effect of the gas.

7.3.7. Miscellaneous Agents

A number of other agents are under development or in limited use. The listing here is a summary of several of these identifying their applications, drawbacks, and benefits.

7.3.7.1. Solid Granules

Using noncombustible pellets or granules (cellular glass) on the surface of a vaporizing liquid or cryogenic liquid (such as liquefied natural gas) prevents vaporization and thus prevents combustion. Solid granules are effective on a stable spill or pool type fire, and their application must not agitate the liquid surface. By way of example, this is in use at HF facilities.

7.3.7.2. Ultra High Speed Water Spray

This application consists of a very finely divided water spray in small droplets triggered by rapid response detection systems. These fast-acting detection systems are usually flame detectors that "see" ultraviolet or infrared light in time frames measured in milliseconds. These systems are in use for hyper- and hypobaric chambers, and locations that work with highly reactive oxidizers and rocket fuels.

7.3.7.3. Emulsifying Agents

Emulsifying agents are common detergent liquids educted and applied by water hose lines in a manner similar to foam application. A great deal of aeration is not required. The agent mixes with the flammable liquid and forms a noncombustible mix or emulsion by raising the flash point of the mix. Emulsifying agents work well to minimize the flash of spilled flammable liquid and aid in the cleanup of spilled materials. The major drawback is the environmentally harmful properties of the emulsifying agent. Runoff is harmful to aquatic life and may be mildly corrosive.

Emulsifying agents have also been used in facilities for spot applications in areas such as grease ducts and large-scale cooking operations.

7.3.7.4. Inert Gas or Steam

Using inert gas such as nitrogen or steam in an enclosed area is an effective way of preventing combustion and retarding the formation of a flammable atmosphere. These gases may prevent fires and extinguish a fire by displacing oxygen (e.g., nitrogen is a common inert medium). They must be applied in sealed areas with no opportunity for air circulation. The life safety aspect is also a consideration because of the exclusion of oxygen in the intended area.

Appendix A to this chapter contains a listing of (Fire) Apparatus Minimum Standards by the Channel Industries Mutual Aid group.

7.4. INHIBITORS, NEUTRALIZERS, SORBENTS

Inhibitors, neutralizing agents, and sorbents are useful for controlling the release of flammable, toxic, corrosive, reactive, or otherwise hazardous materials outside their normal containment or process area. Their use lessens or mitigates the harmful properties of these chemicals much the same as an extinguishing agent extinguishes a fire.

7.4.1. *Inhibitors*

Inhibitors are agents that may prevent or lessen a vigorous reaction and can be effective in stabilizing an incident involving highly reactive chemicals. The use of this tactic can resolve an incident by making the product less reactive and therefore safe for other operations. Responders rarely perform this operation and, preferably, it should only be done by knowledgeable operators.

Using chemical inhibitors is an inherently dangerous operation requiring careful determination of type, amount, and application rate. However, if no other alternative exists to stabilize the release and make the area safe, the application of an inhibitor may eliminate the problem at the source. This operation is especially well suited for small spills and localized problems.

The issues of compatibility and rate of application is critical to the use of inhibitors. Sufficient supply of the correct inhibitor is essential to success. After consultation with operating personnel, inhibitors may be applied by responders who are properly trained, protected, and supervised.

7.4.2. *Neutralizers*

The neutralization method is similar to the use of an inhibitor. In the case of a neutralizing agent, the harmful, active properties of the released substance are reversed, destroyed, or significantly reduced. The considerations and benefits are very similar to inhibitors but with a few key differences.

Neutralizing a released chemical on site is appropriate in several situations as it actively eliminates the problem at the source rather than diluting, moving, or covering it up. While there is generally some risk, the need for environmental cleanup is lessened and the emergency can be resolved in a safer overall manner.

The released chemical must be one that lends itself to the neutralization process. Among these are acid/alkali and oxidizer/reducing agents. Specific examples are calcium hydroxide on acids, dilute acetic acid on bases, activated carbon on oxidizers, and calcium hypochlorite on reducing agents.

Proper amounts and types of neutralization agents should be stockpiled on-site or be readily available for use on an incident. The neutralization method must ensure that the original chemicals' properties have been reversed yet the neutralization reaction is not always predictable. Neutralization must be complete, but not too rapid to control the generation of heat. Therefore, the type, amount, and application rate of neutralizers is important. It is not typically applied at a 1 : 1 ratio [2]. Have a knowledgeable person, such as a chemist, determine the ratio, rate of application, and method of application.

Applying neutralizers is done by responders in close proximity to the spilled material and is therefore inherently risky. The neutralization reaction can release heat, pressure and other by-products.

Difficult spills sometimes can be mitigated by the neutralization process that results in little harmful residue remaining. This can be a safe, proactive response to a release if all safety procedures are followed. Neutralization can lessen the time needed to mitigate an incident.

7.4.3. Sorbents

Released or spilled materials must be removed in a controlled fashion. Environmental regulations typically prohibit responders washing away or otherwise indiscriminately disposing of hazardous materials. Contingencies must exist for response personnel to safely remove or otherwise take up spilled material. Even if other control methods are used, picking up and removing spilled or contaminated material will be necessary. A proper and efficient sorbent is a good method for removing a hazardous material chemical from a spill site and targeting it for disposal.

The term "sorbent" includes any nonreactive product that soaks up, picks up, collects, or otherwise impounds spilled or released products for removal and disposal. *Absorbents* (those materials that soak up or take in materials) and *adsorbent* (those materials that cause other materials to cling or bond to the surface of the sorbent) are often used in the same context. Many types of absorbents and adsorbents exist, and planners must identify proper and compatible sorbents for stockpiling. Sorbents can be selected based on the processes and chemicals used (considering the hazardous properties and release characteristics identified).

Response personnel use sorbents to mitigate the spill situation by removing the hazard and alleviating the problem. This lessens the risk of an ignition. Sorbents can also be used to channel and impound the flow of spilled material. In most cases, personnel will work in close proximity to the spilled product and, therefore, appropriate protective gear must be used at all times.

Many types, shapes, and forms of sorbents are available. Various natural materials are used such as hay/straw, cotton, clay granules, vermiculite, ground corn cobs, diatomaceous earth, peat, activated charcoal, and rice hulls. Synthetics include plastic foams, polypropylene, and other synthetic plastic and/or fiberglass formulations. Booms, pads, pillows, loose granules, wicking agents, and other rigid or flexible containers can be found as sorbents carriers. The shape and arrangement will depend on the application.

Some aggressive chemicals, such as fuming acids or strong oxidizers, will react with organic sorbents to the point of combustion. Others will merely destroy the sorbents and aggravate the spill situation. Even if there is no hostile reaction, an unsafe and inefficient situation will develop if the wrong sorbent material (natural or synthetic) or package (pad, pillow, boom) is selected. It is important to use the correct sorbent package for the spill medium (ground or water).

Unless specifically indicated by the manufacturer, sorbents do not change the properties of the spilled material and they retain the material's hazardous characteristics. The full sorbent material must then be disposed by a safe, timely, and legal means.

7.5. PERSONAL PROTECTIVE EQUIPMENT

Working in a hazardous environment or atmosphere requires that personal protective equipment (PPE) be used by the responders in that area. This section focuses on the PPE necessary for emergency response. It identifies alternative types, fabrics, ensembles, and designated level of PPE. The various criteria, considerations, and benefits of each are identified.

7.5.1. *Materials for Protective Clothing*

The most basic protective gear in most facilities is the fire fighter turnout ensemble that is designed mainly for use in interior structural fire fighting (consisting of pants, jacket, helmet, hood, gloves, and fire boots). Fire-fighter gear is designed primarily for abrasion and heat resistance. Unfortunately, this gear is not suited for exposure to chemicals and offers only limited (if any) protection in chemical situations. It can actually aggravate chemical exposure by absorbing released chemicals.

A wide range of chemical resistant materials is available for response personnel. Table 7.2 represents a partial listing of materials available for use as chemical-resistant garments. New products are continually developed. Layering different materials may be beneficial in planning for emergencies. A Tyvek® or Saranex® coverall over a base garment may increase mechanical and chemical resistance. In recent years, manufacturers have used this layering to good advantage by bonding a highly resistant material, such as Viton® or other fluoroelastomer, to a base material such as neoprene, butyl, Nomex®, or fiberglass. This combination provides a good blend of lightweight, chemical resistance, and good endurance to abrasions, cuts, tears and punctures.

7.5.2. *Considerations*

Table 7.3 lists a number of considerations to evaluate chemical protective clothing.

Proximity suits allow responders to work in high-temperature areas for a short period of time when no direct contact with flame is expected (e.g., a responder working near a flammable liquid fire).

TABLE 7.2
Chemical-Resistant Garment Materials

Material	*Description*
Natural rubber	Resists degradation by alcohols and caustics, susceptible to damage by UV rays and excessive heat, used in boots and gloves.
Neoprene	Synthetic rubber, resists degradation by caustics, acids, alcohols, used in boots, gloves, splash suits and fully encapsulated gear. A good, all-round protective material
Butyl rubber	A synthetic rubber, resists degradation by many contaminants except halogenated hydrocarbons, and petroleum compounds. Used in boots, gloves, suits, and aprons.
PVC (polyvinyl chloride)	Resists degradation by acids and caustics, used in boots, gloves, and suits.
PVA (polyvinyl alcohol)	Resists degradation by aromatic and chlorinated hydrocarbons, petroleum compounds. Used in gloves. Offers no protection in or near water, is water soluble.
Tyvek® (Product of DuPont)	Spun-bonded nonwoven polyolefin. Has marginal tensile strength but good abrasion resistance. Is well suited against particulate contaminants or as over garment in conjunction with other material.
Saranex® (Made by Dow)	Usually coated on Tyvek® or other substrate, very good general purpose disposable material.
Viton® (Product of DuPont)	Fluoroelastomer similar to Teflon®, offers wide range of resistance to aromatic and chlorinated hydrocarbons, petroleum compounds, oxidizers. Has little tensile strength and is used as a "coating" material over a neoprene, butyl, Nomex® or fiberglass substrate in encapsulated suits.

Full fire entry suits provide the protection necessary for entry into a total flame and high heat environment. Entry suits allow responders protection against flame contact for a short duration and are only used so that a responder can make an entry through flames or work on a task such as closing a valve where limited flame contact is anticipated. These suits are extremely heavy, they lack mobility and flexibility, and therefore are fatiguing to the user.

None of these suits offers any protection against chemical degradation or permeation.

7.5.3. Flash Protection

Using a flame-resistant overgarment in conjunction with chemical protective equipment is a way of addressing a thermal hazard in chemical response operations. This garment is made of a reflective (usually aluminized) coating over a

TABLE 7.3
Chemical Protective Clothing Issues

Factor	*Description*
Compatibility	The facility must be closely surveyed for products to which the responders could be exposed. The protective gear must match the hazardous characteristics of the chemicals it will encounter. Compatibility charts are available from the manufacturers and from reference sources. These should be consulted often in the planning process.
Selection	A definite selection criteria should be used both in planning and on incidents.
Use and limitations	The indicated use of the suits should be identified in advance; any limitations should be researched and stated in training programs.
Work mission duration	The issue of heat stress is a critical one. Responders should be trained to combat heat stress and management systems should be in place to prevent this life-threatening condition.
Maintenance, storage, and inspection	A reliable system should be developed to ensure proper inspection, testing, and maintenance of PPE.
Decontamination and disposal	A positive method of ensuring decontamination and proper disposal should be in place. Fabrics are now available that combine good chemical and mechanical protection with reasonable cost allowing for disposal versus reusing.
Training, donning, doffing, and proper fitting	Responders must be trained in all aspects of operation in chemical PPE. The training must match the level of performance expected of them and the hazards to be encountered. Operations in chemical protective ensembles are fatiguing and highly stressful both mentally and physically. Personnel expected to work in encapsulated suits must be in top shape and well-trained to ensure safe and efficient operations.
Temperature extremes	With the exception of those ensembles equipped with flash protection, none of the fabrics offer protection against fires or extreme cold

fire-resistant substrate (PBI®, Nomex® or Kevlar®). The entire garment fits over an encapsulated chemical suit. The ensemble offers only momentary protection against flash fire and should not be used where direct flame contact is expected.

7.5.4. Thermal Protection

In routine fire fighting, responders can wear fire-fighting gear (known as bunker or turnout gear). Turnout gear offers good protection for most fires; however, situations arise that may require responders to enter and work in areas of high ambient heat. These temperature extremes are well beyond the protection level expected of structural turnout gear; therefore, special high temperature clothing is necessary, such as proximity or entry suits.

7.5.5. Choosing Appropriate Levels of Protection

When choosing appropriate levels of protection, first determine the range of response operations and conditions that may be performed. Is fire fighting, Hazmat response, or a combination likely?

For determining chemical protective clothing needs, the level of response (offensive versus defensive) dictates the type of protection to be used (see Table 7.4). Responders trained only for defensive (first responder at the operations level) activities will likely require a lesser degree of protective equipment than responders who will take offensive actions (Hazmat technicians and specialists).

The next consideration is determining the likely chemical hazards the responders could be exposed to. Planners should review all the chemicals and compounds in the plant that responders may encounter to determine PPE requirements. Hazards that planners should consider include:

- Immediately dangerous to life and health (IDLH) concentration of chemicals
- Corrosivity
- Flammability
- The routes by which the material can enter the body (inhalation and or skin absorption hazards)
- The physical state of the material(s) (i.e., liquid, gas, solid, or combination)
- The permissible exposure limit (PEL)
- The duration of possible exposures during response activities
- The warning properties (odor, eyes, hearing, burning sensation, etc.), early symptoms and possible delayed or desensitizing effects of an exposure, and
- Other pertinent factors such as the probability that a fire, explosion, or violent reaction may occur while the responder is in close proximity to the material.

Beyond the chemical hazards just described, chemical protective clothing choices should account for physical hazards that responders might encounter, and heat stress.

Planners must consider the physical hazards that will be found throughout the plant such as thermal (steam lines, open flame), cut and abrasion hazards, confined space hazards, and seasonal weather conditions. More people are injured by simple physical hazards at hazardous material sites than by chemical exposures. The clothing material must be durable and be of sufficient strength to withstand the physical stress of the tasks required. Planning should also consider cold flex characteristics when handling cryogenic materials.

Heat transfer is another important consideration. The body's natural cooling system is limited since most chemical protective clothing is impermeable (and prevents sweat from evaporating.

Once the hazards are understood, the planner can determine what combination of protective clothing will work best. In the past, Hazmat responders used

TABLE 7.4
Personal Protective Clothing

Type	*Description*	*Application and Use*	*Limitations*
Structural fire-fighting clothing	Gloves, helmet, or bunker coat, bunker pants (NFPA No. 1971, 172, 1973) and boots. [3, 4, 5]	Protects against heat, hot water, and some particles.	Does not protect against gases or chemical permeation or degradation. Should not be worn in areas where protection against gases, vapors, chemical splashes is required.
High-temperature clothing—proximity suits	One- or two-piece overgarment with boot covers, gloves, and hood of aluminized nylon or cotton fabric. Normally worn over other protective clothing such as chemical-protective clothing, bunker gear, or flame-retardant coveralls.	Protects against brief exposure to radiant heat. Can be custom manufactured to protect against some chemical contaminants.	Does not protect against chemical permeation or degradation. Auxiliary cooling and an SCBA should be used if the wearer may be exposed to a toxic atmosphere or needs more than two or three minutes of protection.
Flame/fire retardant coveralls	Normally worn as an undergarment.	Provides protection from flash fires.	Adds bulk and decreases mobility. May add to heat stress.
Nonencapsulating chemical protective suit (Level B)	Jacket, hood, pants, or bib overalls, and one-piece overalls.	Protects against splashes, dusts, and other materials but not against gases or vapors. Does not protect parts of head or neck.	Is not gas tight and does not provide protection around the neck area. Duct tape seals may become loose or have gaps.
Fully encapsulating chemical protective suit (Level A)	One-piece garment. Boots and gloves may be integral, attached and replaceable, or separate.	Protects against splashes and dusts. Most suits also protect against gases and vapors.	Does not allow body heat to escape. Heat stress may increase, particularly if worn in conjunction with a closed-circuit SCBA. Impairs worker mobility, vision, and communication.

the EPA method of determining levels of protection, which provided somewhat generic advice. Table 7.5 describes each level.

While this system is good as a starting point, planners now have other standards to use to enhance the level of protection.

The National Fire Protection Association (NFPA) issued a number of standards that can assist in determining the type of garments to be considered:

TABLE 7.5
Levels of Protection

Level	*Description*
Level A	Level A should be worn when the highest level of respiratory, skin, and eye protection is needed.
Level B	Level B should be worn when the highest level of respiratory protection is needed, but a lesser of skin protection from toxic vapors is needed.
Level C	Level C should be worn when a lesser level of respiratory protection but some level of skin protection is required.
Level D	Level D should be worn only as a work uniform and not on any site with respiratory or skin hazards. It provides no protection against chemical hazards.

- NFPA 1991. *Vapor-Protective Suits for Hazardous Chemical Emergencies* [6].
- NFPA 1992. *Liquid Splash-Protective Suits for Hazardous Chemical Emergencies* [7].
- NFPA 1993. *Support Function Protective Garments for Hazardous Chemical Operations* [8].

Some manufacturers and distributors of chemical protective clothing offer a complete ensemble including inner boots, over boots, gloves, outer gloves, visor, and suit. While this may be a convenient way of buying the equipment, it may not meet the plant's specific needs or adequately protect against unique hazards. In purchasing chemical protective clothing, the planner should evaluate the effectiveness of each component in light of the plant's hazards. Combining the most suitable components in a manner that will best protect the body, hands, feet, face, and respiratory system often makes a great deal more sense than purchasing prepackaged ensembles.

In an acid leak, the only protection that might be necessary is splash protection for the body (depending on the concentration, amount spilled, and possible reactions), proper chemical gloves, chemical boot protection, eye and face protection. This combination of garments will provide the best protection.

However, another acid spill might entail a reaction causing fuming and splattering, and therefore additional protection would be necessary. This situation would require protection for the entire body (total encapsulation including face, hands, feet, respiratory) because of the fuming and splash hazard.

A second example could involve a flammable product that is also a skin-absorbed toxic. The first thought might be to protect the responder by wearing chemical protective clothing, but because of the flammable nature of the product—which represents the higher hazard to the responder—thermal protection must be considered. A combination of chemical protection (Saranex® suit) under bunker gear with chemical gloves under the fire-fighting gloves would provide the necessary protection. Another alternative might be a Level A suit with flash protection.

7.5.6. Respiratory Protection

7.5.6.1. Self-Contained Breathing Apparatus

The next protective component that needs to be addressed is self-contained breathing apparatus (SCBA). SCBA usually consists of a full facepiece and a regulator connected to a cylinder carried by the wearer. Emergency responders must use only positive-pressure SCBAs since it is assumed that atmospheres in which they will work might be IDLH. SCBAs offer respiratory protection against most types and levels of airborne contaminants; however, SCBA usage planning is important because the duration of the air supply is limited by the amount of air carried and its rate of consumption. Also, SCBAs are bulky and heavy; they increase the likelihood of heat stress and may impair movement in confined spaces.

The choice of what SCBA will be used must be based on the plant's specific response needs.

The planner should determine whether high-pressure (4500 psig) or low-pressure (2216 psig) SCBAs will be used. The advantage of using a high-pressure system is its ability to accommodate increased air usage time for the responders.

While less important in fire situations, this factor can be critical in Hazmat response, since a Hazmat incident typically requires greater time to mitigate. Consider the typical time a Hazmat responder will need to enter an area, fix the problem, exit the area, and go through decontamination.

Since a 30-minute cylinder contains approximately 45 cubic feet of air, it typically supplies breathing air to a responder anywhere from 15 to 25 minutes (the 30-minute rating is based on an averaged sized person at rest so actual usage will vary). This varies greatly depending on environmental conditions (e.g., external temperature), physical exertion, and the person's physical fitness level. Based on the time estimate in Table 7.6, the 30-minute air bottle may not contain enough air for responders to safely perform their duties. Considering the expected

TABLE 7.6
Time Requirements during Hazmat Response

Task	*Typical Duration*
Time it takes a responder to walk into a work area	3 minutes
Time for a responder to work on a problem in a hot zone	10 minutes
Time it takes a responder to exit a work area	3 minutes
Decon time	5 minutes
ELAPSED TIME	21 minutes

mission time requirements may help in deciding between high- and low-pressure systems, and often the high-pressure system will be the best choice.

Another consideration is how the cylinders will be refilled after each use. If the plant currently has the ability to fill only low-pressure cylinders, then the use of high-pressure SCBA will preclude on site refilling or it will require the additional purchase of high-pressure refilling apparatus. If the SCBA filling capabilities can accommodate high-pressure systems, then low-pressure cylinders can be filled as well. Upon initial acquisition of new bottles, ensure that breathing air has been supplied.

Other considerations in deciding which SCBA to use include:

- Weight factor (different manufacturer's packs weigh from 20 to 30 pounds).
- Type of SCBAs presently being used in the plant (if present packs are suitable for emergency response use, then maintaining consistency is important),
- Types of SCBAs used by any organization that may come on site to help (are the plant's SCBAs compatible with primary offsite response agency's SCBA),
- Do the SCBAs meet NFPA Standard 1981 *Open-Circuit Self-Contained Breathing Apparatus* (1992 Edition) [9], and
- Communication interface issues.

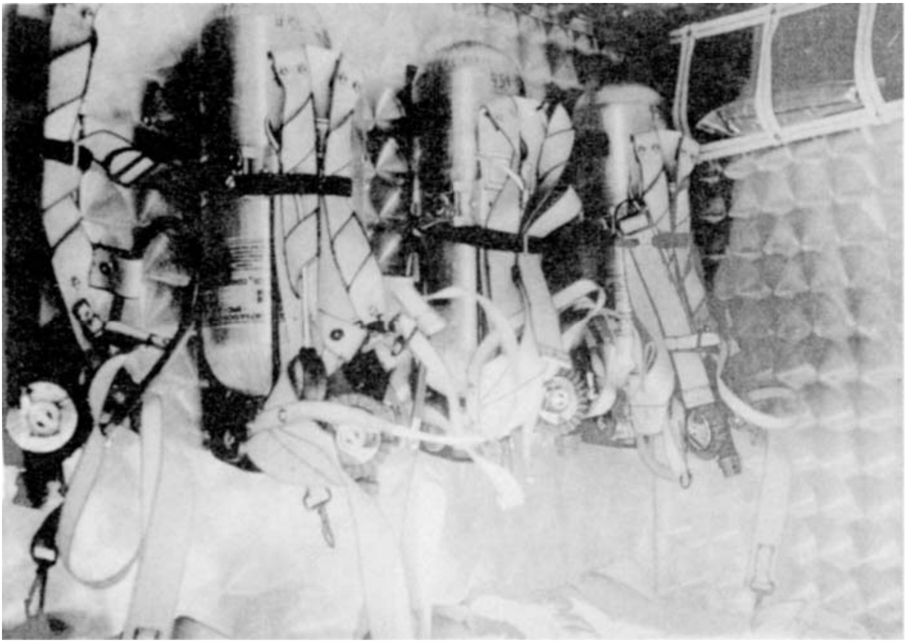

PHOTO 11. Self-Contained Breathing Apparatus in a Command Post Vehicle.

7.5.6.2. Supplied Air Respirator

Supplied-air respirators (SARs), also called air-line respirators, supply air from a source located some distance away and connected to the user by an air-line hose. Supplied-air respirators enable longer work periods than a SCBA. They are less bulky and less heavy than a SCBA. SAR equipment weighs less than 5 pounds (or around 15 pounds if escape SCBA protection is included).

SARs protect against most airborne contaminants, although they are not approved for use in IDLH atmospheres or in oxygen-deficient atmospheres (unless equipped with an emergency egress unit such as an escape-only SCBA that can provide immediate emergency respiratory protection in case of air-line failure).

MSHA/NIOSH certification limits hose length to 300 feet (90 meters). As the length of the hose is increased, the minimum approved air flow may not be delivered at the facepiece. Also, the air line is vulnerable to damage, chemical contamination, and degradation. Decontaminating hoses may be difficult.

Finally, mobility can be restrained and workers must retrace their steps to leave work area. They also require supervision and monitoring of the air supply line.

7.6. HEAVY EQUIPMENT

Heavy equipment is sometimes necessary for controlling an emergency. The term includes items usually associated with road or heavy construction projects. Examples of heavy equipment that might be useful in emergencies include:

- Backhoes
- Front-end loaders
- Dump trucks
- Bulldozers
- Fork lifts
- Cherry pickers
- Cranes (fixed and mobile)
- Portable electric generators
- Earth movers.

Heavy equipment can help responders by facilitating the completion of large tasks that are difficult or impossible using manual labor. To contain or divert a spill, for example, responders may use a front-end loader to build a temporary earthen dike. Also, responders might use a cherry picker with an aerial basket to rescue a person from an elevated platform.

Most heavy equipment can only be operated by specially licensed persons. The heavy equipment operators must be briefed on the hazards in the area and the risks associated with their assigned duties.

7.7. ADEQUATE INVENTORY AND ALTERNATE/OUTSIDE SOURCES OF SUPPLY

Emergency planners should maintain an inventory and provide alternate sources of emergency response equipment. A good inventory system not only keeps track of the amount of a specified supply but also indicates the location, the supplying vendor, alternate vendors, maximum and minimum quantities, and provides some form of alert when the minimum quantity of a material has been reached.

Typically, plants use paper lists to indicate the location of equipment and their quantities. However, computer database systems provide the added benefit of tying the information together with vendor purchasing information. Existing plant computer inventory systems easily adapt to tracking emergency response equipment and supplies.

Lists of supplies can also be shared with off-site response organizations and neighboring industrial facilities. Coordinating the area response equipment and knowing the equipment capabilities of off-site responders and neighbors could be useful in an extended incident where a quick replenishment of supplies could be accomplished by borrowing supplies from a neighbor. Some areas pool emergency inventories under a mutual aid or similar organization. Another method of ensuring an adequate supply of materials is to have the supplier stockpile an adequate reserve.

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Other References

NFPA 10. Portable Fire Extinguishers. 1990. Quincy, MA: National Fire Protection Association.

NFPA 11. Low Expansion Foam. 1994. Quincy, MA: National Fire Protection Association.

NFPA 11A. Medium and High Expansion Foam. 1994. Quincy, MA: National Fire Protection Association.

NFPA 11C. Mobile Foam Apparatus. 1990. Quincy, MA: National Fire Protection Association.

NFPA 17. Dry Chemical Extinguishing Systems. 1990. Quincy, MA: National Fire Protection Association.

NFPA 17. Wetting Agents. 1990. Quincy, MA: National Fire Protection Association.

APPENDIX A. CHANNEL INDUSTRY STANDARDS FOR APPARATUS

Resource and Components	*Types*			
	1	*2*	*3*	*4*
Engine (E)				
Pump	1500	1000	1000	≤750
Tank	500	500	500	≤500
Hose LDH	1000′ 5″ *	1000′ 5″ *	—	—
Hose 2½–3″	750′	750′	1000′	<1000′
Hose 1½–1¾″	600′	600′	600′	<600′
Heavy stream	1000 gpm	1000 gpm	1000 gpm	—
Personnel	4	4	4	4
Aerial (A)				
Pump	1500	1000	1000	<1000
Tank	—	—	—	—
Hose LDH	1000′ 5″ *	1000′ 5″ *	—	—
Hose 2½–3″	—	—	1000′	1000′
Hose 1½–1¾″	—	—	—	—
Elevated stream	1250 †	1000 gpm	1000 gpm	<1000 gpm
Personnel	4	4	4	4
Height	75′	50′	<50′	Any height
Foam Engine (FE)‡				
Pump	1500	1000	1000	≤1000
Tank	500	1000	1000	
Hose LDH	1000′ 5″ *	1000′ 5″ *	—	—
Hose 2½–3″	750′	750′	1000′	<1000′
Hose 1½–1¾″	600′	600′	600′	≤600′
Heavy stream	1000 gpm	1000 gpm	1000 gpm	—
Personnel	4	4	4	4
Foam Aerial (FA)‡				
Pump	1500	1000	1000	<1000
Tank	500	500	500	<500
Hose LDH	1000′ 5″ *	1000′ 5″ *	—	—
Hose 2½–3″	300′	300′	1000′	<1000′
Hose 1½–1¾″	300′	300′	300′	—
Elevated stream	1250 †	1000 gpm	1000 gpm	<1000 gpm
Personnel	4	4	4	4
Height	>75′	50′	<50′	Any height

* Engines carrying 5″ hose should have hose coupled with either 5″ Stortz or 4½ ″ NST couplings. Adapters must be provided so that one supply line with either coupling can be hooked up on both supply and discharge side of pump.

Engines carrying 4″ hose can be considered type 1 provided they (1) Have a minimum of 1000′ and (2) have the necessary adapters to allow the hookup of two 4″ lines on both the suction dan discharge side of the pump, and to convert, if necessary, the couplings to either 5″ Stortz or 4½ ″ NST. Two 4″ lines are necessary to obtain the same hydraulic equivalent as one 5″ line.

†May be through one nozzle or may be split between two nozzles provided either flowrate is not less than 500 gpm.

‡ A foam engine or foam aerial must have a foam proportioning system (balanced pressure or servo-command) that is capable of proportioning the water pump capacity at either 3 or 6% and be capable of transferring its foam concentrate load by pumping. Pumping concentrate through a metering orifice does not meet this requirement. The intent is to be capable of pumping the rated capacity of foam solution through one large-diameter line. If large diameter discharge is not present, suitable siamese must be provided.

Resource and Components	*Types*			
	1	*2*	*3*	*4*
Foam Trailer (FTR)				
Type System	Tank with self-educating nozzle; min. 500 gpm	Balanced-pressure	Bladder tank	
Personnel	4	4	4	
Foam Tanker (FT)				
Tank	4000	2000		
Pump	250	250		
Personnel	2	2		
Dry Chemical (DC) 500 lb. (specify type DC)	Turret and handlines; min. 100′	Handlines only		
Twin Agent (TA) 500 lb. DC; 100 gal foam solution (premix or proportional)	Turret and handlines; min. 100′	Handlines only		
Ambulance BLS (AMB-B)	IFTB approved Personnel: 2			
Ambulance ALS (AMB-A)	IFTB approved Personnel: 2			
Rescue (R)	*Heavy*	*Medium*	*Light*	
Generator	10 KW	5 KW	5 KW	
Air cascade	Yes	Yes	No	
Elevated rescue	Yes	Yes	No	
Confined space	Yes	Yes	No	
Fixed/portable lighting	Yes	Yes	Yes	
Hydraulic (Heavy)				
Extrication tools	Yes	Yes	No	
Light extrication	Yes	Yes	Yes	
Chemical suits	Yes	No	No	
Medical equip.	Yes	Yes	Yes	
Stokes	Yes	Yes	Yes	
Excavation rescue	Yes	No	No	
Air bags	Yes	No	No	
Personnel	4	4	4	
Manpower (CREW): 4 personnel with SCBA and protective clothing.				
Fuel Tender: Specify diesel, gasoline JP-4, JP-5				
Breathing Air (BA)	Cascade	Mobile comp.		
Light unit (L): Generator with floodlights				

Resource and Components
Command Vehicle (CV)
2 Mobile radios: CIMA 490 MHz
1 Mobile radio
State fire mutual aid
HAHERN with digital dial
Police intercity
Police car to car
2 Cellular phomes
1 Fax unit
1 Computer with CIMA resource database and chemical hazards database and/or access to CHEM-trec HIT System
1 Printer
Sit down space for 4 personnel
Table

PART A

PREVENTION

1

PREVENTION THROUGH PROCESS SAFETY MANAGEMENT

1.1. TECHNICAL MANAGEMENT OF CHEMICAL PROCESS SAFETY: BASIC ELEMENTS

The Center for Chemical Process Safety (CCPS), founded in 1985 by the American Institute of Chemical Engineers (AIChE), is dedicated to preventing serious accidents in the process industries by publishing guidelines and conducting seminars, courses, and research. This book is a guideline on technical planning for on-site emergencies, and it complements other CCPS guidelines, especially *Guidelines for Technical Management of Chemical Process Safety* [1] published in 1989. Along with work by the Organization Resource Counselors [2], the American Petroleum Institute [3], and others, the 1989 CCPS book was a resource used in the development of OSHA's Process Safety Management standard and the EPA Risk Management Program (RMP). AIChE and the chemical process industry have recognized that accident prevention must include sound technology and management systems to assure safe operating conditions. Table 1.1 presents the key elements and components of process safety management developed by CCPS in *Guidelines for Technical Management of Chemical Process Safety*. The OSHA PSM standard and EPA's RMP regulation include most of these elements and components.As indicated by the nature of these elements, process safety management systems purposely include more than technological measures. They also broadly encompass policies, procedures, and practices that provide barriers against the technological and human causes of major incidents.

1.2. THE ROLE OF EMERGENCY PREPAREDNESS

Despite the best efforts of responsible facilities to safely manage hazardous chemicals, there may still be incidents that might escalate into catastrophes;

TABLE 1.1
Elements and Components of Process Safety Management

1. Accountability: Objectives and Goals Continuity of operations Continuity of systems (resources and funding) Continuity of organizations Company expectations (vision or master plan) Quality process Control of exceptions Alternative methods (performance vs. specification) Management accessibility	**6. Process and Equipment Integrity** Reliability engineering Materials of construction Fabrication and inspection procedures Installation procedures Preventive maintenance Process, hardware, and systems inspections and testing (pre-startup safety review) Maintenance procedures Alarm and instrument management Demolition procedures
2. Process Knowledge and Documentation Process definition and design criteria Process and equipment design Company memory (management information) Protective systems Chemical and occupational health hazards	**7. Human Factors** Human error assessment Operator–process and equipment interfaces Administrative controls versus hardware
3. Capital Project Review and Design Procedures (for new or existing plants, expansions, and acquisitions) Appropriation request procedures Risk assessment for investment purposes Hazards review (including worst credible cases) Plot plan Project management procedures	**8. Training and Performance** Definition of skills and knowledge Design of operating and maintenance procedures Ongoing performance and refresher training Instructor program Records management
4. Process Risk Management Hazard identification Risk assessment of existing operations Residual risk management (in-plant emergency response and mitigation) Process management during emergencies Encouraging client and supplier companies to adopt similar risk management practices Selection of business with acceptable risks	**9. Incident Investigation** Major incidents Follow-up and resolution Incident recording Third-party participation as needed
5. Management of Change Change of technology Organizational changes that may have an impact on process safety Variance procedures Temporary changes Permanent changes	**10. Standards, Codes, and Laws** Internal standards, guidelines, and practices (past history, flexible performance standards, amendments, and upgrades) External standards, guidelines, and practices Resolution and close-out procedures
	11. Enhancement of Process Safety Knowledge Internal and External Research Improved Predictive Systems Process Safety Reference Library

therefore, facilities must prepare to respond effectively to minimize possible injuries and property damage. Table 1.2 presents a list of selected incidents, from 1974 to 1993, illustrating the range of process industry catastrophes from fire, explosion, and hazardous material release. These incidents demonstrate the ongoing need for high-level competence in emergency preparedness and continued attention to preventing and mitigating such events.

TABLE 1.2
Tragic Events of Two Decades Spur Efforts to Improve Process Safety*

INCIDENTS ABROAD	
1974	FLIXBOROUGH, ENGLAND—Twenty-eight deaths resulted from the explosion of a cyclohexane vapor cloud released when temporary piping failed.
1976	SEVESO, ITALY—Thousands affected by dioxin release from a runaway reaction.
1984	CUBATAO, BRAZIL—Some 508 people killed in Shantytown built over swamp where 700 tons of gasoline leaked from ruptured pipe and ignited.
1984	MEXICO CITY—An explosion and fire at a liquefied petroleum gas facility in San Juanico suburb killed 542, injured more than 4,000.
1984	BHOPAL, INDIA—More than 2000 died and hundreds of thousands affected by a massive leak at a methylisocyanate facility due to a runaway reaction after water contaminated a tank.
1986	BASEL, SWITZERLAND—Thirty tons of pesticides from a warehouse fire spilled into the Rhine.
1987	ROS AL JUAYMAH, SAUDI ARABIA—Vapor cloud explosion at the natural gas complex reportedly killed as many as 22 and injured 15 others.
1993	FRANKFURT, GERMANY—Explosion in polyvinyl alcohol plant killed one and injured one.
INCIDENTS IN THE UNITED STATES	
1985	INSTITUTE, WV—Vapor cloud of aldicarb oxime and methylene chloride from a plant injured 135.
1987	TEXAS CITY, TX—Vapor cloud of hydrofluoric acid from a refinery drifted through community; 1,000 received medical treatment.
1988	HENDERSON, NV—Ammonium perchlorate explosion killed two and injured 350.
1989	PASADENA, TX—Cloud of ethylene and isobutane exploded in a plant, killing 23 and injuring 132.
1990	CHANNELVIEW, TX—Wastewater tank exploded, killing 17 and charring an area the size of a city block.
1990	CINCINNATI, OH—Resins plant explosion left one dead, 71 injured.
1991	CHARLESTON, SC—Phosphorus chemicals plant explosion killed six, injured 33.
1991	PORT LAVACA, TX—Blast at ethylene oxide unit in a plant killed one, injured 19.
1991	STERLINGTON, LA—Eight deaths, 128 injuries from explosion and fire at a fertilizer facility.
1991	CORPUS CHRISTI, TX—Hydrofluoric acid vapors at a plant killed two workers.

*Adapted from *Chemical and Engineering News,* November 29, 1993.

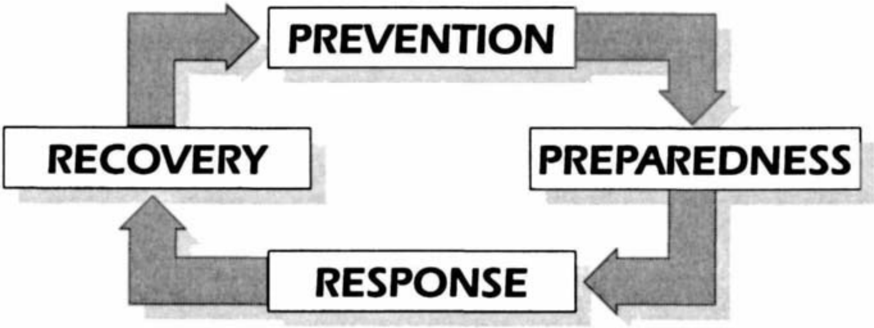

FIGURE 1.1. Four phases of emergency management.

This book provides technical guidance for plant supervisors and managers to plan for emergency situations that may never happen but are nevertheless possible. Technical guidance in this book provides an understanding of the tools and techniques important to prepare for and manage on-site emergencies; however, the book does not provide detailed specifications on the use of the tools involved.

As Figure 1.1 demonstrates, emergency planning is a continuous, cyclical process, starting with prevention and including preparedness, response, and recovery. The CCPS title *Guidelines for Technical Management of Chemical Process Safety* focuses on prevention as the first phase of the emergency management cycle.

However, CCPS recognizes that emergency management must also consider the preparedness and response phases and consider planning for recovery after an incident in order to minimize the effects of incidents that may occur despite a facility's prevention efforts. This book organizes the chapters under major headings that correspond to all four phases (prevention, preparedness, response, and recovery) of emergency management. In the prevention section, the book briefly reviews engineering features in plant and process design intended to prevent or mitigate the effect of significant accidental releases. The next section addresses the main features of a preparedness program, including recognizing credible incidents, planning practical approaches and tactics to deal with those incidents, choosing necessary physical support systems and equipment, and developing a complete workable plan. The section on preparedness also discusses using dispersion and other accident-consequence modeling to aid in shaping the plan and summarizes personnel training necessary for a reliable and appropriate response. The response section outlines the various functions implemented during an actual emergency, including the applicability of various support systems. Finally, in the recovery section we review a plant's needs for managing cleanup and restoration of operations.

Since this Guideline focuses on on-site emergency management, it does not deal in any detail with emergency responsibilities and activities of outside officials, either local, state, or national. This document also does not deal with response to transportation accidents involving hazardous materials outside the plant or with on-site medical emergencies generally categorized as acute illness.

REFERENCES CITED

1. CCPS. 1989. *Guidelines for Technical Management of Chemical Process Safety*. New York: AIChE. ISBN 0-8169-0423-5.
2. Organization Resource Counselors (ORC). December 1988. *Recommendations for Process Hazards Management of Substances with Catastrophic Potential*.
3. API. January 1990. *Recommended Practice (RP) 750, Management of Process Hazards*, 1st Edition.

Other References

CCPS. For other CCPS *Guidelines* references, please see Chapter 2 of this book.

CCPS. 1992. *Plant Guidelines for Technical Management of Chemical Process Safety*. New York: AIChE. ISBN 0-8169-0499-5. (Provides examples of management systems for the safety elements developed in CCPS, 1993.)

Kelly, Robert B. 1989. *Industrial Emergency Preparedness*. New York: Van Nostrand Reinhold. ISBN 0-442-20483-3.

APPENDIX B. SAMPLE EMERGENCY PROCEDURE FORMAT AND INSTRUCTIONS

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I. Purpose

The primary purpose of the SITE EMERGENCY PLAN is to maintain a state of preparedness to prevent or reduce injury to personnel and minimize property loss as a result of emergency situations that may occur within the Site.

An additional purpose is to provide procedures for factual and timely communications with employees and the public during an emergency, either within the plant, in the surrounding communities, or in the distribution or utilization of products.

The Site Emergency Plan:

- is a reference for those coordinating emergency activities and supervisors;
- documents the general plans for various types of emergencies and offers some credible scenarios;
- defines the roles of the Site Emergency Manager as well as Plant Security, Industrial Hygiene, Environmental Services, Site Emergency Representative, Public Affairs and Medical personnel during emergencies;
- provides the criteria for the site to develop unit specific plans; (**Individual unit plans are of vital importance in coping with any emergency situation and must be well known by each supervisor and employee.**)
- provides training guidelines and requirements; and
- will be reviewed and updated, as appropriate, by the Division Emergency Planning Committee.

Unit Plans shall be kept at the workplace and made available for employee review, (MIOSHA law).

FOR ALL EMERGENCIES CALL 1-2-3

II. Definitions

A. Site: The Chemical Company
The facilities located inside the site fences on both sides of the river belonging to The Chemical Company. The term "site" used in this plan refers only to The Chemical Company, and includes all individuals within the site at the time of an emergency, e.g. contractors and visitors, etc.

B. Emergency Planning Committee
The committee appointed by the General Manager with emergency planning responsibilities for the site.

C. Area Major Manager
The Major Manager who is normally responsible for the area where the emergency is taking place.

D. Emergency Coordinating Center (ECC)
The County Commissioners' area of the County Services Building where County Emergency Services personnel meet to mitigate emergencies. Site Emergency Representative and Public Affairs personnel report to this area for community level emergencies.

E. Emergency
For purposes of this plan, emergency means any significant deviation from planned or expected behavior; an unplanned course of events or natural disaster involving any site operation or neighboring operation that could endanger or adversely affect the health of plant personnel, the community, or the environment. Also included is any situation that could significantly affect the property or the business image of The Chemical Company.

F. Emergency Communications Van
The Chemical Company's mobile control center that can be placed in operation to serve as a back-up communications facility or field headquarters for any emergency. It can be placed into service by either Plant Security or the County Sheriff's Department.

G. Emergency Training Exercises
Quarterly training exercises conducted by the Emergency Training Exercise Committee, under the auspices of the Safety & Loss Prevention Department, to evaluate portions of Site emergency response capability.

H. Emergency Medical Technician (EMT)
A member of Plant Security who is trained to State Standards and currently certified in first aid emergency procedures.

I. Hazardous Waste Operations and Emergency Response (HAZWOPER)
A federal law (29 CFR 1910.120) that became effective March 6, 1990 regulating actions to be taken during emergency response activities. The emergency response portion of the standard is applicable to all operating units in the Site in the event of an unusual situation, i.e., spill, release, etc.

If an incident, i.e., "unusual situation," is upgraded to a HAZWOPER emergency, **control of the site becomes the responsibility of the Incident Commander**. In the Site, this is the Security/Emergency Services Shift Supervisor at the scene of the incident.

The Incident Commander shall control and coordinate the efforts and communications to all emergency responders and affirm that appropriate countermeasures are implemented to mitigate the situation.

J. MIDAS (Meteorological Information and Dispersion Assessment System)
The acronym for a computer program designed to predict dispersion of gas releases into the atmosphere, given variable input criteria.

K. County Emergency Services
A department created by the County Board of Commissioners to make use of all available governmental and private resources to mitigate emergencies throughout County. Appropriate emergency functions are assigned to various governmental departments in line with normal daily operations.

L. Sheltering in Place
The preferred action to take when a chemical release first occurs. First response is to leave the affected area, shelter in a building, turn off ventilation systems, shut doors and windows, and wait for updates from Security & Emergency Services.

M. Site Emergency Action Organization
Those site employees who are available 24-hours, 7 days a week, to meet site emergencies. They are the following:

1. *Site Emergency Manager (SEM):* The representative of the General Manager during site emergencies. SEM's are members of the General Manager's

staff who, on a weekly rotation, are on call in the immediate vicinity 24-hours, 7 days a week.

2. *Security and Emergency Services:* Located in 1100 Building, this department's personnel deal primarily with security, fires, leaks, spills, and traffic control. They are on site 24 hours per day.
3. *Incident Commander:* The Emergency Services Shift Supervisor responding to an emergency who becomes the individual in charge of a site-specific Incident Command System (ICS).
4. *Environmental Services:* Personnel trained to provide environmental and regulatory information to the SEM and Incident Commander during an emergency. They are on call 24-hours per day.
5. *Industrial Hygiene Services:* Personnel trained to evaluate and advise site personnel in the controlling of health hazards. An assigned individual is on call 24-hours per day.
6. *Public Affairs:* Media specialists on call 24-hours per day who would staff the Emergency Coordinating Center at the Count Services Building and respond to the needs of the SEM and the press during an emergency situation.
7. *Site Emergency Representative:* Those site employees who are on call 24-hours per day and who would staff the Emergency Coordinating Center at the County Services Building and be the communications link between the SEM and the County Emergency Services Director in the event of a community emergency.
8. *Dispatcher Center:* This is the Security Dispatcher's headquarters at 1100 Building and is staffed by two people 24-hours per day. All radio communications for the Site are monitored at this location. Also located in 1100 Building are direct line phones to key community agencies for use during emergencies. The telephone alert system, MIDAS and some plant alarms are also monitored in 1100 Building. The SEM utilizes this area as a base of operations during an emergency.
9. *Medical Department:* A physician is on call 24 hours per day, 365 days per year to answer any medical or toxicological questions.

N. Tornadoes

1. A Tornado Watch means that tornado conditions exist in a given area, but no immediate danger is present. Going to shelter is not required during a watch. However, all employees and visitors should be alert of any changes and watch for possible tornadoes. This condition will be communicated to the site by the telephone alert system.
2. A Tornado Warning means that a tornado has been sighted in the vicinity and could strike in the area. An up grade of the plant alert will be issued to the site. Employees and visitors should go to designated shelters immediately. According to their Unit Plans, emergency workers should rapidly secure their plants for temporary abandonment before seeking shelter.

O. Unit
"Unit" means a group of employees in a plant, building or lab that have a common interest, develop an emergency plan and execute it together.

III. Levels of Emergencies

Introduction
The following telephone communication procedure between the Security dispatcher and 911 Central Dispatch will be used for the purpose of alerting the city fire department of a potential problem, whether internal or external. The call will be updated as soon as additional information is received from the scene. The event will be upgraded/downgraded depending on this information.

A. Minor Incident
Will be used when hazardous materials are or may be involved, but no leak, spill, fire or explosion has occurred or is expected to occur.

B. Informational Call
Will be used when there is not, and will not be adverse health effects. However, the release and/or fire may be detectable by the public as an odor or visible cloud and the public may be concerned and call with questions.

C. Site Emergency
Will be used when a release or potential release does not threaten the public's health and is not likely to because of control measures being employed. At this level, city and county first responders will be alerted and be prepared to take actions if needed. If control is lost, the release could escalate to a community emergency, or if control is successful, downgrade to an informational call. The community at large is not notified of this condition.

D. Community Emergency
Will be used when a release has occurred that could have adverse effects on the community at large. At this level, City and/or County first responders will be notified and will take appropriate action. Appropriate response measures will be communicated to the public at large.

IV. Site Emergency Organization and Responsibilities

A. Organization
Emergency Planning Organization for the Site:

1. *Emergency Planning Committee:* The committee has the responsibility to oversee all changes to the Site Emergency Plan. Committee members include Site Emergency Managers.

2. *Task Force for Auditing and Annual Review of Emergency Plans:* The responsibility of this task force as established by the Division Safety & Loss Prevention Manager is to:
   a. assess the results of site-wide quarterly emergency training exercises;
   b. receive suggestions for improved emergency planning;
   c. periodically review the Site Emergency Plan; and
   d. make recommendations for improvement to the Emergency Planning Committee.

The task force members include representatives from Security, Environmental Services, Industrial Hygiene, Public Affairs, Medical and the Division Safety & Loss Prevention Manager, who chairs the task force.

The Site Emergency Planning Organizational chart (Figure 1) shows the structure and functions of various groups involved in the planning.

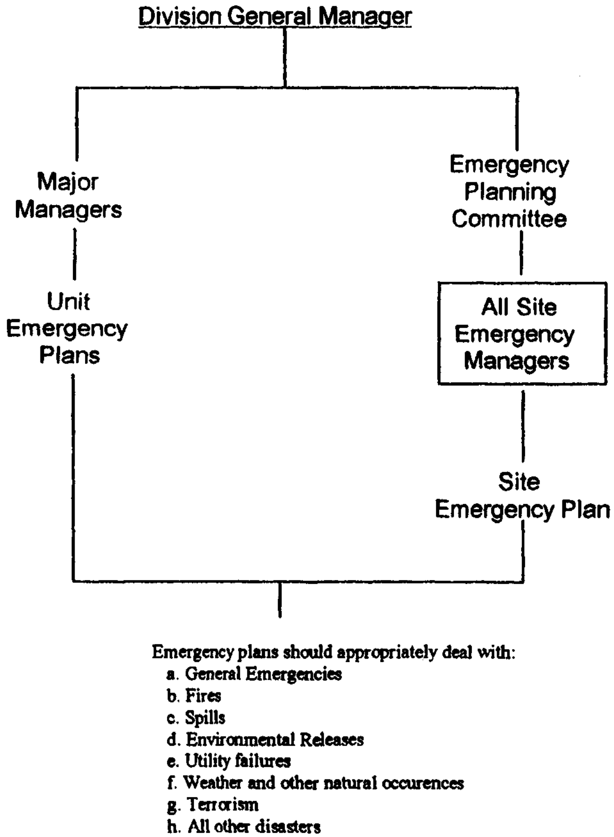


FIGURE 1. Site emergency planning organizational chart.

B. Site Emergency Action Organization

1. Responsibilities of the Site Emergency Action Organization are:
    a. to provide systematic and prompt response to all emergencies to prevent or reduce personal injury from hazards, including, but not limited to, chemical, fire, and weather hazards;
    b. to minimize property loss and business interruption at the site; and
    c. to prevent or reduce adverse effects on the environment and in the community.

2. The Site Emergency Action Organizational chart (Figure 2) lists the positions and the functions that are involved in various types of emergency incidents. An incident may require the participation of all or part of the function shown on the chart, depending on the type and severity of the incident. Each employee representative of the function shown on the chart, with the exception of Purchasing, has a backup to ensure there is 24-hour coverage of those functions. Purchasing has identified suppliers, established contracts and set up procedures for obtaining materials and services by personnel, if needed in an emergency situation. A call list of Purchasing contacts is available at Security & Emergency

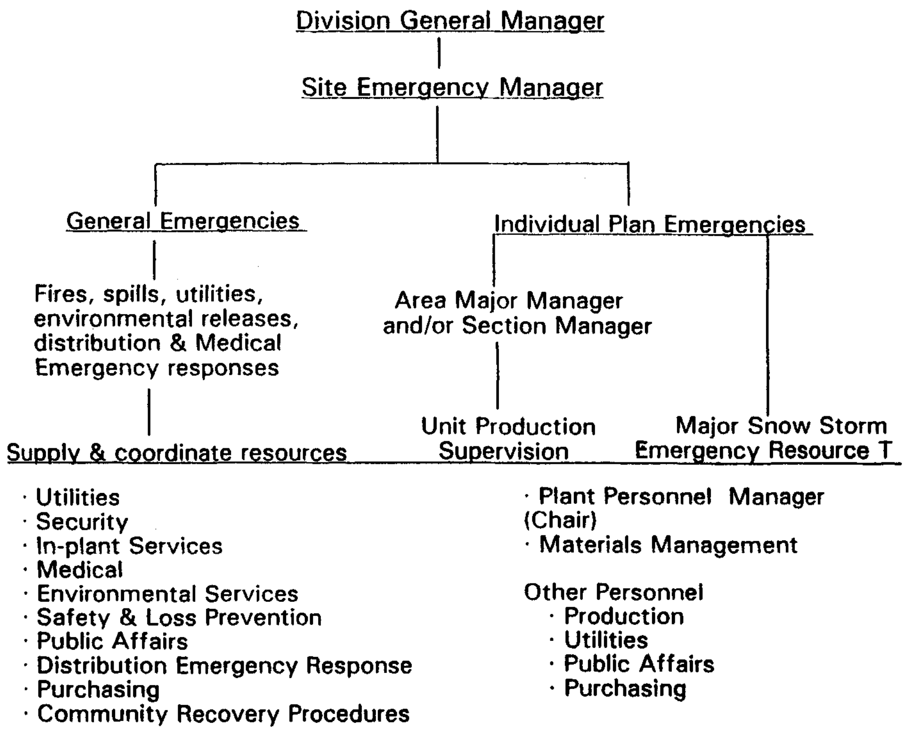


FIGURE 2. Site emergency action organizational chart.

Services, if additional support or information is needed from the Purchasing function.

Each representative must be available to be rapidly contacted by Plant Security. Telephones, Pagemasters, and the site radio system are the established methods of communication.

C. Management Responsibilities

1. Community Recovery Procedures

The Chemical Company will assist the adjacent community, both residential and industrial, in their recovery needs caused by an emergency occurring at the Chemical Company Manufacturing Site. This process can begin by contacting via the telephone number that will be communicated through the Crisis Management Team.

A pre-plan has been discussed with the community "Local Emergency Planning Committee" (LEPC) with the following needs assessed:

- Basic Services
- Medical Care
- Insurance Concerns
- Means of Communication

Departments from the Site representing:

- Controller
- Maintenance
- Environmental
- Occupational Health
- Security/Emergency Services
- Property and Insurance
- Emergency Response
- Public Affairs
- Legal
- Purchasing

have been made aware of this plan. The Crisis Management Team will become involved as necessary.

2. Site Emergency Manager (SEM) Responsibilities

When the emergency plan is activated, the SEM checks that proper resources are deployed which will assure a safe and timely end to the emergency situation. The SEM also communicates with the Site Emergency Representative and Public Affairs personnel at the ECC and with personnel at the Dispatcher Center. The SEM must remain available for the duration of the emergency.

The Site Emergency Manager:

- Will serve as SEM on a weekly rotating basis (8:00 a.m. Wednesday to 8:00 a.m. Wednesday). A schedule is issued by Plant Security twice per year for six months in advance. The Plant Security dispatcher will be kept informed of the SEM's location during the week the SEM is scheduled.

- Will provide, by mutual agreement, a substitute from the other appointed managers to serve as SEM. The Plant Security dispatcher will be notified of such changes prior to the substitution. If, by chance, the SEM cannot be contacted or if the emergency occurs in the SEM's area and the SEM requests a backup, then the dispatcher will contact the next scheduled SEM until a backup is found.
- Must be available to be on site within 30 minutes after being contacted. The SEM will go directly to the Dispatcher Center at 1100 Building for an update of the situation and will communicate and coordinate incident response with the Incident Commander at the scene.
- Will maintain radio contact with all emergency personnel through the Plant Security dispatcher or by direct radio
- Will utilize, if necessary, a call list of telephone and pagemaster numbers of major managers and plant and service employees on call. The list is maintained by the Plant Security dispatcher.
- In the event of casualties, the SEM will assure that the next of kin are informed and assisted per Medical Department guidelines.
- After the incident is over, and after communication with the Incident Commander, the SEM declares the "all clear" for the site, which is issued over the telephone alert system and site radio system.
  Note: If a Community Emergency was declared, the SEM needs to contact the Incident Commander after the SEM and all emergency responders agree that the cloud or vapor has dispersed from the community. If after collecting data from all responders, and if all responders agree, then the SEM shall recommend that the Incident Commander communicate to the City Fire Representative at the scene that suggests that an "all clear" be issued for the Community Emergency. Also, when the Incident Commander, SEM, and all emergency responders agree that the incident is under control and resolved, the Incident Commander will authorize clearance from the scene and will advise the SEM to authorize an "all clear" for the Site.
- Is knowledgeable about 1100 Building Dispatcher Center and its communications facilities.
- Will attend a biannual refresher training program administered by the Safety & Loss Prevention Department that will assist the SEM in the performance of SEM duties and also help to remain knowledgeable of the Dispatcher Center and ECC.
- Will perform the following duties at the time of the emergency:
  —Affirm that appropriate countermeasures are implemented to correct the situation.
  —Direct the Plant Security dispatcher to alert call list 1 or 2 (if not previously done).
  —Verify local unit emergency plan activation and assure that adjacent plant personnel are informed of the situation.

—Determine what plant shutdowns may be necessary and assure execution.
—Assure that supervisors are available to give directions for maintenance and utility needs.
—Communicate status, activity and plans to the General Manager. In the event of a site and/or community emergency, the Division General Manager or the Public Affairs Manager or their designate (such as the SEM) will personally call appropriate U.S. Area and/or corporate personnel who have a need to know about the emergency. "Who" is called will depend on the products involved, and the nature and extent of the emergency.
—Approve all news media releases through a Public Affairs representative.
—Maintain direct communication with the Site Emergency Rep at the ECC. This communication link can be expanded to include state and local officials when necessary.
—Approve resumption of operations.
—Assist with community recovery procedures.

- Should a significant incident occur at an outlying site of the Chemical Company, the outlying site's plan covers mitigation of the incident and requires that notification be made to the dispatch center at 1100 Building. The Dispatcher will notify the SEM immediately. The SEM will assess the situation and provide whatever assistance or communication that is requested.

3. *Area Major Manager Responsibilities*
   - Works closely with the SEM during the emergency. If the Area Major Manager travels to the scene of the emergency they shall identify themselves to the Incident Commander, stay in contact with the Incident Commander, and periodically brief the SEM of the situation.
   - Obtain assistance of appropriate production supervision.
   - Help to ensure that unit emergency plans are implemented and carried out.
   - Help to determine that adjacent plants are informed of the situation, either directly or through Security.
   - Make sure that production supervision give the necessary process information and direction to the Incident Commander, maintenance, utility and environmental personnel.
   - Request appropriate plant shutdowns. If other plants need to be shut down, the Area Major Manager shall transmit the request to the Incident Commander who will notify the SEM of the request.
   - Coordinate accounting for all personnel in the area.
   - Notify the Incident Commander and SEM of any employees that are not accounted for.
   - Plan for resumption of production with guidance from production planning and control when appropriate.

- Coordinate resumption of operations in the area.
- Assist the SEM in returning the site to normal conditions.

4. *Public Affairs Responsibilities*
   - The on-call Public Affairs representative will go to the County Services Building ECC or an alternate site within 30 minutes after being notified of a community emergency due to a incident. During first contact with Security, the Public Affairs representative shall ask for confirmation on the site to report to. The Public Affairs representative at the ECC will establish contact with the SEM. All information will be released by the Public Affairs person at the ECC in coordination with, the local government Public Information Officer.
   - Clear all press releases with the SEM. Casualty information will be released only after the Medical Department has given approval and next of kin have been notified. See Medical Emergency Response - Section VI.E.4.
   - Maintain a plan for emergency public relations.
   - Complete a biannual refresher training program.
   - Representative will notify Security of on-call list changes.

5. *Environmental Services Responsibilities*
   - Reports to the site within 30 minutes for informational, site and community emergencies and maintains radio or telephone contact with the Site Emergency Manager and the Security dispatcher. The on-call person will approach the downwind side of the site for estimating the released material's location and extent of plume.

     Once any plume or extent of contamination has been determined and communicated, the on-call person will respond to the scene, if practical, to aid in environmental decision making. The on-call person will also ensure that formal regulatory requirements for the released material are satisfied in a timely manner. The department and representative will notify Security of on-call list changes.

6. *Industrial Hygiene Responsibilities*
   - For a Site Emergency the "on call" Industrial Hygienist reports to the place of the emergency within 30 minutes.
   - For a Community Emergency, the hygienist will report to the Fire Station. In that case, an Industrial Hygiene backup will report to the scene of the emergency. The Industrial Hygienist will also maintain radio or telephone contact with the dispatcher throughout the emergency.
   - The department and representative will notify Security of on-call changes.

7. *Site Emergency Representative*

The Site Emergency Rep (SER) is a knowledgeable person who, in the event of a Community Emergency, will report to the ECC or other designated site within

30 minutes. The SER will confirm the site to report to with the Dispatcher upon first contact. The SER shall act as a communications link between local government and the SEM in addition to the following items.

- Provide site representation by serving as a consultant to the County Emergency Services Director.
- Communicate the extent of the emergency and its effect on the community by providing feedback on the emergency to the SEM.
- Complete a biannual refresher training program.
- Notify Security of on-call list changes.

8. Incident Commander

If an incident is considered a HAZWOPER emergency then control of the site becomes the responsibility of the Incident Commander. In the Site this is the Security & Emergency Shift Supervisor at the scene of the incident. (rev. 4/94)

a. Responsibilities of the Incident Commander:

- Coordinate communications with emergency response personnel. All emergency responders and their communications shall be coordinated and controlled through the Incident Commander who is in charge at the scene and is assisted by the senior official present for each employer.
- Identify, to the extent possible, all hazardous substances or conditions present and shall address as appropriate site analysis, use of engineering controls, maximum exposure limits, hazardous substances handling procedures, and use of any new technologies.
- Implement appropriate emergency operations, and assure that the personal protective equipment worn is appropriate for the hazards to be encountered. However, personal protective equipment shall meet, at a minimum, the criteria contained in 29 CFR 1910.156(e) when worn while performing fire fighting operations beyond the incipient stage for any incident or site.
- Limit the number of emergency response personnel at the emergency site, in those areas of potential or actual exposure to incident site hazards, or those who are actively performing emergency operations. However, operations in hazardous areas shall be performed using the buddy system in groups of two or more. The Incident Commander shall also ensure that only trained personnel are used to mitigate the emergency.
- Determine hot zone, warm zone and cold zone and ensure that employees who are not trained do not enter the hot zone.
- Will ensure that back-up personnel shall stand by with equipment ready to provide assistance or rescue. Advanced first aid support personnel, as a minimum, shall also stand by with medical equipment and transportation capability.
- Designate a "Safety Official" who is knowledgeable in the operations being implemented at the emergency response site, with specific responsibility to identify and evaluate hazards and to provide direction with respect to

the safety of operations for the emergency at hand.
The Safety Officials' responsibilities are:
—to determine if activities are Immediately Dangerous to Life and Health (IDLH) and/or involve an imminent danger, and alter, suspend, or terminate those activities,
—immediately inform the Incident Commander of any actions taken to correct any hazards at an emergency scene.

- After emergency operations have terminated, the Incident Commander shall implement appropriate decontamination procedures.
- Institute a post-emergency critique and review This will include plant, unit and site personnel involved in the incident as appropriate.

b. Incident Commander Post-Emergency Response

- If clean-up activities are required and the Incident Commander has not declared the emergency over, then department personnel can begin cleaning up the site, if the clean-up is a hazard related to the emergency and if they have had the required training.
- If the IC has declared the emergency over and no clean-up is required, the incident is over.
- If clean-up is required after the emergency has been declared over and the site has been declared an uncontrolled hazardous waste site by a governmental official a written generic site safety and health plan must be completed regardless of who conducts the clean-up activities. If clean-up is conducted by non-workplace employees a written generic site safety and health plan must be completed and those employees must have completed the required HAZWOPER training.
- If the site has not been declared an uncontrolled hazardous waste site and the clean-up can be carried out by workplace employees, then training requirements listed under the Hazard Communication program, Respiratory Protection Program, and Unit Emergency Plan are necessary to complete the clean-up operation.

V. Emergency Equipment and Hardware

A. Emergency Communications System

Plant Security is the focal point for communications and provides the following services:

1. Telephones

- The Telephone Alert System provides information to the entire Site.
- Plant or home call lists for all departments can be activated by the Plant Security dispatcher upon receipt of an emergency message or order from the SEM. All units are required to maintain up-to-date call lists with Security.

- Direct "hot line" telephone lines are installed between the Dispatcher Center and the following locations:
  —County ECC
  —City of Fire Department
  —City Police Department
  —County Sheriff Department
  —9-1-1 Central Dispatch
- A internal system telephone is located at the ECC in the County Services Building for use by personnel when the ECC is activated.

2. Radios

- Plant Security monitors radio frequencies for the following groups
  —Plant Security
  —Priority (includes all emergency responders)
  —Environmental Control, Shipping, Instrument Department
  —Energy & Utilities
  —In-Plant Services
  —Plastics Warehouse
  —Industrial Hygiene
  —County ECC (On Plant Security)
- In case of emergency, any of the above listed radios systems can communicate with Plant Security. Also, an exclusive emergency frequency is operational with most hand-held transceivers in addition to the operating frequency used by individual production plants. The emergency frequency is given priority status by Plant Security.
- Readily available mobile or spare units would be adapted to base station usage if required.
- The group page system can be activated by the Plant Security dispatcher with the message extended beyond the normal page time. That system is tested every Monday morning at 11:00 a.m. Activating the group page system alerts the following:
  —Environmental Services (on-call person)
  —Site Emergency Rep (on-call person)
  —Industrial Hygiene (on-call person)
  —Plant Security (Department Manager & Emergency Services Supervisor)
  —Public Affairs (on-call person)
  —Site Emergency Manager (SEM)
- Radio usage should only be for radio checks and response action and information vital to the emergency. **All other information should be transmitted by telephone or in person.**

3. Coaxial Cable. A site "Coaxial" cable is used throughout the Division for transmission of general purpose announcements, information, and safety messages or video tapes to in-plant television sets as well as transporting closed circuit

T.V. signals from a number of cameras located around the Site fence-line to the Dispatcher at 1100 Building.

4. *Emergency Communications Van.* The Emergency Communications Van is a mobile communications control center that can be dispatched to the scene of an incident. The van has backup capability for the emergency radio frequencies and is also equipped with a cellular telephone. When needed, Security makes the request to the County Sheriff's Department and the van is delivered to the desired location. Depending upon the emergency, it can be staffed by the Sheriff's Department personnel.

5. *Emergency Generator.* An emergency generator supplies necessary backup power for communications at 1100 Building. The generator is located near 1101 Building and is tested weekly.

B. Emergency Alarm System

In the event of an emergency, building alarm systems are the key to each unit's alert system. This subject is covered in Safety Standard S-715. NOTE: For ease in understanding to site personnel, all audible alert systems shall be uniform throughout the site.

VI. Topical Index for Emergencies and/or Probable Scenarios

A. Fires or Explosions

FOR ALL EMERGENCIES CALL 1-2-3

What happens when a call is received?

The Security and Emergency Services dispatcher, Fire Section and Medical Department simultaneously pick up the phone and listen to the call. The caller should give name, location, description, extent of emergency and type of assistance needed. If there is adequate time the message is repeated to the caller to make sure there has been no error in communications.

THE CALLER SHOULD NOT HANG UP UNTIL CLEARED.

In addition, the radio priority frequency may be used to report any emergency to the Plant Security dispatcher.

Action Taken

1. Security's emergency personnel, with the necessary emergency equipment to cope with the situation, go to the scene.
2. The Security shift supervisor normally goes to the scene of the incident and activates the on-scene incident command post.
3. The Emergency Medical Technician (EMT) provides first aid assistance and communicates with the Medical Department concerning any injuries.If there are no injuries or minimal injuries, the EMT assists with the emergency.

4. The SEM, Environmental Services and Industrial Hygiene on-call personnel are notified by the Security dispatcher as appropriate.
5. For all Electrical Fires, Electrical Distribution Maintenance on-call personnel and the Instrument/Electrical shift craft person are notified for all electrical fires and will respond to the scene. They will take necessary action to isolate the problem.

At the Scene of Emergency

If the emergency appears to have significant and immediate affect outside the plant fence ("C or D" release, see MIDAS) then the dispatcher will immediately activate the telephone alert system and notify the plant and city facilities of a community emergency. A Security shift supervisor, and/or the EMT, in conjunction with building personnel, are to assess the situation and serve as Incident Commander following the assessment. Necessary information is immediately relayed to the SEM at 1100 Building Dispatcher Center .

The dispatcher notifies the SEM and other personnel as appropriate per the call list. (See call lists, Appendix A).

After Assessment and Coping with the Emergency at the Scene:

Emergency Services Personnel

1. Extinguish the fire.
2. Cool nearby equipment, if necessary.
3. Operate or assist plant personnel in operating equipment in sprinkler booths.
4. Provide ambulance service if necessary. An EMT is with the ambulance at the scene.

Incident Commander

1. Coordinates City Fire Department or County Emergency Medical Services if called to the scene.
2. Stays in constant contact with building supervisor and the Dispatcher Center at 1100 Building.
3. Secures affected areas and limits plant access, e.g. barricades or blocks roads and access points into the site.
4. Provides additional fire personnel, if needed, and assistance to the injured, if any.
5. Activates the On-Scene Incident Command Post ,if needed.
6. Counsels with building personnel and helps make decisions to evacuate, if necessary.
7. Is the direct communications link between the SEM and the scene.

Operating Personnel

1. Activate their Unit Emergency Plan, including emergency call list and communications with Emergency Services personnel.
2. Meet emergency personnel and direct them to the incident or location, and offer assistance.
3. Remove the source of fuel from fire if properly trained.

4. Shut down the involved process.
5. Assess criticality of an ongoing fire in their area for the safety of themselves, service personnel, nearby personnel, adjacent buildings, and community residents.
6. Improvise barricades to define emergency areas and restrict entry. (See Safety Standard S-700.)

Dispatcher Center at 1100 Building

1. The headquarters for the SEM and Security & Emergency Services dispatchers.
2. Maintain contact by radio with the emergency personnel at the scene.
3. Provide, through notification of predetermined personnel, any requested services needed at the scene.
4. Assist in procurement of equipment and material required to cope with emergency
5. Serve as a central communications hub.

B. Environmental Release (Chemical Spill, Leak or Vapor Release)

In the event of an environmental release, it is the responsibility of the generating plant to alert surrounding buildings and downwind personnel of the potential of the problem. That should be done by the most expeditious method whether it be by telephone, radio, siren or site alert phone. Procedures should be developed in the Unit Emergency Plans to address alerting, installing the necessary equipment, training personnel, testing the system, and conducting drills.

When a report of a spill, leak, or vapor release is received by Plant Security, the following may occur:

Inside the Site Scenario

1. A vehicle is dispatched immediately to the area to make a physical check, identify problem(s) and establish contact with the plant involved. During an emergency, appropriate emergency equipment is requested and necessary roads are barricaded by Security personnel, with help from the In-Plant Services Department if requested.
2. If technical assistance is needed, Environmental Services, Industrial Hygiene, and Environmental Operations personnel are called to the scene as appropriate.
3. The site telephone alert system is activated if asked for by the reporting party, Plant Security officer at the scene, Industrial Hygiene, SEM, or Environmental contacts.
4. When a chemical has contaminated a sewer, or the possibility of contamination is imminent, the Waste Water Treatment Plant operator is immediately notified by phone or radio.
5. The hazard magnitude of the spill, leak or fume release will be determined by the building supervisor, environmental contact, industrial hygienist and/or plant security supervisor.

6. A call list may be activated, if warranted. (See Appendix A for call lists.)
7. Many chemical release emergencies require timely notification to government regulatory authorities. Depending on the circumstances, either Environmental Services or Industrial Hygiene Services will make the determination as to notification requirements.

Outside the Site.

During a emergency of sufficient magnitude that might affect the community, the Security Department dispatcher will communicate with the 911 Central Dispatcher who will notify appropriate members of the Local Emergency Planning Committee (LEPC). The LEPC will work through those local government agencies which have jurisdiction. The County Emergency Services Director works with all Township, City and County personnel in response to an emergency and directs these resources.

Through Plant Security, the company will furnish personnel and equipment to work with County Emergency Services to block off roads or warn people of the danger, when requested to do so and when personnel and equipment are not needed at the site.

MIDAS (Meteorological Information Dispersion Assessment System)

MIDAS is used in the Division to graphically display, on a CRT screen, the predicted dispersion pattern of an atmospheric release. This system is currently operated by Security & Emergency Services dispatchers at 1100 Building. A unit or observer notifies the Plant Security dispatcher that a release has occurred. A plant contact relates what has been released, where, and makes an estimate of the quantities being released or the size of the liquid pool. The Security shift supervisor should prompt the plant for this estimate or should make an independent assessment of the release size. (See Appendix B for plant-based Chemical Emergency Release Program criteria.)

The Plant Security dispatcher enters the name of the material released, the location, the time since the release began, the estimated size of the release (A, B, C, D), and MIDAS automatically retrieves real time atmospheric conditions and displays projected dispersion patterns on a high resolution color CRT.

There are four categories of vapor releases that have been programmed into the computer. **These categories are based on amount of the material entering the atmosphere as a vapor.** They are based on the plant pre-planned emergency scenarios as specified in the plant-based internal CAER manuals. (See Appendix B.)

CATEGORY FOR VAPOR RELEASES:

Category	*Vapor Release Rate (lb/hr)*	*Classification*
A	less than 200	SMALL
B	200–1000	MODERATE
C	1000–5000	SIGNIFICANT
D	greater than 5000	MAJOR

There are also four categories of vapor releases from liquid pools that have been programmed into MIDAS. **These categories are based on the square foot area of the liquid pool.**

CATEGORY FOR LIQUID POOL

Category	*Pool Area (sq. ft.)*	*Classification*
A	less than 100	SMALL
B	100–500	MODERATE
C	500–2500	SIGNIFICANT
D	greater than 2500	MAJOR

The Security & Emergency Services dispatcher immediately notifies all "Radio Units" and activates the site Telephone Alert System, both inside and outside the Site, with the information on the material, source location, wind direction and speed, and notification to activate their local Unit Emergency Plans.

If MIDAS calculates that the atmospheric gas will leave the site, a map of is displayed on the screen. The dispatcher can activate remote display screens that will allow local emergency response groups to see the display of the release plume. Additionally, if other evidence confirms that the plume is actually leaving, or has the potential to leave the site, the dispatcher should upgrade the release and activate the remote display screens. The most important step is early notification to the community.

In the case of a "MAJOR" release, which could affect the community, the group page system is activated simultaneously notifying the following emergency personnel:

Notify	*Action*
SEM on call	Acknowledges the message and reports to the Dispatcher Center at 1100 Building.
Environmental on call	Acknowledges the message and approaches the outside fence line area of the release very cautiously, determines the extent of the plume and reports to the Plant Security dispatcher and the on-call Industrial Hygienist. The EVS person continues to make observations on changing conditions and offers advice on the proper emergency action needed to mitigate the emergency.
Industrial Hygiene	Acknowledges message and immediately goes to the Haley Street Fire Station to assist their emergency personnel in interpreting vapor concentration data developed by various field representatives. The Industrial Hygiene back-up responds to the scene.
Site Emergency Rep on call	Acknowledges the message and immediately goes to the ECC to serve as consultant to the County Emergency Services Director. The Site Emergency Rep stays in contact with the SEM and informs him/her of the developments at the ECC.
Public Affairs on call	Acknowledges the message and immediately goes to the ECC to aid management in communicating the emergency and arrange for post emergency press communications.

Notify	Action
Security Manager	Acknowledges the message and immediately goes to the Dispatcher Center to assist the SEM.
Security Supervisor	Goes to the scene and maintains contact with the Dispatcher Center.

If the above person(s) do not acknowledge the group page, then they must be contacted by other means.

All of the above persons remain in telephone or radio contact with the Dispatcher Center throughout the emergency.

Any release, regardless of what MIDAS displays, for which the Environmental on-call person in consultation with the Industrial Hygiene on-call person identifies significant concentrations outside the fence will also lead the security dispatcher to trigger the above group page system. The information provided to the dispatcher on the location and concentrations of the vapor allows the dispatcher to check the MIDAS display. If the initial release estimates have changed, then the revised data will be entered and a new dispersion pattern will be displayed.

That new information will then be shown on CRT's located in the 911 Central Dispatch office, County Services Building, the Haley Street Fire Station and the Corporate Center 2010 Building dispatcher's office. The information displayed on these CRT's can then be radioed to all county emergency units, by their respective dispatchers, to assist in determining proper emergency action.

The SEM directs emergency operations while at the Dispatcher Center and informs the General Manager of the situation. In the General Manager's absence the SEM communicates the information to the U.S. Area Operations Manager.

C. Weather and Natural Emergencies

Weather and Natural Emergencies Including Snow Storm, Tornado, High Winds, Floods, Electrical Storm, Earthquakes

A "Snow Emergency Plan," published separately, is updated annually and available by contacting the Road & Yard Services. When the amount of accumulated snow and/or anticipated snow makes travel within the Plant hazardous, Security and Road & Yard Services will recommend to the Site Emergency Manager that all or portions of the Snow Emergency Plan be activated.

1. Plant Security dispatcher receives weather information either by telephone or radio from the Fire Department or weather consulting sources. If the report forecasts a tornado watch or warning, damaging weather, high winds, or floods, the dispatcher will:
   - alert available Security Personnel to observe and report any tornadoes sighted;
   - notify all buildings by activating the site Telephone Emergency Alert System;

- notify the SEM on nights, weekends, and holidays (on all weather-re lated emergencies); and
- issue the "all clear" if necessary. Since Watches and Warnings have a time frame predicted, an "all clear" is generally not given.

2. Each department is responsible for activating the portion of its Unit Emergency Plan covering severe weather emergencies.

D. Distribution Emergency Response

The following procedures will be used for handling incidents involving both inbound, outbound, and intraplant movement of material by railroad tank car, tank truck, container, marine, and package shipments. Also included are incidents involving materials in storage off-site.

1. Plant Security dispatcher receives emergency call and obtains all available information from the person reporting the emergency per established Emergency Response System Guide.
2. Plant Security dispatcher calls the information to the knowledgeable contact, as defined in Emergency Response System Guide.
3. On serious distribution emergencies outside the site, the Plant Security dispatcher also calls the Distribution Emergency Response Coordinator
4. The distribution emergency is then handled as outlined in the Emergency Response System Guide.

Reference: Emergency Response System Guide

E. Medical Emergency Response

DIAL 1-2-3. Give your name, the nature and location of the incident. Meet the ambulance and direct the attendant to the injured.

Inside the Site

1. After the phone call to report an injury, illness, or exposure, the following happens when a nurse is on duty at 607 Building Monday–Friday, 6 a.m.–midnight; Saturday, Sunday 7:30 a.m.–3:30 p.m.
   - Security & Emergency Services Department dispatcher, Fire Section, and Medical Department monitor the 1-2-3 phone line.
   - Ambulance and Emergency Medical Technician (EMT) go to the scene.
   - As soon as the EMT has the patient stabilized, they radio the Medical Department and give the nurse on duty the patient's vital signs and, if a employee, the patient's master number.
2. When there is no nurse on duty at 607 Building and the injuries are minor, EMTs will take employees to the Medical Department to await the nurse and if necessary, the physician. Employees with serious injuries will be transported directly to the Mid-Michigan Regional Medical Center's Emergency Room. The Security & Emergency Services dispatcher will notify the nurse and physician on call.

Supervisor Responsibility for Transportation

Ambulance service is provided at the site by the Security & Emergency Services Department who will transport all injured or ill employees to Medical, or if necessary, to the Mid-Michigan Regional Medical Center. It is the responsibility of the injured/ill employees' supervisor to assure that transportation is available to the employee after the employee has received treatment. If building supervision cannot meet this responsibility then they shall contact the Security & Emergency Services Department for assistance. Nonpersonnel will also be handled in the same manner.

Triage rev.

The Medical Department is responsible for developing, implementing and training in a plan for multiple injury incidents. Activation of the plan is at the discretion of the SEM and the on-call Medical Department physician with advice from the Security Supervisor and EMTs at the scene. Also see Safety Standard S-122. In the event of a plant incident requiring the delivery of emergency medical services, timely communication shall occur between designated contacts at the site (i.e. Incident Commander, EMT) and the Medical Department in order to activate the appropriate response and utilization of available resources. The following services shall be made available.

1. Provide immediate first aid/decontamination and transport to the appropriate medical facility (Medical/hospital) for:
    - Any situation where obvious immediate medical attention is required to prevent loss of life or morbidity
    - Any employee who requests medical evaluation for symptoms thought to be related to a specific incident
    - All circumstances where federal, state, or guidelines mandate immediate medical attention for a given incident.
2. In circumstances where there is no clear need for immediate transport of an employee for medical care, an arrangement may be made to have a health professional come to the site (after the ALL CLEAR signal has been received) to perform the following services:
    - Record all pertinent data surrounding the incident and the employees involved
    - Review with the employees all potential health consequences of the incident.

    **Note:* This on-site service should be utilized for asymptomatic employees only.

Medical Department Personnel

The Medical Director or his/her designee will arrange for appropriate additional personnel to be stationed at 607 Building and at the location of the emergency.

Notification of Supervisor and Next of Kin

1. The Medical Director or designee will immediately inform the following as to the status of each patient (degree of severity of the injury and patient's condition):
   - Employee's Supervisor.
   - Employee's Major Manager or Section Manager who will be responsible for informing the Division General Manager, if necessary.
   - If necessary, the Plant Security dispatcher who will notify applicable persons.
2. Guidelines for notification of next of kin in the event of a fatality, serious injury, or acute illness, of an employee are as follows:
   - If an injury and/or illness is serious and the patient is conscious, rational, and capable of talking as determined by a physician, the patient will be encouraged to use the necessary means to call relatives or friends. The physician should impress upon the employee the possible effects on relatives or friends if they learn about the injury from a third party.
   - The Medical Department will maintain contact with the hospital and/or the employee's physician to determine the condition of the patient and the prognosis during the period of illness or injury. The Medical Department will keep the employee's supervisor informed of the employee's condition during this period.
   - In the case of a fatality or if the patient is in serious or critical condition from either an injury or illness and the above plan is not feasible, notification will be made by the employee's supervisor in person, if possible, and accompanied by a physician from the Medical Department.

Family Assistance

Supervision, working with the Medical Department, Human Resources Department, and other appropriate groups, will be responsible for providing assistance to the family where needed. This assistance could include transportation, temporary housing and check cashing. The employee's supervisor, working with Plant Security and Medical, will make provision for transportation of relatives or the listed contact, if needed.

F. Industrial Hygiene Emergency Response

Industrial Hygiene Services maintains professional personnel on a 24-hour on-call basis to respond to emergencies. Industrial Hygienists are available to monitor the air, provide advice on toxicity of materials, provide information and advice on proper protective equipment and proper protective actions. The following actions will activate the Industrial Hygiene call list:

1. A release or personnel exposure involving the following regulated materials:
   - chloromethyl methyl ether (CMME),
   - bis chloromethyl ether (bis CME),
   - vinyl chloride (V1),

- acrylonitrile (AN),
- Ethylene Oxide (EO),
- Formaldehyde (CH20),
- Asbestos and
- Benzene (BZ).

2. Any vapor or liquid release that results in a site or community alert.
3. An incident involving radiation, radioactive materials or radiation producing equipment.
4. Response to a request by the SEM, Plant Security, or the Environmental on-call person.

G. Utility Failures (General)

In the event of loss of, or significant reduction in, the level of service or pressure of site utilities, immediately notify either Energy & Utilities Operations on 24 hours per day, 7 days per week, or the Plant Security dispatcher on. With the monitoring systems now in place, Energy & Utilities Operations personnel should be aware of, and attending to, any problem(s). Each utility has a unique emergency plan as follows:

Electrical Supply Loss

1. In the event of an electrical failure, notify Energy & Utilities Operations on or the Plant Security dispatcher.
2. Electrical Distribution Maintenance (EDM) during normal working hours. During off hours, the EDM person on call will be contacted. EDM and Energy & Utilities Operations will be responsible for correcting the failure and coordinating a return-to-normal status.
3. If the electrical failure results in a vapor release or fire, the emergency procedures listed under Fire and Explosion and Environmental Releases (Section VI. A & B) are to be put into effect.

Steam Supply Loss

If steam loss, break in a steam line, or if steam pressure is observed going down in a certain area on a particular steam distribution system (400, 175, or 25 psi system), notify Energy & Utilities Operations on .

1. Energy & Utilities Operations will be aware of loss of flow or pressure and will be taking corrective action. It should be noted that the 175 psig and 25 psig systems are supplied from Cogeneration Venture (MCV) or back-up facilities. Loss of the 175 psig system will result in loss of the 25 psig system. The 400 psig system is completely independent.
2. If notification comes from Energy & Utilities Operations:
   - Plant Security will alert all zones; and
   - the affected building(s) will then activate the portion of their Unit Emergency Plan concerning steam loss.

3. When a steam line break is reported:
   - Utilities Distribution Services (UDS) will be notified during normal working hours. During off hours, the UDS on-call person will be notified. If the break will affect steam supply, Security & Emergency Services will alert the building(s) affected through the site Telephone Alert System.
   - Security & Emergency Services will place barricades, as necessary.

Water Supply Loss

When a water line breaks or pressure loss occurs on any site-wide water system:

1. Notify Energy & Utilities Operations.
2. Energy & Utilities Operations will contact UDS for further information or assistance.
3. Plant Security will notify affected buildings if so requested.
4. Security & Emergency Services will place barricades, if necessary.

NOTE:

- Service water is river water backed up by water from the pond and is used for cooling water and fire protection and is the water supply for fire hydrants and sprinkler supply systems.
- City water is primarily used for hygiene and is potable. It is the water source for safety showers and eye baths and drinking water.
- Huron water is filtered Lake Huron water and is not potable.
- Demineralized water is deionized Huron water.

Air Supply Loss

Plant Security dispatcher receives the necessary emergency alarms automatically from the Plant in case of loss of air pressure.

The emergency call list is activated, i.e., Plant supervision and UDS on-call person.

If a significant leak in the distribution system is detected elsewhere, call Energy & Utilities Operations. If a total loss occurs, a site-wide alert will be issued by the Security Department. Plants must take immediate action as per unit emergency plans to minimize the potential of any fire, explosion or chemical release.

Nitrogen Supply Loss

Energy & Utilities Operations receives the necessary emergency alarms automatically from the Nitrogen Plant, in case of loss of nitrogen pressure. The emergency call list is activated, i.e., Plant supervision and Utilities Distribution Services person on call.

If a significant leak in the distribution system is detected elsewhere, call Energy & Utilities Operations.

If total loss occurs, a Division-wide alert will be issued by the Security dispatcher. Plants must take immediate action as per their individual emergency plans to minimize the potential of any fire, explosion or chemical release.

Natural Gas Leak/Loss

In the event of a gas leak in the Division distribution system, the following actions must be taken:

1. Notify Energy & Utilities Operations.
2. Energy & Utilities Operations will notify UDS during normal working hours. During off hours they will contact the UDS person on call.
3. Security & Emergency Services will barricade the area and alert surrounding buildings, if necessary. The gas distribution system supplies natural gas to the M.E. Research Center at 1776 Building, the Corporate Center, the Center, Bay City Plants, and Plastic Lined Pipe. A map showing the line location is on file at the UDS offices, 702 Building.

H. Bomb Threat Scenario

Each Unit Emergency Plan shall include information on what to do in case of a bomb threat, including who helps in the search, who would evacuate, where a bomb could be hidden, and other necessary planning guidelines.

1. In the event of a bomb threat, keep the caller on the phone as long as possible, and fill in the Bomb Threat Response form as completely as possible. (See Appendix D.)
2. After the caller has hung up, notify Plant Security on at once. Plant Security will relay the message to people in the Division who need to know.
3. The supervisor of the building or area where the bomb is alleged to be will be notified and will provide people to Plant Security who are familiar with the area or building to assist in a search. In any case, never utilize a two-way radio during the search. It could ignite the bomb.
   - If the caller states the floor number or exact location of the bomb, search there first.
   - If the caller does not state any exact location of the bomb, have all personnel search their own work area for anything suspicious or out of place.
   - When management decides that a formal search is necessary, teams of two searchers should thoroughly comb the areas for suspicious items.
   - Work from the perimeters inward, checking all access areas. Check most likely areas first.
   - Stairwells are often chosen by bombers as a good location to plant bombs. Before you evacuate people down a stairwell, check it from bottom to top for suspicious objects.
4. Should a bomb or suspicious package be located, do not touch or move it under any circumstances. Notify Plant Security immediately. They will call the State Police and FBI who are trained to dispose of bombs.

5. If management gives the order to evacuate, follow your written plan and evacuate personnel to a safe location, under shelter if possible, and as far away as is practical from the bomb site, i.e., at least 300 yards.
6. All elevators should be taken to the ground floor and locked there. Do not use an elevator to evacuate people during a bomb threat incident.
7. All doors and windows should be left open to vent the blast if an explosion occurs. Personnel should shut off their office machinery, leave their desks and filing cabinets unlocked, and take all personal belongings out of the building with them.
8. Lights should be left on to aid the searchers. Deenergize the power to heavy machinery and shut off the natural gas supply to the building, if possible.
9. In addition to the above, Appendixes E and F contain an employee training guide and general search and evacuation procedures.

I. Emergency Training Exercises and Drills

Quarterly site and/or community Emergency Training Exercises will be conducted under the auspices of the Emergency Training Exercise Committee (ETE), a group chartered through the Safety & Loss Prevention Department. The ETE committee will utilize appropriate line management to evaluate major portions of the site emergency response capabilities. The results will be reported to the task force for auditing and review of emergency plans and to the Site Emergency Planning Committee.

All employees, contractors and visitors will participate in these exercises as if the emergency were real except that plant operations should not be jeopardized. Supervisors should assess their units level of response to these events, proceed through the exercise, discuss with employees what would be the unit response if the event were real, and then return to normal operations.

Emergency Training Exercises shall also be conducted during the year by each unit or group of units to develop and maintain key skills and to test various parts of the site and unit emergency plans. Site employees are required to participate annually in these exercises.

The Site Emergency Plan is shared with the County Local Emergency Planning Committee (LEPC) and becomes part of the integrated County Community Awareness Emergency Response (CAER) plan. The County Emergency Services Director is notified of each quarterly Emergency Training Exercise. Participation in ETEs are at the discretion of the County Emergency Services Director and the County LEPC.

VII. Plan for Securing/Obtaining Off-Hour Services

The Plant Security dispatcher has telephone numbers for the services available within the site. The dispatcher also has a supervisor call list to cover services not available during off hours.

Calling of maintenance and service personnel located outside the plant should be done through or in conjunction with the Plant Security dispatcher to prevent duplication of calls.

Units are responsible for maintaining an up-to-date building call list with the Security Department at all times. That list should include the primary and at least two back-up contacts by Building number for all Buildings in the unit.

VIII. Unit Emergency Plans

Each operating unit, service group and lab shall have a "Unit Emergency Plan" in place tailored to meet the needs of each group. Departments and groups sharing building space with others, e.g. office buildings, etc. may wish to co-author a generic building emergency plan or adopt the current plan if already written. Each method shall address the building as a whole as well as specific department emergency policies.

When writing unit plans, the Site shall follow and comply with the procedures and guidelines as listed in Appendix B of the Site Emergency Plan.

IX. Environmental Contingency Plans

All operating units that treat, store, or dispose of hazardous waste shall have a "Contingency Plan" as required in Federal Law CFR 264 Subpart D. The contingency plan is designed to minimize hazards to human health or the environment from fires, explosions, or any unplanned sudden or non-sudden release of hazardous waste or hazardous waste constituents to air, soil, or surface water.

Contingency plans for operating units within the Site shall be consistent with local Unit Emergency Plans and the Site Emergency Plan.

SEE YOUR AREA ENVIRONMENTAL CONTACT FOR COMPLIANCE TO THIS PROGRAM.

Appendix A—Emergency Call List #1 (Maintained by Security & Emergency Services)

Regular Working Hours, 8:00 a.m.–4:30 p.m. Monday–Friday

In case of fire, accident, explosion or other unusual occurrence involving considerable damage to Company property and/or considerable injury to personnel at the Site, the Security dispatcher will call that information to the following functions:

Function	*Position Contacted*
Security and Emergency Services	Manager (*) Emergency Services Supervisor (*)
Site Emergency Manager	Major Manager on call (*)
Environmental	Person on call (*)
Industrial Hygiene	Person on call (*)
Site Emergency Representative	Person on call (*)
Public Affairs	Person on call (*)
Division Manager	General Manager
Unit Major Manager	Manager
Safety/Security Administration	Major Manager
Medical Department	Person on call
Energy & Utilities	Department
Electrical Department	Department
Utilities Distribution Services	Department
Safety & Loss Prevention	Department Manager
Legal Department	Division Counsel

*indicates also on gang pager system

Appendix A—Emergency Call List #2 (Maintained by Security & Emergency Services)

After Hours, Weekends, and Holidays

In case of fire, accident, explosion, or other unusual occurrences involving considerable damage to company property and/or considerable injury to site personnel, the Security dispatcher will call this information to the following:

Function	*Position Contacted*
Security and Emergency Services	Manager (*) Emergency Services Supervisor (*)
Site Emergency Manager	Manager (*)
Environmental	Person on call (*)
Industrial Hygiene	Person on call (*)
Site Emergency Representative	Person on call (*)
Public Affairs	Person on call (*)
Division Manager	General Manager
Building Personnel	Superintendent or Alternate (Superintendent will call Section Manager and/or Major Manager)
Medical Department	Person on call
Energy & Utilities	Person on call
Safety & Loss Prevention	Department Manager
Legal Department	Division Counsel

*indicates also on gang pager system

Appendix B—Unit Emergency Plans and Guidelines

Introduction

The objective of the Unit Emergency Plan Guideline is to provide guidance for all units to use in developing their own "Unit Emergency Plan." All units in the Site shall use the recommended format and develop their unit plan accordingly. If a particular area in the Emergency Response Plan is not applicable, an explanation is required. Unit plans should also consider checklists that unit personnel can quickly scan to determine what to do in emergencies originating in their plant or in nearby facilities.

Plant/unit supervision must verify competency levels of their personnel prior to emergencies. Verification can be through written tests, evaluating performance during hypothetical exercises, and oral reviews. Plant supervision must certify that the appropriate department personnel are trained to perform expected actions during an emergency. The certification may be a listing of people trained, the required knowledge or skills, verification methods, and signature of the department head. This applies to refresher training also.

Policies Regarding Unit Emergency Plans

1. *Written Unit Emergency Plans are required for each unit.* The plans are to be reviewed by the unit management at least once every year and updated as appropriate. Employees shall be notified and/or trained on all changes. Local unit emergency response training shall be based on the duties and functions that are to be performed by each employee or responder. Also see Safety Standard S-715 for emergency procedures.
2. For handling of emergencies dealing with hazardous waste, Unit Emergency Plans must fulfill hazardous waste generator, storage, treatment and disposal requirements.
3. Emergency call lists for notification of supervisors must be updated immediately after changes are made and copies sent to Plant Security.
4. Some plants may need to develop separate specific emergency plans to cover pipelines, transportation, or hazardous waste emergencies.
5. In the event of a significant chemical release of a hazardous material, the unit that is experiencing the emergency is responsible for requesting that the Telephone Alert System be activated to notify downwind personnel of the emergency.
6. *Emergency training exercises must be conducted by units at least annually, for all shifts, to develop and maintain proficiency.* Plant Security should be notified when this practice will affect other departments. Evacuation exercises must be conducted at least annually for all personnel in buildings or areas where emergency alarms are required. Also, site-wide Emergency Training Exercises (ETE) will be held each quarter under the auspices of the Site ETE Committee. These exercises will deal with procedures for emergency situations originating within or affecting the Division, and for incidents

that could affect the community. All units will participate in Site Emergency Training Exercises. (Reference: Safety Standard S-715.)

7. *Evacuation Procedures versus Sheltering in Place.* In the case of a sudden gas or vapor release in the site, immediate attention should be given to sheltering in place and closing off unnecessary ventilation, before considering evacuation. Sheltering in place is the preferred action to consider when a chemical release occurs. Once additional information and data are gathered, i.e., estimated length of the event, the potential hazards of sheltering in place long term, etc., appropriate action can then be considered. The first response should be to get out of the effected area and shelter in a building, turning off ventilation systems, shutting doors and windows, and waiting for updates from Security & Emergency Services.
   NOTE: This topic is discussed fully in Corporate Safety & Loss Prevention 1993 edition of "Chemical Hazard Engineering Guidelines" part 3, beginning on page 244.
8. *Shutdown Procedures.* Shutdown procedures for the process are to be part of the operating manual. Loss of utilities is to be considered as a cause of shutdown.
9. *Gate Remote Operation and Evacuation Routes.* In the event of a major site disaster, gates 4, 6, 11, 12, 17-A and 23 can be opened remotely by Security & Emergency Services.

Each department shall designate its unit evacuation route by highlighting it on the map on page 225 and including it in the building unit emergency plan training.

Unit Plan Template

To meet the requirements of this section, all units within the Site can update local Unit Emergency Plans following the outline listed in the General Procedures section or use the "Unit Emergency Plan Template" developed by the Safety and Loss Prevention Department and Safety Engineers' Network. This template is located on the Operating Discipline File Server and can be accessed using the following procedure.

Step	*Action*
1	Log into the Operating Discipline File Server.
2	Copy either one of the following files into your computer: Mac users—Oper.disc.shared\Safety\forms\Unit Emg Plan DOS users—Operdisc\DOS\Safety\Forms\EmgPlan.doc
3	Open the file using MS Word.
4	Follow the instructions on the template to input your plant-specific documentation into the template.

If you need more information on how to use the operating discipline file server, contact the operating discipline group.

Typical Index

I. GENERAL PROCEDURES
   A. General Emergency Procedures—S-715.
   B. Shelter-in-Place and Evacuation Procedures.
   C. Evacuation routes, assembly locations and alternatives, safe distances
   D. Roles and Responsibilities of Person(s) in Charge.
   E. Head Count and Search Procedure including maintenance personnel and contractors that might be in the area.
   F. General operational roles for shutdown procedures and procedures to be followed by employees who remain to operate critical plant operations.
   G. Use of Portable Radios.
   H. First Aid—What to do until Emergency Services arrives.
   I. Decontamination procedures for equipment and personal protective gear.
   J. Training.
   K. Inventory of hazardous substances and quantities.

II. INTERNAL EMERGENCIES
   A. Emergency Recognition and Prevention.
      1. Leaks and spills—spill to sewer system, airborne release—notification of Waste Control and notification of Superfund Reportable Quantity.
      2. Fires and spills of flammable materials.
      3. Explosion potential.
      4. Any chemical release (gas, vapor, liquid, solid).
      5. Pipeline Emergency Plans & Procedures.
      6. Loss or shutdown of utilities—water, steam, nitrogen, natural gas, electricity, sewer.
      7. Computer halt or malfunction.
      8. Weather emergencies, tornado, winds, snow, etc.
   B. Fire Control Equipment, Systems and Procedures.
      1. Fire extinguishers, fire hose locations and use.
      2. Deluge, sprinkler or foam systems description—location, activation and shutdown procedures.
      3. Evacuation switch system—operation, system design, shutdown procedures.
   C. Reporting Procedures.
      1. Unit Grey phone intercom system
      2. Regular plant telephone alert system, (1-2-3) plus other numbers.
      3. Radios—plant and mobile.
      4. Call lists.

5. Personnel lists for roll call—operations, maintenance, contractors, service groups (& Contractor).
6. Neighbors within ¼ mile.

D. Basic Emergency Rules (See Safety Standard S-715.)
1. Emergency Alarm System
   - alarm system (siren, etc.)
   - standard signals

E. Responsibility for Initiation of Procedures
1. From building, zone, plant (fire, explosion, vapor release, etc.) final check for employees in building
   - alternate routes
   - assembly area (primary & alternate)
   - roll call by supervisors or wardens
2. To shelter areas (severe storms, etc.):
   - final check of building or area for employees
   - roll call in shelter by supervisor

F. Criteria and Procedures for "Shutting Down" and Decisions for Evacuation
1. Include respiratory equipment requirements. Also include procedures to be followed for those employees who remain to operate critical plant operations before they evacuate.

G. Evacuation.
1. What to take.
2. Where to go-consider wind direction, location of release or spill.
3. How to communicate.

H. Task Assignments.
1. Monitoring status.
2. Wind direction.
3. Sewers and sumps—need sewer maps.
4. Notification of supervision.

I. Weather Alert Procedures.

III. SPECIAL CONSIDERATIONS FOR RESUMPTION OF NORMAL OPERATIONS
1. Checking of building and equipment.
2. Reentry/inspection and report of damage.
3. All clear.
4. Reassignment of tasks.
5. Restart of equipment.

IV. UNIT AND SITE PLAN EMPLOYEE TRAINING

Per MIOSHA part 6, rule 623, building supervision shall review their unit plan with each employee to whom the plan applies:

- when the plan is developed,
- if an employee's responsibilities or designated actions under the plan change,
- if the plan is changed

Plant-Based Emergency Chemical Release Program

This section has been moved to the Unit Emergency Plan Guideline since it requires buildings to annually review their pre-emergency planning guide plus also requires each plant to send a copy of their scenario sheets to the Security & Emergency Services Department, 1100 Building.

There are two key factors in developing a good plant-based emergency chemical release program.

1. Pre-planned emergency chemical release credible scenarios for the hazardous, toxic, or odor producing chemicals in your plant.
2. Training to ensure that employees know how to respond to the pre-planned scenarios if release occurs, how and when to communicate the information to the Security dispatcher, and actions that should be taken to mitigate the effects of the release.

Credible Release Scenarios

The release events you may want to consider could include:

1. evaporation rates from dikes or pools
2. pinhole leaks
3. gasket failures
4. seal failures
5. pop valve or rupture disk release
6. other events from plant experience

These pre-planned release events can then be combined with the "worst-case" scenarios that were developed for the CEI program. The list of release events can then be ranked by:

1. Chemical (or chemical composition)
2. Approximate release rate (or category/description/total amount)
3. Type (gas, fume, vapor, etc.)
4. Location (typically the plant but you should consider remote tank farms or pipe lines)
5. Duration (an estimate, in minutes, as to how long before the release can be stopped).

MIDAS is pre-programmed to model the chemical release dispersion using pre-planned rates. If you can pre-plan a scenario release with an exact rate, MIDAS can handle that. This dispersion modeling tool is important in assisting Security & Emergency Services and local county government in determining what part of the plant or county should be informed to take necessary precautions.

The CEI dispersion models should also be used to determine the effects of each scenario on neighboring plants and the public.

It is impossible to pre-plan every emergency chemical release that could occur in your plant, and that is not the intention of the program. The aim should be to develop a realistic set of pre-planned scenarios so that a particular chemical release can be rapidly approximated as to the size and extent. Rapid communication of the problem will do more to assist you, as well as and community first responders, than more lengthy gathering of precise or exact information. Your goal is to provide your people at the source with a tool to assemble information that can be readily characterized for quick and accurate communication to the dispatchers at 1100 Building. The following is an example of a notification procedure with pre-planned scenarios that has been in use in one of the Division plants, with good success, for several years.

Plant CEI Program Check List

1. Assemble a team knowledgeable in chemicals, equipment and your plant processes.
2. Review introduction and background information in Internal CAER/CEI Manual.
3. Develop list of realistic or likely emergency release scenarios for all hazardous chemicals handled at your unit. Worst-case scenario from CEI audit should be reviewed and included.
4. Do release/evaporation rate calculations for the scenarios using the methods and techniques in the CEI draft manual. Do dispersion calculations using model from Process Engineering.
5. Rank the scenario release rates by chemical(s) in descending order by category (D,C,B,A) and enter them on the Procedures for Notifying Security & Emergency Services of Emergency Chemical Releases form. Indicate for each:
   - Chemical name
   - Brief description of release situation
   - Category
   - Yes or No to SARA/CERCLA reportable
   - Yes or No to "Could it affect nearby plants/community?"
6. Plan and conduct training/safety meetings to ensure that all employees in your area are:
   - Aware of the release scenario sheets;
   - Know how to use them in judging an actual release;
   - Knowledgeable in the procedures for notifying security;
   - Knowledgeable in any special procedures you may have for containing or mitigating the release; and
   - Include these plans and procedures in your Unit Emergency Plan manual.

7. Post the procedures/scenario form(s) near all phones in the area that could be used to notify Security.
8. Send a copy of your scenario sheets to Security & Emergency Services at 1100 Building.
9. Ensure that the "Unit Emergency Plan" is reviewed and that training is conducted annually.

PROCEDURE FOR NOTIFYING SECURITY & EMERGENCY SERVICES OF A PLANT CHEMICAL RELEASE

Dial 1-2-3 or use your plant radio if you have one.

Give the following information:

"Hello, this is (your name) at (plant name) in building (building number).

We have a category ____(A,B,C,D) release. Please follow the alert procedure.

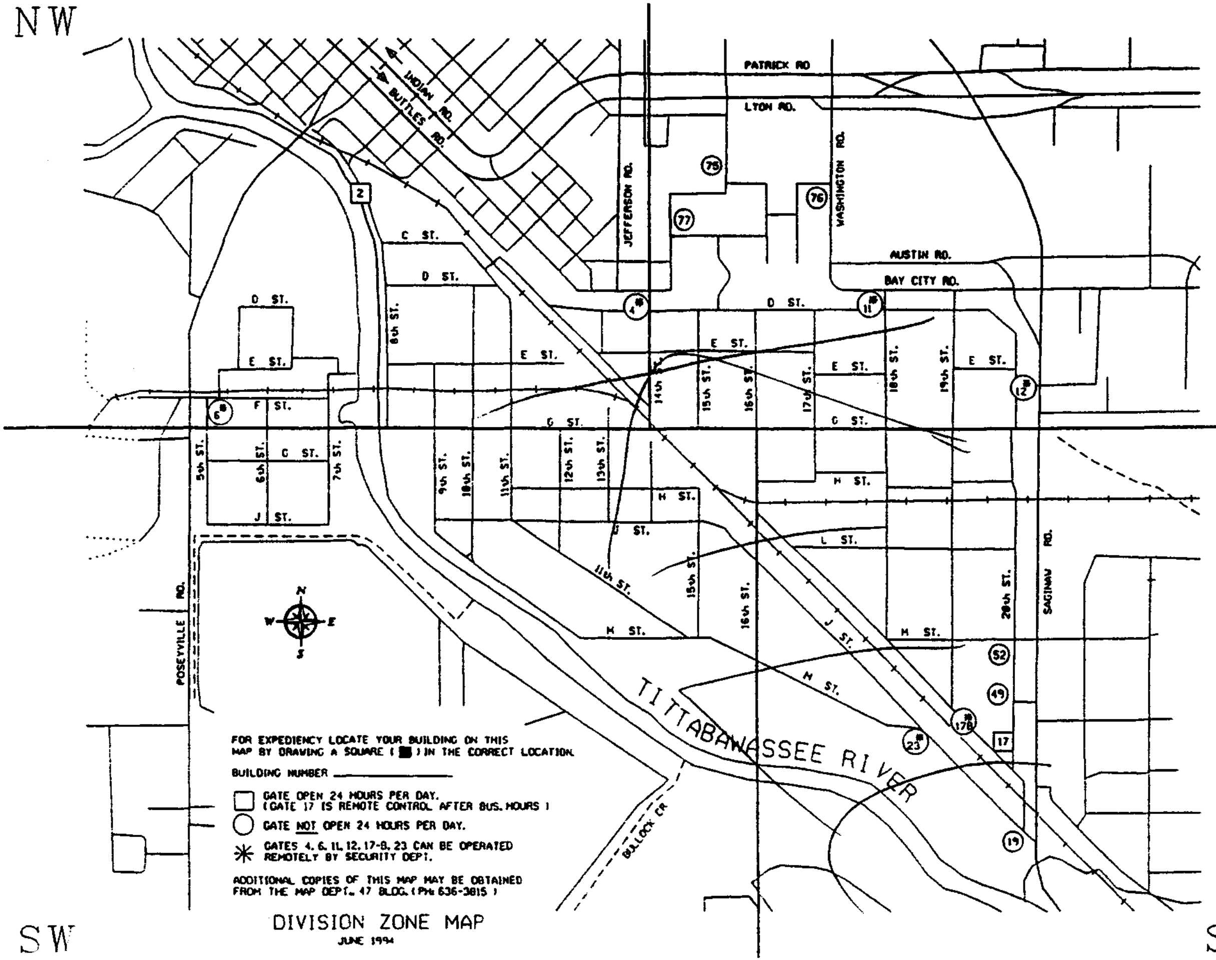
The source of the release _______(has been corrected, will be corrected in ___minutes, is unknown). The release _______(may/will not) affect nearby plants and the community.

This _____(is/is not) a SARA/CERCLA reportable release.

Wait for a reply, do not hang up !

Typical categories and examples are given. Remember that Category D is major, C is significant, B is moderate, and A is minor.

Chemical	*Emergency Release Description*	*Category*	*SARA / CERCLA reportable (y/n)*	*Affect Nearby plants (y/n)*



PLOT YOUR UNIT EVACUATION ROUTE, ALTERNATE ROUTE (S) AND TRAIN YOURE EMPLOYEES.

Appendix C. Description of MIDAS

Introduction

The following information is required to produce the graphical computer disper sion pattern of the release.

Information	*Function*
1. Name of chemical	Input by plant to the dispatcher
2. Estimated size of the chemical release	Input by plant to the dispatcher or estimated by the Security shift supervisor with the plant's help
3. Location of the chemical release	Input by plant to the dispatcher
4. Prevailing atmospheric conditions at the time of entry of release/event (latest 5-minute average wind speed and direction; updated every 5 minutes)	*Primary* Automatically entered into computer from MIDAS weather gathering equipment every 5 minutes. *Secondary* Manual entry of current wind speed and direction based on Dispatcher Center wind gauge.
5. Chemical molecular weight, permissible short-term exposure limit in parts per million, dispersion coefficient	These data are pre-programmed into the computer for all chemicals listed.

Most chemical releases can be approximated by choosing one of the listed chemicals that most closely resembles the released chemical at it's vapor pressure at release conditions. Remember, MIDAS provides a dispersion model of a chemical release.

Four CRTs are located off site. One is located at the County Services Building Emergency Control Center, one at the Haley Street Fire Station, one at the Chemical Corporate Center 2010 building in the dispatcher's office and one at 911 Central Dispatch

CRTs are used to graphically display to County Emergency Services personnel the identical dispersion pattern displayed on the MIDAS System. The Security Dispatcher transfers the dispersion pattern to 911 Central Dispatch, Fire Station, County Services Building ECC when MIDAS has calculated that the gas will leave the site and impact the community.

The Plant Security dispatcher confirms via dedicated telephone line with 911 Central Dispatch, Haley Street Fire Station, ECC, and dispatcher that all CRTs are functioning. The transmission system is fully function-tested at least weekly. The integrity of the dedicated phone lines are tested by the MIDAS System once per week.

Appendix D. Handling Telephone Bomb Threats

WHEN . . . BE ALERT
WHERE . . . GET SPECIFICS SUCH AS VOICE, TONE, BACKGROUND
WHAT . . . BE RESPONSIVE

YOUR NAME ______________________
LOCATION ______________________
DATE ______________________

EXACT WORDS OF THE CALLER:

____
____
____
____
____
____

TIME_____A.M./P.M. YOUR EXT.#________

NAME OF THE PERSON THE CALLER REQUESTED:__________________________

I SAID:

____
____
____
____
____

WHEN WILL IT EXPLODE? (RECORD EXACT WORDS):

____
____
____
____
____

WHERE IS IT? (RECORD EXACT WORDS):

____
____
____
____
____

WHAT DOES IT LOOK LIKE? (RECORD EXACT WORDS):

____
____
____
____
____

WHAT TYPE OF DETONATOR WAS USED?

____
____
____
____
____

WHO IS THE CALLER?

NAME: ______________________
ADDRESS: ______________________
____
TELEPHONE # __________________
ORGANIZATION __________________

OTHER STATEMENTS (RECORD EXACT WORDS):

____
____
____
____
____

TIME CALLER HUNG UP ________ A.M or P.M. ?

THE CALLER'S SEX: MALE___ FEMALE___

APPROX. AGE_______

LOCAL CALL___ LONG DISTANCE___

VOICE WAS (CHECK ALL APPROPRIATE)

FAST___ SLOW___ STUTTER___ DISTINCT___ DISGUISED___

LANGUAGE WAS: (CHECK APPROPRIATE ONES)

EDUCATED___ SIMPLE___ INTERNATIONAL___ CURSING___

ACCENT: LOCAL___ FOREIGN___ IMPEDIMENT___

MANNER:

CALM___ ANGRY___ EMOTIONAL___ LAUGHING___ DELIBERATE_____

I CAN___ CANNOT___ IMITATE UNUSUAL CHARACTERISTICS OF THE CALLER'S VOICE.

THE VOICE WAS___ WAS NOT___ FAMILIAR TO ME

WHAT WERE THE BACKGROUND SOUNDS (IF ANY):

____

____

____

____

____

I NOTIFIED WHOM:

____

SECURITY DISPATCHER

____

TIME:______________________

OTHERS:

____

____

____

____

____

SIGNED: ______________________

DATE: ______________________

TIME: ______________________

Appendix E. Bomb Threat Employee Training Guidelines

(See Bomb Threat Search & Evacuation Procedures Appendix F.)

1. Determine search coordinator for unit operation. This may be a designated person, head operator, superintendent, etc. Assure that the search coordinator will be on site.
2. Define breakdown of areas to be searched. Examples are tank farms, offices, control rooms, lobby, rest rooms, and exterior of the building.
3. Method of search can be either **grid** or **spiral**

Divide the area into three search levels:

1. floor-to-waist lever
2. waist lever to shoulder level
3. shoulder level and up (remember false ceilings)
4. Define search teams. It is recommended that searches be done in groups of two.
5. Mark or label searched areas with appropriate tape or barricades,
6. Types of items to look for and report:
   - unmarked packages
   - unusual objects
   - unowned objects such as briefcases, purses, lunch boxes
   - objects that are ajar, i.e., ceiling panels, light fixtures, HVAC ducts
   - potted plants
   - packages (do not open)
   - trash cans
   - dumpsters
7. Common types of bomb material:
   - pipe
   - letter (look for oily appearance, unusual thickness, handwritten)
   - booby trap (bomb can be hidden in cigarette box, lunch box, file cabinet, etc.) *Note:* bombs can be disguised in any manner
8. Things to avoid:
   - do not use radios during the search
   - do not wet the object
   - do not touch or move the object
9. Things to aid the search:
   - employees take personal items if they evacuate
   - turn off all appliances, motors (where practical)
   - listen for ticking with eyes closed and mouth open
10. If suspicious items are found, call the proper number:
    - Site: 63
    - Bay City Site: 667-0235
    - Plastic Lined Pipe: 667-2500
    - Site: 845-4466

11. What to do if something suspicious is found and there is time:
    - evaluate the need to search further
    - open doors and windows to minimize blast damage
    - assure plant is in safe condition
    - secure the area against further entry
    - evacuate at least 300 yards
    - barricade the area
12. Have yearly training on bomb threat planning and searches. Emergency Training Exercises are recommended.

Bomb Threat Search and Evacuation Procedures

If you receive a telephone bomb threat, refer to the following procedures.

Step	*Action*
1	If the caller states the floor number or exact location of the bomb, search there first.
2	If the caller does not state any exact location of the bomb, have all personnel search their own work area for anything suspicious or out of place.
3	When management decides that a formal search is necessary, teams of two searchers should thoroughly comb the areas they have been trained to check for bombs.
4	Work from the perimeters inward, checking all access areas. Check most likely areas first.
5	Stairwells are often chosen by bombers as a good location to plant a bomb. Before you evacuate people down a stairwell, check it from bottom to top for suspicious objects.
6	If management gives the order to evacuate, follow your written plan and evacuate personnel to a safe location, under shelter if possible, and as far away as practical from the bomb site, i.e., at least 300 yards.
7	All elevators should be taken to the ground floor and locked there. Do not use an elevator to evacuate people during a bomb threat incident.
8	All doors and windows should be left open to vent the blast if an explosion occurs.
9	Personnel should shutoff their office machinery, leave their desks and filing cabinets unlocked, and take all personal belongings out of the building with them.
10	Lights should all be left on to aid the searchers, de-energize the power to heavy machinery, and shut off the natural gas supply to the building if possible.

PART D

RECOVERY

13

MANAGING RECOVERY

13.1. INTRODUCTION

As the emergency response phase winds down, it will become clear that recovery from the emergency will require time, personnel, resources, and leadership. A preplanned capability to recover is important because the longer it takes to recover, the higher the ultimate cost. For example, several industrial facilities were impacted by hurricane Hugo in 1990. Some took months to fully recover and the financial loss could never be recouped. Another plant had preplanned its recovery and was back at full production within weeks. This facility had thought through the issues described in this chapter, and was better off because it had.

Recovery is initiated toward the conclusion of the emergency response phase. Factors that determine how long the recovery will take include:

- Extent of damage.
- Availability and commitment of personnel, resources, and finances to expedite recovery.
- Regulatory agency requirements.
- Other (weather, delivery of critical items).

Recovery evolves in three distinct levels:

1. Activity immediately following the emergency characterized by high energy, intensity, and desire to get things done.
2. Following the initial recovery stage, there is a period when progress is being made but people become tired with the amount of effort and time required. Employees may be trying to do both their normal jobs and recovery functions.
3. The final period when the facility is nearly back to normal and mostly administrative activities need to be completed.

This chapter describes many important recovery functions such as:

- Managing recovery.
- Scene security.
- Employee assistance.
- Damage assessment.
- Process data collection.
- Incident investigation.
- Restoration of safety and emergency systems.
- Legal.
- Insurance.
- Public information.

13.2. MANAGEMENT DURING RECOVERY

The recovery phase presents unique circumstances and challenges for management. Operations might not immediately return to normal since an area of the facility is damaged. Additionally, not every key person will be readily available or physically able to contribute to recovery activities.

The recovery's success is determined to a large extent by how well it is managed. A respected manager needs to be appointed to manage the recovery process. Management may need to establish a special organization or task force to carry out recovery functions.

In the beginning of the recovery phase, the designated recovery manager will need to suspend normal responsibilities and focus on getting the recovery under way. The recovery manager's role is best handled by an individual who is able to focus on the big picture. Duties include coordinating a recovery team's efforts, assigning tasks and responsibilities, supervising equipment inspection and testing, overseeing the clean-up methods being used, communicating with representatives from internal organizations (corporate, legal, insurance) and external groups (regulatory agencies, media, public).

For recovering from a large incident, the recovery manager cannot do everything alone. Thus a recovery team is essential in ensuring a complete and successful recovery. The recovery team's composition, depending on the size of the incident, typically includes individuals representing some or all of the following:

- Engineering
- Maintenance
- Production
- Purchasing
- Environmental
- Safety and health
- Human resources
- Public relations
- Legal

The team may also include representatives from unions, contractors, and suppliers. Identifying and training recovery team personnel during the preparedness phase will permit them to quickly begin functioning following an emergency. However, if a recovery team has not been previously identified, the recovery manager will need to appoint team members quickly. The recovery manager, supported by top managers, should ensure that each team member is available to spend considerable time on recovery issues and, if necessary, relinquish normal responsibilities until the recovery is well underway.

The recovery manager should conduct regular team meetings to chart progress and resolve new issues until the area is restored to its former use or a new use. An important recovery manager function is to establish priorities and coordinate critical recovery functions:

- Scene security and safety,
- Employee assistance,
- Damage assessment,
- Process data collection,
- Incident investigation,
- Damage assessment,
- Clean-up,
- Legal,
- Insurance and financing (expedited), and
- Public information and communication.

Appendix A contains a checklist of key recovery functions. Clean-up is dealt with in Chapter 14.

The first issue to be faced by the recovery manager is to secure the area and to attend to those affected by the emergency.

13.3. SCENE SECURITY AND SAFETY

Once the emergency response phase is over, it is essential to isolate the incident scene for the following reasons:

- The site may present a physical danger to anyone who is in the area.
- The incident investigation team needs to determine the incident's cause; therefore, physical evidence must not be disturbed or destroyed.
- If there have been serious injuries or fatalities, an official investigation (OSHA, coroner, etc.) will likely take place.
- Other regulatory agencies may also investigate (EPA, Department of Health).
- Insurance companies will want to determine the extent of damages.
- Engineers need to examine the area to determine the extent of damage and identify salvageable equipment.

The area should be cordoned off with brightly colored tape, signs, or other devices. Security personnel should deny entry to unauthorized personnel. Management should provide the security staff with a list of personnel who are authorized to be in the area. Security should also be notified how to handle regulatory inspections (whom to call, escorting, etc.).

Safety and industrial hygiene personnel should determine the presence of contamination or physical hazards. If the area presents a danger to personnel, appropriate safety measures should be taken, including personal protective equipment and a buddy system for personnel who are in the area for legitimate reasons. Inform all employees, contractors and guests of the entry and safety limitations for the damaged area.

13.4. EMPLOYEE ASSISTANCE

13.4.1. General

Employees are a company's most valuable asset and are invaluable in expediting the recovery process. However, all personnel will be affected by an emergency in some way and employees who are concerned about their personal situations may not be as productive or fully capable to work. Therefore, following an emergency, employees may require company support.

Recovery issues for the employees that should be addressed by the company involve:

- Ensuring that adequate medical or psychological assistance is provided to employees following the emergency.
- Ensuring that families of injured or deceased employees are cared for in accordance with company practice.
- If the emergency has affected an employee's family or residence (e.g., following a hurricane or other natural disaster), ensuring that the employee has time, or is otherwise assisted, in recovering from his or her personal loss.

Depending on the size and extent of damage, the company may want to consider a range of services to be provided to employees:

- Cash advances,
- Salary continuation,
- Flexible or reduced work hours,
- Crisis counseling,
- "Care" packages, and
- Day care.

13.4.2. Supervisors' Role

Following an emergency, the recovery manager should brief all management and supervisory personnel on the need to be sensitive to employees' physical and psychological needs. Providing counseling, time off, and other assistance will greatly reduce employee stress and ensure a more rapid return to full production at the facility.

Supervisors should be alert for changes in employee behavior which may indicate stress resulting from the disaster experience and may result in poor job performance. Some symptoms to look for include:

- Chronic gastrointestinal upset.
- Sleep disturbances.
- Headaches, skin rashes, allergy flare-ups.
- Disturbed memory, inability to concentrate.
- Excessive irritability.
- Accident proneness while performing routine duties.
- Changes in eating habits.
- Increased alcohol or cigarette use.
- Amount and quality of social interaction (depression, withdrawal, increased use of profanity, increased quarreling, shortened temper).
- Any obvious, unusual, and marked change in typical behavior.

Establish informal discussion sessions to provide employees with an opportunity to describe what happened during the emergency, discuss their feelings, and realize others are going through the same experiences. If desirable, arrange for psychologists to work with employees to assist in their recovery from the emergency. The safety manager or similar person should ensure that emergency response team members are provided with a debriefing to focus on their emotions and to allow them to deal with their feelings.

13.4.3. Human Resources Department

The availability of personnel to assist in recovery or maintain production will be directly dependent on how the emergency affected each employee. Recognizing employees may have suffered from the injury or death of a relative or friend, or had their homes damaged, the human or employee relations department could:

- Arrange for employees to have time to make funeral arrangements, for visits to hospital and doctors, meet with contractors, arrange for disaster recovery loans, and facilitate returning their private lives to a normal condition.
- Arrange work schedules to keep employed as many employees as possible.
- Assist displaced employees in finding new jobs.

- Provide other assistance to employees, such as arranging for cash advances, flexible or reduced work hours, crisis counseling, "care" packages, or day care.

13.4.4. Federal Assistance

If the community where employees live is included in a presidential disaster declaration, various federal assistance is available. The recovery manager should consider contacting the local emergency management director to arrange for a disaster assistance center to be established either on site or nearby so employees can quickly file necessary federal assistance applications.

13.5. DAMAGE ASSESSMENT

Another recovery function is to assess damage, focusing on how to repair and restore the plant after an accident. This should occur quickly but without interfering with the incident investigation. The recovery manager might consider appointing a dedicated team to carry out this function. Team personnel should include engineering, financial, purchasing, and maintenance personnel. After assessing the damage due to an accident and establishing priorities, the actual clean-up and initial restoration can be carried out. Since the damage assessment and final restoration are closely related, the same team that performed the damage assessment could oversee the clean-up and initial restoration. Long-term building and complex restoration will revert to the company's normal management hierarchy.

The damage assessment team could examine the affected area(s) using something like the damage assessment checklist (Appendix B) as a guide. Everything in the checklist may not be applicable to a specific incident but this list can be used as an "idea list" of what to look at after an emergency. The checklist provides several columns for recording information about repairs to equipment and areas. This will serve as a reference tool for plant modifications by the engineering department. The team should determine which repairs or replacements should be made and the order of priority.

After assessing the damage, the recovery team should meet and review the items. Each item requiring immediate restoration or repair should be assigned to a particular person or a department. The purchasing department should have the overall responsibility for seeing that all critical requests are expedited.

Damaged equipment should be placed in a safe storage area or disposed of in a proper manner. The incident investigation team should be consulted to ensure that equipment review has been completed prior to any disposal. Appropriate documentation should be maintained. Upon completion, the method of repair and date finished should be recorded on the damage assessment checklist.

Once the type and extent of restoration or rebuilding is determined, items to be addressed involve:

- Determining schedule and costs.
- Developing plans, drawings and contracting criteria.
- Hiring contractors and/or assigning personnel.

Early decisions may include making contractual arrangements with vendors for such postemergency services as records retrieval and preservation, equipment repair, earth moving, or engineering, and debris disposal. During the entire recovery phase frequently photograph or videotape the facility to document progress.

Cleaning and restoring the damaged area (see Chapter 14) are the most visible elements of the recovery operation and to many it may appear that the recovery phase is over when the construction is complete. However, many other recovery activities are important and ongoing.

13.6. PROCESS DATA COLLECTION

One of the duties of operations, including production and technical personnel, after an incident, is to collect all pertinent process data leading to and during the incident. These data typically can include:

- Inventories of materials involved.
- Process conditions prior to the incident.
  —Temperatures
  —Pressures
  —Flow rates
- Unusual observations by operators (or others).
  —Noises
  —Leaks
  —Weather conditions
  —Seismic events

Quick action is normally required to recover computer process records since they can be lost. The incident process data collection is critical in reconstructing the cause(s) of the incident and, therefore, in providing a path towards prevention of this or related incidents in the future.

13.7. INCIDENT INVESTIGATION

Incident investigation focuses on how and why the incident happened, with a diligent search for root causes. The objective is to identify any changes in procedures, work environment, or safety management that could be made to prevent recurrence. CCPS's *Technical Guidelines for Incident Investigation* contains extensive guidelines on properly conducting an incident investigation [1]. This book is not intended to review this subject extensively and readers should refer to this guideline for more information.

In accordance with company practice, the incident investigation team should be composed of various technical and operational personnel (engineers, safety specialists, manufacturer's representatives, process operators, etc.). The team should perform the following steps:

1. Survey the scene.
2. Collect and preserve evidence.
3. Identify and interview witnesses.
4. Review photographs and videos of incident scene.
5. Review process data.

Following these initial activities, the team should analyze the incident following company procedure and other guidelines such as the CCPS Incident Investigation guidelines. The primary objective is to identify and evaluate the incident's causes (both root causes and contributing causes) to determine and evaluate corrective actions and to assign responsibility for the correction actions. The team must then document their findings and recommendations in a detailed report. The report should clearly state which corrective actions are already completed at the time the report is issued; what actions are currently planned (along with an implementation schedule); and also report actions that are recommended, but require higher management approval or further study and identify the accountability for completing these recommendations.

The plant should have a procedure for investigating incidents, including near misses. Typically, if any of the following conditions apply, a formal and extensive incident investigation is conducted:

- A fatality, a serious injury, or extensive property damage has occurred.
- Initial observations reveal information that points toward a high potential for a similar accident in the future.
- The investigation reveals that more serious consequences could occur in the event of a similar accident.
- Hazards are revealed that were previously unrecognized.
- Risks of exposure appear much greater than previous estimates.
- Additional technical information or skills are needed to analyze the accident's roots.

13.8. RESTORING SAFETY AND EMERGENCY SYSTEMS

It is imperative that any safety or emergency system be checked and immediately repaired following an emergency. The maintenance department could establish standing work orders to get this work performed. Purchasing should expedite all repair orders regarding these systems (sprinklers, ventilation, process controls, signal systems, etc).

13.9. LEGAL

The recovery manager should include a legal representative in all recovery operations. Following any significant emergency, it is likely that issues pertaining to liability and regulatory compliance should be a concern. Obtaining the advice of counsel should help ensure compliance with pertinent regulations and protect the corporation from a liability perspective.

13.10. INSURANCE

Insurance is an integral part of the recovery process. While many firms are self-insured, there is usually secondary coverage and therefore, the company's insurance, risk management or loss control representatives should be contacted. The coverage provided by an insurance carrier could play a significant part in the decisions about the size and scope of the recovery.

13.11. PUBLIC INFORMATION AND COMMUNICATION

The recovery manager should strive to open and maintain a dialogue with the public and other stakeholders. This will include:

- Local emergency officials.
- Neighbors and the general public.
- Other community officials.
- Employees.
- Owners.
- Customers.
- Suppliers.

The purpose of this communication is to keep them apprised of the progress being made in the recovery phase. Communication methods to be used may include:

- Press releases.
- Television and radio appearances.
- Briefings to civic, fraternal, and religious organizations.
- Tours of the facility.

A plant should periodically update employees and the community on the progress of recovery. A central element of this communication is that steps are being taken to eliminate or reduce the likelihood of such an emergency happening again. A further element is to assure the general public that all damaged property is being properly disposed.

Also, if the plant emergency caused any damage to neighboring homes or resulted in an evacuation, the company should consider prompt payment for repairs and any out-of-pocket expenses.

13.11.1. Business Relationships

Immediately following an emergency it is imperative that customers and suppliers be informed of the situation and how it affects them. This is important in order to minimize the effect on customers and suppliers.

The first step in handling business relationships should be to determine:

- The amount of supplies or finished products on hand.
- The amount of supplies or finished products that are available from other company facilities.
- The availability of transportation resources for product delivery.
- The estimated time for resuming production.

This information should be reviewed with company managers and a plan determined for offsetting production losses along with determining how customer needs will be met.

The recovery manager or purchasing department representatives should inform suppliers to either make deliveries to other locations (within the facility, to another company plant, or to a neighboring location) or to withhold delivery for a specific time period. Managers should consider the legal obligations to accept delivery of goods and services based on existing contracts.

The sales department should notify all customers of the effect of the emergency on their needs. If the company is unable to meet customers' needs, it may be necessary to arrange for competitors to provide products to customers until the plant can resume operations.

As recovery operations continue, regularly notify suppliers and customers of the progress and any changes in the anticipated restart date.

CITED REFERENCES

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APPENDIX A. SAMPLE RECOVERY MANAGEMENT CHECKLIST

Immediately after an emergency, take steps to resume operations.

I. **Secure Area**
- Maintain security at the incident scene.

II. **Employee Assistance**
- Consider providing adequate medical or psychological assistance.
- Ensure that families of injured or deceased employees are cared for.
- Assist employees in recovering from their personal loss.

III. **Notify**
- Follow notification procedures.
- Notify off-duty personnel about work status.
- Notify insurance carriers and appropriate government agencies.
- Conduct employee briefings.
- Maintain contact with customers and suppliers.

IV. **Investigation**
- Collect all key process data related to the incident.
- Keep detailed records. Consider audio recording all decisions. Take photographs or videotapes of the damage.
- Account for all damage-related costs. Establish special job order numbers and charge codes for purchases and repair work.
- Coordinate actions with appropriate government agencies.
- Assess the value of damaged property.
- Assess the impact of business interruption.

V. **Operations**
- Establish priorities for resuming operations.
- Protect undamaged property.
- Close up building openings.
- Remove smoke, water, and debris.
- Protect equipment against moisture.
- Restore sprinkler systems.
- Physically secure the property.

- Restore power.
- Conduct salvage operations. Segregate damaged from undamaged property and keep damaged goods on hand until an insurance adjuster has visited the premises. Move material outside if it is in the way and exposure to weather elements won't cause further damage.
- Take an inventory of damaged goods. This is usually done with the adjuster, or the adjuster's salvage company if there is any appreciable amount of goods or value. Obtain a signed inventory stating the quantity and type of any goods being removed by the salvager.
- Obtain proper documentation of all materials removed to a landfill or incinerated.
- Restore equipment and property. For major repair work, review restoration plans with the insurance adjuster and appropriate government agencies.

APPENDIX B. SAMPLE DAMAGE ASSESSMENT CHECKLIST

Area	*Extent of Damage*	*Suggested Fix*	*Actual Fix*	*Corrected Date*	*Person*
I. CRITICAL EQUIPMENT					
1. Storage tanks					
2. Process vessels					
3. Distillation columns					
4. Heat exchanges					
5. Process instrumentation					
6. Chemical lines					
7. Pumps					
8. Valves					
9. Loading docks					
10. Forklifts					
11. Fences					
12. Warehouse					
13. Office areas					
14. Computers					
15. Walls					
16. Roof					
17. Plumbing					
18. Foundation					

Area	*Extent of Damage*	*Suggested Fix*	*Actual Fix*	*Corrected Date*	*Person*
19. HVAC					
20. Structural					
II. EMERGENCY EQUIPMENT					
1. Fire extinguishers					
2. Foam units					
3. SCBAs					
4. First aid equipment					
5. Eye wash station					
6. Shower station					
7. Fire/heat/smoke sensor					
8. Sprinkler heads					
9. Water lines and pumps					
10. CO_2/halon systems					
III. MACHINE (GENERIC)					
1. Power cord(s)					
2. Emergency cord/switch					
3. On/off switch(s)					
4. Other switches/controls					
5. Wiring for switches					
6. Outgoing/incoming wires					
7. Incoming/outgoing pipes					
8. Manual valves					
9. Electric valves					
10. Sensors/detectors on equip.					
11. Fire extinguishing equip.					
12. Moving parts					
13. Machine base					
14. Floor around area					
15. Emission controls					
16. Other					
IV. ELECTRICAL					
1. Switches					
2. Light switches					

Area	*Extent of Damage*	*Suggested Fix*	*Actual Fix*	*Corrected Date*	*Person*
3. Light sockets					
4. Outlets					
5. Conduit					
6. Wiring					
7. Transformers					
8. Generators					
9. Emergency lights					
10. Emergency batteries					
11. Outdoor lights					
12. Other					
V. ALARMS					
1. Sensors					
2. Electrical lines					
3. Manual actuator					
4. Automatic actuators					
5. Relays to pumps/valves					
6. Alarm bell/siren/light					
7. Radio					
8. Computer					
9. Other					
VI. PA SYSTEM/RADIOS					
1. PA wires					
2. Speakers					
3. Two-way radios					
4. Charging units for radios					
5. Other					
VII. PHONES					
1. Phone wires					
2. Phone					
3. Battery backup					
4. Other					

Area	*Extent of Damage*	*Suggested Fix*	*Actual Fix*	*Corrected Date*	*Person*
VIII. OTHER					
1. Time clock(s)					
2. Restroom					
3. Chair(s)					
4. Table(s)					

8

DEVELOPING A WORKABLE PLAN

8.1. INTRODUCTION

Industrial and government emergency planners place great emphasis on preparing the written emergency plan. This is understandable since most related regulations and industrial management guidelines emphasize the need for a plan. However, planners and responders can have confidence in the plan only if it is the result of an effective planning process. To emphasize this point, it is worth remembering General Douglas MacArthur's comment: "Plans are worthless, but planning is everything."

The previous chapters outlined many of the early steps in the emergency planning process. These steps included identifying credible incidents, evaluating resources, devising response tactics, organizing properly, and defining necessary resources. Having completed the planning, it is important to document the important facts, analyses, and decisions in the form of a plan so that others in the organization have a tool for effective emergency management.

The emergency plan becomes, therefore, the blueprint for action before, during, and after an emergency. Managers will use it before an emergency to train employees and prepare the organization for credible incidents. Emergency response personnel and managers will use it during an emergency as an aid in mitigating an incident. Following an incident, personnel will use it to recover and identify opportunities for improvement. The type, content, and format of the emergency plan is dependent upon the facility's needs and objectives. A good emergency plan will:

- Identify emergency authority and responsibilities.
- Describe the plant's emergency organization.
- Identify emergency operations facilities and systems.
- Address regulatory requirements.
- Establish training and other preparedness programs.
- Communicate specific response actions.
- Identify company, community and regulatory notification requirements.

This chapter examines these issues to help the planner translate sound planning into an effective plan.

8.2. REVIEW EXISTING PLANS OR PROCEDURES

The status and condition of emergency plans vary from plant to plant. Some facilities may have no plan at all, or a minimal fragmented plan while still others may be satisfied with their plans, but are always looking to build on prior successes. In any of these circumstances, it is always advisable to review existing plans before revising or developing new ones. This would include reviewing the facility's existing related plans and procedures, neighboring facility plans, and community plans.

8.2.1. Review Existing Emergency-Related Facility Plans

Reviewing emergency-related plans provides an understanding of the way emergencies were managed in the past. Even if the planner is a long-time employee, reviewing these plans and procedures is advisable. Related plans and procedures would include the facility safety manual or procedures, evacuation plan, fire prevention plan, hazardous materials spill response plan, a natural disaster plan, and corporate policies. The planner should also review operating procedures that may cover emergency shutdown and similar activities to ensure consistency. In examining these documents, the planner might notice a degree of redundancy and inefficiency. Individuals might have overlapping responsibilities or there may be an inefficient use of resources. The planner might notice that maintaining these separate plans requires a Herculean effort and that an opportunity exists to consolidate and streamline essential information.

8.2.2. Review Neighboring Facility Plans

Planners also will find it worthwhile to review neighboring facilities' plans to understand how they prepare for emergencies. Reviewing their plans might provide an idea that might otherwise have been overlooked. For example, a neighboring facility's plan might provide insight as to how the plant emergency brigade should collaborate with community response agencies. While this review can generate good ideas, planners should exercise caution so that another plan's mistakes or deficiencies do not find their way into the facility's plan.

Along with reviewing written plans, planners should discuss with their counterparts at neighboring facilities information pertaining to credible incident scenarios, resources and capabilities, and the concept of emergency operations. Planners will generally find that new and innovative approaches to plant level emergency planning result from these discussions. Such discussions might also lead to developing a mutual aid organization that benefits all organizations involved in emergency management.

8.2.3. Review Community Plans

Next, the planner should understand the workings of the community's emergency response network. This should include diverse government and private support organizations such as:

- Fire Department,
- Police Department,
- Emergency Medical Services (Ambulance),
- Office of Emergency Services, Emergency Preparedness Organization, or Civil Defense Agency,
- Local Emergency Planning Committee,
- Department of Health,
- Highway Department,
- Public and private hospitals, and
- Voluntary agencies (e.g., Red Cross, Salvation Army).

Depending on the nature and magnitude of an emergency, a community's emergency organization can be quite complex, yet also comprise many capabilities and resources. The actual make-up of community emergency organizations varies greatly from region to region, if not community to community. A planner should become familiar with available capabilities, and the community emergency plan is a good place to start.

The local office of emergency management is the most likely source for this information since they typically coordinate community emergency planning and know key personnel. The local emergency planning committee (LEPC), created by federal mandate to develop hazardous materials response plans, is also a good information source. In addition to the overall community plan, planners should also review the fire and police departments' emergency operations procedures, which outline exactly how they will carry out their emergency responsibilities. This will help the planner determine how plant response activities would be affected by local response actions.

Beyond reading the community plans, the planner should meet with officials of key response organizations to explain the facility's emergency planning objectives and concepts. This will likely result in a general exchange of ideas on how to better integrate community and facility resources and actions during an emergency. More specifically, it will allow for discussion of detailed response activities such as:

- Which gate or entrance will responding units use?
- Where and to whom will they report?
- How will they be identified?
- How will facility personnel communicate with outside responders?
- Who will be in charge of response activities?

Reviewing neighboring facility plans and community plans will provide the planner with an understanding of how individually and collectively these organizations prepare for, respond to, and recover from emergencies. This is an essential step in creating a dialogue that will permit the company and community to support one another in a time of emergency.

8.3. DETERMINING APPROPRIATE PLAN TYPE

8.3.1. Plan Types

Many types of emergency plans exist to meet the facility's needs and the choice largely depends on the intended scope and usage. Each type possesses certain advantages and disadvantages that planners should consider when choosing a particular plan. This section describes three common plan types and explains the differences and advantages of each. The three types of emergency plans discussed are:

- Contingency plan,
- Response plan, and
- Comprehensive plan.

It is important to recognize that various facilities refer to their plans by different names depending on the plan's purpose. Examples include Hazmat response plan, evacuation plan, emergency management plan, notification plan, hurricane plan, hazardous waste contingency plan, and oil spill response plan. Regardless of the plan's name, it can generally be classified under one of the three aforementioned types of plans.

8.3.1.1. Contingency Plans

Planners use the contingency plan to address one particular hazard and enact it only when the specific incident occurs. Contingency plans address specific emergencies such as tornadoes, hazardous materials spill, fire, bomb threats, power outage, and floods. Most contingency plans generally cover only the response phase of an emergency, although some may cover preparatory measures as well. Rarely do these plans address prevention programs or recovery activities following the incident. The advantages of this type of plan are that it is highly focused on responding to the hazard and usually very well thought out.

A disadvantage of the contingency plan is that it cannot be used to address potential hazards outside its narrow scope. Since a typical industrial facility faces a multitude of hazards, it would need an entire series of contingency plans to manage all credible incident scenarios.

A historical reason for developing contingency plans stems from a natural inclination to write a plan after recognizing that a hazard exists. Unfortunately, some contingency plans are all too often written only after an incident strikes.

Another reason for developing separate contingency plans stemmed from government regulation. For example, when OSHA promulgated regulations concerning fire prevention and employee evacuation, management would develop an evacuation plan. Years later, when OSHA instituted a regulation covering hazardous materials response, the management responded by developing a Hazmat response plan. Meanwhile, EPA promulgated regulations covering oil spills and hazardous waste spills and environmental managers developed separate, but similar, contingency plans.

Whether the plans were written in response to an incident or government regulation, it is common to find plans written at different times to suffer from major inconsistencies. A series of hazard-specific documents, rather than a cohesive whole document, can be effective but requires close coordination among the various management and response personnel. Otherwise, there may be inconsistencies in response approaches from contingency to contingency and personnel could become confused about which contingency plan to follow in an emergency.

Also the use of contingency plans has often led to the development of multiple response teams with different personnel to respond to distinct hazards. For example, one facility organized a Hazmat response team, an entirely separate hazardous waste spill team, and a third response unit for oil spills. People in charge of these teams were different and key managers had different responsibilities for each hazard. This leads to higher training costs than necessary and potentially more confusion during the response.

Since contingency plans are stand-alone documents, a series of plans typically include a fair amount of duplication in the description of responsibilities, systems, and facilities. This makes maintaining the plans difficult and costly to do in a timely manner.

In summary, contingency plans can be very effective for facilities facing few hazards; however, for multiple hazard facilities, these plans may lead to confusion and maintenance difficulties and may involve higher than necessary training costs.

8.3.1.2. Response Plans

Response plans do exactly what their name implies, they describe the immediate, specific response to an emergency. They address the general actions to be taken regardless of the hazard, such as notification, medical, communications, and evacuation. In most cases, response plans are a bound series of concise, action-oriented procedures. Response plans are usually very detailed and designate responsible individuals and the actions they must implement to mitigate the problem at hand.

The primary disadvantage of response plans is that they typically do not address either preparedness (e.g., training, drills, and exercises) or recovery activities. Some response plans will not adequately address the unique characteristics of specific process or other hazards, but this is readily overcome by additional planning.

8.3.1.3. Comprehensive Emergency Plan

The comprehensive emergency plan (CEP) consolidates all responsibilities, duties, and procedures associated with preventing, preparing for, responding to, and recovering from potential emergencies. Some view it as a combination of a response plan and contingency plan, yet extended to all four phases of the emergency management cycle.

To many, a CEP may initially appear overwhelming, but it actually contains less redundancy than a series of contingency or response plans. At the same time, its comprehensive nature allows it to be used as a single source for information regarding how a facility manages emergencies in four logical phases: prevention, preparedness, response, and recovery. It can also address applicable regulations.

Table 8.1 summarizes the advantages and disadvantages of the various emergency plan types.

8.3.1.4. Action Checklists

Regardless of the type of plan chosen, a common criticism of emergency plans is that they are too complicated or detailed to be used during an emergency. However, the purpose of the emergency plan is to cover all requirements and details in advance of any emergency. Emergency plans must also address government requirements and document the decisions made during the planning process. It is impossible to do this in a manner that is so brief and succinct that it can readily be used during an emergency. For this reason, planners should develop emergency action checklists to augment the emergency plan by providing memory joggers

TABLE 8.1
Emergency Plan Advantages and Disadvantages

Plan Type	*Advantages*	*Disadvantages*
Contingency Plan	• Highly focused on hazard	• Difficult to maintain if many contingency plans exist at facility • Inconsistent in response and management from contingency to contingency
Response Plan	• Allows for effective response to most hazards	• Does not address certain aspects of unique hazards • Does not typically deal with the preparatory or recovery phases of an emergency
Comprehensive Emergency Plan	• Very comprehensive; deals with all phases of emergency management • Incorporates the best elements of response and contingency plans • Single source coverage of applicable government regulations	• If not well organized, can be unwieldy and overwhelming

for actions. Action checklists are concise reminders to personnel of key actions that need to be undertaken. They are intended to be more of a reminder and not a substitute for a more expansive plan. Further, it is preferable to have trained and experienced staff who understand the plan's provisions so well that they need not refer to the emergency plan at all during emergencies.

8.3.1.5. Detailed Action Plan

A pre-plan technique widely used in the chemical industry is the detailed action plan (DAP). The DAP allows the initial action plan for each significant credible incident scenario to be written in a concise, action-oriented format. DAPs are usually area-oriented procedures and should specify actions to take for each particular type of emergency anticipated in that area. DAPs must be kept short and action oriented, and not be detailed reference manuals. The detail should be provided in advance by training.

DAPs address the personnel, equipment, countermeasures, and shutdown procedures to effectively combat the emergency situation. They generally take the form of an action checklist.

Important elements to consider when developing DAPs include:

- The individual or organization responsible for implementing the DAP during the emergency.
- Precautions and restrictions that may exist when the DAP is implemented.
- Protective measures to be used by emergency personnel.
- Step-by-step listing of action steps:
  —Size up,
  —Search and rescue,
  —Protection,
  —Confinement,
  —Extinguishment,
  —Clean up,
  —Special precautions,
  —Site specific problems:
- Notifications to be made to emergency response contacts throughout the course of the emergency and upon completion of action.
- Ability to call in additional personnel if necessary.

Additional information can be found in CMA's *Site Emergency Response Planning Guidebook* [2] and in *Plant Guidelines for Technical Management of Chemical Process Safety*, Appendix 6D, including an example DAP [1].

8.3.2. Plans, Procedures, and Instructions

OSHA's process safety management (PSM) standards (29 CFR 1910.119) and international quality assurance standards have caused organizations to review how they have written various plans and procedures. OSHA's PSM regulation brought about the need to change operating and maintenance procedures while international ISO 9000 standards encouraged development of a series of documents designed to formalize quality assurance programs. The formality of the ISO 9000 program provides a good framework for structuring emergency management documents. This section somewhat mimics, but may not be identical, to quality assurance document management framework.

Four levels of documents generally exist. The Level One document is an overall management plan or manual containing emergency management policy, program objectives, organization, and responsibilities. This plan should be somewhat brief in describing the purpose and overall structure for the plant's emergency management program.

Procedures need to be developed to demonstrate how the emergency management policy and objectives will be achieved. To implement an emergency management program properly, the planner will need to write several preparedness, response, and recovery procedures. Examples include a training procedure, a medical surveillance procedure, a notification procedure, a fire response procedure, and a damage assessment procedure. Section 8.4 of this chapter provides additional information on other procedures necessary for full implementation.

Procedures are Level Two documents that specify the purpose and scope of an activity, what shall be done and by whom, when and where documentation is necessary, and how the activity will be controlled. Procedures tend to describe interdepartmental activities. Procedures should be simple but provide sufficient information to carry out required actions. Planners should write procedures in the active voice so there is no misunderstanding who will perform each task.

Procedures can be written in any number of formats such as narrative, flow chart, drawings or, preferably, a combination of all three. While each organization will need to adopt a procedure format that is appropriate for its culture, Appendix B to this chapter contains a sample of an acceptable format.

Instructions are Level Three documents that describe how to carry out specific tasks identified in the procedures. Instructions are typically written for intradepartmental use or for an individual. For example, there may be an instruction specifying how incident commanders or safety officers should perform their duties, or an instruction for using certain monitoring equipment.

Finally, Level Four documents are records of emergency activities. These might include records of notifications made during the emergency, the safety officer's record of personnel entering a hot zone, or a report to government agencies. Procedures will dictate the required records to be maintained for each critical activity, as necessary.

8.3.3. Coordination and Commonalty

Developing emergency plans and procedures requires close coordination with the various elements within the facility and with outside organizations. Planners should involve all functional groups within the facility in developing and organizing the plan and procedures. This should include managers and staff from human resources, maintenance, engineering, safety, environmental, public relations, security, sales, legal, finance, purchasing, utilities, and operations functional groups. Each department has a role to play in the emergency response and its input is critical to the success of the program.

Table 8.2 lists the possible roles various departments can have, although it is by no means all encompassing. Also, one person may be assigned multiple duties.

TABLE 8.2
Possible Emergency Roles

Functional Groups	Possible Role
Engineering	Assist in prevention measures, provide technical advice to incident commander during emergencies.
Environmental	Determine government notifications, provide advice on preventing environmental impacts, communicate with government environmental officials, assist in environmental sampling efforts.
Finance	Assist in tracking expenditures and damage assessment; assist other managers.
Human resources	Provide victim assistance, coordinate with corporate insurance, finance, or risk management officials. Serve as interface with hospital. Provide comfort items.
Legal	Assist general managers in determining notification requirements. Review press releases prior to issuance.
Maintenance	Provide staff for emergency teams, provide technical advice on incident mitigation measures, assist in prevention activities, evaluate damage following an incident, participate in incident investigation. Maintenance can also provide riggers, electricians, pipefitters, and other logistical support.
Medical	Provide first aid to victims and support to response team.
Plant operations	Perform personnel accountability, provide technical advice on shut-down process equipment. Assist in size up. Provide analytical sources.
Public relations	Coordinate media relations, prepare press releases.
Purchasing	Assist in obtaining necessary logistics (backup supplies and equipment) to support emergency operations.
Safety and industrial hygiene	Provide advice to incident commander, provide MSDS and other information to hospitals and physicians, make notification to OSHA or state agencies as required. Monitoring and sampling. Document needs information.
Sales	Provide assistance to managers, notify customers of potential delivery disruptions following an emergency.
Security	Secure the facility and incident scene during and following an emergency, make notifications, prevent interference of onlookers and media with essential operations.
Utilities	Maintain or shut down operations as necessary to ensure safety.

As mentioned earlier, outside sources include corporate or regional offices, community response organizations, utilities, contractors, and insurance carrier(s).

8.4. DETERMINING CONTENT

The plan's content, as discussed earlier, depends on the type of plan to be employed. A response plan will address general actions to be taken in response to any emergency. Contingency emergency plans will include specific actions for the identified hazard. The comprehensive emergency plan (CEP) normally consists of a general overview of the emergency organization followed by specific procedures for each emergency management phase.

The CEP normally consists of the elements of both the response plan or contingency plan, Table 8.3 provides a typical outline of a comprehensive emergency plan and compares elements of the response and contingency plan. Table 8.4 defines the important plan sections of the CEP.

While a plan can be as simple or comprehensive as desired, a few key functions should be outlined in procedures. The next few sections describe the important preparedness and response functions to address in the CEP. Prevention is discussed in Chapters 1–3, while recovery is discussed in Chapters 13 and 14.

8.5. PREPAREDNESS

Preparedness procedures should describe all activities necessary to ensure a high degree of readiness so that response to an incident will be swift and effective.

8.5.1. Training

Training procedures should contain guidelines ensuring that effective training is provided for all personnel. An effective plan must specify what is to be done, how it is to be done, and who is to do it. The plan will not succeed, however, without trained personnel who have the knowledge and skills necessary to carry out assigned tasks. Providing training that meets the needs of each individual's role is a key element of a successful emergency response program. Chapter 10 includes more information about emergency training.

Emergency response training should address all hazards and response duties outlined in the plan as well as applicable regulations. Some key training requirements for nonemergency response employees that should be written into the training procedure include:

- Familiarizing employees with the general principles of fire extinguisher use,
- Providing emergency plan and fire prevention plan training to employees upon initial employment and at least annually thereafter,

TABLE 8.3
Comparison of Plan Elements for Various Types of Plans

Section	*Element*	*Contingency*	*Response*	*Comprehensive*
1	Basic Plan		✔	✔
1.1	Introduction	✔	✔	✔
1.2	Credible Incidents and Assumptions	✔	✔	✔
1.3	Concept of Emergency Operations	✔	✔	✔
1.4	Emergency Responsibilities and Organization	✔	✔	✔
1.5	Plan Distribution	✔	✔	✔
1.6	Plan Review and Maintenance	✔	✔	✔
2	Prevention			✔
2.1	Fire Prevention			✔
2.2	Hazmat Emergency Recognition and Prevention			✔
3	Preparedness			✔
3.1	Training			✔
3.2	Drills and Exercises			✔
3.3	Facilities and Equipment			✔
3.4	Medical Program			✔
4	General Response Procedure		✔	✔
4.1	Notification and Warning	✔	✔	✔
4.2	Direction and Control	✔	✔	✔
4.3	Evacuation and Personnel Accountability	✔	✔	✔
4.4	Security	✔	✔	✔
4.5	Emergency Public Information	✔	✔	✔
5	Response Team Procedures	✔	✔	✔
5.1	Fire		✔	✔
5.2	Hazardous Materials		✔	✔
5.3	Medical and Rescue Emergencies		✔	✔
5.4	Personnel Decontamination		✔	✔
5.5	Postincident Critique and Debriefing		✔	✔
5.6	Clean-Up		✔	✔
6	Hazard-Specific Procedures	Specified hazard		✔
6.1	Bomb Threat	✔		✔
6.2	Tornado and High Wind	✔		✔
6.3	Hurricane	✔		✔
6.4	Freeze Protection/Winter Storm	✔		✔
6.5	Credible Incident Pre-Plans	✔		✔
6.6	Environmental Incidents	✔		✔

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TABLE 8.3 (continued)
Comparison of Plan Elements for Various Types of Plans

Section	Element	Contingency	Response	Comprehensive
7	Recovery Procedures			✔
7.1	Incident Investigation			✔
7.2	Establishing a Recovery Team			✔
7.3	Damage Assessment			✔
7.4	Cleanup and Restoration			✔
7.5	Post-Emergency and Recovery Reporting			✔
A	Position Checklists	✔	✔	✔

TABLE 8.4
Description of Key Sections of a Comprehensive Emergency Plan

Section	Title	Description
I	Basic Plan or Executive Summary	Provides an overview of the emergency management program including organization, responsibilities, emergency action levels, notification and facilities. Briefly describes potential emergencies, assumptions and credible incidents and other situations, plan maintenance and distribution. This might include organization statements required by OSHA, such as a fire brigade organizational statement.
II	Prevention Procedures	These procedures describe the actions to be taken to identify potential emergencies and to prevent or mitigate their effects. Some of these procedures may be covered by a safety plan or other document and they may be referenced in this section rather than reproduced.
III	Preparedness Procedures	All the activities taken to prepare the facility and personnel for an emergency, including training, drills and exercises, equipment acquisition, development of mutual aid agreements, community relations, annual reviews and testing.
IV	General Response Procedures	The functional procedures that apply to any emergency, including alerting and warning, communications, evacuation, security, mutual aid, public information, reporting requirements, and procedures. They provide details on the actions to be taken by the appropriate personnel and organizations, equipment to be used, and the operation of the facilities.
V	Team Procedures	The emergency response team's procedures.
VI	Hazard-Specific Procedures	Explains the specific actions to be taken in response to a specific emergency such as credible incidents (fire, explosion, chemical spill, etc.) and natural disasters.
VII	Recovery Procedures	Explains necessary actions following the response to the emergency. These include incident investigation, employee support, community coordination, and recovery operations.
VIII	Appendix	Contains useful reference materials such as maps and diagrams.

- Training a sufficient number of persons to assist in the safe and orderly emergency evacuation of employees,
- Informing employees of the hazards of the materials and processes to which they may be exposed, and
- Informing contractors, subcontractors, or their representatives of the site emergency response procedures and any potential fire, explosion, health, safety, or other hazards.

Regardless of the regulations, training at a minimum might cover the following:

- Personal protective equipment,
- Identifying hazardous circumstances,
- Leak warning signs (odor, smoke, sounds, etc.),
- Emergency reporting procedures,
- Evacuation and assembly procedures, and
- Proper fire extinguisher use.

Emergency response personnel require training that provides all the knowledge and skills necessary to carry out their duties. OSHA's HAZWOPER regulation (29 CFR 1910.120) and fire brigade regulations (29 CFR 1910.156 and Appendix A to Subpart L) outline many of the requirements for emergency response team members. Chapter 10 reviews emergency response training requirements in greater detail.

The plan should also contain provisions for administering the training program. An individual should be designated to administer the emergency training program, develop new courses, and continually review the adequacy of the training. This person should also be capable of determining the minimum training levels for all emergency response positions. Training recordkeeping procedures should also be outlined in the plan and should specify the documentation requirements including the student's name, type of training, date of training, and results of testing.

8.5.2. Drills and Exercises

While drills and exercises are used for training purposes, their primary function is to provide the means of testing the plan's adequacy, facility resources, equipment, and the readiness level of response personnel. The objectives of a drill and exercise program are to:

- Test the adequacy of plans and procedures,
- Test the effectiveness of emergency training and personnel proficiency,
- Test the adequacy (quantity and quality) of existing emergency facilities, supplies, and equipment,
- Describe the type and frequency of drills and exercises,
- Increase coordination with off-site emergency response agencies, and
- Identify and correct any deficiencies in plan through post drill critique.

PHOTO 12. Community-Wide Emergency Drill on Company Plant Site.

The procedure should specify the type and frequency of exercises, and procedures for organizing, conducting, and evaluating them. The plan should at least contain the following provisions: scheduling and conducting drills/exercises, provisions for including all management levels in the exercise program, provisions for involving off-site personnel/agencies in the drill, provisions for correcting defects in the plan that are detected by the drills/exercises, provisions for conducting an annual "full scale" exercise, and periodic drills. There should be drills for each department or process, as well as drills for credible incident scenarios.

8.5.3. Supplies and Equipment

The emergency plan should contain procedures for controlling and maintaining special supplies and equipment for emergency response. It should contain an equipment and supply inventory that lists all emergency supplies and equipment currently available at the site including type, quantity, location, description, intended use, and capabilities. The planner should also identify local vendors who can quickly resupply necessary items during an emergency (include both day and night telephone numbers).

Emergency personnel should have easy access to equipment; however, there should be enough security to ensure that easy access by unauthorized personnel is minimized. The personal protective equipment and other emergency response supplies should be kept separate from normal operating supplies. Equipment maintenance procedures should be established that are based on manufacturer recommendations.

Chapter 7 contains a description of important emergency equipment and supplies. Appendix A to this chapter contains some, but not all, of the regulatory requirements for emergency equipment and supplies that must be addressed in the plan.

8.5.4. Community Awareness

Another essential preparedness activity is implementing community awareness activities. Events over the past decade have raised community concerns regarding the efficacy of industries' emergency, safety, and environmental programs. Without effective communication, a company will not be able to build the relationship it needs to be recognized as a responsible corporate neighbor.

The Chemical Manufacturers Association's Responsible Care® program outlines several ideas that can help build community relationships. Among the activities are a community awareness program that provides information to nearby residents and community officials regarding the plant emergency management program. While each company may have a different approach to this issue, the program should be documented in a preparedness procedure.

8.5.5. Medical Surveillance Program

The planner should develop a procedure establishing a medical surveillance program that monitors the health of emergency response team members in accordance with OSHA's regulations (29 CFR 1910.120 (f)). A medical surveillance program should monitor the health of emergency response team members before and during their term. Additionally, special medical surveillance should be extended other employees who become exposed to hazardous substances or other health hazards as a result of an emergency situation.

8.6. GENERAL RESPONSE PROCEDURES

These procedures are the activities that are common to any emergency situation and need only be described once. This eliminates redundancy between plans and procedures while ensuring consistency in responding to any emergency. The following sections describe ten functions that are common to most organizations and their key elements.

8.6.1. *Alerting and Warning*

The procedure should describe the alerting and warning functions to be performed by security guards, operators, maintenance personnel, and any other employee. Any employee may discover an emergency and his or her first action should be to report the emergency.

The type of alerting and warning system used may change somewhat based upon the type of emergency. Some of these alarms may be automatic. For example, detection of a fire may be signaled by an alarm rather than by an individual and subsequent notification may include not only personnel in the immediate area, but all facility personnel and the community fire department.

The size of the emergency may also determine who and how many should be notified. If the incident can be successfully mitigated by one or two people, the extent of notification may be limited to just a few people. But if the emergency response team is needed, notification may go beyond them to include general employees, visitors in the surrounding area, and off-site emergency responders.

The type of emergency may also dictate who needs to be notified. For specific types and quantities of chemicals, the notification may have to include the entire facility, the local emergency planning committee (LEPC), corporate headquarters, the state Environmental Protection Agency and the National Response Center.

This procedure should also describe using the warning and alerting equipment, which may include telephones, alarms, buzzers, lights, horns, public address systems, radios, and pagers. A useful addition to this procedure is a simple flow diagram indicating how information is distributed, an emergency call recording form and a regulatory reporting requirements form.

8.6.2. *Communications*

This procedure should describe the communications systems that will be used during an emergency, who is allowed to communicate on each system, the control center for each system, and backup systems. If this procedure includes confidential telephone numbers, it should not be included in the copy that is provided to the LEPC other than those telephone numbers they will need to communicate with the facility. Consider communications between:

- Emergency responders.
- Responders and the incident commander (IC).
- The emergency operations center (EOC).
- EOC and employees.
- EOC and outside response organizations.
- EOC and neighboring businesses.
- EOC and employees' families.
- EOC and customers.
- EOC and the news media.
- EOC and corporate manager.

An attachment to this procedure may include a listing of key personnel with home, office, and mobile telephone numbers, pager numbers and radio frequencies, a listing of emergency powered telephones, and names and numbers for key contacts such as news media, corporate office, state officials, and regulatory agencies.

8.6.3. Management Functions

Certain management personnel have responsibility for overseeing operations and coordinating with outside organizations. This procedure will primarily outline the roles and functions of the key managers. Management positions and functions needing to be addressed include the following:

- Plant manager.
- Security coordinator.
- Safety and health coordinator.
- Evacuation coordinator.
- Environmental coordinator.
- Engineering and maintenance coordinator.
- Human resources coordinator.
- Planning and logistics coordinator.
- Public relations coordinator.
- Affected area unit managers.
- Documentation coordinator.

Designated managers normally function from an EOC and are not at the incident scene. They are responsible for the overall situation and generally:

- Determine the short- and long-term effects of an emergency.
- Order the evacuation or shutdown of the site.
- Interface with outside organizations and the media.
- Issue press releases.
- Coordination with corporate management.

The emergency response team, led by an IC, responds to the incident scene and conducts required response activities. The IC organizes personnel based on their training and the incident needs (Chapter 11 discusses response). Thus the IC may have subgroups, or teams, specially trained and equipped to effectively respond to medical, hazardous materials, rescue and fire incidents.

The IC is responsible for front-line management of the incident, tactical planning and execution, for determining whether outside assistance is needed, and for relaying requests for internal resources or outside assistance through the EOC.

8.6.4. Evacuation and Personnel Accountability

This procedure details the actions necessary to evacuate one or more areas within the facility. It also addresses the personnel accountability system used to determine the status of all employees, contractors, visitors, and guests. The safe evacuation and accounting of all personnel are the most important emergency response actions.

The procedure should describe the conditions that warrant an evacuation, and identify who determines the extent of evacuation (e.g., a small area versus a total evacuation). The procedure should describe any special codes that are used to alert personnel to evacuate along with any devices indicating the proper evacuation route depending on the type of disaster. If the facility is divided into evacuation zones, then these are described along with their corresponding assembly area. If personnel are to be transported off-site, then how this will be accomplished is discussed. Special attention should be paid to mobility or speech impaired personnel.

Attachments to this procedure might include lists of the assembly areas, floor plans of the assembly areas showing where the various departments report, and maps of the evacuation areas and routes.

A corresponding attachment to this procedure is one for the sheltering of personnel. In some emergencies, the best means of protection is to take shelter either within the facility or away from the facility in a public building. The sheltering procedure should consider the conditions for taking shelter (e.g., tornado warning); identify shelter space in the facility and in the community; identify emergency supplies such as water, food, and medical supplies; and designate shelter managers.

8.6.5. Emergency Shutdown Procedures

Shutdown procedures are important [and required if covered by OSHA's PSM standards (29 CFR 1910.119)] because of the additional harm that might occur if the shutdown is not done correctly. Most facilities choose to include emergency shutdown procedures as part of the unit's standard operating procedures instead of as part of the emergency plan. Shutdown procedures generally apply to process units and utilities, but they also include the shutdown of laboratories and computer systems. The procedure should indicate the approximate time required for both orderly and rapid shutdowns.

8.6.5.1. Orderly Shutdown

This procedure encompasses either by reference or directly the shutdown steps recommended by the process design. A basic assumption of this procedure is that there is enough time to shut down operations in an orderly manner and safely evacuate the area. Provisions must be made for operators to use personal protective equipment to escape threatened areas once the shutdown is complete.

While these are emergency procedures, they should be maintained as part of the unit operating procedure. They may be referenced with the location of the procedure noted.

8.6.5.2. Rapid Shutdown

This portion of the procedure identifies the conditions under which a rapid shutdown will be accomplished. A rapid shutdown is necessary if the operator's safety would be jeopardized and if an orderly shutdown would take too long.

8.6.6. Security

This procedure describes the functions to be performed by the security force during an emergency. At many facilities, security is responsible for:

- Alerting/notifying.
- Securing the incident scene.
- Securing the facility.

Depending on the number of security officers available, additional personnel may be necessary to augment and carry out security functions during the emergency.

8.6.7. Mutual Aid

This procedure details how to obtain aid from outside organizations based on a previously prepared mutual aid plan. It states the manner in which requests for assistance are made. The additional help can be especially critical at the beginning of the emergency making response time a key issue. An attachment to this procedure lists key organizations, names, and telephone numbers for assistance.

8.6.8. Public Information/Media

Public information and media coordination are an important factor in emergency management. This procedure focuses on who will compile and present the information, the presentation format, and who will receive the information. The procedure recognizes the unique requirements of the different media. For example, the print media includes newspapers and magazines while the electronic media includes television and radio. Each have different time deadlines and informational needs. Television will want visuals while the print media will want more details and photographs. These needs should be accommodated if safe access is possible.

Attachments to this procedure should include a listing of news media contacts, media briefing center checklist and layout, sample press release, typical questions asked by the news media, and sample background information packet.

8.6.9. Special Notifications and Fatality Procedure

The most difficult activity that may have to be performed is notification of the families of employees who suffered injury or fatality. This special notification procedure describes who will make these notifications, how they will support the family members, and what restrictions exist on providing information to the media. Where possible, a team approach of trained personnel is important to take care of various details and answer a variety of questions.

While Human Resources or other departments may already have a special notification procedure, it should be reviewed to determine if any unique emergency circumstances will affect its implementation. For example, if the site manager normally makes such notifications, he or she might not be available to perform the notification during an emergency. It is important that plant personnel be the first to provide this information to the family.

8.6.10. Reporting Requirements

This procedure describes the types and frequencies of reports that must be made to meet company, local, state, and federal requirements. It identifies who is responsible for preparing the report and who is authorized to submit the report. This procedure should include an attachment that is used to transmit information in the appropriate format. It is important to have legal council involved in reporting.

8.7. HAZARD-SPECIFIC PROCEDURES

Hazard-specific procedures describe the specific actions to be taken in response to a unique risk. These actions are specific to the type of emergency and discuss activities not contained in general response procedures.

8.7.1. Fire

The purpose of the fire procedure is to describe the actions the emergency response team should take in responding to a fire. The procedure should include an organizational statement and structure policy that meets OSHA requirements and specifies the capabilities, mission, and limitations of the team's fire-fighting capabilities. The procedure should also clearly state the responsibilities of key individuals, including the incident commander, safety officer, and other fire functions.

The procedure should outline how the IC should gather information about the fire, which is known as the initial assessment and size-up. Contacting knowledgeable operating personnel at the site is important in size-up. The procedure should specify criteria for determining if additional assistance is necessary. It can also provide guidance for establishing a command post, developing a tactical action plan, searching buildings, and terminating operations. Many of the chemical release procedure tactics make sense for fires.

8.7.2. Chemical Release

The chemical release (also known as a hazardous materials release) procedure describes the specific actions and responsibilities taken by the emergency response team when containing and controlling a hazardous materials release.

The procedure should again state the steps the IC should take to recognize and identify hazards of a chemical release drawing upon the knowledge of operating personnel. The initial information to be collected includes:

- Which chemical is leaking?
- Where is the leak location?
- What is the leak's description?
- What is the leak severity?
- Where is, or is there a visible cloud?
- What are the details on the cloud path?
- Is the cloud flammable; are ignition sources in its path?
- Is the leak contained?
- Is the leak repairable?
- What is the estimated time to contain?
- Is there any assistance requested (list)?

The procedure should then provide criteria for establishing an Incident Command Post that allows for:

- Controlled access.
- Safe distance and wind direction
- A good view of the incident (if possible).
- Enough room for the team to operate.

The procedure should also include:

- Assigning personnel to the required positions. These positions should include safety officer, entry team, back-up team, and decontamination team. The entry team should initially perform reconnaissance operations.
- Checking with operating personnel.
- Establishing team communications.
- Spelling out safety officer duties, including verifying that the function is being performed as safely as possible, recording pertinent details, ordering cessation of operations if the response presents imminent danger to responders, and developing a safety plan in conjunction with the incident commander that outlines work zones, details the best entry and exit points

in zones, determines the most efficient and safe way(s) of dealing with the hazardous material, and provides for general safety of the whole area.
- Instructions for choosing appropriate personal protective equipment (PPE) for all responders.
- Ensuring that entry team members and other responders should use the "buddy system."
- Setting proper decontamination procedures for team members.
- Conducting reconnaissance (recon) operations.
- Establishing an action plan taking into consideration any information gathered about the incident, relevant site information (topography, weather), manpower availability, equipment (availability, proper usage, pros/cons of different types of equipment, etc.), control issues (diking, containment), monitoring needs, and other special concerns (daytime versus nighttime operations, seasonal considerations, flammability of the release, ignition sources, nearby hazards, etc.).
- Termination, including response critique and documenting.
- Medical follow-up.

8.7.3. Medical and Rescue

The medical/rescue procedure describes specific actions taken during the rescue and extrication of any injured person. The procedure should discuss rescuing personnel caught in machinery, including properly locking out the machinery and shutting off energy. In all medical emergencies it is important for emergency responders to follow good practices regarding bloodborne pathogens.

Rescue from collapse might also need to be addressed in the procedure. This section would include provisions for conducting primary and secondary searches for victims. The emergency response team should quickly conduct a primary search immediately upon their arrival and focus on the obvious places where victims might be. The IC would then develop a search and rescue plan based on information from the primary search, observations of the scene, information from employees familiar with the structure or the incident, and any other sources. The IC should consider the size and nature of the collapse, suspected number of employees trapped, time of day, weather, and any other special concerns. The search plan should focus its attention on the location and removal of any survivors. Effort should not be spent on the removal of bodies until it is certain that there are no remaining survivors, keeping in mind any local coroner requirements.

The search plan should also address excavation issues. Excavation rescue may go slowly, and to rush in could risk further weakening and collapse of the structure. The team must be careful not to dig too rapidly or forcefully and risk injuring trapped employees. There may be a need for heavy equipment such as backhoes, cranes, and bulldozers to dig victims out from beneath the rubble. Other possible needs include light equipment such as shovels and picks, and personal equipment such as hard hats, steel-toed boots, work gloves, and breathing apparatus.

The IC should shut down nearby operations that would exacerbate the situation. This would include any hydraulic, electric, and/or steam systems possibly damaged by the collapse that could harm victims and rescuers. Providing prompt medical attention to injured victims who have been freed is essential.

Confined space rescues are also governed by regulation (29 CFR 146). The procedure should outline steps unique to confined space rescues, such as using appropriate monitoring devices (combustible gas indicator, indicator tubes, oxygen and hydrogen sulfide monitors, etc.) to monitor the specific and nearby areas for any harmful or otherwise unexpected atmospheric conditions. No rescuer should enter the confined space before taking and analyzing atmospheric readings.

8.7.4. Hurricane

If the initial hazard assessment identified hurricanes as a potential emergency condition, then the on-site emergency response procedure should be tied very closely to the actions and recommendations that will be made by the county emergency management agency and the National Weather Service. The facility will have between 24 and 48 hours to take appropriate actions based upon information and guidance provided by the National Weather Service. In developing a hurricane procedure, it is important to review the Hurricane Intensity Classification System. Table 8.5 provides a brief description of the typical effects of each class of hurricane.

The hurricane procedure should describe actions to be taken based on the hurricane category and expected landfall. Because the hurricane will impact the entire facility, each department should be assigned certain actions based upon specific times prior to land fall. Other procedure elements might include the annual hurricane preparation activities that are done in the spring and hurricane evacuation decision criteria useful in making evacuation decisions (making sure this coincides with county or state evacuation criteria).

8.7.5. Tornado and High Wind

This procedure outlines basic actions in preparing for tornado and high wind storms.

Many areas of the United States are vulnerable to tornadoes. If a "tornado watch" is issued by the National Weather Service, some staff member should be responsible for monitoring weather conditions, listening for broadcast warnings, and reporting on threatening conditions.

If a "warning" is issued by the National Weather Service (meaning that a tornado has actually been sighted in the area) or if a funnel cloud is seen by personnel, the following steps should be considered:

- Activate the emergency alarm system.
- Personnel should seek shelter in ground-level interior rooms, rest rooms, or hallways.
- Personnel should shut off all nonessential utilities.

TABLE 8.5

Hurricane Intensity Classification System

Category	*Wind (mph)*	*Storm Surge (ft)*	*Description*
I	74–95	4–5	Winds of 74 to 95 miles per hour. Damage primarily to shrubbery, trees, foliage, and unanchored mobile homes. No real wind damage to other structures. Some damage to poorly constructed signs. Storm surge possibly 4 to 5 feet above normal. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.
II	96–110	6–8	Winds of 96 to 110 miles per hour. Considerable damage to shrubbery and tree foliage; some trees blown down. Major damage to exposed mobile homes. Extensive damage to poorly constructed signs. Some damage to roofing materials of buildings; some window and door damage. No major wind damage to buildings. Storm surge possible 6 to 8 feet above normal. Coastal roads and low-lying escape routes inland cut by rising water two to four hours before arrival of hurricane center. Considerable damage to piers. Marinas flooded. Small craft in unprotected anchorage's torn from moorings. Evacuation of shoreline residences and low-lying island area required.
III	111–130	9–12	Winds of 111 to 130 miles per hour. Foliage torn from trees; large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings; some window and door damage. Some structural damage to small buildings. Mobile homes destroyed. Storm surge possibly 9 to 12 feet above normal. Serious flooding at coast and many smaller structures near coast destroyed; larger structures near coast damaged by battering waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives.
IV	131–155	13–18	Winds of 131 to 155 miles per hour. Shrubs and trees blown down; all signs down. Extensive damage to roofing materials, windows, and doors. Complete failure of roofs on many small residences. Complete destruction of mobile homes. Storm surge possibly 13 to 18 feet above normal. Major damage to lower floors of structures near shore due to flooding and battering by waves and floating debris. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives. Major erosion of beaches
V	156+	19+	Winds greater than 155 miles per hour. Shrubs and trees blown down; considerable damage to roofs of buildings; all signs down. Very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings. Extensive shattering of glass in windows and doors. Some complete building failures. Small buildings overturned or blown away. Complete destruction of mobile homes. Storm surge possibly greater than 18 feet above normal. Major damage to lower floors of all structures less than 15 feet above sea level. Low-lying escape routes inland cut by rising water 3 to 5 hours before hurricane center arrives.

After the passing of a tornado, personnel should inspect their areas for damage. If a tornado strikes the facility, the plant's response team personnel should begin rescue, first aid, and damage control activities.

8.7.6. *Freeze/Winter Storm*

The procedure should describe the precautionary actions that are taken each fall to prepare for a potential freeze or winter storm. This should include identifying back up supplies and equipment, testing lines, updating telephone numbers for contractors, and identifying and correcting any piping systems that may be exposed to freezing temperatures.

The procedure can include a description of the three winter storm National Weather Service advisories which can be issued:

- Winter Storm Watch—Severe winter weather is possible.
- Winter Storm Warning—Severe winter weather is expected.
- Blizzard Warning—Severe winter weather with sustained winds of at least 35 mph is expected.

The freeze or winter storm procedure should identify contractor services for removing ice and snow from plant roads and parking lots (especially main routes), walkways, loading docks, etc. It should also contain a precaution about starting equipment that has been shut down during freezing temperatures.

8.7.7. *Flood*

The flood procedure recognizes that the facility may be in a flood plain or has a history or potential for floods or flash floods. The county may have available a study that indicates the level of flooding to be expected by the facility for a variety of floods. The procedure ties actions to be taken by the facility with messages being issued by the county emergency management organization and the National Weather Service.

The procedure identifies warning signs (heavy spring rains, heavy thunderstorms, and winter snow thaws) that will trigger precautionary activities prior to the declaration of a flood watch or flood warning by the National Weather Service. The procedure also identifies the limited actions that can be taken in the event of a flash flood.

Specific actions include identification of areas that need to be sand bagged; obtaining, filling, and stacking sand bags; movement of essential equipment and records to high levels or other buildings; verification of evacuation routes; and relocation areas for employees. Rail cars should be moved to safe locations and they should be filled, not empty. Storage tanks should also have sufficient material in them to prevent floating.

8.8. WRITING THE PLAN

Writing the plan should be a cooperative effort, even though one person will have to have responsibility for its completion. The plan should reflect how the facility will prepare for, respond to, and recover from an emergency. Planners should consider all of the potential emergencies contained in previous sections.

Determine specific goals and milestones. Make a list of tasks to be performed, by whom and when. If more than one person will write the plan, assign each member a specific section to write. Establish an aggressive timeline with specific goals providing enough time for completion of work, but not so much as to allow assignments to linger. Establish a schedule for:

- First draft.
- Review.
- Second draft.
- Tabletop exercise (to validate tasks and sequencing).
- Final draft.
- Printing.
- Distribution.

Table 8.3, presented earlier in this chapter, contains a detailed outline for different types of plans, and Appendix B to this chapter provides a sample procedure format.

The facility has other plans, procedures, resource lists, maps, notification lists, etc. that complement the plan. These documents can be attached as appendices, if they have not already been made a part of a procedure. Examples include the spill prevention, control and countermeasure plan; damage assessment checklist; and the oil spill response plan in accordance with the Oil Pollution Act of 1990. Some of these documents may best be left separate. When this is the case, the CEP can reference the related documents.

8.9. ENSURE INTEGRATION WITH OTHER PLANS

Ensuring that the facility plan integrates with other organizational plans is important. While this should have already occurred before the plan writing stage, planners should coordinate with other organizations to ensure effective emergency management and response collaboration between your facility and others. This coordination should exist with other corporate or regional facilities of your company, community emergency response organizations, and neighboring facilities.

When the plan is in its final draft status, the planner should share those applicable sections of it with outside response organizations. This will ensure that your assumptions about their capabilities are correct and they may be able to add other services or resources.

8.10. PLAN REVIEWS AND MAINTENANCE

Facilities should formally review the plan at least annually. The planner should request all departments who have responsibilities under the plan to review their sections and suggest changes based on events and changes in personnel and/or equipment over the previous year. Ask two or three individuals to conduct a cover-to-cover review of the CEP. Once recommendations for changes have been made, the planner can determine which recommendations will be incorporated.

After each drill, exercise, training session, or real emergency, suggestions and recommendations for changes to the plan should be evaluated. If possible, the planner should incorporate the change immediately. If it is a minor change that will not affect emergency response, the planner may decide to forego that change until the annual review.

As part of the critique of an actual emergency, involved personnel will document recommended changes including identifying the schedule and responsibility for the change.

Final plans can be distributed using one of two primary means:

- Every department and/or position receives a complete copy, or
- Every department and/or position receives only those sections that apply to them.

Either approach is acceptable provided a listing is maintained of who received what. Each copy of the plan should be numbered and signed for by the recipients. When changes are made, the changed pages should indicate the date and number of the change. The new pages should be signed for by the recipients.

8.11. EXERCISE REGULARLY/CRITIQUE TO VERIFY PLANNING ASSUMPTIONS

Drills and exercises are the most effective means for training personnel, testing equipment and ensuring the validity of the plan and procedures. Facilities should conduct drills and exercises on a regular basis using a wide variety of exercise types. It is a good idea to involve off-site personnel frequently. Five types of drills and exercises can be a part of the facility's exercise program. The five types of exercises are shown in Table 8.6 from table top to full-scale.

8.11.1. Planning an Exercise

Planning an exercise takes time and thought. A successful exercise is dependent on the planning that is done beforehand to clearly establish all of the elements of the exercise. The following elements should be considered and addressed when designing any drill or exercise:

TABLE 8.6
Exercise Types

Type	Description
Tabletop exercise	Is most effective in training personnel on responsibilities, use of facility's plan and procedures. The participants are seated in a conference room, or the EOC, and are presented with a scenario. They are asked to use the materials at hand to describe how they would respond to the scenario. All participants describe their activities permitting the sharing of ideas. This allows the participants to identify areas of overlapping responsibility or flaws in the program. This exercise is conducted in a nonthreatening manner and no emergency response equipment is used nor are people required to simulate response to an incident. This exercise takes between one and three hours depending upon the objectives, number of participants and number of scenarios.
Walk-through drill	This drill focuses on the learning of new procedures or use of equipment. The participants are not expected to perform perfectly or with complete knowledge of the procedure or equipment. They are asked to take their time in learning the new procedure or equipment.
Functional drill	A drill designed to test one or more components of an emergency response system without involving other elements. This is an effective drill for communication systems, warning systems, set-up of the EOC, medical, fire, or hazardous materials response. People are expected to perform correctly and in the appropriate time frames.
Evacuation drill	Can be considered a functional drill but if done for the entire facility it is in a category by itself. This is a very specific drill which is to be completed within a prescribed time frame. It may be combined with another type of exercise but has great value on its own.
Full-scale exercise	The most complete and complex exercise. All elements of the emergency management organization participate plus outside emergency response organizations and other company facilities. This exercise takes a lot of planning and coordination.

- Objectives.
- Type of Drill/Exercise.
- Assumptions.
- Scenario.
- Timetable.
- Expected Responses.
- Map of Locations.
- Communications Directory.
- List of Departments/Key Personnel.
- List of Evaluators.
- Evaluation Forms.

Organizing all the components of an exercise can be facilitated if the exercise designer uses an exercise notebook. The exercise notebook can include the information outlined in Table 8.7.

In most instances, the exercise designer/coordinator will possess the only complete exercise notebook. Evaluators and controllers should have their own notebooks containing many of the same items but geared toward their specific duties. The exercise notebook should become a part of the official record of the exercise and be used as a reference in developing future exercises.

A regular schedule of drills and exercises will ensure the effectiveness of the individuals and organizations who will be called on to respond to an emergency. By using a variety of drills and exercises, participants from all shifts are provided with a variety of activities and their participation is kept high.

The personnel required to successfully design, conduct, and evaluate a drill or exercise will vary depending on the size of the drill or exercise. For a full-scale exercise, the roles to be filled include exercise designer/coordinator, controllers, evaluators, participants, and observers.

A small committee may design the exercise. Each member may also serve as a controller and/or evaluator during the exercise. It is especially helpful if the evaluators from other departments, response organizations, or other companies can participate. They provide a fresh set of eyes to the exercise and will enrich the quality of the evaluation.

8.11.2. Exercising without Interfering with Plant Operations

Some people mistakenly believe that exercises interfere with plant operation and production. Conducting drills and exercises is possible with a minimal impact on plant operations. This can be done using tabletop exercises, walk-through drills, and functional drills (because of the limited number of people involved).

Evacuation drills can be at the change of shift requiring only those personnel coming off shift to report to the assembly areas, thereby avoiding production impacts.

Full-scale exercises may have an impact on production but this can be minimized by using additional personnel on an overtime basis to either participate in the drill or maintain production.

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2. Chemical Manufacturers Association (CMA). 1992. *Site Emergency Response Planning Guidebook*. Washington, DC.

TABLE 8.7
Exercise Information

Item	*Description*
Objectives	What does management want the exercise to accomplish? The number of objectives will vary, but list every one because the design, conduct and evaluation of the exercise are dependent upon the objectives.
Type	Identify the type of exercise - functional, tabletop, evacuation, full-scale. And the exercise scenario—hurricane, hazardous materials spill, train derailment, building collapse, strike.
Assumptions	Every exercise has assumptions, and they need to be clearly defined to the participants and evaluators. They may include: • A real emergency takes precedent over the exercise (Code "Real"). • Certain areas of the facility will not participate in the exercise. • All messages and radio communications will begin and end with "This is an exercise." • All communications outside of the facility will be simulated.
Scenario	A scenario includes the events, problems, and conditions that will drive the exercise. The scenario should be organized by time and department, clearly identifying which events/problems are the primary ones and which are secondary. The identification of both primary and secondary problems is essential in providing the controllers with limited discretion in including or omitting problems based upon the flow of the exercise, skills of the participants, and available time. The scenario should also contain extra problems that can be inserted during the course of the exercise if needed.
Timetable	The practical side of the exercise. Based on the amount of time available for the exercise and using the objectives and scenario, develop a chart indicating when the exercise will begin, times for scenario problem introductions, breaks, and the end of the exercise. During the course of the exercise, the original time schedule may accelerate or slip, but the timetable will help the controllers keep the exercise moving at a proper pace.
Expected responses	In a chart format, for every scenario event list the anticipated response(s). Among other benefits, this activity helps in developing scenario events by identifying which organizations need either more or less activities to meet objectives. The expected responses should be based upon the emergency management plan, procedures, checklists, equipment, facilities and training. The expected responses should be shared with the exercise evaluators so they have a clear understanding of what they should be observing and evaluating.
Map of locations	Where are events going to take place? What areas, or portions of those areas, will be physically impacted by the exercise? Place this information on maps so the exercise designer, controllers, evaluators and participants know the physical locations of the exercise.

Item	Description
Communications directory	Develop a communications directory with the telephone numbers and radio frequencies that will be used during the exercise. Ensure that all participants, controllers, and evaluators have this information and, if need be, instruct nonparticipants not to use those telephone numbers or radio frequencies for the duration of the exercise.
List of departments/ key personnel	Identify the departments that will be involved in the exercise and their degree of involvement. Then identify by title those individuals who should be participating.
List of evaluators	Identify the individuals who will be serving as evaluators and the locations from which they will operate.
Evaluation forms	Design forms that establish the standards all evaluators will follow. What actions/events should the evaluators pay special attention to during the exercise? How do they record their findings? What do they do with the forms after the exercise?
Other	The exercise designer should customize the exercise notebook to suit the needs of each specific exercise. Some of the items to add might be: • Specific departmental procedures. • Clean paper. • Sample press release. • Additional nonpublished telephone numbers:

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APPENDIX A. REGULATIONS APPLICABLE TO EMERGENCY EQUIPMENT AND SUPPLIES

Regulation	*Summary of Requirement*
29 CFR 1910.038 (a)(3)(i)	Has the employer established an employee alarm system that complies with 1910.165?
29 CFR 1910.038 (a)(3)(ii)	If the employee alarm system is used for alerting fire brigade members, or for other purposes, is a distinctive signal for each purpose used?
29 CFR 1910.038 (b)(2)(ii)	Does the fire prevention plan include the names or regular job titles of those personnel responsible for maintenance of equipment and systems installed to prevent or control ignitions or fires?
29 CFR 1910.120 (p)(8)(ii)(K)	Does the emergency response plan address personal protective equipment and emergency equipment?
29 CFR 1910.120 (p)(8)(iv)(E)	Is an employee alarm system installed in accordance with 29 CFR 1910.165 to notify employees of an emergency situation, stop work if necessary, lower background noise to speed communication, and begin emergency procedures?
29 CFR 1910.120 (q)(2)(xi)	Does the emergency response plan include personal protective equipment and emergency response equipment?
29 CFR 1910.120 (q)(10)	Do chemical protective clothing and equipment used by organized Hazmat team, or hazardous materials specialists, meet the requirements of paragraphs (g)(3) through (5)?
29 CFR 1910.120 (q)(11)(ii)	Is all equipment to be used in the performance of clean-up work in serviceable condition and inspected prior to its use?
29 CFR 1910.133 (a)(1)	If there is a reasonable probability of injury that can be prevented by protective eye and face equipment, is such equipment required?
29 CFR 1910.156 (d)	Does the employer maintain and inspect, at least annually, fire fighting equipment to ensure the safe operational condition of the equipment?
29 CFR 1910.156 (d)	Are portable fire extinguishers and respirators inspected at least monthly?
29 CFR 1910.156 (d)	Is fire fighting equipment that is damaged or in nonserviceable condition removed from service and replaced?
29 CFR 1910.156 (f)(1)(i)	Does the employer ensure that respiratory devices worn by fire brigade members meet the requirements contained in 1910.134, this paragraph, and 30 CFR Part 11?
29 CFR 1910.156 (f)(1)(ii)	Are approved SCBA provided and worn by fire brigade members while working inside building or confined spaces where toxic products or combustion or an oxygen deficiency may exist? Are these worn during an emergency situation involving a toxic substance?
29 CFR 1910.156 (f)(1)(iii)	Are approved SCBA equipped with either a buddy-breathing device or a quick disconnect valve?

29 CFR 1910.156 (f)(1)(v)	Do SCBA have a minimum service life of 30 minutes, with the exception of escape SCBA used only for the purpose of emergency escape?
29 CFR 1910.156 (f)(1)(vi)	Do SCBA have an automatic audible alarm which sounds when the remaining service life of the apparatus is reduced within a range of 20 to 25 percent of its rated time?
29 CFR 1910.157 (c)(1)	Does the employer provide portable fire extinguishers and mount, locate, and identify them so that they are readily accessible to employees without subjecting the employee to possible injury?
29 CFR 1910.157 (c)(2)	Are approved portable fire extinguishers used?
29 CFR 1910.157 (c)(4)	Does the employer ensure that portable fire extinguishers are maintained in a fully charged and operational condition and kept in their designated places except when in use?
29 CFR 1910.157 (d)(1)	Are portable fire extinguishers provided for employee use selected and distributed based on the classes of anticipated workplace fires and on the size and degree of hazards that would affect their use?
29 CFR 1910.157 (d)(2)	Are portable extinguishers for use by employees on Class A fires distributed so that the travel distance for employees to any extinguisher is 75 feet or less?
29 CFR 1910.157 (d)(3)	If standpipe systems are provided, do they meet the requirements of 1910.158 or 1910.159 to provide total coverage of the area?
29 CFR 1910.157 (d)(4)	Are portable extinguishers for use by employees on Class B fires distributed so that the travel distance from the Class B hazard area to any extinguisher is 50 feet or less?
29 CFR 1910.157 (d)(5)	Are portable fire extinguishers for Class C hazards distributed on the basis of the appropriate pattern for the existing Class A or Class B hazards?
29 CFR 1910.157 (d)(6)	Are portable extinguishers for use by employees on Class D fires distributed so that the travel distance from the Class D hazard area to any extinguisher is 75 feet or less?
29 CFR 1910.157 (d)(6)	Are there portable fire extinguishers for Class D hazards in those combustible metal working areas where combustible metal powders, flakes, shavings, or similarly sized products are generated at least once every two weeks?
29 CFR 1910.157 (e)(2)	Are portable extinguishers or hoses used in lieu thereof visually inspected monthly?
29 CFR 1910.157 (e)(3)	Are portable extinguishers subjected to an annual maintenance check and is that information recorded?
29 CFR 1910.157 (e)(4)	Are dry chemical extinguishers that require a 12-year hydrostatic test emptied and subjected to applicable maintenance procedures every 6 years?
29 CFR 1910.157 (e)(5)	Does the employer ensure that alternate equivalent protection when portable fire extinguishers are removed from service for maintenance and recharging?

29 CFR 1910.157 (f)	Are extinguishers hydrostatically tested at the intervals listed in Table L-1 of this section, and in accordance with the details of this section?
29 CFR 1910.160 (b)(17)	Does the employer provide and assure the use of the personal protective equipment needed for immediate rescue of employees trapped in hazardous atmospheres created by an agent discharge?
29 CFR 1910.165 (b)(1)	Does an employee alarm system provide warning for necessary emergency action as called for in the emergency action plan, or for reaction time for safe escape of employees from the workplace or the immediate work area, or both?
29 CFR 1910.165 (b)(2)	Can the alarm be perceived above ambient noise or light levels by all employees in the affected portions of the workplace?
29 CFR 1910.165 (b)(2)	Are there tactile devices to alert those employees who would not otherwise be able to recognize the audible or visual alarm?
29 CFR 1910.165 (b)(3)	Is the employee alarm distinctive and recognizable as a signal to evacuate the work area or to perform actions designated under the emergency action plan?
29 CFR 1910.165 (b)(4)	If a communication system services as the employee alarm system, do all emergency messages have priority over all nonemergency messages?
29 CFR 1910.165 (c)(1)	Are all devices, components, combinations of devices or systems constructed and installed to comply with this standard approved?
29 CFR 1910.165 (c)(2)	Are all employee alarm systems restored to normal operating condition as promptly as possible after each test or alarm?
29 CFR 1910.165 (d)(1)	Are all employee alarm systems maintained in operating condition except when under repair or maintenance?
29 CFR 1910.165 (d)(2)	Is a test of the reliability and adequacy of nonsupervised employee alarm systems made every two months?
29 CFR 1910.165 (d)(2)	Is a different actuation device used in each test of a multiactuation device system so that no individual device is used for two consecutive tests?
29 CFR 1910.165 (d)(3)	Are power supplies maintained or replaced to ensure fully operational condition?
29 CFR 1910.165 (d)(4)	Is alarm circuitry (which is capable of being supervised) supervised that it will provide positive notification to assigned personnel whenever a deficiency exists in the system?
29 CFR 1910.165 (d)(4)	Are all supervised employee alarm systems tested at least annually for reliability and adequacy?
29 CFR 1910.165 (d)(5)	Is the servicing, maintenance, and testing of employee alarms done by personnel knowledgeable in the design, operation, and functions necessary for reliable and safe operation of the system?
29 CFR 1910.165 (e)	Are manually operated actuation devices for use in conjunction with employee alarms unobstructed, conspicuous, and readily available?

2

PREVENTION AND MITIGATION

2.1. INTRODUCTION

While preparing for an emergency is essential, preventing the event or mitigating its effects so that it never reaches emergency proportions is more desirable. Most incidents that lead to an emergency are caused by deviations from normal conditions. If these causes and their potential consequences are identified in advance, several measures can be taken to minimize the likelihood of events causing an emergency or to reduce an incident's impact on the plant or its surroundings. Industry and regulatory authorities recognize and promote the need to plan for unforeseen circumstances that may lead to emergencies.

Risk management in process industries handling hazardous materials has tended toward using a multilayered approach for protective systems. Minimization of risk due to process incidents is achieved by the independence of the layers of protection employed and the unlikelihood of simultaneous failure of several such layers. A diagrammatic presentation of the multiprotective layer concept was published recently by Drake and Thurston [15]. An adaptation of this diagram is presented in Figure 2.1. The diagram shows the protective layer concept where initial reliance is on the process operation itself followed as needed by various layers of protective systems. These protective layers include engineered process shutdown systems, followed by both active and/or passive release controlling systems.

Should the inner layers of safety protection fail to prevent or sufficiently mitigate the incident's effects, both on-site and off-site, then emergency response protection layers may be necessary. It is important to note that multiple layers may be damaged or fail in a single event (e.g., an explosion can damage process controls, engineered shutdown systems, and release protection systems).

The preceding chapter identified the PSM elements and components of process safety management employed in chemical process design, operations, and maintenance for prevention of incidents involving hazardous materials. Successful risk management is a blend of sound organizational practices and the use of basic

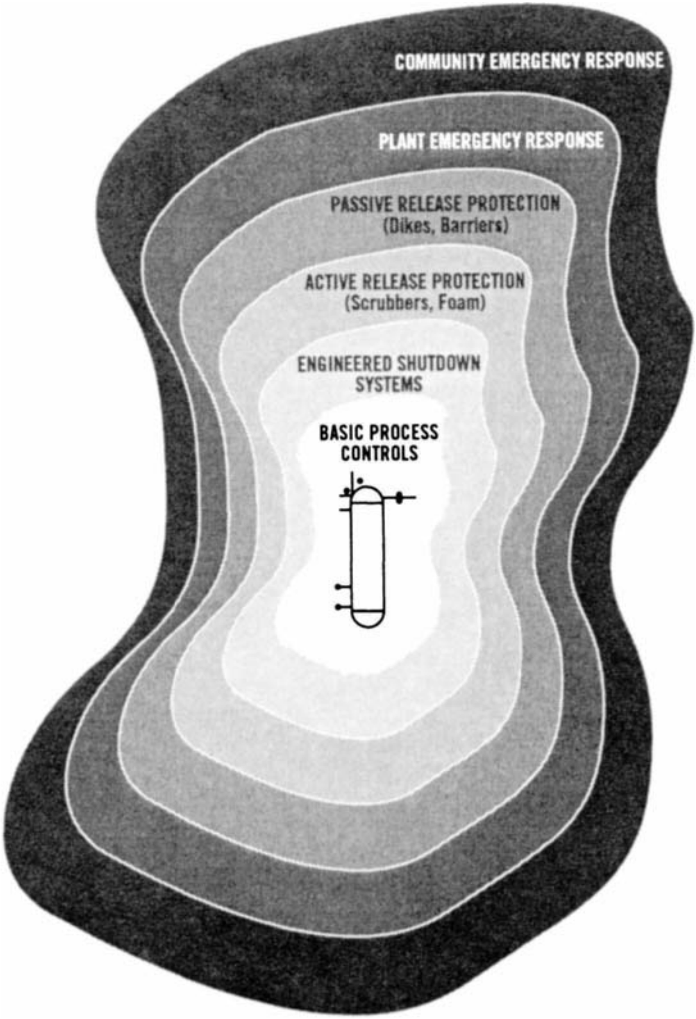


FIGURE 2.1. Typical layers of protection in a modern chemical plant. (Adapted from Drake and Thurston [15].)

safety-related technology. Sound organizational practices that prevent or mitigate incidents include documented operating procedures, operator training, preventative maintenance, management of change, and other human factor components. This chapter reviews some engineered plant and process design safety features that are used to prevent or mitigate hazardous material releases.

2.2. PRINCIPLES OF PREVENTION

2.2.1. Process Hazard Recognition

Preventing a hazardous release must start with recognition of the hazard, which has been defined as "a chemical or physical condition that has the potential for causing damage to people, property or the environment" [5]. Hazards can usually be identified by knowing the properties of the materials in question or knowing how they are used. In this book we are focusing on hazards in the use of chemicals in the process industries.

2.2.1.1. Identify Chemical and Physical Properties

Among the chemical and physical properties important to safety, we include such characteristics as toxicity, vapor pressure, flash point, autoignition temperature, flammable range, odor, corrosivity, solubility, and others. Toxicity must be understood in terms of acute versus chronic effects and the physiological results of possible alternate routes of exposure such as inhalation or absorption. The properties most important for emergency planning relate to fire, explosion, and acute toxicity. Planners must consider physical properties that affect mobility, volatility, fluidity, and vapor density. Other hazards such as corrosivity are also often considered in prevention as they may affect equipment integrity and personnel safety and health. Common information sources on these properties are Material Safety Data Sheets (MSDS) and commercially available references.

2.2.1.2. Identify Reactivity and Incompatibility Hazards

Less commonly recognized hazards are potential problems with chemicals involving their reactivity (i.e., self-reactive) or incompatibility with other substances. Self-reactive materials may include certain monomers that polymerize when not properly inhibited, thermally unstable materials like peroxides, and shock-sensitive materials. A search for potential chemical incompatibility hazards in a process system can be facilitated by use of an interaction matrix such as described in [6, pp. 45 and 242]. Chemicals incompatible with common materials such as water, oxygen, or iron can be extremely hazardous due to the availability of these reactants in the plant environment. Contaminating materials can sometimes act as catalysts for decomposition, such as copper in hydrogen peroxide solutions. Incompatible combinations of materials that are coprocessed or stored in close proximity may result in acid–base reactions releasing heat, toxic gases or mists; oxidizer/flammable reactions initiating fire and explosions; and many other reactions producing energy and possibly gaseous by-products. The sources noted in 2.2.1.1 should be supplemented by an examination of the *Guidelines for Chemical Reactivity Evaluation and Applications to Process Design* [7], *NFPA 491, Hazardous Chemical Reactions* [23], and others.

2.2.2. *Inherently Safer Plants*

A first step in risk management is to reduce or eliminate the hazard if possible. In his publication "Plant Design for Safety, A User-Friendly Approach," Trevor Kletz notes that "WHAT YOU DON'T HAVE CAN'T LEAK." Kletz presents many graphic and detailed examples that illustrate these concepts [20, 21]. Similarly, the second chapter of the *Guidelines for Engineering Design for Process Safety* [8] presents an excellent overview of the benefits and approaches to inherently safer plants. Usually one thinks of this approach for new plants; however, opportunities to improve inherent safety are also possible with existing plants. To achieve success, creative thinking and sound engineering judgment are needed to analyze and balance tradeoffs that may be introduced. Following are a few methods for developing inherently safer chemical processes and examples that typify their application.

2.2.2.1. Material Substitution and Attenuation

Hazard can be reduced simply through material substitution—using alternate chemical process routes that employ less hazardous materials, such as using sodium hypochlorite solution rather than pure gaseous chlorine for disinfection of water. Other substitutions might involve a change in the vehicle or carrier for a product such as using water-based paints or pesticide sprays versus using toxic and/or flammable carrier solvents. In plant auxiliary services, an example might be converting a process heating system from hot oil to steam resulting in a reduction in fire hazard. In most cases, the customer and the manufacturer will likely benefit from inherently safer products made by inherently safer processes.

Attenuation or dilution of a material can often be used to reduce hazards such as toxicity and high vapor pressure. Common examples include using aqueous solutions of hydrogen chloride or ammonia rather than the pure materials where possible.

2.2.2.2. Reduced In-Process Inventories

Enhancement of inherent safety is sometimes achieved by reducing quantities of intermediate hazardous materials in-process. A striking example of not reducing such inventories occurred in Bhopal, India, where a hazardous intermediate, methylisocyanate (MIC), was produced and put in protected storage for later use in herbicide production. Other plants have utilized closely coupled reaction steps where the product from one stage is fed directly into the next reaction stage, thereby eliminating the need to store a high hazard material like MIC. Eliminating large inventories of intermediates may introduce process inefficiencies since process interruptions can reduce final product output. It has often been necessary in such cases to improve the availability or on-stream time for the segments of the processes closely connected in this manner. As a result, in such cases safety and economy can be served.

2.2.2.3. Reduced Storage Capacities

Reduction of storage inventories of hazardous raw materials has become more common in the chemical process industry. Large inventories are often carried as a defensive measure to protect against the effects of a supply interruption, even when the risk of interruption is low. In such cases, inventory reduction can be very successful. Before proceeding, engineers should carefully examine the patterns of use and the reliability of supply to ensure that plant shutdowns due to raw materials shortages will not occur. This concept also applies to hazardous finished products.

In other cases, tank and container size have been reduced, thereby lowering the risk of huge leakage. For example, to reduce a potential leak's impact area, chlorine cylinders have been used in place of tank car quantities. While this reduces the magnitude and impact of a larger release, a trade-off is the likelihood of a higher frequency of small leaks and associated worker exposure due to the increased number of material transfers. Minimizing storage in such cases may require greater attention to training plant operating personnel and instituting system safeguards to prevent an increased risk to individuals who may still be affected in a smaller release.

2.2.3. Process Design Modifications

Process engineering has long involved scale-up of processes to achieve needed production capacity and product quality while ensuring safe and reliable plant operation. As part of their scale-up procedures, engineers normally determine in theory the effect of possible scale-up parameters on all these desired results. At this stage, several process options may be available that have different implications for efficiency, cost, environmental releases, and safety. Process design modification to enhance safety works best when starting with a new process because flexibility is greatest and the cost of a change is lowest; however, opportunities can often be found for modifying existing processes with attendant benefits such as reduced likelihood for releases or a reduced consequence. A more complete discussion of process design modifications can be found in the *Guidelines for Engineering Design for Process Safety* [8].

2.2.3.1. Continuous versus Batch Reactions

Chemical processes are generally more tightly controlled in continuous processes that operate under steady-state conditions within a narrow band of desired parameters (e.g., temperature, flows, pressures). Continuous processes generally require fewer operating steps for normal operations and involve lower material quantities in the reaction stage. These characteristics often make continuous processes inherently safer than batch processes, particularly for large capacity plants; however, continuous processes do not operate at steady-state conditions during startup and shutdown and are, therefore, more prone to accidents during these operational phases than during normal operations.

Continuous processes usually require high production rates and a high capital expenditure in specialized equipment; therefore, batch processes are quite common in the chemical process industry since a great variety of process conditions can be achieved while producing even small quantities of material in more general purpose equipment. Scaling up to continuous process operations is desirable, but not always practical or economically feasible, particularly for small capacity plants. Batch processes involve greater potential for human error largely because of the sequenced steps and varied process operations needed.

Many techniques, however, exist for enhancing batch process safety. For example, batch reactors can run more safely by gradually adding a limiting reactant to avoid accumulating unreacted materials. Additionally, operational methods that utilize heat balance or utilize tests on the properties of the batch itself can offer a higher degree of control assurance for batch operations. Batch reactors can be built in a robust manner with corrosion-resistant materials capable of withstanding elevated pressures that enhance their integrity. Some other common features that improve safety of batch reactor systems include agitation/feed interlocks, catch tanks for collecting emergency emissions, runaway reaction inhibitors, and high-cooling capacity for excess heat removal.

2.2.3.2. Pressure versus Vacuum Operation

The pressure of a process sometimes depends on required temperatures and reaction kinetics. Safety considerations often govern the selection of operating pressures. Some processes that utilize toxic gases are operated under partial vacuum conditions so that a loss of containment results in leakage into the process stream rather than into the atmosphere. This is true in many continuous chlorinated hydrocarbon manufacturing processes and also in water treatment using chlorine. Vacuum conditions are also commonly used in the process industry to reduce the temperature needed for distillation where decomposition and residue formation may be serious issues. In the case of flammable materials, on the other hand, positive pressure is generally maintained because air leakage into the process streams could result in potentially explosive conditions.

2.2.3.3. Gas versus Liquid

In some process applications, a choice exists whether a material can be introduced as a liquid or as a gas in the process. Where practical, plants should reduce the total inventory of materials in equipment by conveying or processing the materials in the gaseous state. The maximum release quantity will be effectively reduced in this portion of the system. This applies when selecting a site for liquefied gas vaporization equipment in a plant where the material is unloaded from rail cars and eventually fed to the process in gaseous form. Many plants have located the vaporization equipment near the unloading location and convey gaseous material to the points of use. This system reduces the inventory in the transfer line and the release rate, which is limited by the heat input to the vaporizer.

2.2.3.4. Control System Strategy

The CCPS addressed the role of process control systems in its *Guidelines for Safe Automation of Chemical Processes* [11]. Although not a substitute for inherent process safety, using well-designed control interlocks is a good way to prevent incidents. The Guideline advice includes separating safety interlock systems from the basic process control system (BPCS) and paying careful attention to the interface of the operator and control instrument systems. There are many choices to be made in controlling a chemical or petrochemical process, and the close coordination of process and control engineering specialists is essential to minimize introducing hidden hazards and to identify failure modes introduced by control system hardware and software.

2.2.3.5. Refrigeration

There is a special hazard associated with the leak of a superheated liquid (i.e., a material held above its normal atmospheric pressure boiling point) when storing and transferring liquefied gases. This type of liquid leak will rapidly atomize and become airborne if there is sufficient superheat, resulting in a possibly toxic and/or flammable cloud containing gas and aerosol material. Additional atomization may be caused by a pressure drop across the leak aperture in the vessel or pipeline of superheated liquid. Both vapor and aerosol production can be reduced by refrigerating the liquefied gas to near or below its normal boiling point. This technique has been practiced at some facilities with materials such as natural gas and ammonia. Further information on this technology is presented in *Guidelines for Postrelease Mitigation Technology in the Chemical Process Industry* [10].

2.3. PRINCIPLES OF MITIGATION

Mitigation in this book differs from prevention in that it focuses on dealing with the hazardous material after it is released from its primary containment. This section briefly outlines passive and active means to limit the amount released or to reduce the consequences of a release.

2.3.1. Plant Siting/Buffers

A passive means to mitigate the effect of a release is to establish maximum distances between the possible release point and sensitive zones. This technique is somewhat more effective for fire and explosion than for toxic releases because significant acute toxic effects can sometimes occur even at the low concentrations present at significant distances from the leak. Buffers of several hundred feet can be useful for fire hazards; for toxic hazards, thousands of feet may be needed. Barriers that enhance the effect of distance on toxic releases include trees, hills, or structures that can either trap or disperse airborne material. The role of models for estimating dispersion of toxic releases will be covered briefly in Chapters 3, 6, and 9 of this book. Further insight can be gained from the *Guidelines for Postrelease Mitigation Technology in the Chemical Process Industry* [10], *Guidelines for Chemical Process Quantitative Risk Analysis* [5], and other sources, including those from air pollution regulatory agencies.

The mitigating effect of risk buffer zones in plant siting will be influenced by the type of occupied area that may be impacted. For example, hospitals and tunnels are particularly vulnerable impact areas, while an adjoining industrial plant may be less vulnerable since the occupants should be prepared for emergency action when needed.

2.3.2. Unit Siting in Plant Design

Many published recommendations exist on unit layout within plant sites that help reduce the chances for propagation of a release, especially where a fire or explosion is involved. The *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires* [12] is especially helpful for development of building design as influenced by the risk of possible fire or explosion in the vicinity.

In general, chemical or petrochemical plants group storage systems away from process operations since storage systems, although experiencing low frequency of serious releases, have the potential for greater area impact accidents, while process systems might have more frequent releases but of generally more local area impact. Special site isolation is usually given to boiler houses, flares, other direct-fired systems, and electrical switch rooms, all of which can cause ignition of flammable releases. The overall layout of large plants is usually designed with multiple access routes for the approach of emergency teams and their equipment.

Among other references especially valuable on unit siting in plant design are those supplied by NFPA [18], IRI [19], API's RP 752 [24] and the earlier *Guidelines for Safe Storage and Handling of High Toxic Hazard Materials* [3] and on *Guidelines for Vapor Release Mitigation* [4].

2.3.3. Principles of Mitigating Chemical Releases

Accidental releases of hazardous materials usually have their root causes in some combination of human and mechanical failure. Process design principles for mitigating releases using countermeasures rest on (1) use of consensus safety codes representing industrial experience, (2) safety experience with the specific process in question, and (3) prospective hazard analysis studies such as those described in the *Guidelines for Hazard Evaluation Procedures* [6]. Learning about accidents from experience allows us to apply the lessons learned to eliminate causes or to reduce consequences. Modern hazard analysis attempts to anticipate situations or scenarios that can result in injury or damage before they actually occur.

2.3.3.1. Release Causes

The *Guidelines for Vapor Release Mitigation* [4] note four general categories to which most releases can be assigned. These include: (1) "open end" routes to the atmosphere; (2) imperfections in, or deterioration of, equipment integrity; (3) external impact; and (4) operating deviations from design conditions. Some examples are:

- Overfilling a vessel
- Leaving a drain valve open
- Pipeline rupture
- Failure of a vessel nozzle
- Overpressuring a process vessel due to loss of process control or external heating.

As noted above, the root causes of releases will usually be some combination of events, both human and mechanical, leading to the loss of containment.

2.3.3.2. Design to Mitigate Releases

Many methods exist to mitigate chemical releases, depending on the nature of the process and the environment in which it exists. A plan to mitigate releases might start with assurance of physical plant integrity, including careful attention to materials of construction, testing during construction and installation, management of change procedures, and sometimes the use of double-containment systems. Critical instrument controls usually have backup features in the event of failure to help assure process integrity. Another typical safety-related backup feature is the use of emergency relief valve systems that ensure physical plant integrity by preventing vessel or pipeline failure caused by overpressure. For nonreactive systems, API 520 [1] provides valuable information on relief systems. The AIChE's Design Institute for Emergency Relief Systems (DIERS) gives attention to the proper design of relief systems [13] for special circumstances such as reactive systems or systems involving two-phase flow. Relief systems may include relief discharge treating systems such as catch tanks, quench tanks, flares, or stacks, as mentioned under the section on postrelease Mitigation below.

2.3.4. Postrelease Mitigation Systems

The purpose of a postrelease mitigation system is to reduce the impact area and the ultimate consequences of an uncontrolled release of a hazardous material. Such systems can be either passive (i.e., requiring no operational action) or active (requiring some mechanical or human action). The releases may be vapor or gas, liquid (with or without significant vaporization), or aerosols (i.e., mists of fine liquid droplets). Releases of chemicals reactive with common environmental materials such as water or air are a special case. Chemicals reactive with water often result in the evolution of gases, whereas chemicals reactive with oxygen (i.e., pyrophoric chemicals) often give off flame and combustion products. Another special case might be protection provided for the release of projectiles from a system that includes the risk of explosion such as blast curtains surrounding an oxygen–hydrocarbon mixing system. Postrelease mitigation systems are in the last layer of protection before emergency response. The *Guidelines for Vapor Release Mitigation* and *Guidelines for Postrelease Mitigation Technology in the Chemical Process Industry* [4, 10] offer considerable insight into the variety of mitigation techniques that have been used by industry (depending on the material) and on the state-of-the-art for several of the techniques. Some examples of postrelease mitigation technology follow.

Several ideas for preventing the spread of contamination after a release are discussed in Chapter 14, Section 14.3 on Cleanup of Facilities.

2.3.4.1. Secondary Containment for Storage, Handling, and Fire Situations

Secondary containment techniques such as berming and diking have long been used for above-ground combustible and flammable liquid storage tanks. Such contained areas are usually graded or sloped to keep a liquid spill away from the storage vessel in case the material ignites. For volatile toxic materials, the contained area may be designed to minimize exposed surfaces and thus limit airborne

PHOTO 1. Storage Tank with Containment Dike.

evaporation. A good practice is to provide berming and containment for transport filling or unloading areas where connections must be made and broken frequently. The principles of spill separation and of exposed area minimization similarly apply in these cases. Berming and containment areas are examples of passive mitigation.

Diked containment areas have sometimes been installed to retain fire water runoff from such areas as process areas or warehouses storing hazardous materials. The desirability of adequate design of this type of retention was exemplified as a result of the 1986 warehouse fire in Switzerland that contaminated the Rhine River. A good summary of this incident was written by H. H. Fawcett [17]. In the absence of runoff control to a sensitive area, responders may at times consider allowing the material to burn to extinction.

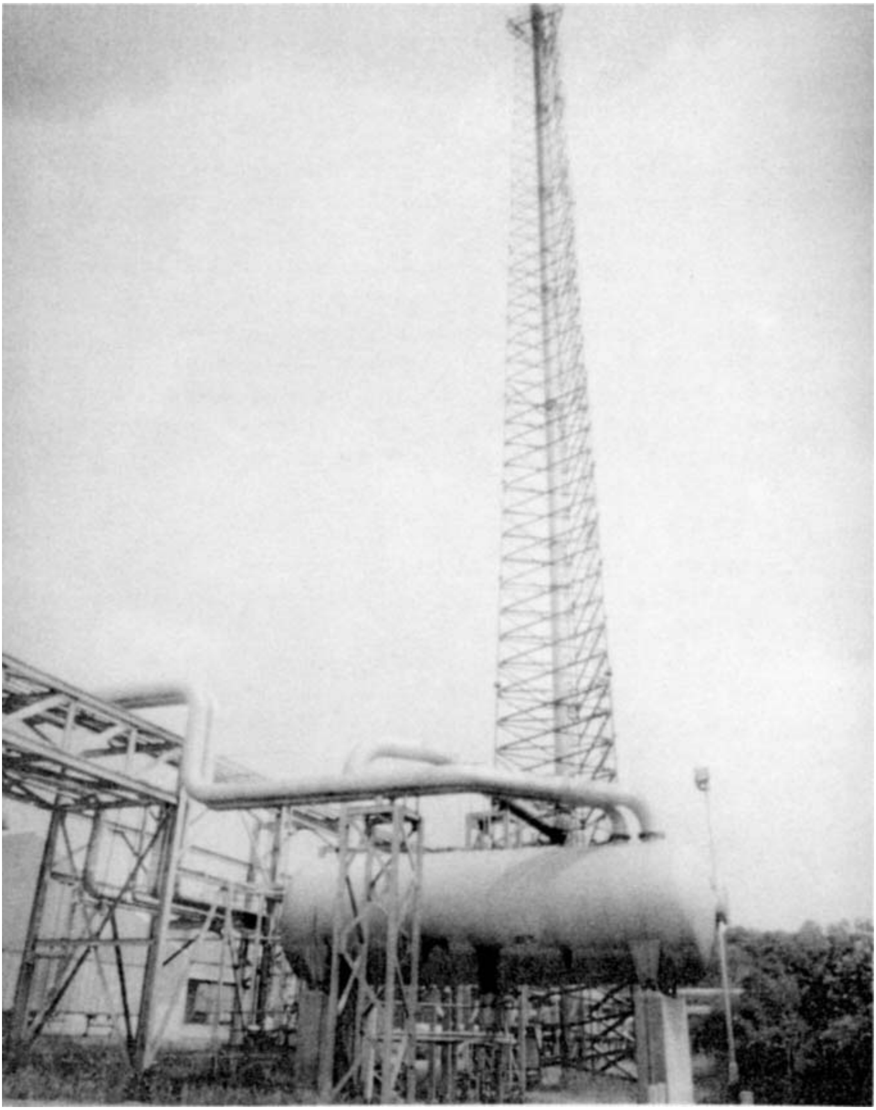
Secondary containment has also sometimes been used in the form of a structural enclosure where volatile acute toxics are handled. Such enclosures can be monitored by detectors, and any exhaust air may be scrubbed, dispersed (e.g., steam dispersion), or incinerated to mitigate releases.

2.3.4.2. Remote Shutoff, Flow Limitation, Transfer

Remote shutoff systems are widely used in the event of a pipe break in a transfer system. A notable example is a remotely operated valve on the unloading dip pipe of a vessel unloaded by pressure (e.g., chlorine tank car under dry air). Simple flow-limiting devices such as orifices and excess flow valves are often included in piping transfer systems to reduce the maximum release rate of spill from a damaged line. Sometimes an alternative empty storage vessel is installed for a hazardous liquid in the event of a leak in the original vessel so that the liquid can be safely transferred to minimize release from the damaged vessel. A variation of this concept is a dump tank system (sometimes also referred to as a deinventory system). An example is the hydrofluoric acid (HF) storage tank and HF settler in the Phillips™ alkylation process. The storage tank directly under the settler is nearly empty and can be used to rapidly receive the HF from the settler in the event of a release in the settler or associated piping [10].

2.3.4.3. Absorbents/Foam and Other Covers

Evaporation of vapors from spilled liquid pools may be significantly reduced by the appropriate application of absorbents, foam, or other suitable covers. Foams or other covers must be selected considering the reactivity of the spilled material. Foams have been used in some installations as the preferred mitigation measure for fire situations where management of water runoff can be a serious problem (e.g., a hazardous material warehouse). A table showing a variety of cover choices made in industry for 22 hazardous materials is presented in *Guidelines for Vapor Release Mitigation* [4]. Most of the mitigating techniques mentioned in this section are of the active type requiring a signal to be initiated.



2.3.4.4. Catch Tanks, Scrubbers, Flares, Stacks

Dealing with discharges from relief devices designed to prevent vessel overpressure is sometimes necessary. Typically, catch tanks or knockout pots are used as passive controls to trap liquids, while scrubbers and flares are used as active controls to destroy vapor emission. Sometimes the catch tanks can also serve as a condenser or passive scrubber for an emergency relief system. Stacks are commonly used to dilute residual vapor emissions. Any of these systems must be carefully designed for the particular process, taking into account quantities and rates of release involved, process conditions, critical physical/chemical properties, and the area to be protected from the emission [10]. Such postrelease mitigation systems include both active and passive types.

2.3.4.5. Water Sprays and Steam Curtains

Water sprays are sometimes installed to absorb highly water-soluble toxics such as ammonia or hydrogen chloride. Steam curtains find an application in the dilution of heavier-than-air flammables by both thermal and kinetic effects. Obviously these systems are active and require considerable detailed design study. The state-of-the-art in using these techniques in postrelease mitigation is also reviewed by CCPS in Chapters 4 and 5 of [10].

2.3.4.6. Detectors

Detectors for identifying and measuring the presence of flammable and certain toxic materials have been used in industry and are now widely available. Their value in activating postrelease mitigation treating systems or alerting emergency response teams is also noted in Chapter 6 of this book. A review of various detectors, their applicability and sensitivity to 22 types of materials is presented in *Guidelines for Vapor Release Mitigation* [4, Chapter 5], whereas *Guidelines for Postrelease Mitigation Technology* [10] provides much valuable detail on design principles of the various units. Detectors and their sampling systems are active systems that have become increasingly valuable for early warning of chemical releases to accelerate the application of mitigation and emergency response measures; however, these systems require carefully planned maintenance to be effective and may be subject to local environmental conditions (e.g., winds, snow), depending on their location.

2.3.5. Principles of Mitigating Fires and Explosions

Fire and explosion protection has long been a feature of plant and process design for chemical or petrochemical facilities to minimize injuries, loss of property, or business loss. Moreover, according to insurance reports, the severity of the largest such incidents has tended to increase over time. One reason is the trend toward construction of larger plants. Other suggested reasons include more remote operation and more plant congestion. Furthermore, in addition to the fire and explosion injuries and the property damage suffered from high temperature and overpressure, environmental concerns have arisen with regard to liquid and vapor discharges.

This discussion will only briefly touch on the principles of mitigating fires and explosions in view of the wide literature on the topic. Recent applicable CCPS

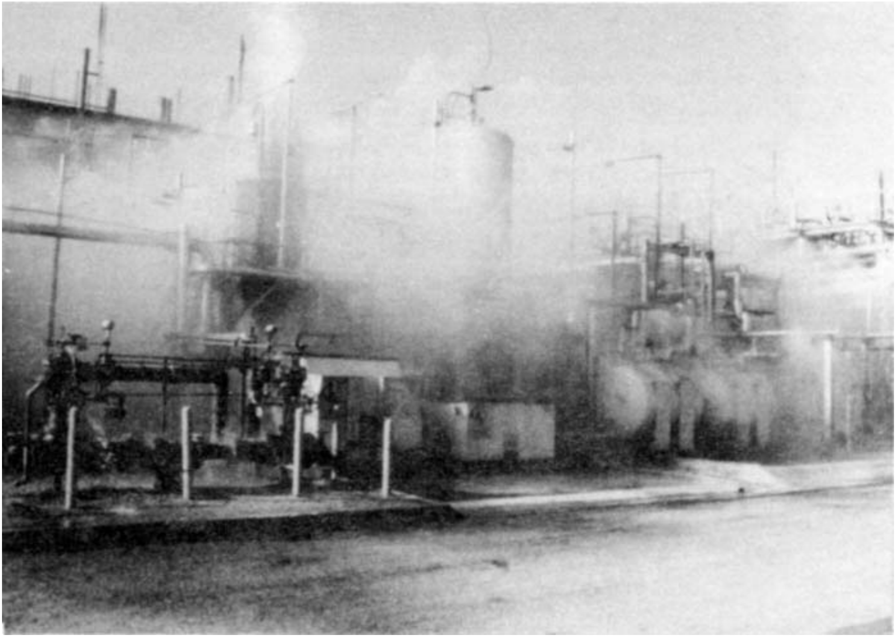


PHOTO 3. Polyethylene Plant Gas Dispersion Sprinkler System—At Start.

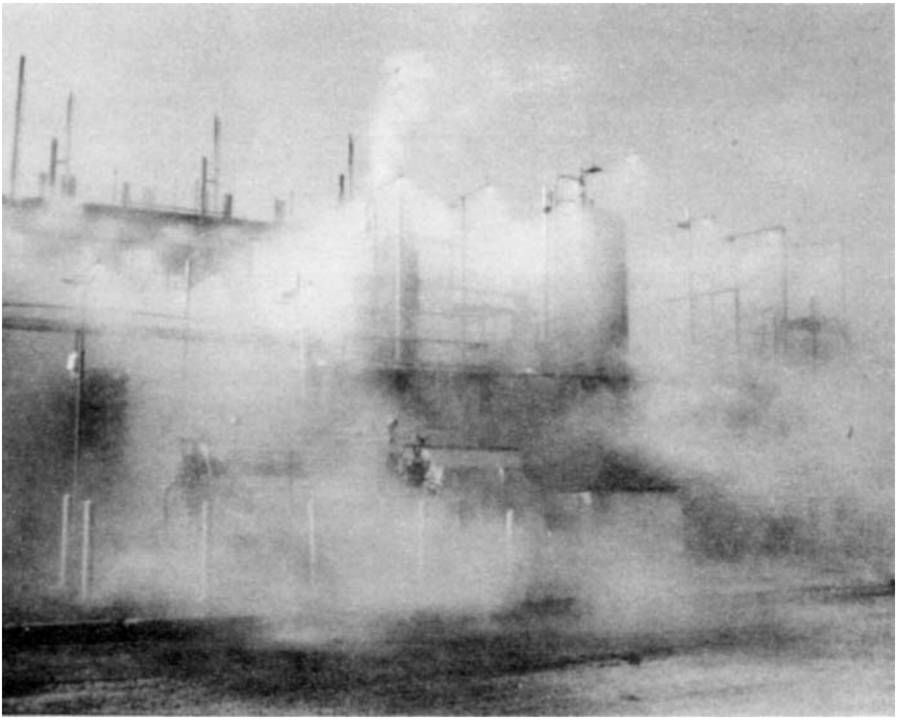


PHOTO 4. Polyethylene Plant Gas Dispersion Sprinkler System—Fully Developed.

publications include the *Guidelines for Engineering Design for Process Safety* [8], the *Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs* [9], and the *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires* [12]. Many National Fire Protection Association standards, insurance guides, and municipal codes may apply. A particularly valuable industry reference is Dow Chemical Company's Fire and Explosion Index now in its seventh edition via AIChE publication [14]. One of the best general references on loss prevention is that by Frank Lees [22]. Several other special references are also listed at the end of this chapter.

2.3.5.1. Fire and Explosion Causes

The basic cause for a fire or explosion is the simultaneous presence of a fuel, an ignition source, and an oxidant (usually oxygen from air) forming the well-known fire triangle. Since chemical and petrochemical processes frequently deal with flammable materials, ignition sources are widespread, and air is our common environment, it takes the utmost care to guard against fire and explosion in process operations. Eliminating at least one of the elements of the fire tetrahedron is necessary and, where appropriate, eliminating two elements would be preferable.

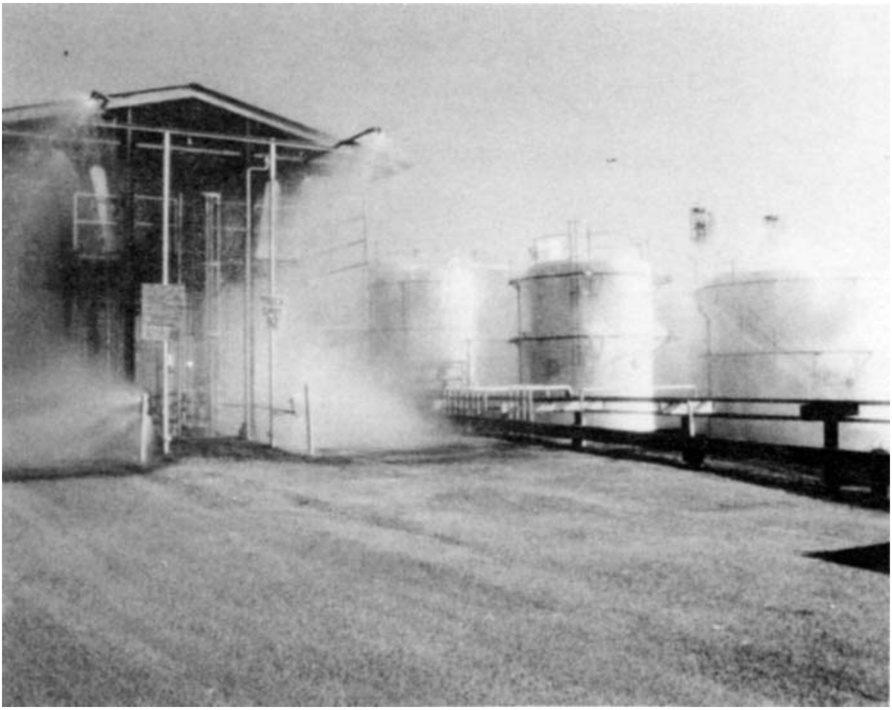


PHOTO 5. Truck Loading Rack for Flammable Liquid with Sprinkler System Activated.

A special fire case can be the result of a BLEVE or boiling liquid expanding vapor explosion. Such an explosion can occur from the sudden loss of containment of any superheated liquid. Where the superheated liquid is flammable and an ignition source is present, a highly dangerous elevated fire ball can result.

Explosions can occur either in confined vessels or in the open air. Confinement in a vessel can result in damage due to flying equipment projectiles as well as an overpressure blast wave. Open air explosions can be minor, such as in a flash fire, or major where there is sufficient fuel and mixing of air. The violence of a nominally unconfined explosion has been shown to be enhanced by structures within the fuel–air vapor cloud. The *Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs* [9] provides an update on explosion technology and includes some of the best recent research.

The complex type and location impacts resulting from a simple release of a flammable material are shown on the incident event tree in Figure 2.2. The position of ignition sources and local weather conditions are important variables for this event tree. The possible outcomes of this event tree are fire or explosion at the source of release, fire or explosion remote from the release, or safe dispersion. A specific evaluation for a given site can help provide input, not only on risk estimating, but also on the potential benefits of possible countermeasures and emergency response.

2.3.5.2 Design to Mitigate Fires and Explosions

First of all, every effort should be made to prevent flammable mixtures in the workplace. Equally important is the elimination of ignition sources by such

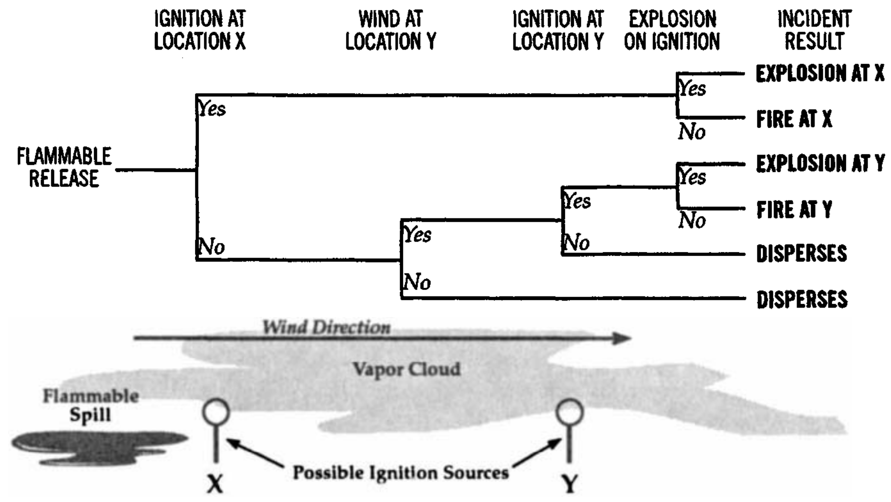


FIGURE 2.2. Event tree for possible outcomes of a flammable release.

measures as the use of area-classified electrical systems, control of hot work in the area, control of static electric buildup by proper bonding and grounding, and control of process flow velocity, the use of flame arresters on vents, and by installation of suitable lightning protection.

Elimination of oxygen within process or storage vessels containing material above its closed cup flash point is often achieved by padding or purging (blanketing) with an inert gas such as nitrogen. Controlled mixtures of low oxygen and nitrogen can also be used where the material needs oxygen for stability (e.g., some monomers) since most hydrocarbons require 8–12% oxygen for combustion. In this case oxygen gas analyzers are commonly used. A useful reference on this subject is to be found in NFPA 69.

Eliminating the fuel for most processes is essentially impossible, but it is helpful to handle a flammable material below its flash point if air can be present and certainly below its autoignition temperature in the presence of air. In some cases it may be possible to dilute with enough air to get below the lower flammable limit (LFL) to prevent ignition.

The controls of releases of fuel to the atmosphere are similar to the controls previously mentioned for chemical releases. Installing tanks either underground or earth covered above ground for highly flammable materials requires special protection to eliminate possible environmental impact due to any leakage. The alternative of locating tanks of highly flammable material above ground necessitates careful review of provisions for fire and explosion protection. Features for such protection include fire-resistant insulation, special venting, inerting, floating roof and weak seam roof/tank hold-down systems where internal explosion is possible.

Some other special precautions for processing flammables include minimizing confinement due to equipment structures where accidental emission and ignition of a heavy gas can occur. A less complicated equipment arrangement has sometimes been an effective countermeasure. Factors influencing gas mixture explosions are covered with extensive examples in *Guidelines for Evaluating the Characteristics of Vapor Cloud Explosions, Flash Fires, and BLEVEs* [9].

The use of countermeasures for possible dust explosions in process equipment or storage bins is another important consideration. Where inerting is not practical and control of ignition sources is not assured, explosion suppression systems are sometimes used. Among the expert studies on dust explosion are those by Bartknecht [2].

Methods to deal with the risk of occupied plant buildings on a site containing flammables are discussed in the *Guidelines for Evaluating Process Plant Buildings for External Explosions and Fires* [12]. Various levels of risk are developed as a function of siting, building design, and overpressure from possible vapor cloud explosions. The methodology, in fact, might be applied to selection processes for any of the foregoing mitigation or prevention features where standards and codes may not be entirely applicable and high process hazards exist.

Some special cases of countermeasures where explosions are possible are the use of bunkers for storing peroxides or the use of three walled barrier systems for high pressure equipment. In both cases, the enclosures are intended to knock down flying projectiles and/or relieve explosion overpressure into a safe path.

The general needs and techniques for emergency fire suppression and for fighting fires with fixed or portable systems will be discussed in Chapters 5 and 6 in this book.

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GUIDELINES FOR

TECHNICAL PLANNING FOR ON-SITE EMERGENCIES

CENTER FOR CHEMICAL PROCESS SAFETY
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS
345 East 47th Street • New York, New York 10017

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Library of Congress Cataloging-in Publication Data
Guidelines for technical planning for on-site emergencies.
p. cm.
Includes bibliographical references and index.
ISBN 0-8169-0653-X : $130.00
1. Chemical industry—Accidents. I. American Institute of Chemical Engineers. Center for Chemical Process Safety.
TP149.G855 1995
660'.2804—dc20 94-46234
CIP

This book is available at a special discount when ordered in bulk quantities. For information, contact the Center for Chemical Process Safety of the American Institute of Chemical Engineers at the address shown above.

It is sincerely hoped that the information presented in this document will lead to an even more impressive safety record for the entire industry; however, the American Institute of Chemical Engineers, its consultants, CCPS subcommittee members, their employers, their employers' officers and directors, and Roy F. Weston, Inc. disclaim making or giving any warranties or representations, expressed or implied, including with respect to fitness, intended purpose, use or merchantability and/or correctness or accuracy of the content of the information presented in this document. As between (1) the American Institute of Chemical Engineers, its consultants, CCPS subcommittee members, their employers, their employers' officers and directors, and Roy F. Weston, Inc. and (2) the user of this document, the user accepts any legal liability or responsibility whatsoever for the consequence of its use or misuse.

PREFACE

The Center for Chemical Process Safety (CCPS) was established in 1985 by the American Institute of Chemical Engineers (AIChE) for the express purpose of assisting industry in avoiding or mitigating catastrophic chemical accidents. To achieve this goal, CCPS has focused its work on four areas:

- Establishing and publishing the latest scientific, engineering, and management practices for prevention and mitigation of incidents involving toxic, flammable, and/or reactive material.
- Encouraging the use of such information by dissemination through publications, seminars, symposia, and continuing education programs for engineers.
- Advancing the state-of-the-art in engineering practices and technical management through research in prevention and mitigation of catastrophic events.
- Developing and encouraging the use of undergraduate engineering curricula that will improve the safety knowledge, and consciousness of engineers.

The current book, *Guidelines for Technical Planning for On-Site Emergencies*, is the result of a project begun in 1992 in which a group of volunteer professionals representing major chemical and hydrocarbon processing companies worked with professionals from Roy F. Weston, Inc., to develop this document. The intent was to produce a book that covers the technical knowledge needed for proper planning and effective response to on-site emergencies. The book was to provide information on topics (primarily technical in nature) not specifically covered by existing documents on emergency planning and to integrate this information into basic emergency planning procedures.

Although this Guideline volume was written to stand alone, it draws on other CCPS publications where emergency planning interfaces with the topics of these publications and upon other sources that discuss emergency planning. This book contains not only direct references, but a substantial list of other reading resources that will expand on the content of each chapter.

The book does not provide detailed emergency plans. It does provide information necessary for selecting the most credible incidents, thereby establishing the basis for the emergency plan. The text then aids in applying this information, along with information on other aspects of emergency planning, to develop an integrated plan for on-site emergencies.

The guideline is directed at plant personnel involved in developing and managing emergency response plans, staffing and supplying the emergency response organization, designing and selecting equipment, and training response personnel. This text should also be useful to off-site emergency planning organizations working with industrial facilities.

The book has been organized into the four phases of emergency planning:

- Prevention
- Preparedness
- Response
- Recovery

Although other CCPS Guidelines focus on the prevention aspects, emergency planners must always be on the lookout for situations, uncovered in their planning activities, where additional preventative measures may be warranted. Thus, the book briefly discusses the prevention aspects, while concentrating on the other three elements.

The book focuses on on-site emergency planning. It does not deal with responsibilities and activities of outside officials (whether local, state, or national) or with response to transportation accidents outside a plant.

ACKNOWLEDGMENTS

The American Institute of Chemical Engineers (AIChE) wishes to thank the Center for Chemical Process Safety (CCPS) and those involved in its operation, including its many sponsors whose funding made this project possible. Thanks are due to the members of its Technical Steering Committee who conceived the idea and supported this project, and to the members of the Subcommittee on Technical Planning for On-Site Emergencies for their dedicated efforts, technical contributions, and enthusiasm. Thanks are also due to the CCPS Vapor Cloud Subcommittee who assisted with the material presented in Chapter 9 on vapor release modeling used in emergency planning.

The members of this subcommittee especially wish to thank their employers for providing the time to participate in this project and those sponsors and Technical Steering Committee members who reviewed and critiqued this book prior to publication.

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We also express our appreciation to Thomas W. Carmody, former Director of CCPS; Bob G. Perry, AIChE Managing Director, Technical Activities; and Jack Weaver, former Project Manager for Weston and now Director of CCPS, for their support and guidance.

ACRONYMS

ACGIH	American Conference of Governmental and Industrial Hygienists
AFFF	Aqueous Film-Forming Foam
AIChE	American Institute of Chemical Engineers
AIHA	American Industrial Hygiene Association
API	American Petroleum Institute
ASTDR	Toxic Disease Registry
ASTM	American Society for Testing and Materials
BLEVEs	Boiling Liquid Expanding Vapor Explosions
BPCS	Basic Process Control System
CAER	Community Awareness and Emergency Response
CCPS	Center for Chemical Process Safety
CEI	Chemical Exposure Index
CEP	Comprehensive Emergency Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Acts
CHEMTREC	Chemical Transportation Emergency Center (operated by CMA)
CHRIS	Chemical Hazard Response Information System
CIMA	Channel Industries Material Aid
CMA	Chemical Manufacturers Association
CO_2	Carbon Dioxide
CP	Command Post
CPC	Chemical Protective Clothing
CRZ	Contamination Reduction Zone

DAP	Detailed Action Plan
DIERS	Design Institute for Emergency Relief Systems
DOT	Department of Transportation's
EBS	Emergency Broadcast System
EHS	Extremely Hazardous Substance
EMS	Emergency Medical Service
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPSS	Emergency Power Supply Systems
ER	Emergency Room
ERPG	Emergency Response Planning Guidelines
ERT	Emergency Response Team
ETA	Event Tree Analysis
FEMA	Federal Emergency Management Agency
F&EI	Fire and Explosion Index
FD	Fire Department
FMEA	Failure Modes and Effects Analysis
FTA	Fault Tree Analysis
Hazmat	Hazardous Material
HAZOP	Hazard and Operability
HF	Hydrofluoric Acid
HIV	Human Immunodeficiency Virus
HMIS	Hazardous Material Identification System
HVAC	Heating, Ventilation and Air Conditioning
IC	Incident Commander
ICP	Incident Command Post
ICS	Incident Command System
IDLH	Immediately Dangerous to Life and Health
IRI	Industrial Risk Insurors
LAN	Local Area Network
LEPC	Local Emergency Planning Committee
LFL	Lower Flammable Limit
LOP	Level of Protection
medevac	Medical Evacuation

MIC	Media Information Center
MIC	Methylisocyanate
MSDS	Material Safety Data Sheets
NFPA	National Fire Prevention Association
NRC	National Response Center
NRC	Nuclear Regulatory Commission
ORC	Organization Resource Counselors
OSHA	Occupational Safety and Health Administration
P&IDs	Piping and Instrumentation Diagrams
PBX	Private Branch Exchanges
PCBs	Polychlorinated Biphenyls
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
PSM	Process Safety Management
RCRA	Resource Conservation and Recovery Act
RMP	Risk Management Program
RMP	Risk Management Planning
RP	Recommended Practice
RQ	Reportable Quantity
RRI	Risk Ranking Index
SARA	Superfund Amendments and Reauthorization Act
SARs	Supplied-air respirators
SCBA	Self-Contained Breathing Apparatus
SHI	Substance Hazard Index
TSP	Trisodium Phosphate
UFL	Upper Flammable Limit
UPS	Uninterruptible Power Source
UVCEs	Unconfined Vapor Cloud Explosions
WAN	Wide Area Network
WIA	What-If Analysis