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BP Process Safety Series

Control of Work

A collection of booklets describing hazards and how to manage them

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This booklet is intended as a safety supplement to operator training courses, operating manuals, and operating procedures. It is provided to help the reader better understand the 'why' of safe operating practices and procedures in our plants. Important engineering design features are included. However, technical advances and other changes made after its publication, while generally not affecting principles, could affect some suggestions made herein. The reader is encouraged to examine such advances and changes when selecting and implementing practices and procedures at his/her facility.

While the information in this booklet is intended to increase the store-house of knowledge in safe operations, it is important for the reader to recognize that this material is generic in nature, that it is not unit specific, and, accordingly, that its contents may not be subject to literal application. Instead, as noted above, it is supplemental information for use in already established training programmes; and it should not be treated as a substitute for otherwise applicable operator training courses, operating manuals or operating procedures. The advice in this booklet is a matter of opinion only and should not be construed as a representation or statement of any kind as to the effect of following such advice and no responsibility for the use of it can be assumed by BP.

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Queries and suggestions regarding the technical content of this booklet should be addressed to Frédéric Gil, BP, Chertsey Road, Sunbury on Thames, TW16 7LN, UK. E-mail: gilf@bp.com

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1 Introduction

1.1 Introduction

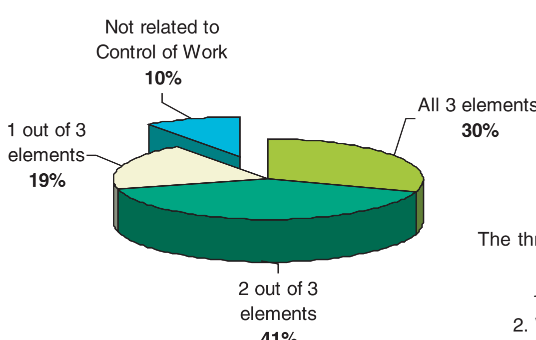
In large facilities where multiple tasks are performed simultaneously, the management of work is essential to ensure that these tasks are accomplished safely. Poor control of work has resulted in many accidents and fatalities over the years.

According to a study performed by a major oil company, factors relating to Control of Work have had direct influences on many of their fatal accidents. In fact, Control of Work factors are the primary causes of fatality after fatalities related to vehicles and driving. A consistent methodology was used to investigate the root causes of the fatal accidents, which includes three factors that relate directly to Control of Work.

The study reviewed fatal industrial accidents over a five-year period and found that all three factors were highlighted in 30% of the accident investigations. At least two out of three were present in 71%, while at least one of the three was a contributory factor in 90% of the accidents.

Since only 10% of the fatal industrial accidents are found to have no association with the Control of Work, it becomes apparent that a good Control of Work system is essential to prevent incidents.

Percentage of fatal industrial accidents relating to Control of Work



The three factors relating to Control of Work

1. Planning of work
2. Work rules, policies, standards or procedures
3. Management, supervision, or leadership

A robust Control of Work process could have helped in preventing the following incidents.

INCIDENT **Inadequate control of work results in fatality!!!**

An explosion occurred in a sulphuric acid storage tank when a spark from hot work being performed in the vicinity ignited the flammable vapour in the tank. The tank exploded with the roof and shell separating from its floor, instantaneously releasing its entire content of sulphuric acid. Other tanks in the common bund were affected by the fire and also released their contents. The acid spill reached the nearby river resulting in significant damage to aquatic life.

Contractors were repairing the grating on the catwalk at the time of the incident. They were issued a hot work permit although it was known that there were holes in the roofs of the nearby tanks. Instead of adhering to the 'absolute spark control' requirement stated on the hot work permit, the contractors changed from oxy-acetylene cutting to air carbon arc gouging, which threw large amounts of molten metal over a wide area. A spark apparently came into contact with the flammable atmosphere within the tank through the holes causing the explosion, which killed one and injured eight others.

(*continued*)

There was inadequate control of the Hot Work Permit System that allowed cutting and welding close to tanks containing flammable atmospheres without extensive safeguards, such as continuous flammable gas monitoring and providing flameproof barriers/blankets to contain sparks. Further, no action had been taken when the hot work permit was denied on two previous occasions for the repair work. The presence of holes in the roofs of the tanks should have been recognized as a significant hazard and effectively communicated to the contractors so that those performing the work could understand the situation better and prevented actions that compromised their safety.

The company pleaded no contest to criminally negligent homicide for failure to maintain the spent sulphuric acid storage tank which exploded, killing one employee.

Aside from the compensation fines to be paid to the victims totalling nearly $37 million, the company was fined a further $10 million for discharging pollutants into the nearby river, and negligently releasing sulphuric acid into the air.

Acid spill into the nearby river

INCIDENT **Disaster on Piper Alpha!!!**

On 6 July 1988, an explosion occurred on the Piper Alpha offshore platform. It set off a chain of fires and explosions, one of which blew down a firewall containing the process facility. As a result, large quantities of stored oil burned out of control. The fire spread to the gas risers causing them to fail catastrophically. The resulting release of fuel from the risers increased the size of the fire into a towering inferno. Flames reached a height of 300 to 400 feet (91–121 m) and the heat could be felt over a mile (1.6 km) away.

The surviving platform crew congregated in the accommodation area, which was farthest from the blaze and seemed the least dangerous. They waited for helicopters to rescue them there, but the helicopters could not land because of the fire. Smoke began to seep into the accommodation area because it was not smoke-proof and a lack of training and awareness meant that crew members kept opening and shutting doors, allowing more smoke to enter. Soon it became apparent to some crew members that to survive, they had to leave the accommodation area and escape by lifeboat. However, they found that all routes to lifeboats were blocked by smoke and flames. Through lack of any other instructions, they jumped into the sea, hoping to be rescued by boat. Sixty-one men survived by jumping. Most of the 167 who died had waited in vain in the accommodation area and were overcome by carbon monoxide and smoke.

Investigations found that the immediate cause of the accident was failure of the Work Permit system to control maintenance and inspection work on the platform, although it was noted that audit findings never showed a sign that the permit system was not working well. A Work Permit had been issued to allow for the maintenance of a condensate standby pump on a hydrocarbon liquids line. The pump's discharge pressure relief valve, located out of sight of the pump, was removed for inspection at the platform workshop, to be reinstalled at a later date.

When the maintenance work was complete for the day, the maintenance supervisor returned the Work Permit to the control room. As the process supervisors and operators were in deep discussion, he left the Work Permit on the desk without any verbal or written handover. This resulted in vital information being overlooked and the next shift commencing without knowing the true conditions of the standby condensate pump. This pump was subsequently started without the pressure relief valve in place and within seconds, large quantities of condensate and gas escaped from the blanked flange fitted to the pipe from where the relief valve had been removed. This release started the whole chain of catastrophic events.

For more details on these two and other major incidents, refer to BP Process Safety Series *Integrity Management: Lessons from Past Major Industrial Incidents*.

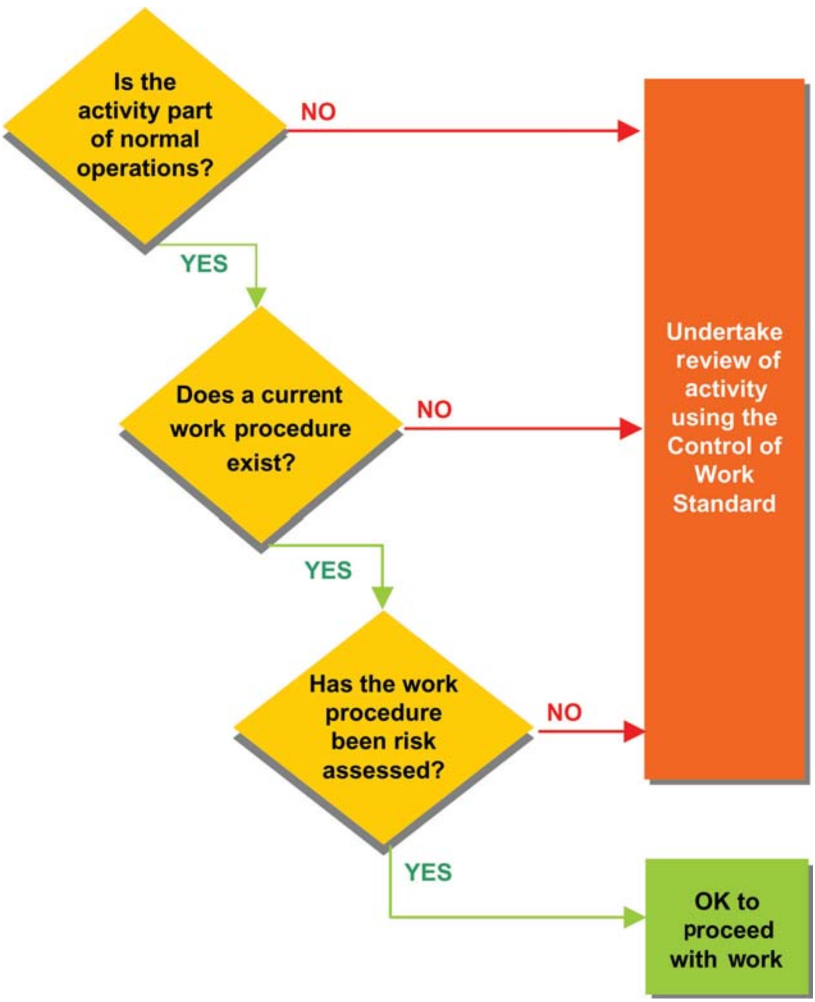
1.2 Control of Work Standard

The Control of Work (CoW) Standard is a formal approach to manage work risk. It is a procedural form of control, consisting of the following 12 elements.

CONTROL OF WORK STANDARD
1. A **written procedure** shall exist describing the CoW process.
2. All identified roles within the CoW procedure shall have defined **accountabilities**.
3. All persons involved in the CoW process shall be appropriately **trained and competent** to carry out their roles.
4. **Planning and scheduling** of work shall identify individual tasks and their interaction.
5. Tasks shall not be conducted without being **risk assessed**.
6. Before conducting work that involves confined space entry, work on energy systems, ground disturbance, hot work or other hazardous activities, a **permit** shall be obtained.
7. The scope, hazards, controls and mitigations shall be **communicated** in writing and signed off by all involved in the task.
8. All ongoing work requiring a permit shall be regularly **monitored and managed** by a responsible person.
9. The work site shall be left in a safe condition on **completion or interruption** of the work.
10. The CoW process shall be subject to a program of regular **auditing**.
11. Internal and external **lessons learned** that impact the CoW process shall be captured, incorporated, and shared.
12. The CoW procedure shall make it clear to everyone that they have **the obligation and authority to stop unsafe work**.

This Standard, developed by BP, covers the means of safely controlling activities such as construction, maintenance, demolition, re-mediation and others. Its purpose is to reduce the risk to which workers in the oil and chemical industry are exposed. It also serves to decrease the potential for harm to third parties. However, the Control of Work Standard does not apply to activities for which adequately risk-assessed operating procedures exist for normal operation of plant and equipment.

It is strongly recommended that this Standard, or a similar form of control be adopted. The 12 elements of the Control of Work Standard are further elaborated in the next chapter.



2

Control of Work process

2.1 Written procedures for Control of Work

There must be a written procedure for the Control of Work process. The document should contain instructions on actions that need to be taken from the moment of inception of work to its completion, with the goal of accomplishing the work successfully and safely.

The Control of Work procedure must be written in a clear, concise, and easy to understand format. If necessary, long and detailed procedures should be broken into small sections or modules.

The advantages of having a written procedure is that it avoids confusion and employees can easily refer directly to the document for confirmation.

When no written procedure exists, it is common for different people to have different ideas of the sequence or correct steps to be taken. For example, there might be different opinions of what is hot work or what constitutes a confined space if no written definitions are available. (Refer to Section 2.6: Permit to Work for the definitions.)

It can also be a checklist for persons involved with managing work and can be shared easily, as opposed to disseminating information verbally. A written procedure is also easy to audit and to check for inadequacies. Any shortfall can be corrected in a systematic and organized manner.

The Control of Work procedures must be provided to employees and kept in readily accessible locations for easy reference. It must be issued in accordance with a Document Control Management System. Any changes or developments need to be subjected to a strict document control procedure before authorization and adoption. This means having trained and competent people to examine the proposed changes and to document the reasons behind the change.

A written procedure describing the Control of Work process must be readily available to all employees involved.
It should be reviewed as often as necessary to reflect current practice and conditions. Any changes to the written procedure must be subject to a strict document control procedure.

INCIDENT Written procedures are important!!!

A contractor crew were removing bolts from the bonnet of a 14-inch (350 mm) isolation ball valve when the valve stem, gear actuator, and hand wheel were ejected from the valve's body into the air. An external gas leak occurred at 840 psi (58 bar). One worker strained his Achilles tendon while trying to escape, but this incident could easily have resulted in fatalities or a vapour cloud explosion.

The Permit to Work Standard required a work procedure, but this was not written. There were also no detailed instruction manuals from the manufacturer detailing the correct procedures for dismantling the valve.

Before

After

INCIDENT Safety clearance in non-native language leaves workers clueless!!!

Two contractor employees were working on high voltage equipment in an electrical substation. They believed it was safe to work on, although they could not read English and were thus not able to check whether a safety clearance had been issued. The contractor employees were in the habit of relying on verbal acknowledgement that equipment was safe to work on, but their contractor supervisor had been replaced by a less experienced person. As a result, they inadvertently short-circuited part of the live system with a spanner and were injured by the flash that followed. They received first and second degree burns.

Prepare procedures with the target audience in mind. Make sure that they are available in the common (or dual) language and written so that there can be no misinterpretation.

2.2 Roles and accountability

All roles and responsibilities required to operate the Control of Work process must be identified. Examples of these roles are gas tester, permit issuing authority, permit receiver, firewatch, etc. These designated persons need to be made aware of and clear about their responsibilities. They also need to demonstrate that their accountabilities are understood and accepted. These responsibilities and accountabilities should be documented as part of the Control of Work written procedures.

Persons with identified roles should be checked for competency before authorized for the role, and documents proving competency need to be kept for control and auditing purposes. The level of authority for approval to proceed with work must match the level of risk involved. There should be a 'single point accountable' person for the management of the Control of Work process.

> **Someone who is deemed as accountable is completely responsible for what they do and must be able to give a satisfactory reason for it.**

All identified roles within the Control of Work procedure must have clearly defined accountabilities.

INCIDENT Fire and fatalities at crude unit!!!

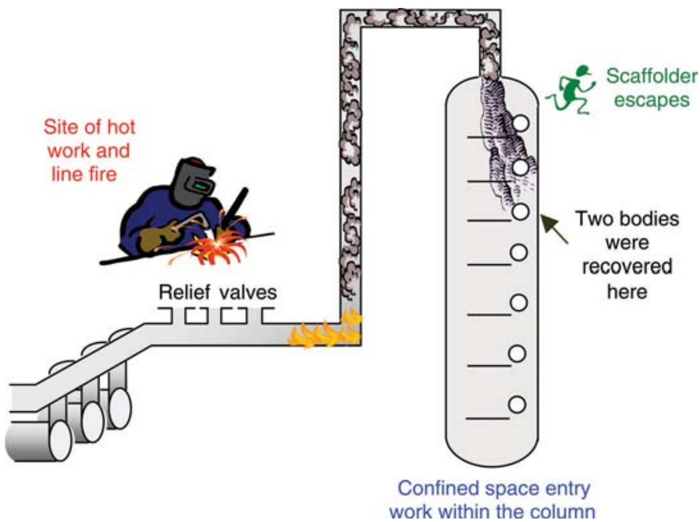
As part of a major overhaul, the Crude Oil Distillation Unit was shutdown and made ready for maintenance work. A hot work permit had been issued for the sections of the unit which had been isolated and were considered to be essentially hydrocarbon free.

A coordination meeting was held on the day before the incident. The intent to carry out four hot work jobs was verbally agreed. However, on the next day, an application for authorization for an additional hot work for repairs on the overhead line of the main fractionating tower was made. Although a hot work permit had been issued for the section of the unit, the work permit system required a separate authorization for each individual job before work could proceed. This authorization was routinely delegated during the turnaround period by the responsible operator to safety agents, who were safety specialists or suitably trained firemen. As such, a safety agent approved the application for hot work on the overhead line after gas test results indicated that no flammable atmosphere was present.

(*continued*)

The maintenance contractor employees began work on the overhead line of the main fractionating tower, cutting out a coupon from a relief valve branch. At the same time, smoke and some flames were seen at the top of the tower.

Inside the tower, a scaffolding contractor working on Tray 1 made a speedy exit because of the incoming smoke, but two operators did not escape. Rescue operations were hindered by the large amount of smoke coming out of the upper manway doors. When the smoke from the manways ceased, the two bodies were recovered from Tray 12.



Responsibility for authorizing hot work had been delegated to a safety agent who apparently had no overview of the work in progress or the hazards involved in this particular job. It was not recognized that hot work at a remote location on a line that had not been positively isolated from a vessel could present a risk to those working within the vessel. Further, although gas tests confirmed that the line was gas-free, there was no guarantee that the lines were clean of deposits or flammable liquids below their flash points, and no extra precautionary measures were taken to ensure that this did not represent a hazard to work.

Those who give final authorization for hot work should be sufficiently trained and suitably aware to competently assess all the hazards and risks. This requires full knowledge of the work in progress within the area concerned. It is therefore preferable that the responsible operator should be directly involved in the issue of every authorization, although it is recognized that this individual may be pressed for time in a major turnaround situation.

The level of authority for approval to proceed with work must match the level of risk involved.

Who are contractors?

A contractor is one who agrees to provide work or supplies. Contractor employees are those who work on a site, but are not directly employed by the owner. Contractors are used to perform work such as construction or modification of process facilities, turnaround work, specialty work, and operation of a facility.

Contractors are responsible for their employees. They need to ensure that their employees are trained to perform their jobs safely and are aware of the process unit hazards and the applicable parts of the emergency response plan. Their training and understanding needs to be documented. It is also the contractor's duty to advise the owners of the installation of any hazards presented by the contractor's work, or any hazards found during work. The contractor must ensure that any subcontractors are also fulfilling their responsibilities regarding safe work.

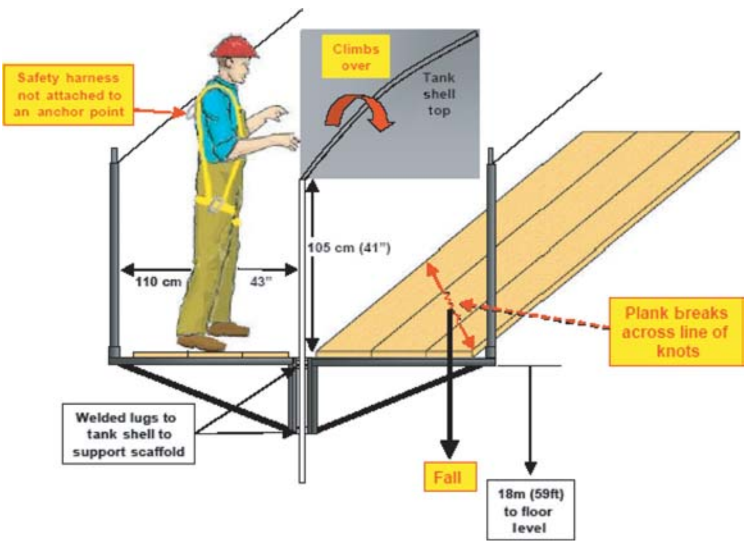
Although it is often the attitude to assume that contractors are fully responsible for their employees and actions, this is not the case from a legal standpoint. The owner of the installation or organization requesting the work is vicariously liable, or ultimately responsible, for all activities conducted on its site or on its behalf at a remote location. As such, it is the owner's responsibility to ensure that contractors are selected based on important factors such as safety performance and safety programmes. Contractors should be informed of the process unit hazards for dissemination to their employees and be evaluated periodically on their safety performance. A contractor employee injury and illness log should also be maintained.

It is the owner's responsibility to ultimately oversee the work of the contractor and their subcontractors! This is also in the owner's best interests as any serious incident may have a negative impact on production and on assests.

INCIDENT Inadequate contractor supervision!!!

A contractor scaffolder was re-assembling portions of the inner platform/walkway at the top of the tank which had been temporarily removed to allow the lifting of the cone roof structure. This involved climbing over the top of the tank shell, approximately 1.05 m (41-inches) high. While climbing over the tank shell, the scaffolder landed heavily onto the wooden platform on the other side, snapping a plank. He fell 18 m (59 ft) to the ground and died.

It was found that the plank on which he landed had a defect (a line of knots across the plank), which weakened it. Although he wore a safety harness, it was not attached to an anchor point.



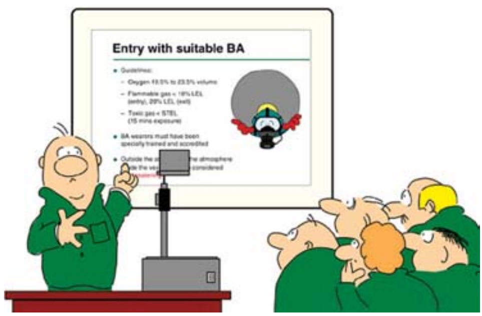
The work permit had been issued without reviewing the method for scaffold erection and no visit to the worksite had been made prior to the commencement of work. Had these been performed, they would have identified the need to provide secure anchor points and adequate access over the high wall, and inspection of all scaffold components would have identified components that were damaged or had defects. It is possible that the permit issuing authority was relying on the contractors to ensure that their workers perform their jobs safely, but the reality is that the owner of the site is ultimately responsible for unsafe acts undertaken by any person working on its behalf on its site.

2.3 Training and competency

Training is defined as 'the effective communication of knowledge and skills in order to develop competency'.
The purpose of training is to equip individuals with the understanding, knowledge and skills necessary to fulfil their responsibilities.

There are three types of training:

- initial;
- refresher—given periodically to maintain proficiency and sometimes to meet regulatory requirements;
- remedial—given to employees whose level of knowledge, skills, or proficiency are below that expected.



All persons involved in the Control of Work process must be appropriately trained and competent to carry out their roles.

All roles identified must have a defined level of competency. Training, including refresher training, should be given to ensure that the roles and responsibilities within the Control of Work process are fully understood, and the competency matches the level defined for the role. Competence levels should be regularly checked, and training and competency records kept and updated. This is to ensure that the Control of Work process is correctly applied.

What constitutes competency?

Competency = Training + Testing (Competence Check) + Experience

An individual is only competent when the person is able to perform the task in the correct manner, with the correct understanding and reasoning behind the task.

Training alone does not denote competency! To be competent, an individual must first be trained, then have their performance of the task and understanding behind it checked through tests, with the results documented. Experience obviously helps a person become more competent but this must be verified through regular tests. Competency must be maintained through retraining, retests, and update of certificates. A quick check of an individual's certification is a common indication of competency.

Training of contract employees is primarily the responsibility of the contractor. However, owners need to ensure that the appropriate training has been identified and received, and that contractor employees are competent for the task being undertaken. Site specific induction is also necessary to describe the hazards and procedures specific to the site.

INCIDENT **Workers unaware of the hazards of pressure!!!**

Three workers were preparing to open and remove polymer from a polymer catch tank. All three employees began removing the bolts on the 5-foot (1.5 m) cover plate of the tank. After half the bolts had been removed, the internal pressure within the catch tank caused an explosion which ripped off the cover plate, striking and fatally injuring the three workers. Another explosion occurred six minutes later and a fire ensued.

The three employees were unaware of the possible hazards of accumulated pressure when they began unbolting the cover plate. There were no maintenance procedures for this task and employees at the site were unaware of potential problems involving the catch tank. Sufficient resources need to be dedicated to training, with the requirements well-documented and periodic competency assessments performed.

The cover plate blew off this polymer catch tank, killing three workers

INCIDENT **Performing hot work while standing on drum!!!**

A welder was installing a security gate at the entrance of a service station. Without proper scaffolding, he stood on an empty 210-litre (55 US gallon) metal drum to reach the top of the new gatepost, approximately 2 m (6.6 ft) above ground level. While he was performing arc welding, the drum exploded. The welder was thrown into the air, approximately 1 m (3.3 ft) above the top level of the drum, before landing next to the drum. He was rushed to hospital, but died the same evening.

(*continued*)

The empty drum, which originally stored flammable materials, contained a flammable atmosphere. There were fumes in the drum that were heavier than air, some of which had escaped out of the inlet hole of the overturned drum. When the welding operation began, sparks from the welding ignited the flammable vapour. The flame travelled into the drum, igniting the vapour inside, causing the explosion.

A reconstruction of the scene as it was before the explosion. The welding assistant, the drum, and the welding machine in position. Circle denotes welding position

Bulging of the bottom of the drum after the explosion

It was found that the welder lacked knowledge of the hazards present. He was unaware of the hazards of (i) working on a drum in an elevated position, (ii) the possibility of fumes in the drum, and (iii) the possibility of igniting the fumes with welding sparks. It is important to ensure that the workforce has the necessary skills and training to competently perform their tasks in a safe manner. Further, he should not have been allowed to work in that dangerous manner.

2.4 Planning the work

Always take time out to properly plan an activity. The planning and scheduling of work should take into account the individual tasks and their interaction with other ongoing activities.

Plan and think through the work in advance, involving the relevant people such as a subject matter expert. Good planning will reduce the chances of things going wrong during work. Some of the considerations when planning work are:

- status of the unit/process/equipment to be worked on;
- hazards involved;
- competencies required to undertake the work safely;
- isolation measures required;
- other activities being or to be conducted within the vicinity (simultaneous operations—SIMOPS);
- suitability of work tools to electrical area classification;
- Personal Protective Equipment (PPE), if required;
- sufficient time to complete work safely;
- permit requirements.

When scheduling the work, remember to take into account the time and resource requirements for risk assessment, preparation of worksite, and permitting. Simultaneous operations need to be identified and assessed for compatibility.

The most frequently overlooked issues during work planning involve the need for written procedures, risk assessments, and effectiveness of isolation.

The type of work permit required is established at the planning stage. For particularly hazardous activities, such as confined space entry or hot tapping into a live line, it is useful to pause a moment to ask the following question:

Can the hazardous task be performed in an alternative, less hazardous way? If so, examine the advantages and disadvantages before deciding to proceed with the work.
Do not neglect to perform risk assessments on any new or modified tasks.

ACCIDENT **Demolition accident!!!**

Contractors were demolishing the brick fire insulation around the skirting of a redundant visbreaker column when the brickwork collapsed. One contractor sustained six fractured ribs and a bruised leg while another escaped with minor injuries.

The demolition work was initially started using a hammer and chisel at the bottom of the column. The removal of the bricks using only a hammer and chisel proved very difficult, and the decision was made to switch to a percussion drill. As more and more bricks were removed, the structure became unsafe and collapsed.

It seems obvious that removing bricks from the bottom of the column would unbalance the structure. More attention to planning would have recognized and addressed this. There was no formal plan or written procedure to remove the bricks and no risk assessment had been performed.

INCIDENT **Fatality at service station!!!**

A fire occurred at a service station that was undergoing major renovations. The renovations included extensive work on three underground storage tanks. Work activities on the day of the event included:

- cleaning and purging of gasoline lines;
- fitting and welding on the tanks;
- open-flame repairs to tank insulation cladding.

Re-enactment of the incident

Five workers were working in the excavated pit at the start of a line purging operation (as seen in the photograph above). A plastic bucket of less than 20 litres (5 gallons) capacity was used to collect the pig and gasoline from the pipe. Unknown to them, there was approximately 29 litres (8 gallons) of gasoline in the pipe being purged. The container, being too small to accommodate the contents of the pipe, overflowed and resulted in a gasoline spill. The fuel was ignited by the hot work in the pit, causing serious burns to one worker (who later died), significant burns to another, and minor burns to the remaining three.

The causes of the incident were:

- performing simultaneous and incompatible work activities in a high-risk work area;
- use of a too-small, open bucket to collect hydrocarbons resulting in emission of flammable vapour and liquid under pressure;
- inadequate site supervision which allowed pipe purging and hot work simultaneously in the same area.

Staggering of the work activities would have avoided this incident. Better PPE (fire protective clothing) could have mitigated the consequences and may have prevented the fatality.

2.5 Risk assessment of work

Do you really understand risk?

Risk is the possibility of loss, injury, damage, or being exposed to a danger. It is a combination of both severity of the consequence and likelihood that the event will occur.

Every activity has some risks associated with it. Can you judge for yourself if an activity is riskier than another, or do you rely on public perception?

Some of the situations we perceive as dangerous and risky are sometimes just that, perceptions. Subconsciously or from experience, we realize that eating fish is more risky so we take measures to carefully remove the bones before eating or only selecting fish that have large, visible bones. We are in 'control' and we exercise suitable precautions. Most people would not take steps to avoid being hit by a satellite no matter how scary or risky it sounds!

Do you still believe that working in a process plant is more risky than crossing the road?

What is a risk assessment?

Risk assessment is the process of identifying hazards, estimating the level of risk involved, and evaluating whether the hazards are adequately controlled. There are many methods and tools available for this purpose. Some, for example Quantitative Risk Assessments (QRAs), calculate risk based on deaths per year. While others, such as Hazard and Operability (HAZOP) Studies and Job Safety Analyses (JSAs), mainly identify problems and dangers using standard qualitative analysis methodologies. The choice of risk assessment tool to use depends on suitability of the tool, the results required, the level of risks involved, time and resources available, amongst others.

There is a need to select the right technique for hazard analysis. Avoid common pitfalls by selecting the right team and using a trained and experienced leader. To read more, refer to the IChemE training package *Practical Risk Assessment* available through the website www.icheme.org.

Why bother?

Work activities in process plants can become dangerous if they are not properly managed. It is important to take steps to identify the hazards and take preventative measures to control the risks. The protection measures put in place are directly related to risk assessments, whether performed consciously or not, formally or informally. The need to protect the health and safety of workers and prevent property damage is a strong incentive to perform risk assessments.

Note: Risk assessments must also be carefully carried out when a change is to be implemented. Incidents have often occurred where all impacts of 'small' changes were not fully assessed and understood. Refer to BP Process Safety Booklet *Engineering for Safe Operations* for more details on Management of Change, QRA, and HAZOP.

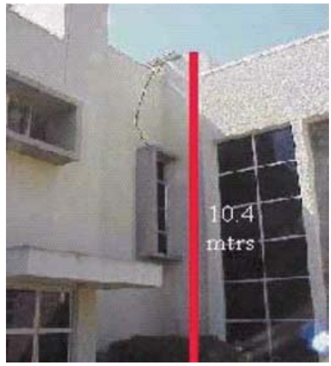
INCIDENT **Dump truck maintenance fatality!!!**

A driver was repairing the pneumatic brake system on a dump truck. To do this, he raised the bed of the truck then switched off the engine. It was held up only by the pressure in the hydraulic lines. No mechanical brake or block was placed to stop the bed from descending.

One or more air leaks in the vehicle's pneumatic system led to a depressurization of the pneumatic system. This affected the hydraulic lines causing the bed to drop suddenly. The driver who had been working under the bed was crushed to death. No job safety assessment had been undertaken prior to work to identify the hazards. There was inadequate energy isolation, with no protective barriers in place to act as a buffer between the driver and the potential energy created by the raised bed.

INCIDENT **Fatal fall from rooftop due to lack of risk assessment!!!**

An electrical subcontractor was installing a new telephone cable on the roof of the main building. Whilst manoeuvring the cable near the edge of the building, he fell 10 m (33 ft) from the roof to the ground.



No risk assessment process had been applied to identify inherent risks and to prevent or mitigate foreseeable hazards. A simple risk assessment would have identified the need for scaffolding, guide rails or a safety harness. There was also inadequate planning of the task. All non-procedural activities should be covered by a formally signed risk assessment prior to commencement of the work.

Tasks must not be conducted without being properly risk assessed.

Make sure that a risk assessment is conducted to ensure that work can be performed in a safe manner. The risk assessment should be able to handle the various levels of complexity, depending on:

- hazards involved;
- likelihood of these hazards being realized;
- extent of the controls and mitigation measures needed.

It is important that the hazard identification be performed adequately. Hazard identification issues are often at the root cause of many incidents.

INCIDENT **Hazards of electrical line not identified!!!**

Two labourers were erecting a 'goal post' around a 10 kV line. They raised it to the vertical position under the electrical line, presumably to check that it was long enough for its purpose. The pole touched the live line above and they both suffered electric shocks, burns, and subsequent respiratory/ cardiac arrest. One labourer was revived but the other was pronounced dead at the scene.

They did not understand the dangers of electrocution on contact with the live line above or consider the likelihood that the pole would touch the line while they were raising it.

INCIDENT **Fatigue leads to lapse in concentration!!!**

A maintenance engineer was performing an engine component change. This was a simple operation which he had completed many times before. Having fitted the component, he had to stop because he could no longer focus on the correct rigging procedures. He had worked too many hours without a break and his concentration had lapsed to the point where he could not conduct this simple task.

Assess and manage the risks presented by extended hours of work.

INCIDENT **Hazards of deep trench not identified!!!**

This 9-foot (2.7 m) deep trench collapsed, completely burying one worker and partially burying another. The buried worker was killed.

The potential hazards of this excavation had not been identified, allowing workers to enter the trench without protective measures such as shoring of trench walls.

INCIDENT **Hazards caused by tarpaulin not identified!!!**

One employee was killed and another was injured when they crawled under a tarpaulin draped over an open flange to conduct stress checks.

Nitrogen coming out of the flange created an oxygen deficient atmosphere under the tarpaulin, which asphyxiated them. The hazards of a temporary confined space created by the tarpaulin had not been identified.

INCIDENT Injury while performing unfamiliar task!!!

Two technicians and one forklift truck driver were dismantling two car wash gantries. They attempted to do this by dismantling the gantries and positioning them horizontally, to be moved using two straps to secure the gantry to the forklift. The straps, going through the driver's cab, had somehow caused the forklift driver to step on the accelerator. The forklift reversed suddenly, with the load catching one of the technicians and pinning him against a wall. He suffered 14 broken ribs and a broken arm and spent five months in intensive care.

There were no procedures for the removal of the gantries and this operation had not been performed on this model before. No formal risk assessment had been undertaken.

Performing unfamiliar tasks or handling strange equipment without adequate thought can have disastrous consequences. Ensure that the proper risk assessments are performed and that adequate leadership and supervision is provided when dealing with new or different tasks.

The technician was trapped between the gantry and garage wall

Reconstruction of the incident. The retaining strap passes behind the driver's heels

For the purpose of Control of Work, Job Safety Analysis (JSA) is the tool of choice, with regards to the nature of the work, time, and resources available.

Job Safety Analysis (JSA)

Job Safety Analysis (JSA), sometimes known as Job Hazard Analysis (JHA), is a methodology or technique that involves identifying the hazards associated with *each job step* and determining if the safeguards or precautionary measures are adequate.

Who should participate?
Other than persons involved in the planning of work, at least one member of the team assigned to perform the work should participate in the risk assessment. This is because those performing the job will be able to add their perspective to the assessment of the situation. They can provide valuable information such as:

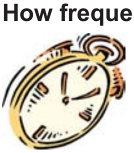
- the operating procedures normally taken for particular work;
- any dangers created by the tools used;
- past accidents with the specialized job;
- incompatible work activities.

A risk assessment conducted with at least one representative from each of the parties concerned will ensure that the task is examined from different angles and that each party understands the existing hazards well. The findings of the assessment should be recorded and communicated in writing, and signed off by all involved in the task.

Ensure that the persons performing the risk assessment for a job are competent and have the necessary knowledge in the field of operation to be assessed, and in the risk assessment technique being used.

It is recommended that formal training be provided to risk assessors, with competency checks to ensure that the individuals are competent. The use of training material, such as IChemE training packages, may prove useful (IChemE training packages are available through the website www.icheme.org).

How frequent?



A JSA should be performed for non-routine tasks, including new or modified tasks. Routine tasks may be covered by a procedural approach, as long as a documented risk assessment has been conducted.

Steps to take for a JSA
Before conducting a JSA, the work site must be inspected by a competent person, as there are many hazards that arise from features of the premises rather than from the work activities. Carrying out a location assessment first before doing individual task assessments will avoid repetition, as many of the prescribed hazards will be common to all the task assessments.

All equipment used in performing work must be assessed as fit for the work purpose by a competent person through inspection and/or review of any certification.

Step one: Break tasks into sequential steps

The first step in a JSA is to break the task into sequential steps. Identify the way in which the task is to be performed, or is likely to be performed, rather than how it should be done. When attempting to break down a job, avoid two common errors:

- making the job breakdown so detailed that an unnecessarily large number of steps results;
- making the job breakdown so general that basic steps are not recorded.

An example to illustrate the breakdown of a job is that of changing a wheel of a car.

List of steps to change a wheel

a) jacking up the vehicle;
b) removing the wheel nuts;
c) exchanging the wheels;
d) replacing the wheel nuts;
e) lowering the vehicle.

Step two: Identify hazards

DATE: WORK ACTIVITY:			ASSESSED BY:			ASSESSMENT NO.: REVIEW DATE:	
NO.	TASKS	HAZARD	SEVERITY X LIKELIHOOD = RISK	EXISTING SAFEGUARDS			ADDITIONAL CONTROL MEASURES
		HAZARDS	HAZARD EFFECTS	S	L	R	

An example of a JSA sheet

Having drawn up a list of sequential steps, identify the potential hazards and possible consequences in a systematic way.

A hazard is a condition that has the potential to cause harm (injury, property damage, environmental pollution, etc.). For example, working from a ladder is a *hazard* with the potential for *harm* to the person working on the ladder (such as harm caused by falling from the ladder). The *hazard* can also have a potential *harm* to the people below (for example, harm caused by being struck by an object dropped from the ladder). Harm is also referred to as hazard effects, consequences, etc., depending on the terminology used at your workplace. Describing the potential consequence is important because it helps focus clearly on the issue of importance—what could happen.

Hazards can be identified effectively using a combination of the following:

- experience;
- checklists;
- past accident reports;
- accident statistics;
- inspection reports;
- discussion/brainstorming;
- previous JSAs;
- task observations;
- publications (legislations, industry standards, etc.).

The *work site inspection* carried out earlier should have been able to identify the most obvious visible physical hazards. The limitations of identifying hazards based only on site inspections are:

- not all hazards are obvious (for example, psychological stress, poor design);
- some hazards are only present at certain times (such as intermittent mechanical faults, leaks);
- some hazards are associated with the methods of work.

Checklists are helpful as a prompt list for identifying common hazards that may be present. However, do not forget that it is important to carefully assess the specific situation, equipment or nature of the task when using checklists. It is easy to miss out on more specific details when checklists deal with more general issues.

Accident investigations reveal the cause of injuries and damage, and ultimately reveal the hazards at the root of these accidents. These reports therefore are valuable sources for the identification of hazards. A study of accident statistics may reveal a pattern of injuries or type of accidents associated with particular hazards.

Many hazards are related to the way the task is carried out, and not to the conditions of the work site. *Task observation* is a planned observation of how tasks are actually carried out. It enables the supervisor to pin-point practices that could cause accidents, injuries, damage, inefficiency, and waste. It also helps to identify areas where coaching or training is needed.

Brainstorming using a team of experienced personnel is another effective way of identifying hazards. By asking personnel involved in a task for their views on the safety aspects of the task, 'near miss' information can often be obtained on certain conditions that would not otherwise be apparent during an inspection. Asking the question 'what could go wrong?' can generate a number of new possibilities for consideration.

Reference to published materials is one of the most important hazard identification techniques. It harnesses the experience of enforcement bodies and specialists who are otherwise unobtainable.

Step three: Analyse risk
After identifying the hazards, it is necessary to evaluate the level of risk, to determine if there is a reasoned case for preventive actions. The hazards identified are ranked to enable priorities to be set for further action.

For JSAs, the preferred method of designating risk level is through the use of a risk matrix.

LIKELIHOOD	SEVERITY		
	HIGH	MEDIUM	LOW
HIGH	H	H	M
MEDIUM	H	M	M
LOW	M	M	L

A simple risk ranking matrix

A risk ranking matrix accounts for both the severity of a consequence and the likelihood of it occurring. It is a qualitative analysis based on judgement and experience. Risk matrices may appear as above where High, Medium, and Low rankings are used, while others assign numbers (1, 2, 3, ...) to risk levels.

Severity
When considering how severe the harm from a hazard could be, remember to be realistic. Almost every hazard could result in death but the most realistic outcome should be considered. For example, it is remotely possible that someone falling off a chair in an office may be killed, but the most probable result is bruising or at worst a fractured bone.

The severity of a consequence for a process plant is usually considered from the viewpoint of injury to people, damage to plant equipment and machinery, delays, business loss, environmental loss, and loss of reputation.

Factors affecting severity include:

- the number of people who may be affected in the incident;
- individuals especially at risk because of disabilities or medical conditions;
- concentration of a substance, speeds, height, weights, amount of energy, etc.

When analysing the severity of a hazard, any control measures already provided (such as guards, protective clothing, permit-to-work) should *not* be taken into account. They can only be considered if they can reduce the risk at its source.

For example, the provision of safety boots to the operator of a hover grass mower does not make the blade less dangerous. It can still cause serious injuries to the hand or ankle. A person who neglects to wear the safety footwear could lose toes. This is not a safeguard that should be considered when analysing risk.

On the other hand, the fitting of a plastic blade does reduce the risk of injury to a minor cut or bruise. This is because the blade tends to snap off before it can do further damage. This safeguard can be taken into account because it makes the blade inherently safer and is not affected by human error.

Risk matrices are generally tailored to suit a facility. A business loss of $100,000 may be considered as a major consequence for a small plant but cannot be classed as such at a large facility where losses can run into millions of dollars.

Likelihood

Judging the likelihood of a hazard actually causing harm is often more difficult. Many assessors underestimate the likelihood, as their experience of actual accidents is usually limited. Reference to national or industry publications of accident statistics is useful to arrive at a more accurate assessment.

Factors which may affect the likelihood of an incident are:

- condition of equipment;
- competence of the people involved;
- work procedure;
- complexity of the task;
- frequency of the task;
- effectiveness of the control measures;
- distractions;
- other work which is being carried out;
- environment, for example, lighting.

An important factor to take into account when assessing likelihood is the control measures already provided. However, it will be necessary to take into account the possibility of the control measures being ineffective or not being used due to human error, lack of maintenance, difficulty to comply, etc. It is also essential to base the assessment on how the task is actually carried out rather than how the task is supposed to be carried out.

The criteria for likelihood (frequent, occasional, unlikely ....) depends again on definitions provided by the organization performing the risk assessment.

When both severity and likelihood are determined, the risk ranking can then be read from the risk matrix. The risk ranking for a particular scenario is read from the intersection between the corresponding severity and likelihood row and column.

It should be noted that the use of numbers on a risk matrix does not make this a quantitative method of risk analysis. Numbers provide a shorthand way of recording the judgement of severity and likelihood and will make it easier to compile a list of priorities. It is important not to become too obsessed with the figures. The objective is not to arrive at a certain number but to provide a systematic and consistent method of assessing the relative severity and likelihood.

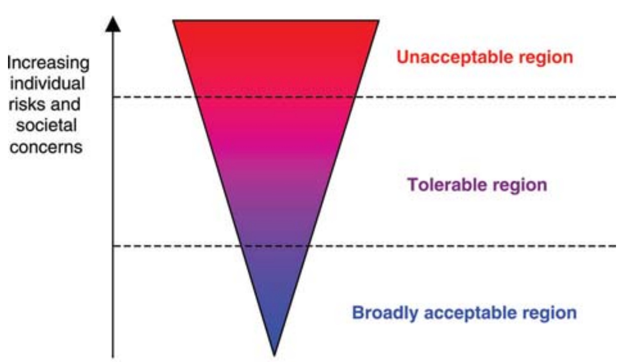
Check the risk ranking against the existing safeguards to evaluate if additional control measures are needed. Ask the question 'Is there anything else that can easily be done to reduce the overall risk?'

What is ALARP?

The ALARP principle recommends that risks be reduced 'so far as is reasonably practicable', or to a level which is 'as low as reasonably practicable'. (These five words form the acronym 'ALARP'.)

According to this approach, a risk is considered to fall into one of three regions classified as 'unacceptable', 'tolerable', or 'broadly acceptable'. Levels of risk considered 'unacceptable', 'tolerable', and 'broadly acceptable' are set according to industry guidelines or the organization using this approach.

Risks above the upper tolerable limit are regarded as unacceptable. Such risks cannot be justified in any ordinary circumstances. The risk must be reduced so that it falls in either the 'tolerable' or 'broadly acceptable' regions, or the associated hazard should be eliminated.



Tolerable risk and ALARP

A risk is considered 'tolerable' provided that it has been reduced to the point where the benefit gained from further risk reduction is outweighed by the cost of achieving it, and that generally accepted standards have been applied towards the control of the risk. A risk reduced in this way is considered to be 'as low as is reasonably practicable', or ALARP.

Below the tolerable region, levels of risk are regarded as so insignificant that no further improvements are required although it is necessary to remain vigilant to ensure that the risk remains at this level.

Step four: Consider control measures
Finally, consider providing control measures for hazards with significant levels of risk that are not adequately controlled despite existing safeguards. Additional control measures should be considered in the following order:

a) elimination;

b) substitution;

c) control;

d) mitigation.

This approach is also qualified as the 5 Ts: Terminate (for elimination), Transfer (for substitution), Treat (for control and mitigation), Tolerate (if residual risk is acceptable) and Track (that conditions do not change during the work).

Elimination involves removing the hazard entirely. An example is providing a socket outlet at the point of use, thus eliminating the need for trailing cable. Another example is to eliminate confined space entry by opting for steam or chemical cleaning of a vessel by recirculating fluids.

Substitution can also reduce hazards. It is often possible to reduce the risk at the source by using a safer alternative. For example, choosing a less or non-flammable solvent to replace a highly flammable solvent can reduce the risk of fire. Using low voltage tools, or using compressed air tools instead of electric tools can reduce the risk of electric shocks while working in a metal tank.

INCIDENT Solvent for weld test leaves two unconscious!!!

An inspector and a worker entered a reactor to check the welds by stain detection tests. The test consists of applying a red dye and cleaning off the excess dye using a solvent. While performing the test, both the inspector and worker collapsed from breathing in solvent fumes. They were resuscitated by rescue services and were sent to hospital for observation. As a result of this incident, the use of a solvent to clean off excess dye in a confined space was replaced with water.

Do not wait for an accident to occur before taking steps to eliminate or reduce a hazard at its source.

Control measures for a hazard can only be considered when the hazard cannot be eliminated or reduced at the source. The hazard can be controlled by providing the following:

- full enclosure of the hazard (such as fixed guard fully protecting dangerous parts of equipment);
- part enclosure (such as providing local exhaust for welding operations);
- keeping people away from the hazard (for example, barrier or cover around a hole in the floor);
- reduce contact with the hazard, in quantity or time (such as providing general ventilation, earth leakage or residual current device on electrical equipment).

These suggestions relate to hazards that arise from physical conditions. Other controls may also be needed for hazards that arise due to human factors to ensure that the physical controls provided remain effective.

From the previous example, even when a hazard has been eliminated, controls, documentation, training, and instruction will be necessary to ensure that a solvent-based cleaner is not purchased by someone in the company who is ignorant of the decision to use only water-based alternatives.

Controls include:

- providing protective devices (such as push stick, insulated hand tools);
- safe systems of work (such as Permit to Work System);
- training to increase knowledge and awareness;
- provision of information (for example, MSDSs, emergency procedures);
- instruction and signs;
- supervision;
- Personal Protective Equipment (PPE).

Personal Protective Equipment (PPE) should be considered as the last barrier of protection before a person is exposed to a hazard. As such, reliance can only be placed on PPE after efforts have been made to eliminate or reduce the hazard.

Mitigation measures should be prepared even when controls are in place because residual risks still remain. These risks must be recognized. Check that emergency response plans are in place and that the emergency response services are fully informed of the activities performed. Make sure that escape routes are clearly marked and free of any obstructions. Verify that personnel involved with the work are fully aware of the emergency response plans.

Be aware of 'recommendation overload'. Make sure an action is necessary, otherwise phrase recommendations as, 'Evaluate need for . . .'. Make sure that the underlying intention to the recommendation is clearly documented. If you feel that the recommendation is warranted, then make it. Do not be swayed by anticipated management response. Make sure someone has been assigned to oversee follow-up to the recommendation.

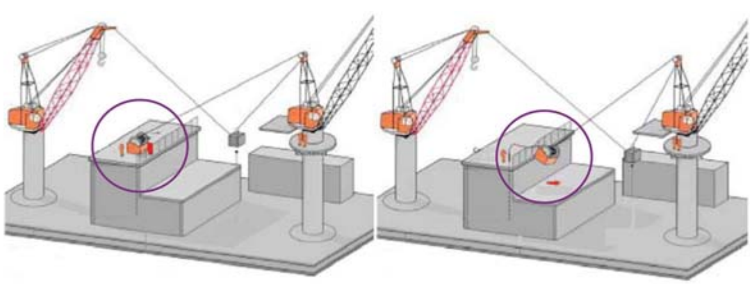
Check that emergency response plans, based on potential emergencies, are in place before starting work.

INCIDENT Job Safety Analysis not completed results in fatality!!!

A crane engine on a rig had to be changed. In previous changeouts of the engine, two cranes were used to carry out the lift. In these cases, the changeouts had been completed successfully and safely. However, this time the team opted for an alternative, untried method, which they thought would be more efficient.

The alternative method involved the use of an air winch to lift the engine and a second crane 'tailing' the load to control lateral movement. With this in mind, the air winch, which was originally bolted in position, was relocated to another location where it was mounted using four welds to the beams on the roof of the emergency generator room.

During the lifting operation, the air winch welds failed, causing the winch to be pulled violently forward. An engineer who was standing between the air winch and the guard rail, was dragged along and eventually fell over the railing, falling 4 m (13 ft). The engineer sustained serious head injuries and died after several weeks of hospitalization. It was found that the four welds had not been designed for the load, and had not been carried out by a certified welder, neither had they been tested before use. A different method was being used, but no consideration had been given to the potential risks. The required Job Safety Analysis was not completed. Management of Change was not recognized as needing to be considered.



The barge engineer was standing between the air winch and guard railing when the welds that held the winch to the roof failed.

The barge engineer fell 4 m (13 ft) from the top of the Emergency Generator Room onto some pipework on the deck below.

ACCIDENT **Welder seriously injured while working on 30-inch pipeline!!!**

A spacer-welder was cutting off a spool section of a 30-inch (750 mm) diameter pipe bend. When the cut was complete, the pipe support became unstable. The pipe bend rotated and crushed the worker against an adjacent pipe bend. He was seriously injured.

The causes of the incident were:

Position of the injured person at the worksite

- The Job Safety Analysis (JSA) did not adequately identify all the potential hazards of the job.
- The procedures for pipe stringing did not include controls for potential hazards of the job (for example, securely supporting cut bends to prevent rotation).
- The worker was in a vulnerable position while working and failed to anticipate the pipe movement upon completion of the cutting work.
- There was inadequate vertical communication because the supervisors and foremen used English while the majority of the workforce spoke only the local language. This would have hampered effective safety pre-job/toolbox meetings, where potential work hazards are highlighted to the workforce.

It is necessary to train personnel to be aware of the risks in the workplace and be able to assess them.

2.6 Permit to Work

After planning the work and identifying the risks involved, the next step in the Control of Work process is to obtain a Work Permit.

Always obtain a permit before conducting any work that involves: confined space entry, work on energy systems, ground disturbance, hot work, or other hazardous activities.

The Permit to Work (PTW) system is an integral part of an organization's effort to maintain a safe system of work. It provides a means to formally authorize plant maintenance, repairs and modifications, which are tasks that are not part of the normal operational or production routine.

A permit is regarded as a signed 'contract' between the party who is responsible for or 'owns' the unit (Area/ Issuing Authority), and the party who will carry out the work (Performing Authority). The Issuing Authority issues the permit giving permission while the Performing Authority confirms by signature that the restrictions and precautions are understood and will be followed by all those involved.

Beyond merely 'giving permission', the Issuing Authority has to guarantee that the workplace is safe and that the equipment is free of energy, toxic, or flammable substances. A visit to the workplace must be made with the Performing Authority to identify the correct equipment to be worked on and to make sure that all safety measures are in place and understood. The permit process forces joint planning of the work by the Issuing and Performing Authorities.

However, the permit by itself is just a tool. Safety depends on the people involved in the Permit to Work System! The protection is provided by checking and using a logical approach to work preparation, which is inherent in the permit system. There is always a danger of going through the motions when filling in the Work Permit form.

There have been many instances where poor application of the permit system led to incidents. The Piper Alpha disaster of 1988 is an excellent example of this. Other examples include instances where the permit was signed from the control room without prior site visit and inspection (refer to page 50), and incidents where the wrong equipment was entered (page 52) or the wrong line broken into because the correct equipment/line had not been shown to workers (page 57).

Only conscientious and exact application of the permit system will prevent accidents.

The work permit should contain at least the following information:

- scope of work;
- duration of work;
- hazards and reference to existing risk assessments;
- isolation of all energy sources required to carry out the job safely;
- control measures to eliminate or mitigate risks;
- link to other associated work permits or simultaneous operations;
- specification of persons carrying out the work and verification of their understanding of the risks and control measures;
- cross-reference other relevant certificates and permits.

The permit should be authorized, monitored, and then re-validated by the responsible person, and the above information must be documented and communicated to all involved in the work. Adequate control over the return to normal operations must be available.

Only perform work covered under the task description of the permit. Any other work would not have been checked for hazards!

There are several types of work permits, including the following:

- Hot Work Permit;
- Cold Work Permit;
- Confined Space Entry Permit;
- Excavation Permit;
- Electrical Permit;
- X-ray/Gamma Permit, etc.

Some permits must be obtained concurrently. For example, a Confined Space Entry Permit will only allow entrance into a vessel. In order to perform work in the space, a Cold or Hot Work Permit must also be obtained.

What is cold work?

Cold work is any work which does not create, or have the potential to create, a possible source of ignition.

Examples of cold work:

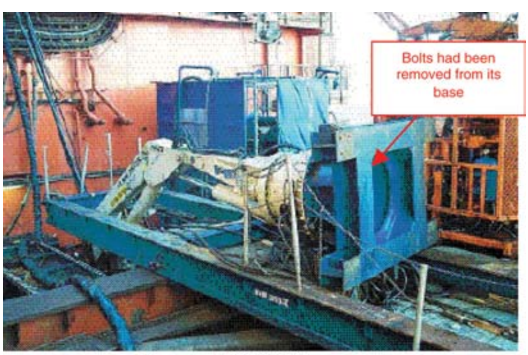
- opening of pipe works by breaking flanges/unions, or by moving blanks/spades;
- replacement of gland packing on valves;
- opening of plant equipment—vessels, towers, drums, exchangers, coolers, filters, tanks, etc.;
- painting, lagging, erection, and dismantling of scaffolding—no use of power tools/machinery;
- use of other non-electric, non-spark creating hand tools.

Since cold work may not be as dangerous as hot work, some people may think that it is too much trouble to have to obtain a Cold Work Permit every time some minor work needs to be done. However, the Cold Work Permit system has an important role to play in the Control of Work. Other than ensuring that isolation and safety measures have been undertaken to guard against hazards such as trapped pressure (refer to BP Process Safety Booklet *Hazards of Trapped Pressure and Vacuum*), it also records what and where activities are being performed on a facility.

INCIDENT **Inadequate planning and control of crane move!!!**

A crane, used as part of Simultaneous Operations (SIMOPS) on a drilling platform for coiled tube downhole activities, needed to be moved to a new well location. It was folded together and 12 securing bolts were removed from its base. No cold work permit or isolation certificate for electrical and hydraulic energy sources were issued specifically for the task. The contractors were allowed to work under a general Permit to Work. The relocation of the crane was viewed as routine work by the service supervisor and no Job Safety Analysis (JSA) was initiated.

A check revealed that in its new position, the crane panel might obstruct a walkway. Wanting to ensure that the crane had direct access to the new well, the service supervisor started to operate the crane, having forgotten that the securing bolts at the base had been removed. After unfolding the boom, the crane became unbalanced and toppled over, narrowly missing the supervisor. He escaped death by a small margin. Extensive external damage was sustained to drilling and SIMOPS equipment with costly delays and repairs.



Toppled SIMOPS crane

Lessons learned:

- Perform critical task analysis for all contractor-related activities.
- Identify activities that require a specific work permit and those that can be covered by a general work permit.

What is hot work?

Hot work is an activity that uses or produces a source of ignition. It is an extremely hazardous activity in the oil and gas industry.

Examples of hot work are:

- welding or brazing;
- cutting by using heat (such as oxy);
- grinding;
- sand or grit blasting;
- using tools that produce sparks or heat;
- heat treatment and stress relieving;
- opening up of electrical equipment;
- motor vehicle access;
- other sources or sparks, heat, or flame;
- generating static electricity.

The main risk of hot work is the simultaneous presence of a flammable atmosphere and an ignition source. Therefore a system is needed to control the presence of ignition sources in areas where flammable liquids, vapours, gases or other flammable materials may be present. This system is the Hot Work Permit.

INCIDENT **Contractor propelled through the air!!!**

An explosion in a floating roof tank propelled two workers off the tank roof, 140 feet (43 m) through the air to the ground. One worker actually survived. His fall was broken by electric cables!

The contractor was using a portable electric saw to cut the roof of the tank, which was being used as a waste water surge tank, but it contained traces of hydrocarbons. The main lesson learned here is the need to check for all sources of flammables, including trapped hydrocarbons, before allowing hot work.

All process plant areas and tank farms are hazardous areas. Site rules and plot plans will precisely define hazardous and safe areas (refer to *Hazards of Electricity and Static Electricity* and to *Safe Tank Farm and (Un)loading Operations* booklets in this series for more information). Check them out for your area. Fixed ignition sources, such as fired heaters, should be located in safe areas, and the mobile sources, such as welding equipment or vehicles, should be strictly controlled by Hot Work Permit.

INCIDENT **Vacuum truck explosion and tank fire!!!**

Explosions and a subsequent fire occurred during the cleaning of a 2,500 m^3 gasoline tank. A vacuum truck was destroyed; the tank and its concrete bund wall were heavily damaged. At the time of the incident, product had been pumped out and the tank was isolated for entry. Vapours from the tank entered the truck engine air intake, the truck engine raced (over-speeding) and immediate attempts to decelerate it from the control panel at the back of the truck were not successful.

Destroyed truck and fire damage on concrete bund wall

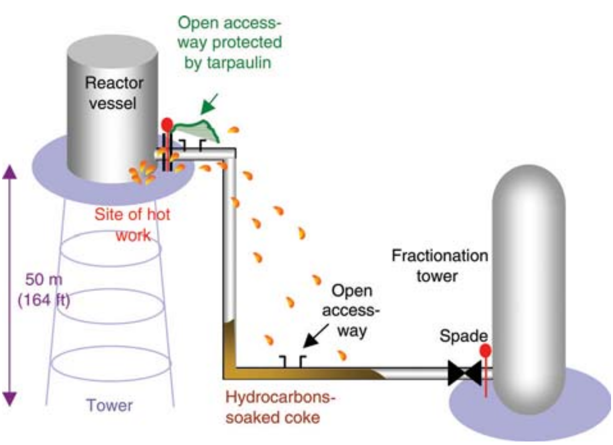
The change in operating conditions from ‘using the vacuum truck near closed manway’ to ‘using the vacuum truck near open manway’ did not trigger reconsideration of the permit to work conditions despite shifting winds and known high vapours levels at manway.

INCIDENT **Hazard overlooked!!!**

Hot work (oxy-cutting) was to be performed on an elevated structure close to a reactor outlet line. Precautions had been taken at the site of the hot work to control the potential hazards by performing gas tests on the open access-way on the outlet line and area surrounding it. No flammable atmosphere had been found. A further precaution was taken to cover the access-way with a tarpaulin, so that the sparks from cutting could not possibly enter the transfer line. The work was initiated with the correct permits issued and necessary precautions taken to perform the work safely.

Although no sparks reached the open access-way close to the hot work, the oxy-cutting debris fell 50 m (164 ft) down into another open access-way below, on the same transfer line. This portion of the line contained hydrocarbon entrained in coke, which remained after initial shutdown and steam out. Hydrocarbons had leached out of the carbon in the line and the flammable atmosphere ignited causing a small explosion which blew the tarpaulin off, shocking the workers above. Fortunately, no one was hurt.

The presence of residual flammable material and a possible flammable atmosphere should have been detected in the first place and actions taken to rectify the matter. Even so, the Permit Issuing Authority had neglected to consider the potential impacts of this work beyond the immediate surroundings.

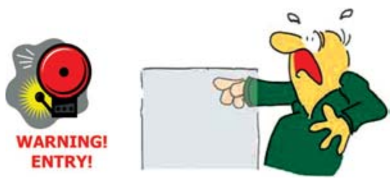


What is a confined space entry?

A confined space has the following characteristics:

- limited openings for entry and exit;
- large enough to enter at least partially;
- not designed for continuous human occupancy;
- has inadequate natural ventilation;
- has potential for a hazardous atmosphere, such as a toxic atmosphere or an oxygen deficiency.

A confined space entry is considered to have occurred as soon as any part of a person's body breaks the plane of an opening into the space.



Any work inside a confined space is considered dangerous because of the ease of which hazardous materials build up in the atmosphere in the space. Oxygen deficiency is also another common problem with confined spaces. Rigorous gas tests are required before any person is allowed to enter a confined space for work.

Refer to BP Process Safety Booklet *Confined Space Entry* for more on this subject.

INCIDENT **Confined spaces can be lethal!!!**

In an attempt to unplug a tank pump suction, a contractor entered a tank through a small opening, wearing only a canister respirator. No confined space entry permit had been issued and he was specifically instructed not to go in. But he went in and would not come out even when he felt dizzy. He was killed by benzene vapours in the tank.

Never enter a confined space without the benefit of a confined space entry permit. The permit procedure would have ensured that space was checked for hazards and measures taken to remove them before being certified safe for entry.

When working under a Permit to Work, ensure that the PPE issued is suitable for the task being performed.

Why does excavation require a permit?

Excavation Permits are implemented for control of hazards and potential damage to buried electrical cables, pipelines and drains, etc., especially when work involves penetration of earth/ground manually or using a mechanical device. This permit needs to be countersigned for cables and buried pipes or drains by competent/authorized persons (such as electrical, civil, or mechanical engineers).

INCIDENT **Buried gasoline transfer pipeline rupture and fire!!!**

A 16-inch (41 cm) buried steel pipeline ruptured and released 237,000 gallons (900 m^3) of gasoline into a creek. About an hour and a half later, the gasoline ignited and burned approximately 1½ miles (2.4 km) along the creek. Three people died and eight were injured. Total property damages were estimated to exceed $45 million.

Aerial view of the fire damage

Removal of ruptured pipe section

Laboratory examination of 20 feet (6 m) of the line revealed 33 gouges in the external pipe surface, almost all of them on the pipe's upper surface. The 27-inch (69 cm) long rupture originated at one of these gouges. It was confirmed that the pipeline had been damaged by excavation work to install buried pipes for the modification of a nearby water treatment plant.

Incidents such as this have resulted in the creation of a specific API Standard in 2001, API-1160 'Managing system integrity for hazardous liquid pipelines'.

Why are X-ray/Gamma permits needed?

Radioactive sources on site require special handling. Exposure to radiation can result in adverse health effects, ranging from skin reddening and increased risk of developing cancer to death. It is good practice to manage work involving radioactive sources using a separate permit, rather than to use a hot work permit or general work permit. In some locations, sites are required to have a designated 'Radiation Officer' who is responsible for radioactive sources used on-site.

An X-ray/Gamma permit will have specific checks such as:

- verifying that the radioactive source operators have up-to-date training;
- checking that electronic meters and personal dosimeters are working;
- limiting the size of radioactive source that can be handled;
- radiation reading at the site's entrance and exit to double check that the radioactive source is held in its container.

INCIDENT **Radioactive material disposed as scrap!!!**

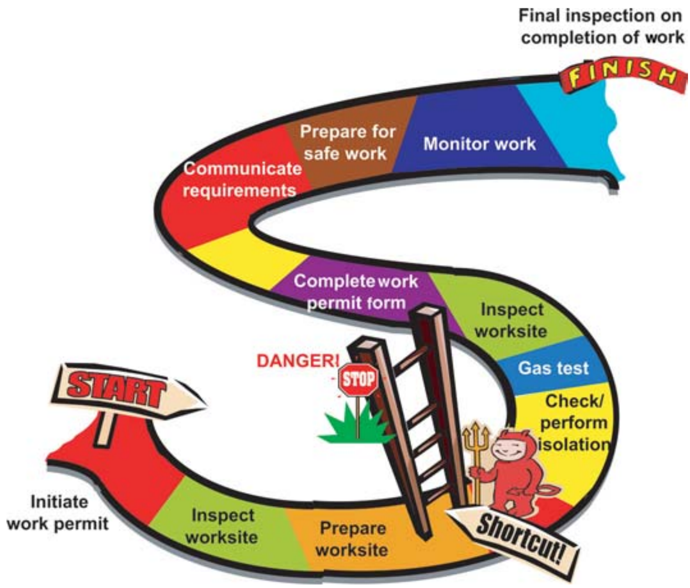
A radioactive level gauge on a tank was removed by mistake while it still contained a radioactive source. The person-in-charge had confused the level gauge on this tank with another tank, where the radioactive material had indeed been removed. A normal work permit had been used instead of the special permit for handling radioactive equipment.

Level gauge on top of tank

The recovered radioactive source holder

This mistake was only traced after the radioactive material was disposed as scrap and had left the site. The disposal company detected high levels of radiation during a routine check at their site and moved quickly to isolate the source.

Permit to Work sequence



INCIDENT **Taking shortcuts!!!**

A bursting disc that had been experiencing regular corrosion was due for inspection. A Permit to Work had been signed and issued. However, no isolation certificate was issued. The isolation of the system was carried out later, using only valve isolation, two of which were actuated valves. The system had not been depressurized to atmosphere but was kept at about 0.25 barg (3.6 psig) pressure.

When maintenance technicians started to loosen the bolts on the flange containing the disc holder, they heard a loud noise and saw the disc eject through the vent pipe and onto the ground. The disc had been partially pulled from its holder and partly ripped. Fortunately, there were no injuries.

There was a serious deficiency in the Permit to Work system and energy isolation procedures. The work permit should only have been signed and issued after isolation had been confirmed. Further, valve isolation does not constitute positive isolation!

Do not take shortcuts with the Permit to Work procedures.
The procedures must be maintained at all times!

Preparation of the worksite

Before a permit can be issued, the worksite must be made ready for work. Hazards need to be eliminated or controlled, and provisions made for the actual work.

Preparation of worksite requires:

- access and egress;
- work area marked off and protected;
- equipment isolated;
- isolation proved;
- removal of hazardous materials, depressurization and draining;
- equipment cleaned;
- drains covered and sources of vapour within 15 m (49 ft) isolated;
- combustible materials (such as dry grass) removed;
- adequate lighting and ventilation provided.

Provision must be made for easy access to and exit from the worksite. Check if scaffolding is needed. Scaffolding must be erected by competent persons for all work areas that cannot be readily accessed from the ground or do not have proper work platforms. Mark clearly the work area with barriers and warning notices if necessary.

Confirm that the section of equipment has been successfully isolated and any stored energies (for example, pressure, potential energy, thermal energy) have been released. Preparation for draining of the section may involve improvization to contain and collect contents. Provide adequate lighting and ventilation where appropriate.

Isolation of equipment

Adequate process and electrical isolation are essential to ensure that no hazardous materials are introduced to the work area and no prime movers such as motors, turbines and engines can be started accidentally during the course of work.

The extent of isolation must match the risks associated with the possibility of the isolation failing.

Isolation can be carried out by the following methods:

- Lock-out and Tag-out (LOTO);
- blanking;
- disconnecting;
- securing.

Some devices can be locked and a tag placed to avoid accidental activation. Examples are electrical switches of mechanical equipment and valves on hazardous material lines.

Mechanical moving parts such as mixers and fans should be secured using latches, chains, chocks, blocks, or other devices if they pose a danger to workers.

High-risk activities such as hot work and confined space entry require what is defined as *positive isolation*. This is achieved by inserting spades/blinds into lines or disconnecting lines to physically separate the work-piece from any possible introduction of hazardous materials. Ensure that the selected means of isolation has been designed to withstand subjected pressures. Valve isolation alone is not enough (even including 'double block and bleed', which is closing and locking/tagging a drain or vent valve between two closed values)! Refer to the BP Booklet *Confined Space Entry* in this series.

Prove the isolation

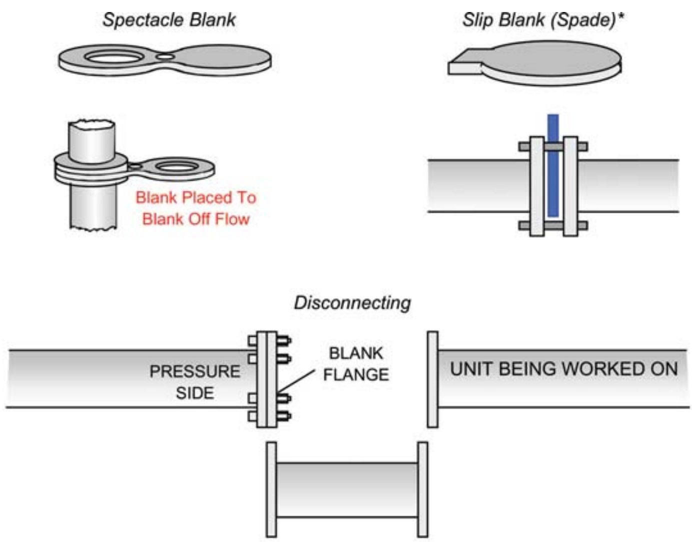
Wherever possible the isolation must be proved. This may involve the 'test start' of electrically driven pumps or compressors or the use of test and drain valves to prove fluid isolations.

INCIDENT A fitter was required to work on a large flue gas fan. The equipment was isolated and the appropriate locks fitted. Before starting work the fitter carried out a 'test start' using the local controls. To his surprise the fan started.

Although the correct item had been isolated, a linkage in the isolation switch had failed.

A blinds list is useful to avoid confusion when there are multiple isolation points.

Blanks, blinds, and spades should have full pressure rating for the system which they are being installed in.



Means of Positive Isolation

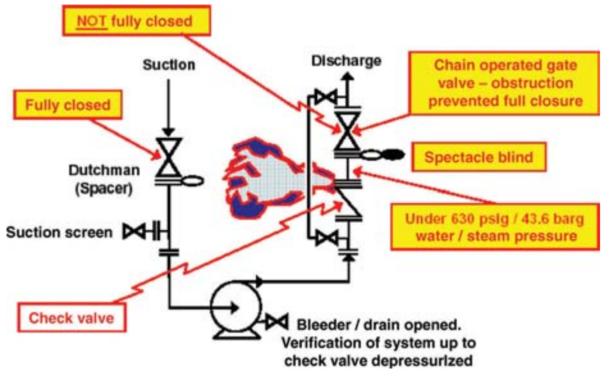
* A slip blank is a solid metal plate inserted in a line between flanges and should be rated for full line design pressure.

INCIDENT Two pipefitters die after being scalded by hot water!!!

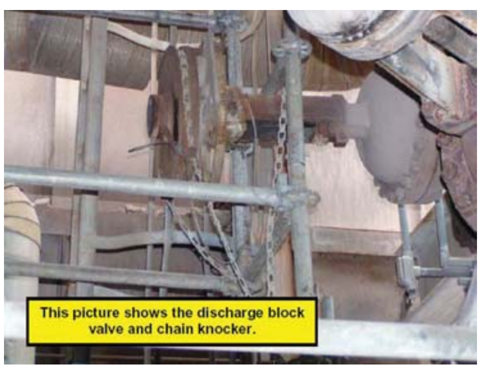
A boiler water circulation pump had undergone maintenance and an attempt was made to put it back into service. This was performed without success, so a decision was made to check the suction screen/strainer. A LOTO (Lock-Out/Tag-Out) and Authorization-to-Work were initiated to clean the suction screen, inspect the pump impeller and check valve, and repair the pump as necessary.

Isolation was achieved by closing the valves on the suction side of the pump and discharge side. The pump case drains were open confirming that the line between the suction valve and the check valve on the discharge side had been depressurized. Unknown to them, the discharge valve had not closed fully allowing hot water and steam to enter the line between the check valve and discharge valve. There was no bleeder and bypass between the two valves to confirm that a safe energy state existed and the spectacle blind beneath the discharge valve had not been swung due to potential re-alignment problems.

(*continued*)



When no screen or strainer was found in place, a joint decision was made to open up the check valve to see if it was stuck in the shut position. Three pipefitters were assigned to remove the check valve. They removed the bolts and proceeded to use a wedge and hammer to spread the flanges when high pressure water and steam [630 psig (43.4 barg) at 500°F (260°C)] came spraying out. The three pipefitters were engulfed in hot water and steam. Two of them received burns to over 80% of their bodies and later died from their injuries. The remaining pipefitter received burns to approximately 60% of his body.



The chain wheel knocker on the discharge gate valve's handle partially obstructed the view of the stem. The fact that the stem extended by 2 inches (51 mm) was not identified

This incident occurred due to inadequate isolation. The discharge block valve (chain-operated gate valve) was not fully closed due to rust/debris below the gate and this was not detected although the stem on the valve was extending approximately 2 inches (51 mm) beyond the valve's hand wheel indicating that it was not in the fully closed position.

The possibility of stored energy above the check valve was not recognized and a safe energy state above the pump's discharge check valve was not established before beginning work activities.

Always assume that a pipe contains residual liquid/gas under pressure when breaking containment and wear the appropriate PPE as a last line of defence against an incident.

Means of verifying that a system is depressurized and drained must be included as part of the design and maintenance procedure, and must be subject to a risk assessment.

Although it is the Permit Issuing Authority's responsibility to hand over equipment in a safe state for maintenance and specify any potential remaining hazards and precautions to be taken, the Performing Authority must also be satisfied that the appropriate preparations and isolations have been carried out before starting work.

INCIDENT **Electrician is injured as a result of lack of identification!!!**

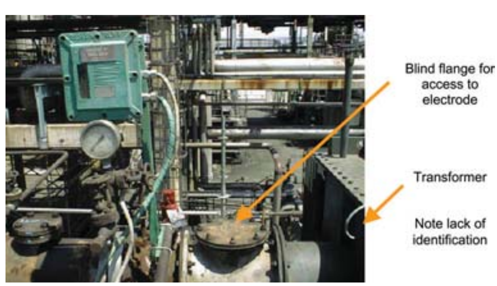
An electrician received an electric shock from 20 kV current while he was working on a live electrode in the desalter of a distillation unit. The electrical equipment used in the desalter is characterized by the fact that only one pull-out circuit breaker is used to protect the three transformers, each of which supplies one electrode grid.

The electrical supply circuit to the faulty electrode's transformer (#3) on the circuit breaker side in the substation had been disconnected but the electrician had mistakenly gone to work on electrode #1 because of a lack of identification.

Fortunately, he was not electrocuted due to the fact that his hand was in contact with the equipment which was earthed/grounded when the tool he was holding touched a live cable. He suffered severe burns to his little finger and third finger on his right hand.

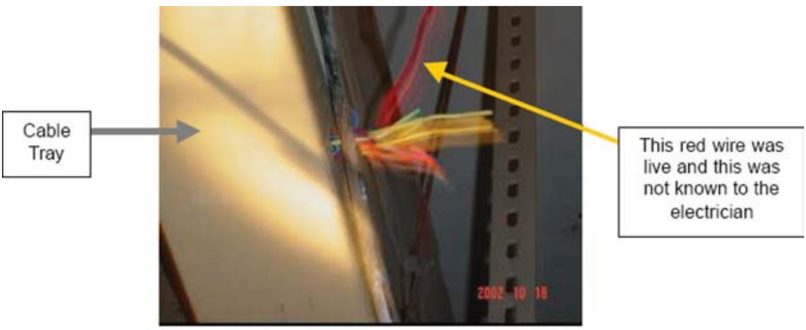
The investigation concluded that the main contributing factors were as follows:

- inadequate checks or tests to determine that the electrical conductor to the electrode was dead;
- inadequate identification/ tagging/labelling of the electrical equipment.



INCIDENT **Inadequate isolation results in fatal contact with live cable!!!**

An electrician was checking existing wiring in the false ceiling of an office when he came into contact with a live wire from another floor which passed through the false ceiling. The building management had electrically isolated the office level but the live wire originating from another floor had not been isolated. He was found collapsed on a cable tray and later died in hospital.

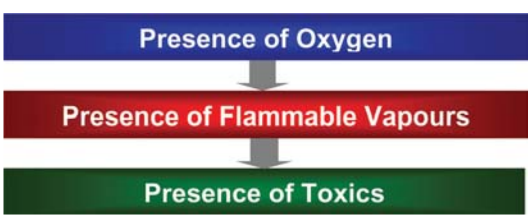


Live cable that electrocuted the electrician

Gas testing

Gas testing is a very important step in the Permit to Work procedure. It is especially important for hot work and confined space entries as it captures hazards in the atmosphere that cannot be seen. When all other requirements are fulfilled (such as hazard identification, isolation, PPE, emergency response plan), gas test results will determine if the work permit application can proceed.

The correct gas testing sequence is as follows:



The reason behind testing for oxygen first is that the flammable gas detector will not yield meaningful results in the absence of sufficient oxygen. Most flammable gas detector instruments works on the basis of combustion.

Testing for oxygen first will also give a quick indication if there are contaminants present in the air. When oxygen readings are below the expected 20.7% present in normal air, there is a contaminant in the atmosphere. An area with oxygen deficiency, usually a confined space, cannot be entered unless the oxygen level is above 19.5%. Conversely, an oxygen-rich atmosphere (above 23.5%) is also undesirable because it enhances combustion.

Flammables are tested next, mainly because it is the more prevalent hazard in oil and petroleum installations. The flammable gas test indicates the amount of flammables present in terms of %LEL (Lower Explosive Limit). Most portable gas detectors operate by the catalytic combustion of a flammable gas on a heated filament (usually platinum). Accordingly, there must be approximately 20.7% oxygen in the sample to give an accurate reading. If the atmosphere is deficient in oxygen, for example, purged with nitrogen, the standard type of flammable gas detector cannot be used. Many have had lucky escapes where regular flammable gas detectors were used in inert atmospheres. Special flammable gas detectors that function in inert atmospheres are now available in the market.

Use the correct gas detector to test for flammable gas. If you have purged a space with nitrogen, check that the flammable gas detector you plan to use is suitable for inert atmospheres.

A competent gas tester is expected to understand the limitations of the instrument. In addition, flammable gas detectors must be maintained, calibrated and operated in accordance with the manufacturer's recommendations in order to give accurate results.

Toxic materials are tested for last. The correct detector to use depends on the type of toxic material and the amount suspected to be present, as each detector is designed only for a specific contaminant. Refer to BP Process Safety Booklet *Confined Space Entry* for more on gas testing.

Ensure that gas test results comply with work and permit requirements. If not, more has to be done to bring it to acceptable levels (for example, improve ventilation, check isolation).

Gas testing should only be performed by a competent person. Qualified gas testers should be trained and accredited in the following:

- calibration and use of gas testing equipment;
- the limitations of testing equipment and test methods;
- tests in the correct order;
- the ability to understand and interpret results;
- have practical facility experience (preferably) or training;
- be formally tested and exceed pass mark;
- be retrained/retested regularly.

INCIDENT **Contractor climbs into inadequately gas tested vessel!!!**

A vertical reactor vessel (7.6 m/25 ft high) had been shutdown, cleaned, inspected, gas tested, and approved for entry. The vessel was then left idle for five days with no mechanical ventilation. When work was ready to start, gas tests were carried out again. But this was done only in the area near the top manhole. Entry was then approved.

A contractor employee climbed down the ladder while an employee lowered an explosimeter/gas sentinel simultaneously from the top of the manhole. No mechanical ventilation had been installed for this entry. Halfway down the vessel, the explosimeter alarmed due to high LEL. The contractor employee immediately climbed out of the vessel. He suffered from a headache and was sent to hospital.

Remember to test at all levels and in all areas. High-risk areas must be identified and checked, such as sumps, dead ends. The limitations of the gas testing equipment or test method must be recognized. All traces of oil, sludge, scale and other flammable materials must be removed before declaring equipment to be 'gas-free'. 'Gas-free' is not 'vapour-free'. Sludge can still give off vapours at certain conditions even if the space has been declared 'gas-free'.

INCIDENT **Gas testing can be a dangerous activity!!!**

An operator was overcome by gas (mainly nitrogen), which flowed from an open flare line while he was attempting to perform a gas test. He was not wearing respiratory protection despite being told to do so by his chief operator. Ironically the gas test was required to permit flash photography of an incident which had occurred earlier in the day!

Site inspection

Prior to approval, conduct a visual inspection of the worksite to identify any overlooked problems. There should be at least one site survey to identify and inspect the worksite or equipment. Aside from confirming that all work permit requirements have been fulfilled, this check is essential to identify any remaining hazards and to see that the threat they pose are controlled or eliminated.

Examples of things to be aware of are:

- residual flammable material;
- adequacy of isolation;
- radioactive sources;
- power isolation to fans, mixers;
- hydraulic drives isolation;
- loose or poorly supported materials/equipment overhead;
- sharp objects;
- drains are covered or enclosed;
- asbestos or synthetic fibre, etc.

The work site should always be inspected by a competent person before the permit is issued to ensure that conditions are safe and have not materially changed.

INCIDENT Supervisor detects incomplete isolation from hissing sounds!!!

A superintendent authorized a Confined Space Entry Permit, without inspecting it, having been assured by personnel from the previous shift that a vessel was safe to enter. Later, as the superintendent was heading for his office from the control room, he decided to stop to have a look at the vessel. When he stood outside the bottom manhole, he heard a slight hissing sound. It was found that the differential pressure instrument lines had not been thoroughly closed or spaded/blinded, releasing hydrocarbons into the vessel. He then cancelled the entry permit.

Check that all hazardous energies are controlled or eliminated. There is no substitute for walking around the isolated equipment to check each connection and verify positive isolation.

INCIDENT Mistaken identity!!!

A fin-fan on a Vacuum Distillation Unit was scheduled to undergo maintenance. This required a scaffold to be erected to gain access into the fin-fan plenum chamber. The scaffolding contractor was requested to erect the scaffold. A permit was issued two hours later.

Later in the day, it was discovered that the scaffold had been mistakenly erected in the wrong fin-fan plenum chamber. This fin-fan had not been electrically isolated and could have been remotely activated while workers were in the chamber.

The equipment to be maintained had not been positively identified and confirmed by the permit issuing and performing authorities and the work was authorized before a permit was issued. Both these critical factors represent a significant breakdown in the Permit to Work System that had the potential for multiple fatalities and equipment damage.

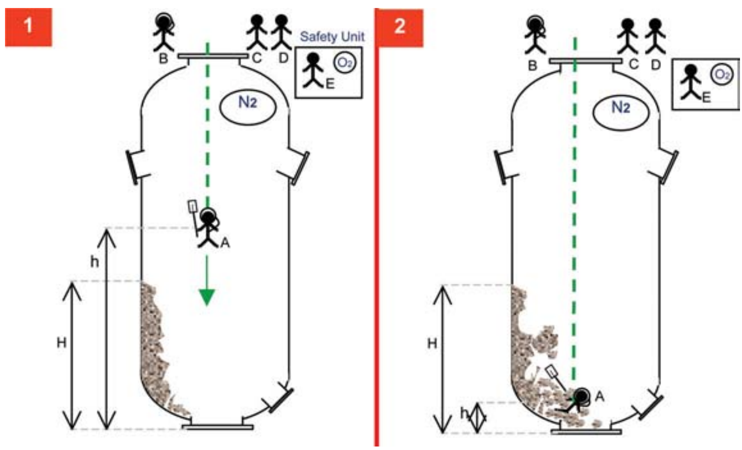
Personal Protective Equipment (PPE) and emergency response

Provide adequate PPE for the job and use the correct respiratory protection, if required. PPE is the last line of defence against exposure to a hazard and should never be considered as a primary measure in ensuring that the work is safe to perform. When dealing with hazardous chemicals, check their respective Material Safety Data Sheets (MSDSs) for the correct PPE to use. Refer to BP Process Safety Booklet *Hazardous Substances in Refineries*. Make sure that a proven emergency response plan is in place before starting work. The site should have a procedure describing the means of rescue based on the full range of identified hazards and risks. However, ensure that the response plan is suited to the hazards involved in the work and the specific location. For example, the emergency response to extract an unconscious victim from a confined space at the top of a tower would differ from the emergency response to remove an unconscious person from between a tangle of pipes. It is no use having an emergency plan if it is not proven to work.

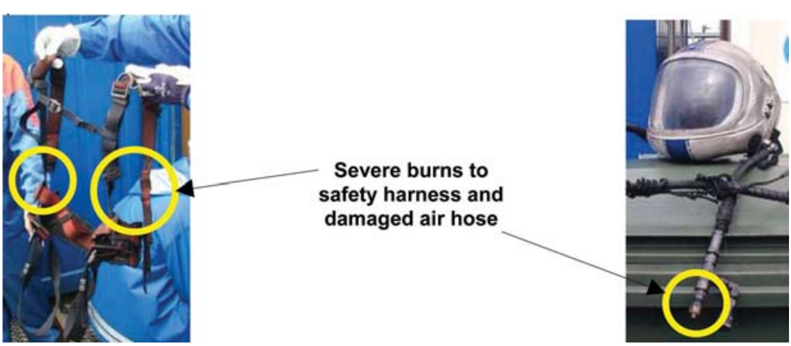
Emergency response drills need to be performed on a regular basis to ensure that the roles, responsibilities and responses are fully understood by those likely to be impacted by an incident. For more specialized rescues, such as confined space rescues, it is useful to perform drills on the equipment itself although this is sometimes impossible. As far as possible, mimic the actual conditions for rescue when conducting drills.

INCIDENT Emergency response plans are important and necessary!!!

A nitrogen entry specialized contractor was buried under hot catalyst while carrying out catalyst unloading work in a nitrogen-purged reactor at a refinery. The contractor had violated a clear requirement on the permit, which stated that ‘the inert entry diver must never come under catalyst level’.



The worker was successfully rescued by his partner who was fully equipped, suited and on stand-by. The victim suffered burns to his neck—local catalyst self ignition was made possible because of air leakage from a damaged supply hose (and perhaps because of the atmospheric disturbance when the catalyst wall fell). This successful rescue was possible due to a recent change of procedures requiring a standby person to be available at all times and prepared during any vessel entry when nitrogen purged. Even though the emergency plans worked, this type of work is always a delicate operation and consideration should have been given to finding a safer way of carrying out this work whenever possible (refer to BP Process Safety Booklet *Hazards of Nitrogen*).

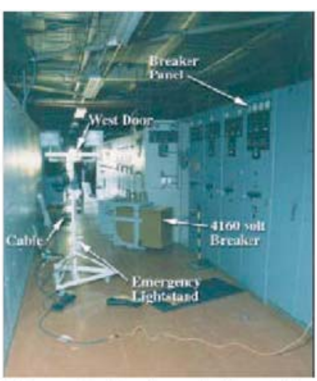


INCIDENT Slow rescue leaves one dead!!!

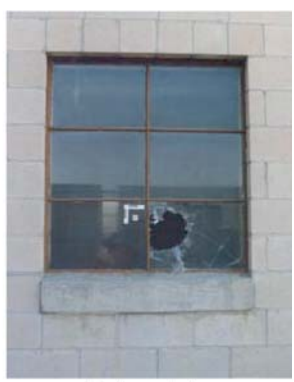
Thirteen contractor workers were engaged in de-energizing electrical circuit breakers in preparation for a preventive maintenance programme on the electrical systems inside a building. The electrical components inside the building were protected against fire by a CO_2 (Carbon Dioxide) fire suppression system. They sought to prevent accidental activation of this system, by disabling it electronically at the control panel thereby impairing the system, rather than physically removing the electric control heads from the CO_2 bottles (lock-out/tag-out).

While working on the circuit breakers, the CO_2 fire suppression system unexpectedly discharged high pressure carbon dioxide creating a lethal atmosphere deprived of oxygen, with near zero visibility. Witnesses described hearing a hissing sound and then a 'woosh', followed by 'total whiteout' conditions within seconds, in which they could not see anything at all.

Most individuals instinctively ran towards the open door by which they had entered. The escape necessitated groping along switchgear and moving around obstacles. One electrician describes running into something, falling down and then passing out as he took a breath of CO_2. Another electrician became entangled in an instrument cart and cable wires. He tripped, rolled, hit his head and passed out inside the building. One operator headed in a different direction and was unable to find a way out. In desperation, he put his hand through a thick glass window embedded with wire, sustaining severe arm lacerations and blood loss before losing consciousness. By this time eight individuals had escaped while five remained unconscious in the building. A call for help was made to summon the Incident Response Team from the Emergency Control Centre.



Switchgear looking towards the exit door



Broken window

The incident response team immediately prepared to set off but they could not open the garage door. The power had been shut off due to the preventive maintenance outage, and the standby diesel generator had not been started. The door could not be opened manually because the manual chain opener was inoperable.

(*continued*)

Meanwhile, initial responders at the scene searched for self-contained breathing apparatus to facilitate safe search and rescue but none were available in the area. Several dangerous attempts were made without the benefit of self-contained breathing apparatus to rescue the unconscious workers. Two unconscious workers near the door were retrieved this way.

After a delay of about five minutes, the diesel generator was started at the Emergency Control Centre and the garage door was finally opened. When the response team arrived at the accident scene, they found that eleven self-contained breathing apparatus had accidentally been left behind at the centre. Despite the setbacks, the last three unconscious workers were finally rescued but one worker died en route to the hospital.

The fire suppression system should have been physically isolated to prevent accidental activation in the first place, but the emergency response left much to be desired.

INCIDENT **Failure of safety showers during emergency!!!**

Two employees were exposed to a mixture of isobutene and hydrofluoric acid (HF). The release was the result of breaking containment on a line being replaced during turnaround. When the two employees accessed the nearby safety shower, no water came out of the shower head. One employee ran to another safety shower but this shower was also found to be not working. He was discovered by an operator and taken to the operators' change house where he received emergency treatment. The Emergency Response team was dispatched to assist the second employee.

The safety shower had been isolated and tests wrongly indicated that the showers were operational due to residual water in the emergency shower system.

Provide working fire extinguishers, showers, and eyebaths for quick initial response. Check that the recommended fire extinguishers for the job are used.

2.7 Documentation, communication and approval

The scope, hazards, controls and mitigation measures must be communicated in writing and signed off by all involved in the task.

It is vital for the safe execution of work that everyone involved is acquainted with:

- the identified hazards;
- likelihood of those hazards resulting in an incident or accident;
- controls and mitigation actions which have been applied to reduce the possibility of an incident or accident.

The person issuing the permit will need to confirm that the party accepting the permit:

- understands the scope and requirements of the work permit;
- is aware of adjacent activities and hazards;
- is shown the correct equipment addressed by the permit (which should be clearly identified);
- is able to identify when changes in the work environment cancels the work permit, and ceases all activity until a re-assessment has been completed;
- has a copy of the permit at the worksite at all times;
- knows the initial emergency actions.

The party accepting the permit must ensure that all involved in the work should sign to confirm that the scope, hazards, controls and mitigation measures have been communicated and understood. Permits need to be kept available until the completion of the work both:

- at the worksite by the Performing Authority for the benefit of workers, and;
- at the local control room by the Issuing Authority for the benefit of operators.

Operations and other relevant personnel need to be told of the impact and status of all work which may affect operations or other ongoing work.

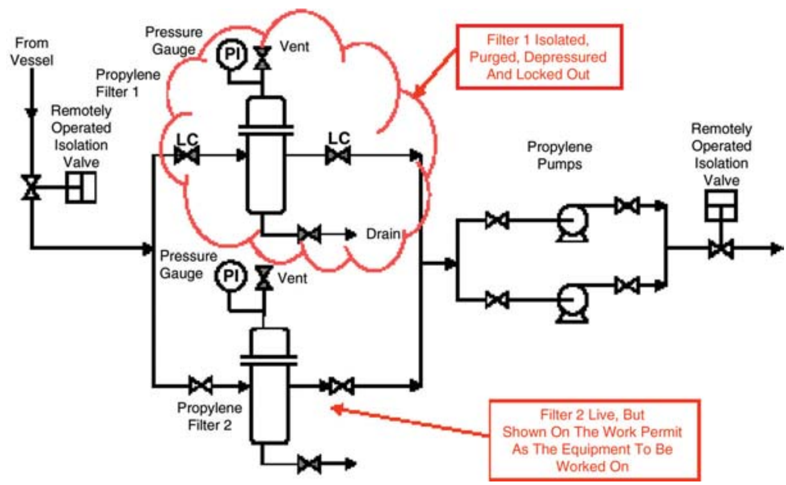
Those performing work at remote locations off-site must have the skills and competency to identify the required work scope, hazards, controls and mitigation measures. Regular communication should be established and maintained, and the permit requirements should be validated with another competent person.

It is not enough to merely tell a person something. There must be effective communication, with the other party fully understanding what is being conveyed and is able to demonstrate this. Poor communication has led to many incidents, including some catastrophic ones as demonstrated in the Piper Alpha incident on page 4.

INCIDENT **Poor communication results in breaking into live line!!!**

For a routine change of one of two parallel filters, Filter 1 had been locked out by operations, and a permit had been prepared and approved. Three contractor personnel assigned to the job then proceeded to work on the wrong filter. A propylene leak occurred and one of them sustained cold burns on his leg.

Filter 2 was in operation but was indicated in the Work Permit as the equipment to be worked on. The isolation certificate, which identified Filter 1 as being isolated, was not attached to the permit and the contractor personnel did not double-check to confirm that the equipment had been isolated. There had been no jobsite visit and the maintenance crew were not shown the equipment to be worked on, or all the isolations in place.



INCIDENT Struck by object!!!

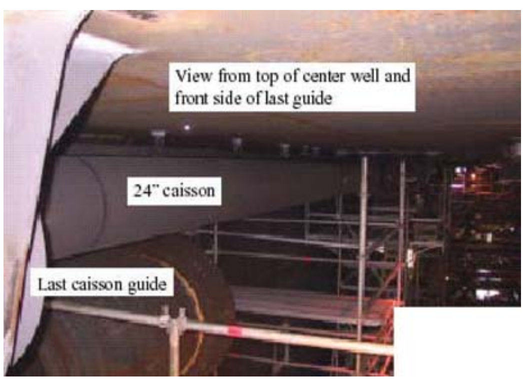
A centre caisson was being installed on an offshore installation at a construction yard. This process involved winching forward cables attached to the 24-inch (600 mm) caisson. A man was positioned to restrict access to the scaffolding in the area during the operation.

When the installation was 95% complete, the person guarding the access to scaffolding left his position. It appeared to him and his supervisor that the danger had passed.

An electrician, who was waiting to enter the scaffolding, saw that the guard had left and proceeded to climb the scaffolding to the centre well. He was preparing to lower a rope to his co-worker on the ground when the caisson was winched forward and struck him. He had head injuries as a result and died en route to the hospital.

No permit to work had been issued nor was any risk assessment undertaken for this operation. Simultaneous operations were taking place but no effort had been made to inform those likely to be in the area of the possible dangers of the operation, although the guard and his supervisor were evidently aware of the hazards. They came to the wrong conclusion that the situation was safe even though the installation had not been completed.

As a result of the incident, a formal safety plan was put in place and Job Safety Analyses (JSAs) were conducted for all hazardous jobs.



Remember to inform those likely to be affected by the work even though they may not be directly involved in the job.

2.8 Work monitoring and management

In order to protect those completing the work, it is essential that competent persons regularly visit and inspect the work site during work. This is to ensure that the conditions detailed on the permit have not been compromised and work is continuing in a safe manner. Only the work as described on the permit can be carried out.

All ongoing work requiring a permit must be regularly monitored and managed by a responsible person.

It is the responsibility of the authority issuing the permit to provide monitoring of the work and maintain regular communication with those performing the work. The responsible person charged with monitoring the ongoing work shall:

- identify when site conditions have changed;
- assess when the original permit no longer accurately covers the task, stop the job if necessary and request a reassessment.

Site conditions can change due to the work being performed or due to external reasons. Hot work such as welding can generate hazardous fumes, which should be removed using local exhaust if there is insufficient ventilation in the area (such as in a confined space).

For particularly risky operations, full time supervision must be provided. Competent persons should be stationed close to the work to watch for hazards and to provide immediate response in an emergency. Standby Persons for confined space entry and Fire Watch for hot work are such examples. These individuals must be fully aware of their responsibilities.

A Standby Person, Fire Watch, or persons in similar capacities, need to:

- prevent unauthorized entry into the work area;
- monitor the atmosphere constantly for combustible or toxic gases;
- remain alert to hazardous conditions;
- remain in constant communication with those performing work;
- quickly raise the alarm and shut down equipment in the event of an emergency;
- provide and inspect fire-fighting equipment and PPE;
- stop the job if conditions become unsafe;
- make sure that the area is evacuated safely in an emergency.

These individuals are sometimes given additional tasks to perform such as wetting down the work area and quenching sparks. However, the standby person for confined space entry is required to monitor the entrants constantly and can never abandon their post to perform other activities. The main purpose of having an additional person is to watch over the safety of individuals performing the work and to provide immediate assistance (for example, extinguishing fire, summoning help) when required.

Precautions against potential for residual hazards for hot work include:

- restriction on tools, equipment and methods to be used;
- awareness of hidden pockets of hydrocarbons, such as in linings;
- precautions for interactions with other work;
- PPE to be worn;
- safe location of equipment, such as welding machine;
- hazard monitoring requirements;
- standby fire equipment.

Monitoring requirements for hot work include:

- repeat gas test or continuous gas monitoring;
- Fire Watch;
- hot work must STOP immediately if general alarm sounds;
- everyone has a duty of care to consider the effects of any changes that could impact the work being undertaken;

Refer to BP Process Safety Booklet *Confined Space Entry* for information on monitoring and managing confined space work.

If there is an interruption or break in work, the site conditions and appropriate control measures must be reassessed before work is allowed to re-commence. At shift change, the hand-over arrangements between all involved in the work must include the status of continuing work, a re-appraisal of site conditions, and the appropriate control measures before work can restart. The status of permits, including a register of inhibits/overrides/isolations, should be accurate, up to date, and available at a designated location for reference.

INCIDENT **Near-miss: Nitrogen blown into confined space!!!**

Conditions inside a knockout drum became hot and dusty during the course of work. Contractors who had been working inside the vessel reversed the direction of the eductor located on the manway before taking a break. They thought to blow air into the vessel to cool it down during their break. (Plant air is normally used to drive the eductors during turnarounds.)

While the contractors were on their break, a safety representative noticed that the eductor was operating in the reverse direction. He immediately removed it from the manway and performed an atmospheric gas test. The oxygen inside the vessel was found to be unacceptable for confined space entry (less than 17% O_2) and the confined space permit was immediately withdrawn.

It was discovered that the eductor air driven hose was connected to the refinery's nitrogen distribution header, instead of the air distribution header.

If there is an interruption or break in work, the site conditions and appropriate control measures must be reassessed before work is allowed to re-commence.

Anyone can and should stop the job if they detect a hazard that compromises safety.

INCIDENT **Contractor lights cigarette while colleague cleans his hands with flammable solvent!!!**

The basement of an office building, storing large quantities of paper, was being used as a temporary changing room by a paint contractor. Two of the contractor's men were in the basement just before the fire occurred. It seems that one of them was cleaning his hands with flammable solvent while the other lit a cigarette! A serious fire broke out, severely damaging the basement and letting off copious amounts of black smoke. The fire was only put out by flooding the basement. Fortunately the two men escaped unhurt.

Smoking is strictly prohibited in all non-designated smoking areas, especially where flammables are likely to be present!

2.9 Safe conditions on completion/ interruption of work

Check that the work site has been left in a safe condition on completion or interruption of work.

On completion or interruption of any work activity, the worksite should be visited by a competent person to ensure that no potential sources of accidents remain and that the equipment can be safely brought back into service without incident.

Where the interruption is an emergency, inspection and confirmation that safe conditions exist at the work site should be undertaken after the emergency has been cleared.

When the work has been completed, the area should be cleared of any tools, rags, rubbish, etc. The area should be cleaned if necessary and any equipment that has been isolated should be de-isolated. The Control of Work process includes de-isolation, reinstatement and testing of the system's integrity.

When safe conditions are confirmed upon completion of work, the permit can then be closed by the appropriate authority. Permits must be signed off and the master copy kept on file. All other copies should be withdrawn or destroyed when the job is finished. There must be no confusion as to whether a permit is valid. Several incidents have happened where an 'old' permit was thought to be valid, and equipment that had been recommissioned and ready to run, was worked on in error.

Originals of permits must be kept at least three months for auditing purposes and in some cases may need to be kept longer by local law (for example asbestos removal).

Special care must be exercised when the permit is handed back and the work is incomplete. It is important that the operating staff are aware of any restrictions on the use of the equipment.

Better procedures for control of incomplete work would have prevented the Piper Alpha tragedy (see page 4).

INCIDENT **Expired permit!!!**

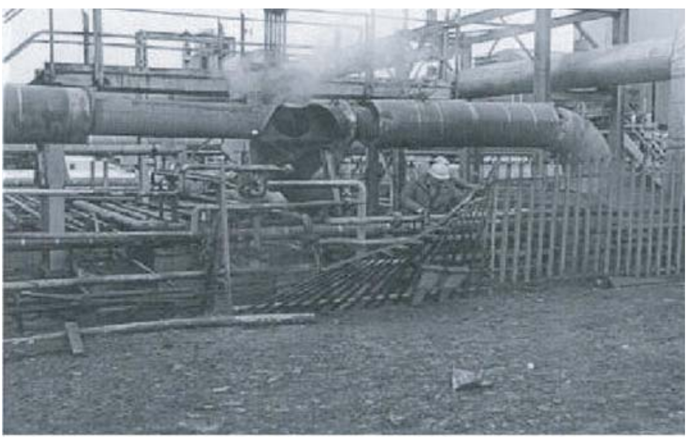
Work, correctly authorized by permit, was being carried out on an ammonia convector heater. The permit expired at 1600 hours on Friday evening. On the following Monday morning, a welder, who claimed to have personally seen a permit (probably the one which had expired) went to the top of the vessel and started welding. A relatively small gas explosion occurred, but no one was hurt.

INCIDENT Condensation induced water hammer!!!

An 18-inch (450 mm) steam line running very close to a major public road failed catastrophically when a water hammer in the pipe burst the line. This incident resulted in injury to a pedestrian walking his dog who was around 300 m (1000 ft) away. He was so shocked when he heard the loud noise that he tripped and cracked three ribs!

A 'condensation induced water hammer' occurs when a steam pocket is totally entrapped in sub-cooled condensate. When the steam rapidly condenses, giving off heat to its surroundings, it induces a sudden pressure drop. The surrounding liquid rushes in to fill the low pressure void, generating an overpressure that reverberates throughout the section of pipeline. It was this phenomenon that damaged the steam line.

This incident occurred because the steam trap had been isolated for inspection work and had ***not*** been de-isolated after the work was complete.



Ruptured steam pipe by the facility boundary

Refer to BP process safety Booklet *Hazards of Steam* for more details on this (and other) steam-related incidents.

Pay as much attention to specifying and checking the correct de-isolations on completion of work as is given to performing the isolations in the first place.

INCIDENT Three children drown in temporary drainage pit!!!

A well location was being prepared for an upcoming rig operation. Standard layout design called for a site clearance and a perimeter drainage ditch to be excavated. The excavation work included a catch-pit (4 m × 4 m × 2 m or 13 ft × 13 ft × 7 ft) at the low point corner to collect water runoff. The catch-pit quickly filled up during the heavy rains. On the day of the incident, the crew left for lunch and a group of children returning home from school decided to go for a swim in the water-filled pit. Three children, aged seven, nine and ten drowned. A fourth ran to get help. Contract workers recovered the bodies from the pit and attempts at resuscitation failed.

The excavation had not been barricaded to prevent trespassing or an accidental fall into the pit. Safe conditions had not been established after the excavation work was completed.

Three young children tragically drowned in this pit. The pit had not been barricaded to prevent access. No signage had been put up to warn against entry (for example, deep water, keep out, no swimming, no fishing, etc.).
As can be seen in the picture, there is no way of telling how deep the pit is as the bottom is obscured by muddy water.

2.10 Auditing the Control of Work process

The Control of Work process must be subjected to a program of regular auditing.

Auditing is a systematic, independent review to verify conformance with established guidelines, procedures or standards. It is used to measure the status and effectiveness of the system against its goals.

Auditing is important because it provides feedback for improvement, reinforces accountability and instils awareness into the plant culture. An independent review provides a higher level of confidence in the Control of Work programme.

A programme of regular auditing should be established to maintain a consistently high standard of application of the Control of Work process. The audits should review and make recommendations for improvements on the correct application of the Control of Work process, including all documentation, controls, training and competency. Any discrepancies noted should be communicated to the site management with a requirement that corrective action plans are developed and that actions are closed out in a timely manner.

Audits must be performed by at least one person knowledgeable in the process. It can be performed with varying degrees of independence—first party, second party, or third party. A written report is required and all recommendations must be resolved promptly and documented. Mini-audits can be performed as part of an ongoing programme.

INCIDENT **Regular safety audits are useless if done poorly!!!**

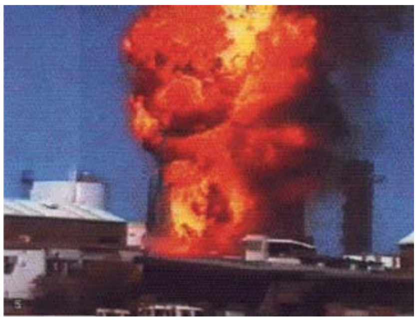
The immediate cause of the Piper Alpha incident discussed on page 4 was the start-up of a condensate pump from which the relief valve had been removed for maintenance, which had not been communicated through to the next shift.

One of the underlying causes that allowed this to occur was the failure of the audit programme to identify problems with the application of the permit system and to initiate an effort to rectify the deficiencies. Even though regular safety audits of the facilities were carried out, they were not performed well. Few, if any, problems were ever identified. Audits are of no use at all if they are not performed well.

Audit results must be recorded, analysed, and used to improve the management and quality of the Control of Work process.

INCIDENT **Accurate audits are important!!!**

A major explosion and fire occurred at a gas processing site, resulting in two deaths and eight injuries. The fire burnt for two days before being declared extinguished. Gas supplies were reduced and 250,000 workers were sent home across the state as factories and businesses were forced to shut down. The gas restrictions were estimated to cost the State's industry over a billion dollars in lost production.



The immediate cause of the incident was a gas release from a heat exchanger rupture due to low temperature brittle failure. A summary of the systemic causes, as determined by an enquiry commission, is as follows:

- The management system manuals were repetitive, circular and contained unnecessary cross references, which made the system difficult to understand by both management and operations personnel.
- No HAZOP study had been performed for the gas plant in question.
- There was no training of personnel with respect to the hazards involved.
- Operators, supervisors, and superintendents were not aware of the dangers and these were not referenced in the operating procedures.
- Ineffective shift handovers and logbook entries.
- Inadequate application of Management of Change.
- Process upsets were rarely, if ever, the subject of an incident report unless they were accompanied by injury to persons or damage to property.

An external assessment of the application of the management system at the site had been carried out six months prior to the accident. The assessment report found that the management system programme at the plant had been successfully applied. This was inconsistent with the enquiry commission's findings. It was concluded that the methodology used by the assessment team was flawed. The assessment had failed to identify the significant deficiencies in the implementation of the management system.

Audits are opportunities to correct faults in the system and should not be seen as a 'blame game'.

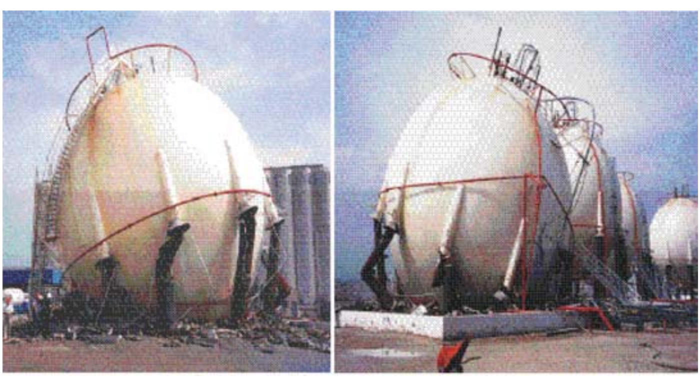
2.11 Lessons learned

'There are no new accidents . . . only repeats of those we failed to learn from'. This well-known quote clearly states that we do not invent new ways of making mistakes or creating incidents. All the incidents we have today are in many ways similar to past accidents. They contain causes and contributing factors that have been identified in previous incident investigations. Hence it is important to learn from past accidents.

INCIDENT **Collapse of LPG sphere supports in 2000 results in fatality!!!**

A 20-year old, 12,580 bbls (2000 m^3) sphere was taken out of service for an internal inspection and hydrotest. It was approximately 75% full of water when the legs collapsed. The legs of the sphere were coated with fire-proof concrete and salt water was used in the water deluge fire protection system on the spheres. The legs had suffered severe corrosion underneath the fireproofing. The structural failure resulted in one death and one injury.

The risk assessment for the task did not consider the failure of the structure during hydrotest. This was why the inspector was allowed under the equipment during the test.



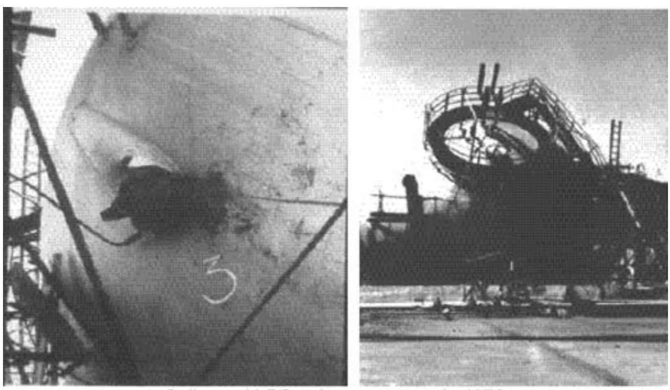
Collapsed LPG sphere supports in 2000

INCIDENT **Collapse of LPG sphere supports in 1972 results in injuries!!!**

A similar incident had occurred in 1972 when repairs were made to the legs of a storage sphere. The hortonsphere involved was designed to withstand a hydrostatic test at the construction stage. However, the deterioration of the support legs underneath the fireproofing over a number of years had reduced their load bearing capacity and the sphere subsequently collapsed.

A cloud of LPG vapour formed over the pipetrack and was ignited, probably by broken welding leads. One welder sustained multiple bruises and seven other employees had minor injuries or suffered slight gassing while escaping over the bund wall.

NOT "LESSONS LEARNED"



Collapsed LPG sphere supports in 1972

Ensure that internal and external lessons learned that impact the Control of Work process are captured, incorporated and shared.

Before the start of any work, it is beneficial to carry out research. The research includes checking if there were any serious accidents associated with similar work as well as incident investigation/root cause analysis.

All major incident lessons should be reviewed for relevance.

NOT "LESSONS LEARNED"

Industry databases and safety alerts provide a substantial resource for use in checking of incidents relating to specific activities or facilities. Reference to internal resources (e.g. BP Refineries Quarterly Safety Bulletins and BP Lessons Learned Intranet site on http://safetylessons.bpweb.bp.com or industry databases such as the ICheme Loss Prevention Bulletin past issues) can be particularly useful. Have you ever referred to these valuable resources before undertaking a new or unfamiliar task?

INCIDENT Crane overturns on soft soil!!!

A crane was helping in soil compaction on a petrochemical plant construction site. It was working on soft soil when it started to list. After 15 minutes, it fully overturned. There was extensive damage to the crane but fortunately no one was injured. No precautions had been taken for the work on the non 'hard-stand' area.

Overturned crane at construction site

INCIDENT Less than 12 months later . . . !!!

Less than 12 months after the crane had overturned on soft soil, a pile-driving rig overturned at the same site.

Fallen pile-driving rig

The partially crushed cab

Due to poor soil conditions, steel mats had been used to provide a stable surface for work. When the steel mat on which the rig was resting sank more than expected, the rig began to list. A foreman, standing on an adjacent mat saw this and alerted the rig driver to move his vehicle, but it was too late. The rig fell to the ground, across the mat on which the foreman was standing. Fortunately, he was able to jump out of the way just in time. The cab of the rig was partially crushed but the driver managed to crawl uninjured out of a broken window. Since this was the second such incident at the site in less than a year, it was apparent that the lessons from the first incident had not been well learned. Appropriate management controls had not been implemented as a follow-up to the initial vehicle overturn incident.

It is important that actions taken to rectify problems are robust and provide long-term solutions.

INCIDENT Fatality during offshore lifting operation!!!

During a routine offshore lifting operation, which involved lifting of a 43-foot (13 m) basket from one vessel to another, the basket slipped. It struck a contractor who had moved into the riser bay area. He suffered fatal injuries.

This incident occurred because the load within the basket was off-centre. This caused an uneven lift, resulting in several failed attempts to land the basket in the right position. This situation should have been identified as a Management of Change issue. Equipment such as support beams, sea fasting, etc., should also be in place to ensure safe lifting.

Load was off-centre within the basket

Result of stacking of basket with imbalanced load

INCIDENT Another offshore lifting fatality!!!

Another lifting operation, this time involving the unstacking of chemical pods, resulted in another fatality just eight months after the previous accident. Two chemical pods were stored on top of each other, and the top pod was to be removed. A rigger climbed up the ladder on the side of the pod to hook the chain sling, after which he signalled for the crane pendant to be lifted. As the pendant was raised, one end of the pod was lifted. When the pod cleared the stacking lugs, it started to slide and toppled over. The rigger was caught between the falling pod and the adjacent container, and died from fatal chest injuries.

Stacking of chemical pods of this type or similar design makes them potentially unstable when stacked on top of each other. The retaining mechanism provided is insufficient to prevent sliding of the pod when a force is applied on an empty pod.

It was found that the stacking lugs were inadequately designed to prevent sliding. Hence, had lessons from the previous accident been learned and adequate equipment used to secure the pods and prevent sliding/slipping, this accident would have been prevented.

An implementation plan for an identified lesson learned should be documented and audited.

Since many accidents are repeats of accidents that have occurred before, we should all take the time to review, document, and learn from accidents, including near-misses and unsafe acts.

Tool box talks are an extremely useful way in which to pass on learnings from previous incidents.

- The two incidents (one in the US and one in Europe) described below illustrate the inherent ignition hazard that is constituted by the truck engine (see also similar incident described on page 38):

INCIDENT Fatal fire when vacuum trucks discharging hydrocarbons

A vapour cloud deflagration and fire occurred at a basic sediment and water disposal facility. The fire was caused by the release of hydrocarbon vapour during the unloading from two vacuum trucks into an open collection pit. As a result, three people were killed and others were seriously burned.

Each truck's engine provided a number of possible sources of ignition. (Flammable vapour can be drawn into the air intake in direct contact with a source of ignition—the engine's combustion chamber. Diesel engines have the ability, due to their compression ignition cycle, to continue to run on flammables even with the normal fuel system shut off. This can cause destruction of the engine itself through overspeeding. Diesel exhaust systems operate with a normal surface temperature of 300–500°C (572–932°F). Such temperatures and surface areas will ignite flammable/air mixtures.

Reference: US Chemical Safety and Hazard Investigation Board Report No. 2003-06-I-TX dated September 2003.

INCIDENT Explosion of a pickup truck that entered a flammable cloud from a vacuum truck vent

An explosion and fire occurred in the engine compartment of a diesel pick-up truck after the engine was switched off. However, it kept 'running/ racing', emitting thick black smoke at the exhaust. The pick-up truck was parked adjacent to an operating vacuum tanker/truck. At the time, the vacuum tanker was removing a large quantity of gasoline from a pipeline via an open trough in preparation for a pipeline modification (See picture). Fortunately, there were no injuries.

CCTV security camera picture showing the vacuum truck and the pick-up truck when the pick up engine exploded.

(*continued*)

- The vacuum tanker's exhaust vent hose was laid on the ground only 4m (13ft) away.
- No warning signs or barriers were placed around the vacuum tanker to warn of a potentially hazardous area.
- An unexpected large quantity of gasoline had to be removed from the pipeline through a split flange into an open trough in the tank farm.
- The area was adjacent to a car park where there was no control over any potential sources of ignition.
- The pick-up truck was not fitted with an automatic over-speed protective device or a spark arrestor.

Incident investigations

An incident is 'an unplanned event with potential for undesirable consequences'. Incidents include both accidents and near-misses. The undesirable consequences include such things as injury, death, loss or damage to property, release of hazardous materials, etc.

An incident investigation is the process of gathering and analysing evidence and developing conclusions and recommendations to control or eliminate a recurrence. It should not be limited to incidents and should also be extended to near-misses.

The incident investigation process is important because:

- it provides information about the causes of each incident (apparent cause and underlying [root] cause);
- it provides the basis for corrective action;
- it provides an opportunity to prevent similar occurrences.

Incident investigations must be documented and lessons shared to achieve the above benefits.

The objective of an incident investigation is not to assign blame but to uncover the root causes and other factors that contributed to the incident.

Once an incident has occurred, investigations must begin as soon as possible, preferably within 24 hours. The investigation team must be multi-disciplined, with at least one member trained and knowledgeable in the process involved and others with appropriate knowledge and experience. Consideration should be given to include safety/HSE representatives. If contractors were involved in the incident, a contractor employee should form part of the investigation team.

An investigation report, as a minimum, should include the following:

- date of the incident;
- date the investigation started;
- description of the incident;
- root causes and contributing factors;
- any recommendations.

The recommendations need to be clearly documented, and the findings and recommended actions communicated to all affected persons.

2.12 Obligation and authority to stop unsafe work

Everyone has an obligation and the authority to stop unsafe work. The Control of Work procedure must make this clear.

INCIDENT **Alert lead technician saves the day!!!**

The process unit had two 480 volt breakers and junction boxes (‘A’ train and ‘B’ train) for the installation of portable chillers. One of these breakers had been locked out and a hot work permit issued to terminate a temporary power cable on a portable chiller.

While technicians were working on the junction box on the ‘B’ train, a lead technician decided to check that the correct breaker was locked out. Upon noticing that the breaker on the ‘A’ train had been isolated instead, he stopped all work at the ‘B’ train junction box. After verification that the wrong breaker had indeed been locked out, all permits for the job were cancelled. The actions of the lead technician saved the technicians working on the live junction box from possible electrocution. This incident could have resulted in death or serious injuries to personnel.

Monitor both yourself and other people conducting work to ensure that no hazards are created and that conditions remain safe.

INCIDENT **Unfamiliar vessel crew found to be untrained!!!**

A vessel had been chartered through a contractor to load acrylonitrile. Acrylonitrile is a highly toxic and flammable chemical capable of causing fatalities at low concentrations.

The vessel arrived at a terminal to receive a load of acrylonitrile. Seeing an unfamiliar vessel, personnel at the terminal decided not to proceed with loading before questioning the crew. It was found that the vessel's crew had no previous experience in loading acrylonitrile nor had they received any training on product handling or the use of appropriate PPE. The vessel was not equipped with the specified emergency kit to treat acrylonitrile poisoning and the crew were not familiar with the emergency response protocols!

Had the loading proceeded without first questioning the crew, they would likely have suffered adverse health effects if a spill or leak had occurred.

3 Glossary

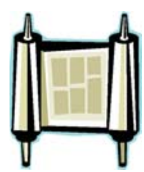
Accountable	The person in the organization who has ultimate responsibility
ALARP	As Low As Reasonably Practicable
Competent Person	A person who has demonstrated that they have the knowledge, training and experience required to perform the defined role to the standard required
CO_2	Carbon Dioxide
CoW	Control of Work
HAZOP	Hazard and Operability (Study)
HF	Hydrofluoric Acid
HSE	Health, Safety and Environment
IChemE	Institution of Chemical Engineers, UK
JHA	Job Hazard Analysis
JSA	Job Safety Analysis
LEL	Lower Explosive Limit
LOTO	Lock-out and Tag-out
MSDS	Material Safety Data Sheets
PPE	Personal Protective Equipment
PTW	Permit to Work
QRA	Quantitative Risk Assessment
Responsible	An individual who has been deemed trained and competent, and has been given specific areas or actions by an accountable person
Roles	The documented description of those people's functions within a management structure
SIMOPS	Simultaneous Operations
Single Point Accountable	The person in the organization (site/business unit) who has been appointed as being accountable for the delivery and performance of an activity.

4

Some points to remember

1. A written procedure describing the Control of Work process must be readily available to all employees involved.
2. It should be reviewed as often as necessary to reflect current practice and conditions.
3. Any changes to the written procedure must be subject to a strict document control procedure.

4. Prepare procedures with the target audience in mind. Make sure that they are available in the common (or dual) language and written so that there can be no misinterpretation.



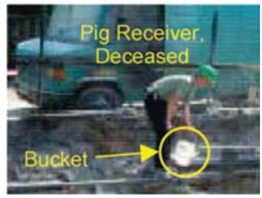
5. All identified roles within the Control of Work procedure must have clearly defined accountabilities.

6. The level of authority for approval to proceed with work must match the level of risk involved.

7. It is the owner's responsibility to ultimately oversee the work of the contractor and their subcontractors!

8. All persons involved in the Control of Work process must be appropriately trained and competent to carry out their roles.

9. Always take time out to properly plan an activity. The planning and scheduling of work should take into account the individual tasks and their interaction with other ongoing activities.



10. Can the hazardous task be performed in an alternative, less hazardous way? If so, examine the advantages and disadvantages before deciding to proceed with the work.

11. Do not neglect to perform risk assessments on any new or modified tasks.

12. Tasks must not be conducted without being properly risk assessed.
13. Assess and manage the risks presented by extended hours of work.

14. Ensure that the persons performing the risk assessment for the job are competent and have the necessary knowledge in the field of operation to be assessed and in the risk assessment technique being used.

15. All equipment used in performing work must be assessed as fit for the work purpose by a competent person through inspection and/or review of any certification.

16. Do not wait for an accident to occur before taking steps to eliminate or reduce a hazard at its source.

17. Personal Protective Equipment (PPE) should be considered as the last barrier of protection before a person is exposed to a hazard. As such, reliance can only be placed on PPE after efforts have been made to eliminate or reduce the hazard.

18. Check that emergency response plans, based on potential emergencies, are in place before starting work.

19. It is necessary to train personnel to be aware of risks in the workplace and be able to assess them.

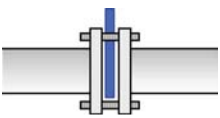
20. Always obtain a permit before conducting any work that involves confined space entry; work on energy systems; ground disturbance; hot work; or other hazardous activities.

21. Only perform work covered under the task description of the permit. Any other work would not have been checked for hazards!

22. When working under a Permit to Work, ensure that the PPE issued is suitable for the task being performed.

23. Do not take shortcuts with the Permit to Work procedures. The procedures must be maintained at all times!

24. The extent of isolation must match the risks associated with the possibility of the isolation failing. All isolations must be proved by test starts or the use of test and drains valves.



25. Blanks, blinds, and spades should have full pressure rating for the system they are being installed in.

26. Always assume that a pipe contains residual liquid/gas under pressure when breaking containment and wear the appropriate PPE as a last line of defence against an incident.

27. Means of verifying that a system is depressurized and drained must be included as part of the design and maintenance procedure, and must be subject to a risk assessment.

28. Use the correct gas detector to test for flammable gas. If you have purged a space with nitrogen, check that the flammable gas detector you plan to use is suitable for inert atmospheres.

29. Ensure that gas test results comply with work and permit requirements. If not, more has to be done to bring it to acceptable levels (for example, improve ventilation, check isolation).

30. The work site should always be inspected by a competent person before the permit is issued to ensure that conditions are safe and have not materially changed.

31. Check that all hazardous energies are controlled or eliminated. There is no substitute for walking around the isolated equipment to check each connection and verify positive isolation.

32. The scope, hazards, controls and mitigation measures must be communicated in writing and signed off by all involved in the task.

33. Remember to inform those likely to be affected by the work even though they may not be directly involved in the job.

34. All ongoing work requiring a permit must be regularly monitored and managed by a responsible person.

35. If there is an interruption or break in work, the site conditions and appropriate control measures must be reassessed before work is allowed to re-commence.

36. Anyone can and should stop the job if they detect a hazard that compromises safety.

37. Check that the work site has been left in a safe condition on completion or interruption of work. Ensure that operational staff are aware of any restrictions if the work is incomplete.

38. Pay as much attention to specifying and checking the correct de-isolations on completion of work as is given to performing the isolations in the first place.

39. The Control of Work process must be subjected to a programme of regular auditing.

40. Audit results must be recorded, analysed and used to improve the management and quality of the Control of Work process.

41. Audits are opportunities to correct faults in the system and should not be seen as a `blame game'.

42. Ensure that internal and external lessons learned that impact the Control of Work process are captured, incorporated and shared.

43. All major incident lessons should be reviewed for relevance.

44. An implementation plan for an identified lesson learned should be documented and audited.

45. Tool box talks are an extremely useful way in which to pass on learnings from previous incidents.

46. Everyone has an obligation to stop unsafe work. The Control of Work procedure must make this clear.

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Test yourself!

1. There are 10 elements in the Control of Work Standard.

   True ☐ **False** ☐

2. There must be a written procedure for the Control of Work, issued in accordance with the Document Control Management System.

   True ☐ **False** ☐

3. All roles and responsibilities required to operate the Control of Work procedure must be identified and communicated to the designated persons.

   True ☐ **False** ☐

4. A Single Point Accountable person must be assigned to look after the management of the Control of Work process.

   True ☐ **False** ☐

5. The Control of Work Standard should also be applied to work undertaken by all contractors and their subcontractors.

   True ☐ **False** ☐

6. Those persons designated to operate the Control of Work procedure need to be competent to carry out their roles. A competent person is one who has been trained and has the necessary experience.

   True ☐ **False** ☐

7. Competency in a task, once demonstrated, does not need to be checked regularly.

   True ☐ **False** ☐

8. The impact of any Simultaneous Operations (SIMOPS) needs to be considered when planning and scheduling any work activities.

   True ☐ **False** ☐

9. Risk assessments only need to be applied for capital works projects and not for non-routine tasks.

   True ☐ **False** ☐

10. A new or modified task that is considered simple does not require a risk assessment.

    True ☐ **False** ☐

11. The worksite should be inspected by a competent person before conducting a risk assessment to capture the hazards arising from features of the premises.

True ☐ **False** ☐

12. There is no need to waste precious time by involving in the risk assessment members from the team assigned to perform the work.

True ☐ **False** ☐

13. Measures to reduce risk are considered in the following order: a) Elimination; b) Substitution; c) Control; d) Mitigation

True ☐ **False** ☐

14. A permit is not required when performing cold work as it has no potential of creating an ignition source.

True ☐ **False** ☐

15. Only work under the task description of the permit can be performed.

True ☐ **False** ☐

16. The flammable gas detector used must be suitable for inert atmospheres if a space has been purged with nitrogen.

True ☐ **False** ☐

17. The worksite must be inspected by a competent person before permit issue to ensure that all the requirements stated in the permit have been fulfilled and that conditions have not materially changed.

True ☐ **False** ☐

18. An emergency response plan must be in place before the start of work.

True ☐ **False** ☐

19. Communication of the scope, hazards, controls and mitigation measures can be given verbally to all involved in the task.

True ☐ **False** ☐

20. All ongoing work requiring a permit needs to be regularly monitored and managed by a responsible person.

True ☐ **False** ☐

21. Only the Permit Issuing Authority can stop hot work if a flammable atmosphere is detected. The Fire Watch’s job is only to extinguish fires that break out.

True ☐ **False** ☐

22. There is no need to reassess the site conditions if an interruption (such as break for lunch) is for a period of less than 30 minutes.

True ☐ **False** ☐

23. Hand-over arrangements for continuing work, such as at shift change, must include all those who are involved with the work.

True ☐ **False** ☐

24. On completion of work, the worksite must be visited by a competent person to ensure that no potential sources of accidents remain and that equipment can be safely brought back into service without incident.

True ☐ **False** ☐

25. Audit results are unimportant if the responsible persons involved in the Control of Work process are satisfied with the performance of the system.

True ☐ **False** ☐

26. Internal and external lessons learned that impact the Control of Work process must be captured, incorporated, and shared.

True ☐ **False** ☐

27. It is useful to examine the lessons learned from relevant incidents when preparing to start work.

True ☐ **False** ☐

28. You have no obligation to stop work which you notice is unsafe when you are directly involved with the work activity.

True ☐ **False** ☐

ANSWERS
1F/2T/3T/4T/5T/6F/7F/8T/9F/10F
11T/12F/13T/14F/15T/16T/17T
18T/19F/20T/21F/22F/23T/24T
25F/26T/27T/28F