The Process Safety Booklet Series: (grey books)

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4. Safe ups and down (2003)
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6. Hazards of steam (2003)
7. Safe handling of lights ends (2004)
8. Safe operation of refinery steam generators and water treating facilities
9. Engineering for safe operation
10. Hazards of Nitrogen, safe handling of catalysts (2004)
11. Hazards of trapped pressure / vacuum (2003)
12. Tank farm and (un)loading safe operations (2004)
13. Safe handling of hazardous petroleum products (2004)
14. Integrity management: learning from past major industrial incidents (2004)

0. Hazards of Ammonium Nitrate

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A. Confined Space Entry (2004)

safety
sharingtheexperience

Confined Space Entry

Safety Booklet A

safety
sharingtheexperience

improving the way lessons are learned through people, process and technology

Confined Space Entry

Booklet A in a series designed to point out potential hazards in refineries, petrochemical plants and related operations and suggest ways and means of correcting or eliminating them.

"It should not be necessary for each generation to rediscover principles of process safety which the generation before discovered. We must learn from the experience of others rather than learn the hard way. We must pass on to the next generation a record of what we have learned."

- *Jesse C. DUCOMMUN*

First Edition 2004.

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CONFINED SPACE ENTRY

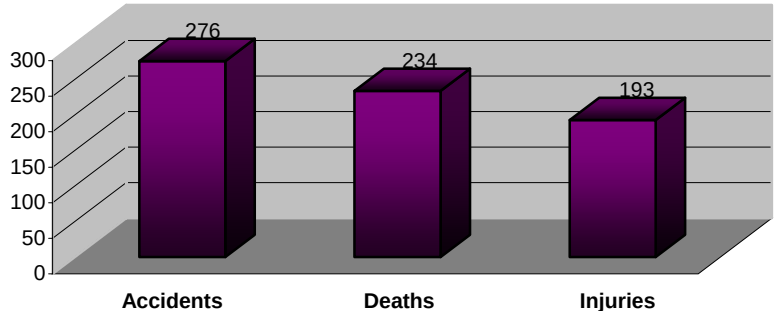
1.0 CONFINED SPACE

1.1 Introduction

It is said that for every person killed in a confined space, nearly two are would-be rescuers. Confined space accidents are responsible for many multiple fatality and injury cases in the industry and many of the victims have died trying to rescue fallen colleagues.

A study conducted by a national agency for occupational health and safety established that an astounding 234 deaths and 193 injuries resulted from 276 confined space related accidents that were reported over three years. These figures alone demonstrate the deadly potential of confined spaces. Assuming that not every accident resulted in an injury or death, which is likely the case, a number of these accidents would have had multiple deaths or injuries.

Number of Accidents, Fatalities and Injuries over a 3-year Period
(As reported by a national occupational safety and health agency)

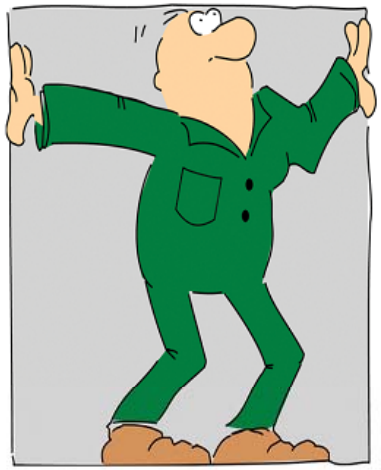


It is estimated that millions of workers may be exposed to hazards in confined spaces each year. Investigations of accidents find that workers often do not recognize that they are working in a confined space, and that they may encounter unforeseen hazards. Specifically in the UK, 15 deaths per year occur on average.

This booklet is intended as a safety supplement to training courses for operators, engineers, and technicians, operating manuals, and operating procedures. It is a compilation of recent experience on confined space entries in the hope that we may increase the awareness of confined space hazards and avoid confined space accidents altogether. This booklet only provides guidance and does not replace site procedures and specific risk assessments. Readers are encouraged to read the reference publications listed in Chapter 8.0 for more information.

1.2 What is a Confined Space?

A confined space is an area that is partially or fully enclosed, where there is a risk of serious injury or death from dangerous conditions.



Characteristics of Confined Spaces

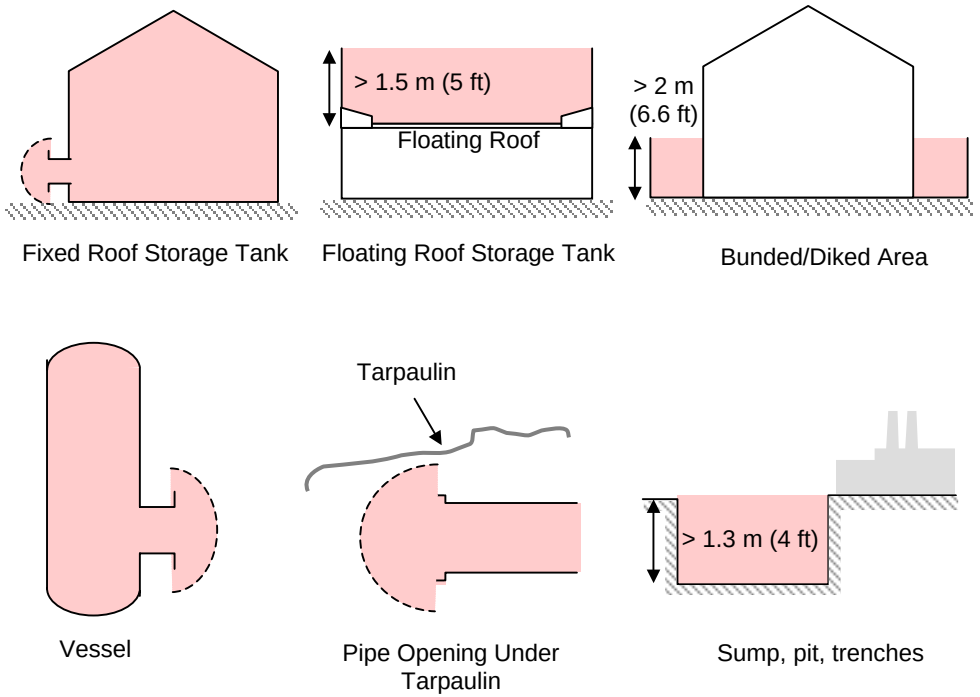
- Limited openings for entry and exit
- Large enough to enter at least partially
- Not designed for continuous human occupancy
- Inadequate natural ventilation
- Contains potentially toxic and/or hazardous atmospheres

1.3 Confined Space Locations in Processing Plants

Some confined spaces are easy to identify, such as storage tanks and reaction vessels, while others can be less obvious but equally dangerous (for example, open-topped chambers and areas under tarpaulins).

Listed below are some examples of confined spaces. They may not always be confined spaces but may become confined spaces under certain circumstances. Can you add to the list?

Storage Tanks	API Separators	Trenches (>1.3 m [4 ft] deep)
Vessels	Ducting	Floating Roofs (> 1.5 m [5 ft] from the rim)
Furnaces	Tunnels	
Towers	Pits	Bunded/Diked Areas (wall height > 2 m [6.6 ft])
Drums	Wells	
Piping Systems	Containers	Temporary Enclosures (e.g. for asbestos removal)
Boilers	Underground Sewers	
Extruder Houses	Catalyst Preparation Buildings	Rooms During/After Spray Painting
Laboratories	Analyser Houses	



Examples of Typical Confined Spaces

1.4 Hazards of Confined Spaces

Confined spaces are potentially hazardous due to the substances they may contain and the nature of the activities undertaken within the space. Poor natural ventilation in these areas allow the buildup of high concentrations of substances which are not usually found in normal, breathable air.

Several key aspects of the atmosphere inside confined spaces must be considered. They are:

- Low Oxygen Level
- High Oxygen Level
- Flammable Atmosphere
- Toxic Atmosphere
- Ingress of Liquids or Free-Flowing Powders

These conditions can be highly lethal and have frequently resulted in serious injuries and deaths upon entry when proper safety measures have not been used.

Other hazards associated with confined spaces are:

- Slippery and uneven walking surfaces
- Obstacles within the space
- Poor lighting and visibility
- Electricity
- Excessive noise
- Excessive heat
- Engulfment
- Drowning in deep pockets of liquids
- Radioactive level gauges
- Hit by falling objects
- Presence of internal equipment/machinery (mixers, heat exchangers, etc.)
- Difficult access and egress
- Falling from height (columns, etc.)
- Pyrophoric materials
- Corroded walkways or objects
- Bacteriological risks (legionella, etc.)
- Animals (snakes in pits, etc.)

Many of these hazards are made worse than usual when associated with a confined space.

Some areas may not seem like confined spaces but may be designated so because of the presence of specific hazards such as:

- Room protected by a total flooding fire fighting system
- Fin-fan cages, etc.

1.4.1 Low Oxygen Level

Low Oxygen Levels are produced through:

- Displacement
- Depletion
- Chemical Reactions

Gases such as methane or nitrogen can displace oxygen, creating oxygen deficient atmospheres. They may be used intentionally to prevent the formation of flammable mixtures inside a storage tank.

Oxygen deficient atmospheres can also be the result of depletion through work performed (e.g. welding) or chemical reactions (e.g. rusting within a tank).

Human beings are highly susceptible to asphyxiation through oxygen deficiency. A person deprived of sufficient oxygen may not be able to move, be unable to rescue himself or herself, and display a lack of concern about an imminent loss of consciousness.

An individual entering a confined space with a very low oxygen level usually shows no warning symptoms but collapses immediately. Death will result unless the individual is quickly rescued.

Refer to Process Safety Booklet 10 “Hazards of Nitrogen, Safe Handling of Catalyst” for more information on asphyxiation by nitrogen.

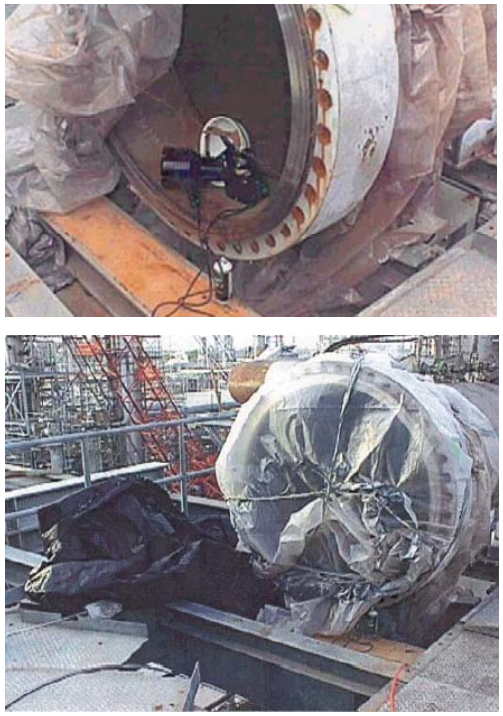
Effects of Lack of Oxygen

21 %	**Typical O_2 concentration in air**
15 - 19 %	**First sign of hypoxia. Decreased ability to work strenuously. May induce early symptoms in persons with coronary, pulmonary or circulatory problems**
12 - 14 %	**Respiration increases with exertion, pulse up, impaired muscular coordination, perception and judgment.**
10 - 12 %	**Respiration further increases in rate and depth, poor judgment, lips blue**
8 - 10 %	**Mental failure, fainting, unconsciousness, ashen face, blue lips, nausea, vomiting, inability to move freely**
6 - 8 %	**6 minutes – 50% probability of death 8 minutes – 100% probability of death**
4 - 6 %	**Coma in 40 seconds, convulsions, respiration ceases, death**

Accident ***One Dead and Another Injured when a Confined Space was Created Inadvertently!!!***

A column had been taken out of service, cleaned, and placed on nitrogen purge with several manholes opened. Two experienced employees were examining the flange surfaces on manholes. They checked for stress cracks by spraying dye on the flanges and using a black light to identify them. The men draped a tarpaulin over the flange either to block the wind or to facilitate using the black light, or both. They then crawled underneath to perform the work.

With no wind, nitrogen filled the confined space created by the tarpaulin. Both men collapsed from lack of oxygen. One died while the other collapsed face down on the metal grating. His position on the grating provided him sufficient oxygen to sustain his life. He was rescued and hospitalized for several days.



Pipe opening where a confined space was inadvertently created

Take care when planning or performing a job to ensure that all types of hazards have been identified and that confined spaces are not inadvertently introduced.

Accident ***Entry into Rusty Chamber Kills Two!!!***

The rusty buoyancy chamber where two persons lost their lives

Two persons collapsed after entering a buoyancy chamber on a barge. The chamber had not been ventilated or gas tested prior to entry. They died of suffocation from low oxygen levels.

The chamber, which provides buoyancy to the barge, had been closed for a considerable period. During this time, rusting and corrosion of steel structures consumed the oxygen within the space creating an atmosphere incapable of sustaining life.

1.4.2 Oxygen Enrichment

There is an increased risk of fire and explosion from high oxygen levels. At these levels, they can be expected to be more violent and intense.

Higher than normal oxygen levels can result from oxygen leakage during oxy/acetylene welding operations.

1.4.3 Flammable Atmosphere

A gas mixture is flammable when the concentration of flammable material in air is within the Lower and Upper Explosive Limits (LEL and UEL). A flammable mixture presents a fire and explosion risk that can kill or injure.

High levels of oxygen, which can occur from leaking oxygen canisters, widens the range of Lower and Upper Flammability Limits thereby increasing the possibility of fire.

The ignition of a flammable atmosphere within a confined space is particularly dangerous because there are limited means of escape, and the depletion of oxygen coupled with smoke and heat generation can quickly render a person unconscious and unable to escape.

Accident

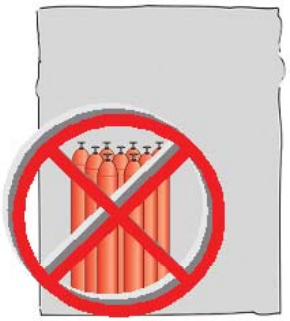
Flash Fire in a Tanker Kills Seven!!!

A tanker was undergoing repair work at a shipyard when without warning, a huge fireball came through a manhole on deck. The same manhole spat out a man engulfed in flames. Fire fighters doused him with water but he died at hospital from serious burn injuries. Below deck, six other workers were dead.

The workers had just returned from lunch and were about to resume cutting away rusted parts of a tank and welding in new steel plates. An ignition in a flammable atmosphere, suspected to have been created by a leak from acetylene cylinders used for cutting and welding, sparked a flash fire below deck.

It was nearly four hours before rescuers could retrieve all the bodies. The searing heat and total darkness in the confined space hampered rescue operations. Two bodies were found untouched by flames indicating that they probably had difficulty escaping and succumbed to the extreme heat, smoke, or were asphyxiated.

Perform gas tests after vacating any confined space for a period of time, e.g. for a break, to ensure that safe working conditions are still present.



Never store compressed gas cylinders/tanks in a confined space, regardless of their contents.

1.4.4 Toxic Atmosphere

Toxic materials can result in many different adverse health effects, ranging from mere itchiness to death. The severity of a human body's reaction depends on the material, concentration, duration of exposure, method of entry into the body and individual susceptibility. The most common method of entry into the body within a confined space is through inhalation.

Some toxic substances typically found in process plants are given below. Can you add to the list?

Hydrogen Sulphide (H_2S)	Chlorine	Organic Lead
Hydrogen Fluoride (HF)	Benzene	Refractory Dust
Hydrogen Bromide (HBr)	Toluene	Cadmium Vapour
Hydrogen Cyanide (HCN)	Hexane	Catalyst
Ammonia	Welding Fumes	Vanadium Pentoxide

The maximum amount of a toxic material that a person can safely tolerate can be represented in different ways.

- The Occupational Exposure Limit (OEL) is the maximum value a worker should be exposed to, through inhalation, over an eight-hour working day without harmful effects.
- The Short Term Exposure Limit (STEL) on the other hand expresses the maximum value that a person can withstand over 15 minutes without harmful effects.

The choice of which value to utilize depends on the purpose of the activity being undertaken.

Exposure to toxic substances can lead to both short-term and long-term adverse health effects. Both conditions are undesirable and steps should be taken to avoid exposure to dangerous amounts of toxic substances. Check your Material Safety Data Sheets (MSDSs) for the safe working concentration levels of hazardous chemicals handled at your facility. (Refer to Process Safety Booklet 13 "Safe Handling of Hazardous Petroleum Products" for more information.)

Dangerous levels of substances are easily formed within confined spaces due to poor natural ventilation. Some toxic atmospheres result in death almost immediately, while others can impede the ability of a person to escape the area, eventually leading to death.

Although hydrocarbons are mostly regarded as fire and explosion risks, many have narcotic effects on humans. Initial signs are typical of intoxication. Failure to respond to verbal commands occurs roughly at the Lower Explosive Limit (LEL), corresponding to about 50% of the general anaesthetic dose required for surgical operations. These narcotic effects can occur very quickly – within only four breaths!

Check your Material Safety Data Sheets (MSDSs) for information on the toxicity and flammability of chemicals where exposure potential exists. Plan your actions accordingly and ensure that the appropriate protective measures are in place.

Accident ***Young Worker Found Staggering Around Inside a Tank!!!***

An apprentice was sent to apply dye on the walls of a tank as part of a testing program. Later he returned to remove excess dye by spraying it with a solvent. He was not wearing (nor apparently told to wear) any form of respiratory protection. As a result, he had been exposed to between 20 and 30 times the STEL (Short Term Exposure Limit) of solvent fumes. He was found staggering around inside the steel tank after being exposed to toxic fumes for several hours.

When authorising entry to confined spaces, remember to consider what is to be taken into the confined space by the workers, e.g., paints, coatings, solvents, burning gas, and inerts for weld shielding. Consider also the consumption of oxygen by metal spraying processes and generation of welding/burning fumes.

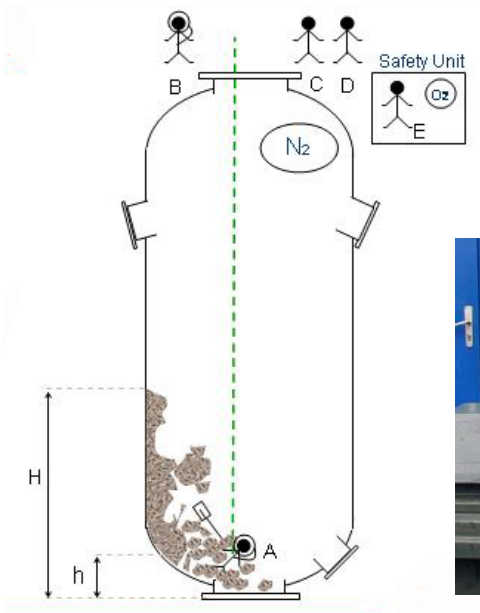
1.4.5 Engulfment by Free Flowing Solids

Engulfment can occur when a person works amid large quantities of fine solids such as salt, sugar, catalyst, and grains. Free-flowing solids have the potential to bury and drown. The danger is more serious when the storage compartment has a sloping floor. The uneven floor can cause a person to trip, triggering a cave-in with disastrous consequences.

When digging through fine solids, take care that no high “walls” are left, ready to collapse when disturbed.

Accident ***Violation of Work Permit Results in Injury!!!***

A unit was undergoing catalyst change when free-flow of catalyst stopped due to agglomeration. A decision was made to unload catalyst from the top of the vessel. This required permits for entry and work in the inert atmosphere. A special note was made on the permit stating that the “inert entry worker must never come under catalyst level”. The worker violated work permit conditions by standing below the catalyst level and was buried under catalyst. He received severe burns as a result.



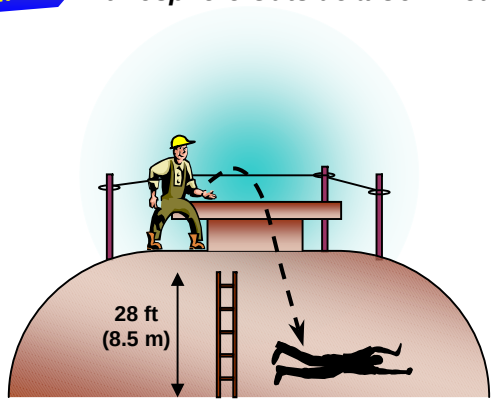
Worker violates work permit conditions by standing below catalyst level “H” and is buried under hot catalyst

Burnt Helmet and Safety Harness

1.5 Other Dangers

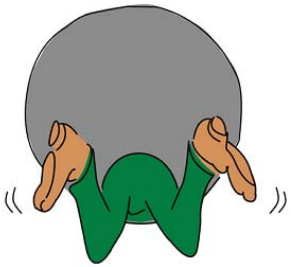
The hazards of confined spaces are not limited to the area inside the space but also at openings to the confined space. The effects on humans depend on the type and concentration of materials within the space. Many incidents associated with equipment purged with nitrogen have occurred and are still occurring. Refer to Process Safety Booklet 10: Hazards of Nitrogen and Safe Handling of Catalysts.

Accident ***Atmosphere Outside a Confined Space can be Hazardous!!!***



A sub-contractor employee, without breathing apparatus or safety harness with an attached lifeline, entered the barricaded area on top of a reactor under nitrogen purge. He was requested to assist a confined space entrant to lift up an access ladder that was about 3 ft (0.9 m) below the manhole flange. He was overcome by an oxygen deficient atmosphere around the manhole and fell into the reactor.

Accident An operator put his head into the tank opening of a barge to check the oil level. He was overcome, fell into the tank and was killed.



Accident A welder was repairing cracks in the manhole of a tank that had been nitrogen purged. Work was not possible with the manhole cover in place so the cover was removed. While working, he dropped a torch tip into the tank, looked inside for it, collapsed, fell in and died.

Accident ***Static Ignition Blows an Operator Off a Tank Roof!!!***

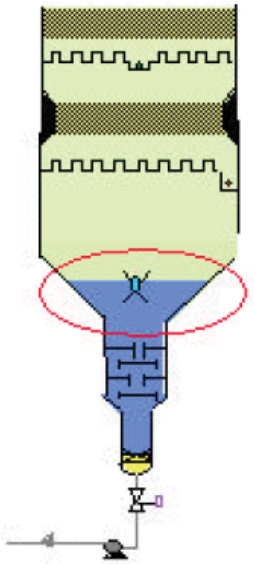
An MTBE tank was being cleaned using a high pressure cleaning device (rotating high pressure water nozzle) through the top manhole. A vacuum truck (used to empty the tank) had inadvertently created an explosive mixture within the tank when it sucked vapours from the tank creating a slight underpressure which drew in air. A static discharge created by the high speed fine particle water mist ignited the explosive mixture resulting in an explosion. An operator was blown off the roof of the tank and killed.

Watch out for sources of static electricity within a confined space. Remember to earth/ground static generating devices to prevent static accumulation.

Refer to Process Safety Booklet 5 “Hazards of Electricity and Static Electricity” for the dangers of static electricity and preventative measures.

Accident ***Contractor Drowns in a Water-washed Column!!!***

A contractor entered alone into the flash area of a vacuum distillation column to look at the underside of the first trays. The column had been water washed during the night but not drained. The contractor accidentally fell into the water and was unable to gain access to the internal ladder. He drowned before emergency services could rescue him.



Accident ***Dry Pyrophoric Scale Auto-ignites in a Slops Oil Tank!!!***

A slops oil tank had been isolated for planned repair work but still contained some hydrocarbons. Nitrogen blanketing was not in service at the time and oxygen entered the tank via the pressure/vacuum safety valve as a result of the breathing process. The dry pyrophoric scale in the tank ignited, causing an explosion and fire that blew the tank roof against the stairs of an adjacent tank. The fire was extinguished after 40 minutes. The incident could have been worse if there were people working in the tank or on the tank roof.

Keep pyrophoric scale *wet* to avoid ignition and fire.

See Process Safety Booklet 4 “Safe Ups and Downs for Refinery Units” for more on pyrophoric scale.

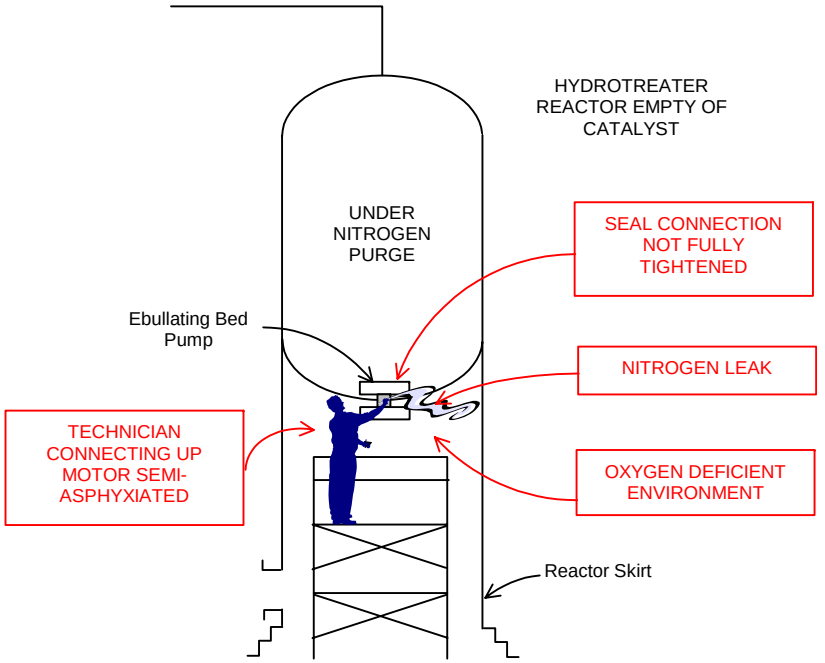
Accident ***Pyrophoric Fire Completely Destroys a Column!!!***

A pyrophoric fire occurred during a replacement of the carbon steel structured packing within a column, which involved cutting out the old column internals and removing each bed of packing. Despite persistent attempts to extinguish the fire, the column fell over and was completely destroyed.

Accident ***Nitrogen Leak Semi-asphyxiates Technician!!!***

A technician was overcome by an oxygen deficient atmosphere while connecting up a motor. The catalyst had been removed and the reactor was floating on nitrogen. The pump seal on the reactor was leaking allowing N_2 to enter the reactor skirt. The supervisor assumed that the reactor seal was tight and there was no requirement for either:

- Air-line breathing apparatus
- Air movers
- Continuous oxygen monitoring with alarm



Skirts surrounding the bottom of vessels must be considered to require a Confined Space Entry Permit.

1.6 Control of Access to Confined Spaces

Due to many multiple fatality incidents that have occurred while working in or encountering confined spaces, the **Confined Space Entry Permit** procedure was introduced as a method to control the hazards involved and ensure the safety of workers. Most countries have legislations in place to enforce the use of this procedure.

2.0 CONFINED SPACE ENTRY PERMIT

2.1 Confined Space Entry Permit

2.1.1 What is a Confined Space Entry Permit?

A Confined Space Entry Permit is a document that carefully controls the entry of personnel into confined spaces. It needs to be filled and signed by relevant authorities before entry can take place. The permit provides a written authorization for entry into a confined space and functions as a control system for this potentially hazardous activity.

A confined space permit is not a replacement for a safe system of work. It is an extension of it.

The Confined Space Entry Permit is only for entry!
In order to perform work within the space, a Hot Work or Cold Work Permit is also required.

2.1.2 General Contents of a Permit to Work

A Confined Space Entry Permit contains the following information:

- Location of work
- Description of work
- Names of entrants and standby attendants
- Permit validity period
- Process and electrical isolation information
- Gas test results with gas tester's name and signature
- Information on the remaining hazards
- Precautions to be undertaken
- Rescue procedures
- Approval by the Issuing Authority
- Acceptance by the Performing Authority
- Confirmation on completion of work
- Entry cancellation and permit withdrawal

The Confined Space Entry Permit is declared void when:
a) Conditions change, making the job unsafe
b) Work is delayed or work is stopped for more than two (2) hours
c) An alarm to exit the space is activated
d) An order is given to exit the space

TO BE USED FOR ENTRY INTO A CONFINED SPACE

ENTRY PERMIT NO.

(Permit Must Be Displayed)

1. Permission is given to under MWO. NO.
2. Location of Work Item No.
3. Item Description
4. Description of Work
5. Validity of Permit — Issued on: Date ..... Time ..... (hrs) — Expires on: Date ..... Time ..... (hrs)
   Permit is void as follows: a) when conditions change making job unsafe b) when starting work delayed or work stopped for 2 hours

* Tick off and delete as necessary

6. **Isolation:** The following precautions have been taken to isolate the plant/working area from likely sources of hazard:

6A. **Process Isolation/Preparations**
☐ Equipment depressured/drained and free of flammable/corrosive/toxic deposits/asphyxiating gases
☐ Isolated by: disconnection/blanks/spades ☐ Drawing attached/Blank List No. .....
☐ Maximum natural/force ventilation is provided
☐ Equipment physically/visually inspected
☐ Other isolation/preparation carried out on:
COLD WORK PERMIT NO. ..... EXCAVATION PERMIT NO. ..... HOT WORK PERMIT NO. .....
Others .....

6B. **Electrical Isolation**
Description and Item No. ..... have been isolated on COLD WORK PERMIT NO. .....

6C. **Gas Test Results** (Gas Test Meter No. .....) **(Calibrated on** .....)

LOCATION	OXYGEN	FLAMMABLE GAS	OTHERS	TIME	DATE	CERTIFIED GAS TESTER'S NAME/SIGNATURE

7. Hazards Remaining:

8. **Precautions That Must Be Undertaken**
☐ Standby man required ☐ Safe lighting required
☐ Cool enough for entry ☐ Breathing apparatus/resuscitation equipment on standby
☐ Platform/ladder for safe access/exit ☐ Covers for nearby sewers/drains etc
☐ Safety belt/lifeline required ☐ Gas monitoring required
☐ Protective equipment must be worn:
☐ Goggles ☐ Gloves/Boots ☐ Full Protective Clothing
☐ Face shield ☐ Dust Respirator ☐ Others .....
Other precautions required .....

9. **Certification (Issuing Authority)**
I certify that the precautions in Section 6 have been taken and that ENTRY may start subject to the requirements of Sections 7 and 8.
Print Name .....
Signed .....
Time ..... (hrs) Date .....

10. **Acceptance (Performing Authority)**
I have read and understood the Permit and accept the precautions to be taken under Sections 7 and 8.
☐ SRC Print Name ..... ☐ Contractor Print Name .....
Signed ..... Signed .....
Time ..... (hrs) Date ..... Time ..... (hrs) Date .....
* All works must stop and all personnel must evacuate the confined space immediately if the refinery fire alarm sounds or if requested to do so by an SRC representative. When the "all-clear" fire alarm is sounded, the Performing Authority will report to the respective Issuing Authority to confirm that the areas are safe and work can be resumed.

11. **Work Completed (Performing Authority)**
The entry has been completed/suspended and all persons under my supervision, materials and equipment withdrawn.
☐ SRC Print Name ..... ☐ Contractor Print Name .....
Signed ..... Signed .....
Time ..... (hrs) Date ..... Time ..... (hrs) Date .....

12. Entry Has Been Cancelled or Permit Withdrawn (Issuing Authority).
Print Name .....
Signed .....
Time ..... (hrs) Date .....

13. Authorisation to Cancel Associated
COLD WORK PERMIT No. .....
HOT WORK PERMIT No. .....
EXCAVATION PERMIT No. .....
Print Name .....
Signed .....
Time ..... (hrs) Date .....

RENEWAL: The work area has been surveyed and conditions have not changed.

VALIDITY EXTENDED

From		To		Issuing Authority		Recertification				
Date	Time	Date	Time	Name	Signature	Location	Oxygen	Flammable Gas	Others	Certified Gas Tester Name/Signature

Example of a Confined Space Entry Permit

2.1.3 Advantages of Having a Permit System

The advantages that a permit system may bring if operated appropriately as part of a Control of Work for Confined Spaces:	
Before Entry	• Makes sure that proper authorization is obtained. • Ensures that management is aware of all confined space entries. • Checks that the work site has been prepared and is safe before work commences. • Informs workers of potential hazards, and the precautions and safety equipment needed. • Ensures that no outside activity that can adversely affect those working in the confined space is performed.
During Entry	• Ensures that the job starts and continues to be carried out in a safe manner. • Prevents entry by unauthorized persons.
After Entry	• Prohibits entry into a confined space after the authorized period.

2.2 Definitions

Confined Space*

- Large enough and so configured that an employee can bodily enter and perform assigned work
- Not designed for continuous employee occupancy
- Has limited or restricted means for entry or exit

Limited or restricted means for entry and exit refer to:

- Confined space openings that are limited by size or location
- Small openings that are difficult to move through and difficult to get needed equipment in or out of the spaces
- Large openings that may require the use of ladders, and where escape may be difficult in emergency situations (e.g. open-topped spaces)

Note: A space containing a door or portal through which a person can walk may still be deemed a confined space if an entrant's ability to escape in an emergency would be hindered.

Note: A confined space can result in a fatality even if not "bodily" entered, as the following incident shows.

Accident A maintenance foreman put his head inside a manhole of a nitrogen-purged vessel to check details of internal fittings. He was found collapsed and dead over the manhole.

Accident ***Small Semi-confined Space!!!***

A workman was relaying plastic floor tiles in a small cupboard in an office corridor using a solvent based quick setting adhesive. The fumes overcame him and he fell face forward into the adhesive, where his face stuck, and unconscious, he died.

Small spaces, such as cupboards and closets, are not always recognized as confined spaces. A confined space large enough to stick a person's head in is often enough to constitute as a potential hazard.

Entry*

- The action by which a person passes through an opening into a permit-required confined space.
- Is considered to have occurred as soon as any part of the entrants body breaks the plane of an opening into the space

WARNING!
ENTRY!

Issuing Authority

- Sometimes called the *Operating Authority*
- Responsible for preparing and issuing a Confined Space Entry Permit application

Note: For 'best practice', the permit should only be authorized by a person who has personally checked and verified that all conditions are suitable for entry. This would be a Competent Person or someone authorized for the purpose by a Competent Person.

Performing Authority

- Responsible for accepting the work permit
- Supervises the work, or undertakes the work personally
- May be employees or contractors

Competent Person

- Responsible for assessment of risks and implementation of safe systems of work for confined space entry

Entry Supervisor*

- Is responsible for determining if acceptable entry conditions are present
- Authorises entry, oversees entry operations and terminates entry

Authorized Entrant*

- A trained person who is authorized to enter a permit space

Attendant/Standby Person*

- An individual stationed outside one or more permit spaces to monitor the authorised entrants and perform all attendant duties assigned (See Section 4.5)

Authorised Gas Tester

- A qualified individual who undertakes tests on the confined space atmosphere using suitable instruments

* As defined in OSHA's Occupational Safety and Health Standards for General Industry

2.3 Identification of a Confined Space

Identification of a confined space should be performed through risk assessment. Some countries require the employer or owner of an installation to establish these spaces as "non-permit requiring" or "permit requiring" confined spaces but it is emphasised that this is not a recommended practice as this "à priori" classification does not consider the activities to be carried out in the confined space. Therefore a case-by-case risk assessment for both the confined space and the activities should be the preferred option where possible.

Non-Permit Requiring

- Does not contain or (with respect to atmospheric hazards) have the potential to contain any hazard capable of causing death or serious physical harm.

Permit Requiring

- Contains or has a potential to contain a hazardous atmosphere
- Contains a material that has the potential of engulfing an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross section
- Contains any other recognized safety or health hazards.

If a space is found to be permit requiring, the entry point must be clearly labeled to inform employees of the dangers.

A list of all confined spaces and their locations should be:

- Distributed to all employees
- Placed in prominent places, such as employee bulletin boards
- Inserted into the written confined space entry procedures

Warning sign posted at the entry to a confined space

LOCKED DOOR

Note: Door has mesh for ventilation

Vessel skirt manhole is closed by a locked door

Access to confined spaces must be physically barricaded and locked at all times when a valid permit is not issued. In this case, use of keys must be controlled.

Accident ***Total Disregard of Confined Space Entry Procedures Results in Fatality!!!***

A construction supervisor entered an underground fuel storage tank illegally with the help of a security guard at a retail facility construction site. He lowered a bucket and shovel into the tank with the intention of removing white sand slurry that was pumped in as part of a cancelled abandonment plan. He stuffed toilet paper up his nose and into his ears, and placed the end of a rubber hose, which was secured near the manhole, into his mouth to be used like a snorkel!

He tied a rope around his waist and lowered himself into the tank. When the security guard heard him cough and saw that he was trying to escape the tank, he tried to help by pulling on the rope. Unable to assist further because the supervisor was too heavy, the guard ran for help. When the fire department arrived, the supervisor was already dead.

The supervisor had entered the tank, even though the area had been cordoned off with yellow tape to forbid entry into the area. A perceived tight construction schedule and poor judgment probably caused him to disregard the entry permit procedure and proceed with entry. The entry should never have taken place without purging, ventilating, gas testing, and the correct breathing apparatus, (all of which are required under the Confined Space Entry Permit).

The supervisor entered the underground tank through this manhole even though the area had been cordoned off.

2.4 Confined Space Entry Process

Before starting an application for a Confined Space Entry Permit, ask the following questions:

Can the confined space be modified so that entry is not necessary? Can the work be done from outside (for example flushing or water jetting blockages, using long-handled paint brushes or other tools, using remote cameras, or other means)?

If 'yes' carry out a risk assessment, set up a safe system of work and do the job without entering the confined space.

If 'no' a risk assessment must be carried out by a Competent Person. Key factors to be considered in the assessment would include:

- Previous contents of the confined space
- Remaining residues
- Surface, and other contamination
- Oxygen deficiency/enrichment
- Physical dimensions of, and equipment inside the confined space
- Chemicals to be used for cleaning or other purposes
- Sources of ignition
- Isolation of the confined space and possible ingress of substances
- The breathing environment inside the confined space

Examine the advantages and disadvantages of alternative methods before deciding.

A safe system of work must then be established and approved by a Competent Person and put into place. This must include consideration of:

- Removal of hazards wherever practicable
- Supervision of, and competence for, confined space working by the individuals concerned
- Communications
- Atmospheric testing
- Purging and ventilation
- Residue removal
- Isolation (process, mechanical, electrical)
- Suitable equipment
- PPE and RPE
- Gas supplies, by pipelines, hoses and cylinders

- Entry and exit
- Fire prevention
- Lighting
- Static electricity
- Emergency procedures
- Working time limits
- Anything peculiar to the industry or works concerned, e.g. radioactivity

Smoking in a confined space must be prohibited and this restriction may extend beyond the confined space itself.

Accident ***Smoking in Confined Space Results in Fatality!!!***

A 78-m (286-ft) diameter floating roof tank used for crude oil storage had been taken out of commission for cleaning, inspection and repair. An Entry Permit and a Hot Work Permit (for diesel engines etc. located in the bund area) had been issued.

Three employees of a contracted specialized tank cleaning firm were working inside the tank removing crude oil sludge, wearing air-line breathing apparatus, when a fire started inside the tank. Two of the contractor's employees escaped from the tank immediately. But the third man failed to exit.

The fire was extinguished by the Safety Services operator assisted by Terminal staff before the Fire Brigade arrived some twelve minutes later. The body of the trapped person was subsequently recovered.

It appeared that the contractor's employees had started smoking inside the crude oil tank, which ignited the residue material in the tank. An inquiry confirmed that the contractor's employees on site knew that smoking was only permitted in the designated areas but had broken this rule.

2.4.1 Preparing the Confined Space for Entry

If a safe alternative to working within a confined space cannot be found, the following steps must be taken prior to entry.

a)	Initiate the Confined Space Entry Permit and Issue Instructions
b)	Purge, Flush, and Remove Toxic Vapour-Releasing Residues
c)	Isolate the Confined Space and Release any Stored Energies
d)	Ventilate
e)	Test the Atmosphere of the Confined Space
f)	Check that all Hazardous Energies are Controlled or Eliminated
g)	Complete the Confined Space Entry Permit Form

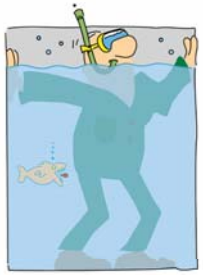
a) Initiate the Confined Space Entry Permit and Issue Instructions

Begin by planning the measures that must be taken to obtain a safe environment within the confined space. Use the Permit form as guidance.

A simple risk assessment (typically called a Job Safety/Hazard Analysis, JSA or JHA, or Task Hazard Analysis, THA) should be performed to identify all the hazards present and determine the consequences of not eliminating or controlling them. A risk assessment can help identify the major hazards, as well as previously unrecognized hazards, and aid in planning and documenting the preparation of a confined space for entry.

Proper planning will not only ensure that the decommissioning and preparation process runs smoothly but also that the target safe conditions are achieved efficiently.

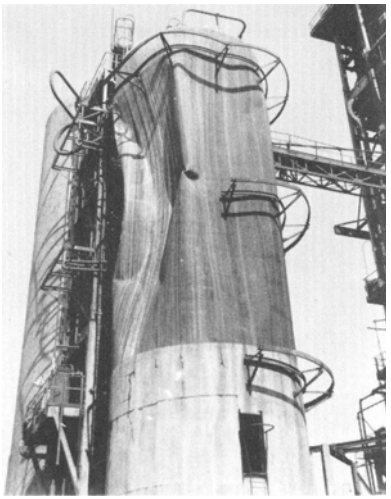
b) Purge, Flush, and Remove Toxic Vapour-Releasing Residues



After a proper shutdown has been performed, the space needs to be purged or flushed to remove residual material. Purging can be accomplished using:

- Steam
- Water
- Inert gas
- Air

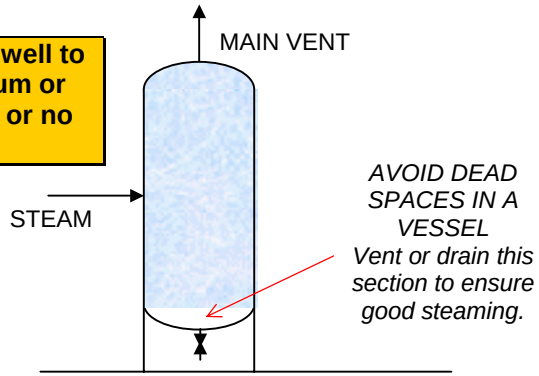
Steam is often the most effective means of purging. However, overpressure of equipment can occur if vents are inadequate or are blocked, or if the equipment is not designed for high pressure steam. Equipment can also be subjected to vacuum conditions on cooling after steam out as the steam condenses. Vessels not designed for vacuum can be damaged or can collapse if subjected to vacuum.



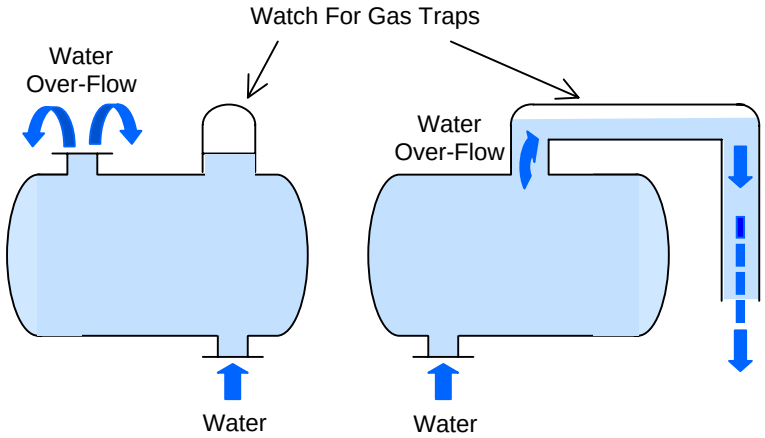
Refinery vessels designed to withstand considerable pressure may be sucked in, warped, or ruptured by vacuum.

Refer to Process Safety Booklet 6 “Hazards of Steam” and Process Safety Booklet 11 “Hazards of Trapped Pressure/Vacuum” for more details.

Plan steam out procedures well to avoid overpressure, vacuum or dead spaces (that get little or no steam) in a vessel.



Water is often used to clean long lengths of lines where steam cannot be used effectively because of rapid condensation in the system. It can also be used to displace vapour space, but care must be taken to ensure that structural strength is maintained and to avoid potential for corrosion problems. Water left inside equipment may freeze in cold weather and should be drained after flushing.



Some residual oil may remain after lines are flushed with only water. Light oil flushing may sometimes be employed to remove deposits before water wash.

Inert gas can be used to displace flammable gases from a system. It may not gas free because of oils left behind in sludge and dead ends, but it can reduce oxygen levels to below the flammable range. Air can be used to purge tanks only if no flammable mixtures can be created. Never use air if pyrophoric materials are likely to be present.

If N_2 is used to purge, this may influence gas testing and result in inaccurate readings. Refer to Section 3.2 for details.

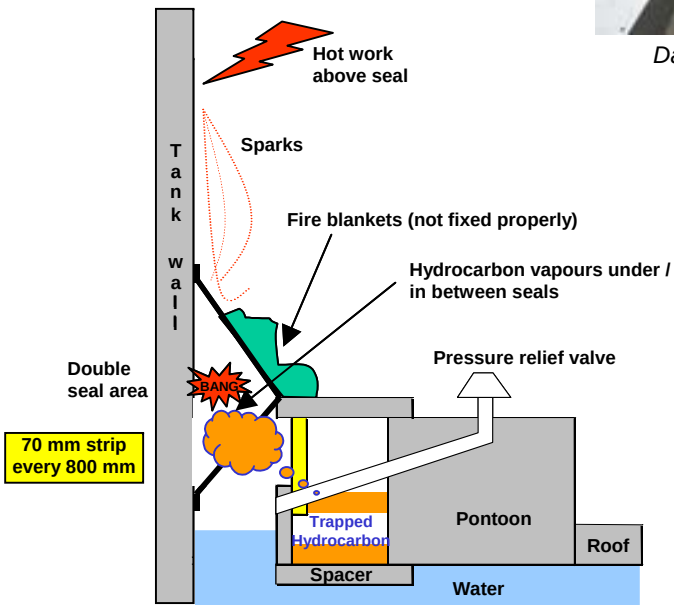
Accident ***Overlooked Hydrocarbon Vapours Result in Explosion!!!***

A floating roof tank holding naphtha had been emptied, cleaned, inspected, gas tested and refilled with water to facilitate repair work on the tank wall. The results of gas tests were acceptable for both inside and on the roof of the tank. Gas tests were performed daily on the roof, around the circumference but the space between and underneath the seals was not tested.

Two months later, an explosion occurred during hot work repairs causing damage to the double seal on the tank roof. Fortunately, three craftsmen working nearby were unharmed.

Damaged Rim Seal

The cause of the incident was inadequate tank cleaning which left hydrocarbon vapours between the double seal of the roof. Incomplete gas testing failed to detect this and fire blankets had not been fixed properly, leaving part of the seal exposed. The ignition source originated from the hot work going on at the time.



c) Isolate the Confined Space and Release any Stored Energies

Isolation involves both process and electrical isolation. The purpose of isolation is to ensure that:

- No gaseous, liquid or solid material enters the space
- Prime movers such as motors, turbines and engines cannot be started accidentally
- Any electrical equipment involved is made safe

Types of energy sources common in confined spaces are: electrical, mechanical, hydraulic, pneumatic, chemical, kinetic, and thermal.

Isolation for a confined space is performed by:

- Locking out and tagging out
- Blanking
- Disconnecting
- Securing

A blinds list is a list used to keep an accurate record of the installation and subsequent removal of mechanical isolation devices. The list should contain:

- Identification of the unit/area
- Equipment
- Location
- Line number, size, and rating
- Dates of installation/removal
- Signatures of persons confirming each change in position of the mechanical isolation device

An isolation/blinds list can help facilitate the activity and ensure that no step is omitted.

Locking out and tagging out

Control of stored energy sources is generally included in the site's Lock-Out & Tag-Out (LOTO) procedure, which may require separate approvals and permits.

Some devices must be locked out and tagged out to avoid accidental activation when a confined space is occupied. For example, valves on lines containing hazardous material need to be locked out and tagged out so that no material is accidentally introduced into the confined space. Electrical sources or switches of mechanical equipment should also be locked out and tagged out to prevent accidents.

Tagging out is necessary to inform others of the purpose of lockout and as a convenient way to check the status of the valve/equipment.

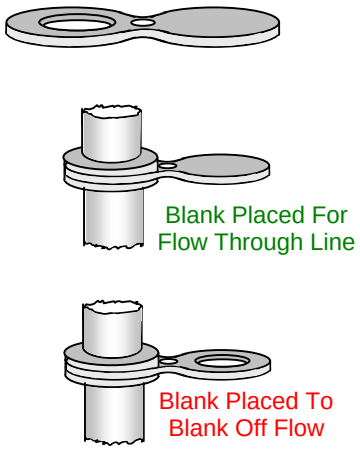
Accident A worker cleaning the inside of a vessel was killed when the (wrong) mixer was inadvertently started. Electrical isolations must be locked out and tagged out, and each vessel should have an isolation list.

In preparation for work within a confined space, all pipes or lines connected to the space must be **positively isolated** from live systems by blinding/blanking or disconnection ensuring that all open ends of adjoining pipes are blinded/blanked or plugged.

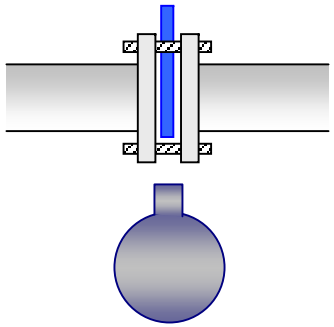
The only acceptable means of isolation are blanking/blinding or disconnecting. Use of simple valve isolation (even including "double block and bleed", which is closing and locking/tagging a drain or vent valve between two closed valves) is not an acceptable means of positive isolation for confined space entry.

Blanking

- Using Spectacle Blanks (Figure 8's)

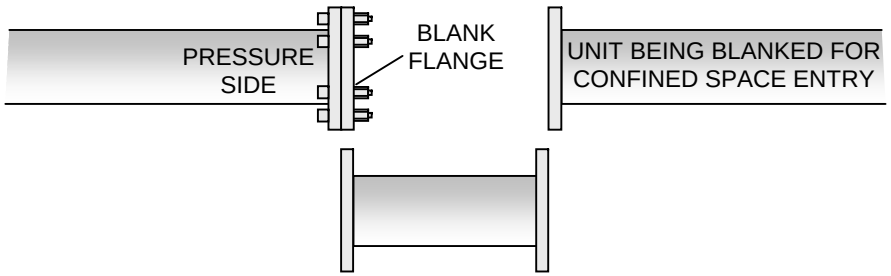


- Using Slip Blanks (Spades)



A slip blank is a solid metal plate inserted in a line between flanges and can be rated for full line design pressure or can be a thin plate (pancake). Wherever possible, full line pressure slip blanks should be used.

Disconnecting



Blanking by removing a spool and installing a blank flange

If entry must be made and disconnection or blanking/blinding is physically impossible, the site procedure shall require all of the following actions.

- Isolating the confined space as rigorously as possible
- Assessing risks present (and potential)
- Approval in writing by a senior level of management appropriate to the risks being assumed

Securing

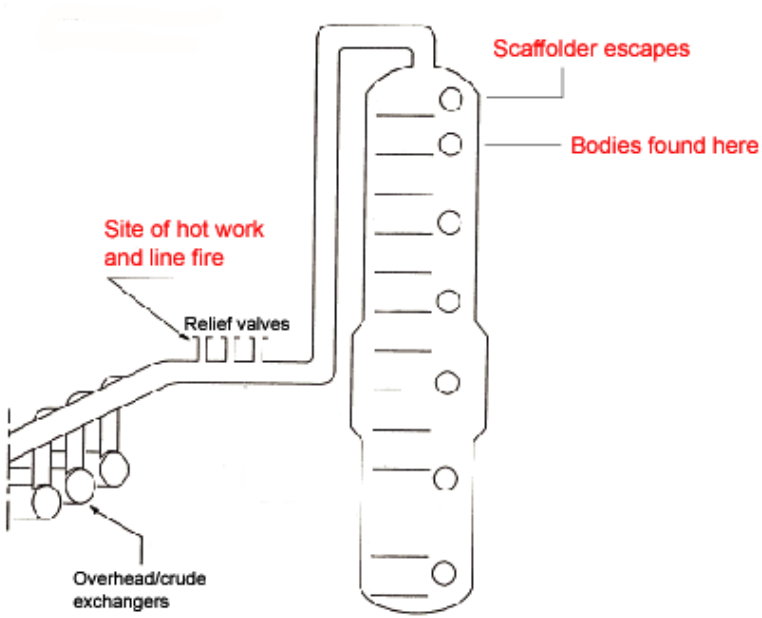
Secure mechanical moving parts within confined spaces such as mixers and fans using latches, chains, chocks, blocks, or other devices.

Accident ***Hot Work on Non-isolated Overhead Line Results in Two Fatalities!!!***

Two operators and one scaffolder were working in a crude oil distillation column when smoke started entering the confined space from the overhead line. The scaffolder in the tower dome quickly exited the column but the two operators working below did not escape. Both died in the fire.

The column had been shutdown and was undergoing major overhaul. The associated pipework had been flushed, emptied, steamed, water washed and isolated following normal procedures. However, the overhead line was not completely drained of hydrocarbon and had not been isolated. This was not detected through gas tests. The hydrocarbon was ignited by hot work that was being performed on the overhead line.

There was inadequate understanding and communication that allowed hot work to be performed on associated pipework while a confined space entry was in progress.



Perform isolation as close as possible to towers and vessels being prepared for confined space entry. Where this is not possible, prohibit entry into the space while hot work is taking place on connected lines or vessels.

"Gas free" does not mean "flammable free".
Deposits or residue material can give out toxic or flammable vapours under certain conditions (e.g. heating). Testing and inspection must encompass checks for these materials.

Some liquids like gas oil and fuel oil will not be detected by gas testing at ambient temperature because of their high flash points. Authorising any hot work on the value of only a gas test can therefore lead to an incident. Refer to Process Safety Booklet 2 "Hazards of Air and Oxygen" for more details on flash points.

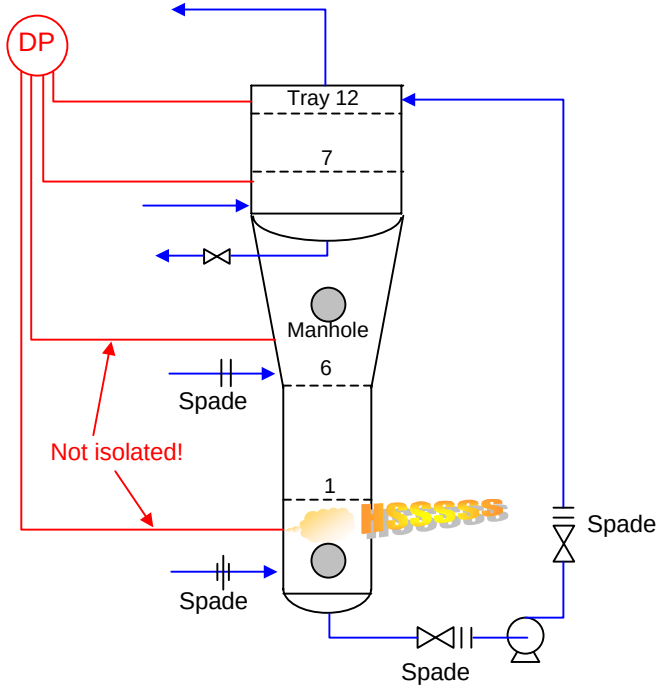
Accident ***Supervisor Detects Incomplete Isolation from Hissing Sounds!!!***

The bottom half a vessel had been taken out of service for inspection. It was emptied, nitrogen purged and air vented. All inlet and outlet lines were blinded. The gas test showed no flammable or toxic materials present and an oxygen concentration of 20.5%. The superintendent, assured by personnel from the previous shift that the vessel was safe for entry, authorised the permit without having inspected it.

The superintendent left the control room and, on the way back to his office, stopped to have a look at the vessel. When he stood outside the bottom manhole, he heard a slight hissing noise. The differential pressure (DP) instrument lines had not been thoroughly closed or spaded/blinded, which permitted hydrocarbons to be released into the vessel. He then cancelled the entry permit.

The DP lines had been missed as they were run with other lines inside cold insulation. The procedure for vessel entry was inadequate. It did not confirm that all lines into and out of the vessel had been identified and were positively isolated with full face blinds/blanks before the permit was issued. The DP lines were spaded/blinded, and the vessel was repurged and air aspirated before a new permit was made out.

Differential pressure (DP) instrument lines had not been thoroughly closed or spaded/blinded allowing hydrocarbon to enter the vessel.



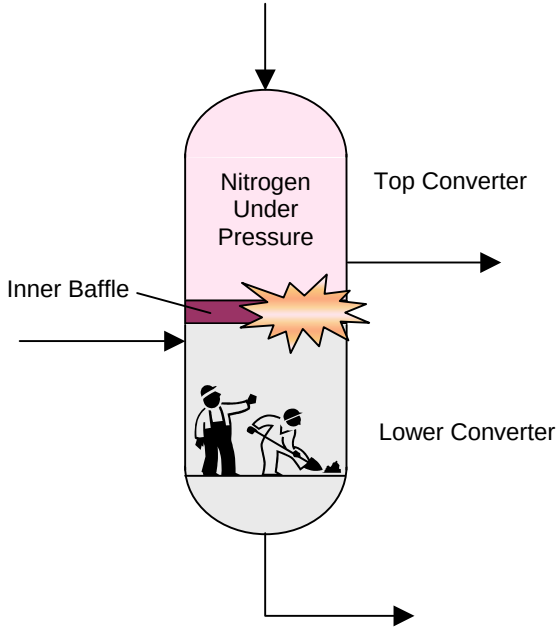
Watch out for unidentified residual or stored energy sources within a confined space after the isolation process.

Never authorize a Confined Space Entry Permit without being absolutely certain that the area is safe for entry.

There is no substitute for walking around the isolated equipment to check each connection and verify positive isolation.

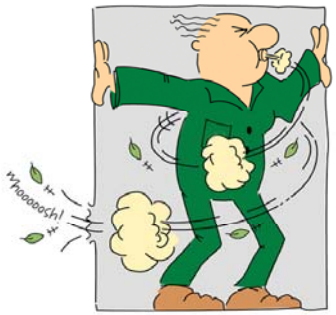
Accident ***Two Workers Killed When Inner Baffle of a Vessel Failed!!!***

A vertical vessel, divided into two sulfur converters by an inner baffle, had been taken out of service and the catalyst removed. The top converter was sealed off and nitrogen at 60 psig (4.10 barg) was introduced because of high H_2S levels. The lower converter was being cleaned by a two-man entry crew with four men assisting from the outside when the inner baffle failed under the differential pressure built up between the two converters. One entrant was fatally injured while another worker was killed when he was blown off the working platform onto the ground. The other four men sustained injuries.



Ensure that the selected means of isolation has been designed to withstand subjected pressures.

d) Ventilate



Ventilation is required to obtain an atmosphere that is as safe as possible for entry. There are two forms of ventilation: natural and forced (which includes general and local exhaust).

The adequacy of natural ventilation depends upon:

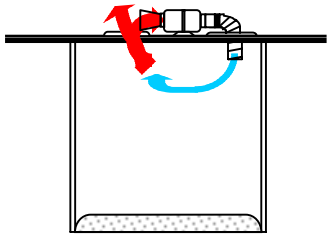
- Number of manholes and their locations
- Size of confined space
- Number of internal obstructions
- Wind and thermal currents

When natural ventilation is inadequate, forced ventilation is needed. *General ventilation* is appropriate for the majority of confined space entries especially when residual sludge is present. It involves the use of large volume air movers.

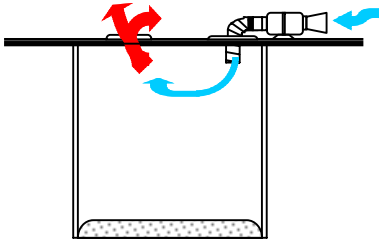
General ventilation is maintained for the entire duration of entry. It is best used when there is a wide dispersion of low- or medium-toxicity contaminants. Exhaust ventilation draws contaminated air out of the confined space while supply ventilation blows fresh air in. Never use pure oxygen to replace fresh air! (Refer to Process Safety Booklet 2 “Hazards of Air and Oxygen” for more details.)

Precautions to take when ventilating:

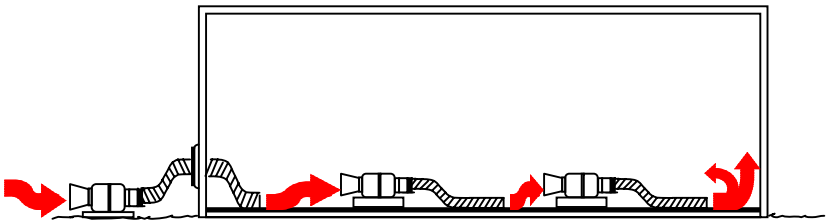
- Ground/Earth electrical equipment
- Electrically bond the ventilation equipment to the confined space
- Use explosion-proof equipment if the atmosphere is flammable
- Do not place air intake near flammable or toxic materials
- Locate exhaust outlet so that contaminants are not returned to the confined space
- Ensure that toxic or hazardous substances are not vented directly to the atmosphere or close to areas that are accessible to workers. Provide for appropriate disposal of exhaust gases
- Check that no ignition sources are present for an exhaust of flammable gases



Ineffective Ventilation – contaminated exhaust circulates back into the space

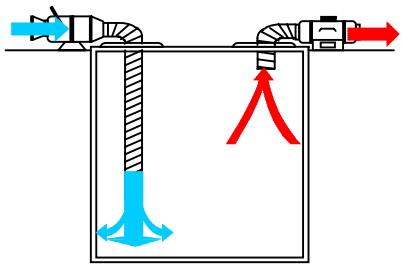


Ineffective Ventilation – no circulation in the lower part of the vessel

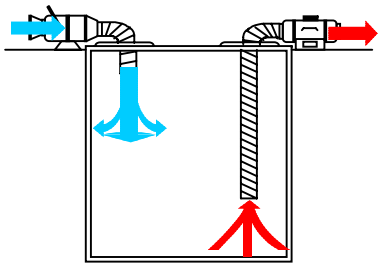


For large tanks, use equipment with sufficient power to ventilate the entire space or use a series of fans as shown above

The placements of supply and exhaust points are important to obtain effective ventilation. For contaminants lighter than air, place the exhaust through an opening at the top of the confined space while for contaminants heavier than air, purge is performed at the base of the confined space. Refer to Material Safety Data Sheets (MSDSs) for the relative densities of gases handled at your site.



*Ventilation arrangement for gases **lighter** than air*



*Ventilation arrangement for gases **heavier** than air*

Local exhaust ventilation uses a long, adjustable section of flexible duct connected to a powered air mover. The suction duct is placed close to the immediate work area and is moved as the work area changes. Local exhaust ventilation should be used for tasks such as welding, cutting, pneumatic removal of refractory, application of coating and cleaning with solvents. It effectively captures contaminants at their points of origin and removes them.

Confined spaces containing flammable or toxic atmospheres should be purged with non-flammable gases before being ventilated with clean air.

Accident ***H_2S Vented from a Vacuum Truck into Work Area Gases Twelve!!!***

An amine knock-out drum had been drained to an atmospheric sump through an open sewer. A vacuum truck was called to the sump area to begin pumping out operations. (All amine sumps at the site are either partially or entirely drained of their contents using vacuum trucks.)

Since it was generally accepted by the employees that pumping out operations of this manner produces H_2S-like odours (the amine contains hydrogen sulfide gas), no further thought was given to the presence of the strong smell.

Unwittingly, a number of contractors walked through the vapour coming from the vacuum truck's vent and as a result, 12 contractors were diagnosed to have been exposed to an amine cloud containing H_2S. Two of them were disoriented while eleven suffered from vomiting. Fortunately, all returned to work following a medical evaluation and there were no lost time injuries.

When venting toxic, inert, or flammable gases, make sure the venting area is far away from the work area, roads, etc. and cordon it off.

e) Test the Atmosphere of the Confined Space

Gas testing is the determining step in the entire preparation process. If the oxygen, flammable, and/or toxic contents meet the acceptable criteria, the Confined Space Entry Permit application process can continue. Otherwise, more efforts must be made to adequately ventilate the space to achieve the desired levels. If the situation warrants it, the entire process of purging, isolating and ventilating must be repeated until satisfactory gas test results are consistently obtained.

If the confined space fails the gas test, take time to examine the situation and perform proper planning before repeating preparation steps.

See Chapter 3.0 for details on gas testing requirements and methods, and refer to the IP Guidance on the Declassification of Tanks Previously in Leaded Gasoline Service.

f) Check that all Hazardous Energies are Controlled or Eliminated

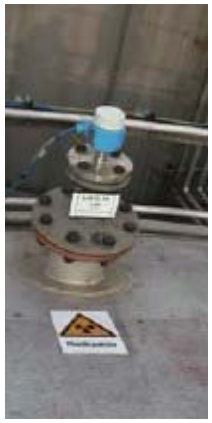
Entry into a confined space is prohibited until both Permit Issuing and Performing Authorities perform the appropriate *visual evaluation* and atmospheric monitoring of the space. This includes at least one site survey to identify and inspect the worksite or equipment.

It is vital that the work area be given a thorough examination to identify any remaining hazards, inside and outside the confined space, and to see that the threat they pose are controlled or eliminated.

Examples to be aware of are:

- Radioactive sources shielded or removed
- Power isolated to fans, mixers
- Hydraulic drives isolated
- Loose or poorly supported materials/equipment overhead
- Residual flammable material
- Sharp objects
- Damaged refractory/insulation
- Asbestos or synthetic mineral fibre

Accident ***Uncontrolled Radioactive Source Discovered Only After Seven Days!!!***



Radioactive type level detector

A radiation type level detector on a vacuum tower had not been isolated prior to entry. This was only discovered seven days after the initial entry, with as many as 36 people exposed to varying levels of radiation from the Cesium-137 source. However, the potential "worst-case" exposure was determined to be well below the safe level.

Investigations indicated that the Isolation Device Listing (IDL) had been signed authorizing work to proceed when there had been no verification that the radiation source had been isolated. General radiation awareness was also found to be lacking.

Accident ***Dropped Burner Tile Injures Worker!!!***

Workers were erecting a 33-foot (10-m) scaffold inside a reformer furnace to repair refractory. A burner tile (weighing roughly 60 pounds [27 kg]) fell against a worker's leg as he was bending down to receive scaffold components passed up to him. He tried to hold on to the burner tile, warning his co-workers to move away. Unfortunately, the tile fell from his grasp and hit an employee working below him, injuring his hand.

Location of burner tile on reformer wall

Burner tile on reformer floor 18 ft (5.5 m) below

g) Complete the Confined Space Entry Permit Form

When the Confined Space Entry Permit form is completed, submitted and approved by the relevant authority, the entry responsibility is ready to be handed over to the Performing Authority at the site of the confined space entry activity.

The original copy is issued to the Performing Authority and must be posted at the worksite until the work is completed. A second copy is kept with the Issuing Authority. Some sites may have additional copies given, for example, to the HSE Department.

2.4.2 Performing the Activity Safely

a)	Prepare for Safe Work Prior to Entry
b)	Inform Personnel of the Confined Space Entry Requirements
c)	Entry to Perform Activity
d)	All Personnel Leave the Confined Space
e)	Final Inspection and All Clear Given to Return to Service

a) Prepare for Safe Work Prior to Entry

Several items should be examined/checked when preparing to work in a confined space. They are:

- Low voltage, intrinsically safe lamps/lights
- Electrical tools, complete with earth/ground leakage or residual current protection
- Integrity of oxy-acetylene hoses and electrical cables
- Communications equipment
- Ingress and egress equipment (e.g. ladders)
- Signs and barriers
- Rescue Services

Lighting

Confined spaces often do not receive sufficient natural lighting. A safe light source has to be provided to enter and work in a dark confined space. Regular lighting may be unsafe to use, especially if the space contains flammable materials. A spark from an unsafe light source can cause a fire or explosion, leading to injury or deaths.

Explosion-proof lanterns or flashlights that have spring-loaded bulbs, which eject from the electrical circuit upon breaking, should be used to light up the confined space. Another option is to use lightsticks. They are safe to use near explosive materials because they contain no ignition source. Another commonly used form of lighting is the droplight. Approved drop lights are vapour-proof, explosion-proof and equipped with ground fault circuit interrupters (GFCIs). Any other electrical equipment must be intrinsically safe.

Lightsticks

Accident ***Use of Non-certified Lamp!!!***

A fire and explosion during tank cleaning operations killed three men at an oil storage installation. The tank was being cleaned by spraying with paraffin-based solvent. It is likely that the flood-light suspended from the tank roof had been splashed with paraffin which had heated up and ignited. The lamp had not been flameproof or certified for use in the confined space.

Explosion-proof drop light

Check that the lighting provided is certified for use in the location and is in good condition before starting work.

Electrical Tools

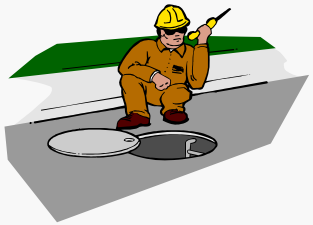
In certain confined space where the hazard of electrical shocks is present (e.g. inside metal tanks), suitable precautions need to be taken. These include using extra low voltage equipment (typically less than 25V) and, where necessary, residual current devices.

Communications Equipment

Communications equipment is often given low priority when preparing for a confined space entry but is usually the first thing we turn to instinctively when something goes wrong. Communication procedures should be appropriate for the workplace and level of risk. It can be achieved by voice, radio, hand signals, or other appropriate means depending on the conditions. A continuous voice communications system is the preferred means.

Ideal requirements for a confined space entry communications system

- Reliable, especially in metallic environments
- Capable of two-way continuous speech communication
- Compact, rugged and environmentally protected from water ingress
- Simple, easily operated, and requiring minimum training
- Operation possible with PPE (hard hats, gloves, breathing apparatus)
- Able to operate in a high noise environment
- Roving capability to permit local mobility
- Sufficient battery life for the task
- Rapid repair and easily maintained



A battery charging and changing regime should be in place to ensure that the user is aware of the status of the equipment and that the procedure is performed as recommended by manufacturers.

Ingress and Egress Equipment

For confined spaces that require vertical access, ladders are usually installed to facilitate entry. Most installed ladders are made of metal and may have been shrouded in moist, chemical-laden atmospheres prior to purging and ventilating. These conditions promote corrosion and the ladder may fail during entry or exit.

Installed ladders must be inspected on a periodic basis to ensure that they are safe for use. It is important to also check the devices holding the ladder, e.g. attachment bolts and screws.

Corroded Ladder Rungs

Accident

Fatal Fall while Ascending Ladder!!!

Two workers were working on a scaffold inside a tower. The scaffold was accessed by entering a manway and descending a 40-foot (12-m) ladder while wearing a self retracting lanyard. One worker completed his work and began to climb the cable ladder. The hole watch reported seeing him near the top of the ladder when they heard him scream. They found him on the scaffold below. The fallen worker was not connected to the self retracting lanyard (fall protection) when he slipped.

Adequate fall protection should always be provided and used for ladders more than 2 m (7 ft) high.

The cable ladder from which the worker fell

When ladders or stairways are not available for safe entry and exit, winches and hoisting devices are commonly used to raise and lower entrants. Only hand-operated lifting devices should be employed. Do not use motorized devices as they continue to pull an entrant out, even when the entrant gets caught up in an obstruction, resulting in severe injuries or a fatality.

Ensure that winching and hoisting devices used for entry into a confined space never leaves the entry/exit point when the confined space is occupied to provide a ready means of retrieval.

Signs and Barriers

Place barriers and shields (manhole guard rail assemblies, guard rail tents, barrier tape, fences, manhole shields, etc.) around the entry point to prevent people from falling into a manhole or entering it illegally. Set up warning signs in prominent locations to warn people from approaching and remind personnel that only authorized persons are allowed into the area.

Accident ***Worker Asphyxiated After Entering Nitrogen Purged Railcar!!!***

A railcar with a defective vent valve cover plate had been sent for repair. It had been purged with nitrogen prior to its arrival to the repair yard. This was not mentioned to repair yard personnel. No signs were placed on the railcar to warn that it contained a mixture of nitrogen and decene. A repair worker assigned to perform repairs on the railcar entered the tank compartment not suspecting that it was under nitrogen and was found unconscious. He died from asphyxiation.

No signs had been placed to warn that the railcar contained asphyxiating gases

Rescue Services

Check that means of rescue and rescue services are present and on standby. It is essential that adequate help is available at all times to allow a quick and effective rescue to be carried out. Refer to Chapter 4.0 for details on rescues.

b) Inform Personnel of the Confined Space Entry Requirements

All entrants and standby attendants must be thoroughly briefed on the full requirements for the confined space entry. The hazards present must be clearly stated and understood. Entrants must also be careful not to introduce additional hazards into the area, for example using sparking tools when flammable vapours are present.

Entrants must know the hazards and mitigation measures, and must be able to recognize changing conditions that invalidate the Confined Space Entry Permit. The permit must be available at all times at the work location.

Wearing suitable and properly maintained Personal Protective Equipment (PPE) is absolutely vital when hazardous conditions warrant it. See Section 3.8 for details.

Do not enter a confined space unless every precaution specified in the entry permit is fulfilled.

Smoking is strictly prohibited in a confined space!

c) Entry to Perform Activity

Double check against the work order and entry permit that the correct equipment is to be entered.

Accident ***Entry into Wrong Air Cooler!!!***

A contractor entered the cage of the wrong air cooler, through a trap door locked with a padlock and key. The padlock was in a bad condition so he cut it off. Luckily the fan was not started while he was inside, as it had not been electrically isolated.

Some additional equipment, apart from work tools, that may be necessary for entry include:

- Fire extinguisher
- Additional radios for communication
- Spare oxygen bottles (for SCBAs and cascade system)
- First aid kit

Where a change in the atmosphere inside a confined space may be expected (e.g. oxygen deficiency/excess, build up of flammable or toxic gases due to disturbance of sludge), continuous monitoring of the atmosphere must be carried out.

This is done by repeating gas tests at frequent intervals or by the use of personal gas monitors with visual/audible alarms. Entrants must leave the confined space immediately when the monitor alarm is activated.

A standby attendant must always be present outside the confined space. Among the duties of a standby attendant is to continuously monitor changes in the atmosphere within a confined space and see that entrants leave the space when a hazardous situation exists. Refer to Section 4.5 for a full description of the duties of a standby attendant.

Effective communication should be maintained continuously between the standby attendant and entrants so that:

- The entrants can alert the standby attendant whenever any warning signs or symptom of exposure to a dangerous situation is recognised
- The entrants can call for help in an emergency and the standby attendant, in turn, summons rescue services
- The standby attendant can order evacuation when conditions change to endanger the people inside

The Confined Space Entry Permit is withdrawn once conditions deviate from the safe levels recorded on the permit. Exit the space immediately and do not reenter until the permit has been reissued.

Emergency situations must be handled according to the rescue plan stated on the entry permit. Never enter a confined space unless properly equipped and authorized to do so. Many rescuers have been killed trying to rescue original victims. (See Chapter 4.0)

Provide continuous ventilation if natural ventilation is inadequate to keep atmospheric levels safe. Hot and humid environments can exist in poorly ventilated confined spaces. Direct heat from the sun can aggravate the situation. Heat stress can affect productivity and safety severely. To prevent heat stress:

- Provide adequate cooling air through effective ventilation
- Use work/rest arrangements – 15 minutes rest in a cool place outside a confined space for every hour of work.
- Provide ample drinking water in rest area
- In severe conditions, use air supplied respiratory suits with vortex and air distribution system

Work activities can often generate unsafe conditions or change the environment within the confined space. Examples of these are such things as:

- Static electricity generated by cleaning system water jets
- Liberation of toxic/flammable vapours when disturbing/removing residues in vessels/tanks
- Solvent sprays while painting
- Removal of insulation and asbestos
- Welding or oxy-cutting

Accident ***Worker and Rescuer Overcome by Solvent Vapours!!!***

A worker was cleaning the inside of a storage tank unsupervised. He was instructed to use a steam cleaner but used solvent because he thought it would be quicker. He knocked over a container of solvent and was overcome by vapours. A second person, who entered the tank without breathing apparatus, was also overcome.

Avoid deviating from work instructions as new actions would not have been properly risk assessed.

Accident ***Adverse Symptoms During Boiler Cleaning!!!***

Workers began reporting of eye irritation and skin lesions during chemical cleaning of a boiler. They also complained of a strong smell coming out of the equipment. Ammonia was suspected so measurements were taken but each time showed nil or very low concentrations.

Interviews and examinations were held with those affected and chemical analyses were performed. Investigations concluded that a chemical reaction between deposits and the acidising solution used as part of the chemical cleaning process produced an atmosphere containing fluoride compounds. The fluoride compounds coupled with hot and humid work conditions were responsible for the symptoms suffered by the workers.

Accident ***Use of Cleaning Agent in a Poorly Ventilated Space!!!***

Three men inside a reactor vessel experienced breathing difficulties. They had inhaled vapour containing 1.1.1 trichloroethane as a result of using a cleaning agent containing solvents in a poorly ventilated space. The air mover/ejector at the top of the reactor had been removed to facilitate access into the reactor.

Adequate air supply and ventilation should always be ensured when toxic vapours are expected. If ventilation is insufficient, self-contained breathing apparatus (SCBA) must be used.

Accident ***Refractory Releases Hydrogen in a Confined Space!!!***

Refractory was being replaced in a regenerator offgas pressure reduction chamber during a maintenance turnaround at a refinery. As the old refractory material (INSLAG) was no longer in production, a new substitute (INSULAG 'AF') was used. An explosion occurred when some hot work was carried out on the equipment. Fortunately no one was injured.

Initially, a leak in a gas line was suspected to have caused the incident. However, it was found later that the new refractory releases hydrogen when mixed with water. There was no indication on the MSDS that any flammable gases would be given off during mixing, and that there was need for good ventilation.

Other materials that can produce hazardous atmospheres:

- Expanded foamed plastic materials releases propane, usually during their bulk storage rather than at the end use (e.g. for insulation)
- Liquids such as dye penetrants for inspecting welds

Accident ***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 excess dye using a solvent. The solvent used was trichloroethylene applied in liquid form.

At the time of the incident, the inspector sent the standby person to obtain more solvent, leaving them unattended in the reactor. When the standby person returned some 10 minutes later, both the inspector and worker had collapsed from breathing trichloroethylene vapours. They were resuscitated by rescue services and were sent to hospital for observation.

As a result of this incident, the use of trichloroethylene was replaced with water in confined spaces.

Accident ***Hazards of Fire Under Tarpaulins!!!***

A fire broke out at an under-construction sphere while eight men were working on the sphere. One worker was fatally injured while another three were injured seriously. Preliminary findings indicate that the fire probably started near the base of the sphere, under the weather protection sheeting (tarpaulin). The presence of polyurethane cold insulation and other combustible materials caused a rapid escalation of the fire to the top of the sphere.

Accident ***Entrant and Standby Attendant Gassed by Engine Fumes!!!***

A worker entered a tank on a ship to remove residual water from the tank. A diesel driven internal combustion water pump was placed in the tank for that purpose. The worker was later discovered unconscious. The standby attendant entered the tank to rescue the fallen worker but was overcome himself. Both workers died later in hospital. Autopsy indicated the cause of death being carbon monoxide poisoning.

The diesel engine used would have consumed the limited oxygen available in the confined space, and emitted carbon monoxide and carbon dioxide, both hazardous in large amounts. Carbon monoxide in the exhaust from gasoline/diesel-fuelled engines is so dangerous that use of such equipment in confined spaces should never be allowed.

Locate machinery and equipment that present ignition sources or give off toxic fumes outside the confined space. (e.g. pumps, engines.)

Welding operations change the environment within a confined space when toxic fumes are given off. Local exhaust needs to be provided to avoid buildup of toxic materials. However, there will still be some exposure of the welder to the fumes.

Take extra care when dealing with riveted tanks. Some riveted tanks have lead seals between two riveted plates. When the rivets leak, it is always tempting to weld them. Welding will melt the lead and intoxicate the welder.

d) All Personnel Leave the Confined Space

Upon completion of work within the confined space, the area should be cleared of all tools and debris. The Performing Authority needs to sign off the entry permit before handing over the space in safe condition to the Permit Issuing Authority/Operating Authority.

e) Final Inspection and All Clear Given to Return to Service

A final inspection must be undertaken by the Permit Issuing/Operating Authority to ensure that the completed work is adequate and matches the work order. Also, the space should be checked to make sure that no tools, objects or debris that may affect operations is left behind.

When everything is in order, the permit can be withdrawn, and the equipment returned to service. The original copy of the permit should be filed away while copies should be destroyed to avoid confusion or abuse.

2.4.3 Permit Issuing Authority and Work Performing Authority Responsibilities

No work may be carried out within restricted areas by engineering, maintenance and inspection, and other services, without written permission from the Permit Issuing Authority/Operating Authority.

The Permit Issuing Authority is responsible for:

- Determining and raising the type work permit required
- Preparing the area for safe entry by proper planning and identification of risk
- Arranging for the isolation of equipment
- Arranging gas testing
- Interpreting gas test results and making the decision to proceed
- Authorising and issuing the Confined Space Entry Permit
- Ensuring that a properly trained standby attendant is present during entry
- Monitoring the conditions within the confined space for changes
- Ensuring that a rescue plan is in place and emergency personnel are informed

The Work Performing Authority is responsible for:

- Identifying the hazards associated with performing work in the confined space
- Selecting suitable entrants to perform work within a confined space
- Ensuring that personnel are aware of the hazards that are present
- Checking that only safe tools are used in the confined space (e.g. non-sparking)
- Ensuring the safety of personnel working in a confined space by taking all prescribed and necessary precautions
- Performing the work
- Clearing the workplace after completion of work

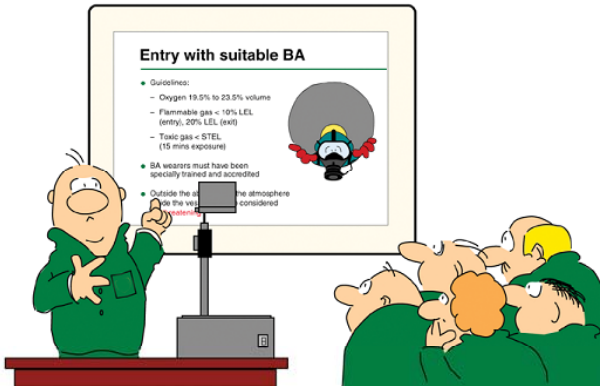
The permit, by itself, does not make entry safe. Workplace safety depends on people factors!

Effective communication and cooperation between Permit Issuing and Work Performing Authorities are essential for a successful Confined Space Entry Permit Program.

2.5 Training and Competence

The purpose of training is to equip individuals (authorised entrant, standby attendant, and entry supervisor) with an understanding, knowledge and skills necessary for work associated with confined spaces.

Training usually consists of written and practical examinations. The employer has to certify in writing that the employee has been trained. Certificates should be kept with the employee's personal and training records.



The following should be covered during training:

- Statutory requirements on confined space entry
- Responsibilities of various parties
- Key definitions
- Exact location of the worksite's permit-required confined spaces
- How to use the confined space permit
- Potential for engulfment
- Potential for hazardous atmospheres
- Explanation and demonstration on how to use air monitoring equipment
- Explanation and demonstration on how to use required confined space entry equipment (PPE, respiratory protection, etc.)
- Procedures for confined space rescue
- Explanation on the interface between confined space entry and lockout/tagout, respiratory protection and other work permits.
- How to properly use a pre-entry checklist

Persons working in confined spaces wearing breathing apparatus should be fully trained in the use of that equipment and given appropriate refresher training/certification. These persons may also be required to undergo medical surveillance, as required by local authorities / medical programmes.

Refresher training must be provided and conducted whenever:

- An employee's duties change
- Hazards in the confined space change
- The entry procedure changes
- An evaluation of the confined space entry program identifies inadequacies in the employee's knowledge

Some local regulators may require refresher training based on a calendar frequency (such as once every two years).

Important considerations when selecting entrants:

- Fitness and health
- Reaction to being in a confined space (claustrophobia)
- Reaction to wearing breathing apparatus
- Ability to perform job in limiting conditions

Overweight or excessively large persons may experience difficulty in entry, which may also cause problems during rescues.

Authorised entrants, standby attendants, gas testers, and entry supervisors must be adequately trained before assuming assigned responsibilities.

2.6 Common Mistakes and Pitfalls

- Failure to identify confined spaces
- Failure to isolate vessels
- Failure to isolate internal appliances e.g. mixers
- Failure to personally check that isolation is complete
- Exposure to explosive, toxic or asphyxiating atmosphere
- Exposure to hazardous materials
- Inability to exit quickly in an emergency
- Risk from activities outside the vessel

3.0 GAS TESTING AND PPE REQUIREMENTS

3.1 Gas Testing

Atmospheric testing must be conducted by an authorised Gas Tester to:

(1) evaluate the hazards of the permit space, and
(2) verify that the confined space is safe for entry.

NEVER trust your senses to determine if the air in a confined space is safe!

You CANNOT see or smell many toxic or combustible gases and vapours, nor can you determine the level of oxygen present.

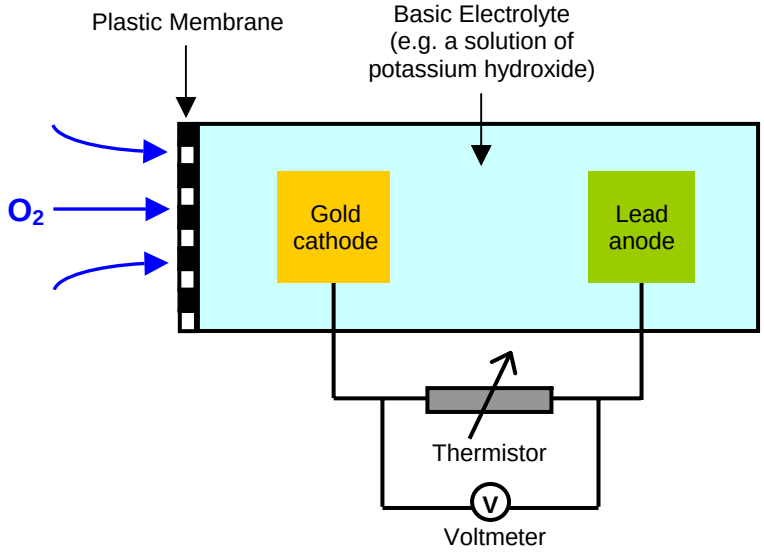
3.2 Order of Gas Testing

First Step	- Test **oxygen** in the atmosphere
Second Step	- Test **flammables** in the atmosphere
Third Step	- Test **toxics** in the atmosphere

A test for oxygen is performed first because most combustible gas meters rely on the presence of oxygen to function and will not provide reliable readings in an oxygen deficient atmosphere. Combustible gases are tested for next because the threat of fire or explosion is both more immediate and more life threatening, in most cases, than exposure to toxic gases and vapours. If tests for toxic gases and vapours are necessary, they are performed last.

Perform gas testing in this order:
(1) oxygen, (2) flammables, and (3) toxics.

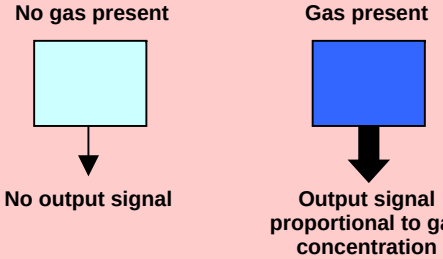
3.3 Gas Testing for Oxygen



Oxygen Analyser

Working Principle

The most common oxygen sensor works on an electrochemical principle. The oxygen diffuses through a plastic membrane into the interior of the electrochemical cell, where it produces a low electric current between the gold cathode and the lead anode. This signal is amplified and transmitted to the indicating instrument and to the alarm unit.

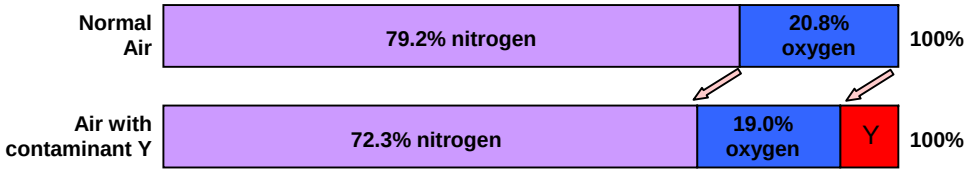


Electrochemical Cell
The electrolyte solution requires a specific gas (such as oxygen) to generate an output signal. Other gases have no effect. When the gas enters the cell, it produces a signal that is proportional to the amount of gas present.

Your oxygen analyzer should indicate 20.8% - the normal oxygen content in atmosphere. If the value is below 20.8%, it indicates that the air contains inert gases, flammables or toxic contaminants. How much inert / flammable / toxic gases are there? The following formula can calculate the percentages of contaminants in air:

$$\frac{20.8}{100} = \frac{X\%}{100 - Y\%}$$

Where
X = % vol of oxygen (as measured by your oxygen analyzer)
Y = % of contaminant gas
For instance, if x = 19.0%, then y = 8.7%.
Note: A reduction of 1.8% of oxygen in air means the presence of 8.65% of a contaminant gas or vapour.



With contaminants in air, the normal percentages of oxygen and nitrogen are reduced to smaller values. Knowing the new and smaller value of O_2 % from the oxygen analyser, the percentage of the contaminant in air can be calculated.

What Is The Contaminant?
It can be an inert, flammable or toxic material. Conduct other tests to determine what the contaminant is.

Oxygen-enriched Atmosphere
If the measured oxygen level is above 20.8%, it is most likely that a nearby oxygen cylinder or source is leaking. This condition is equally dangerous as an oxygen-enriched atmosphere (>23.5%) will cause flammable materials such as clothing, hair and oils to ignite more easily and burn violently.

- Inspect and ensure that any leaking oxygen source is identified and eliminated
- Never use pure oxygen for ventilation
- Never store or place compressed tanks or cylinders in a confined space

Refer to Process Safety Booklet 2 “Hazards of Air and Oxygen” for more details.

Oxygen Analyser Limitations

- The lead anode is used up over time and the sensor must be replaced every one to two years
- Oxygen analysers may be affected by prolonged exposure to acid gases such as carbon dioxide, and are not recommended for continuous use in atmospheres which contain > 25% CO_2
- The electrolyte will freeze below –20°C (5°F)

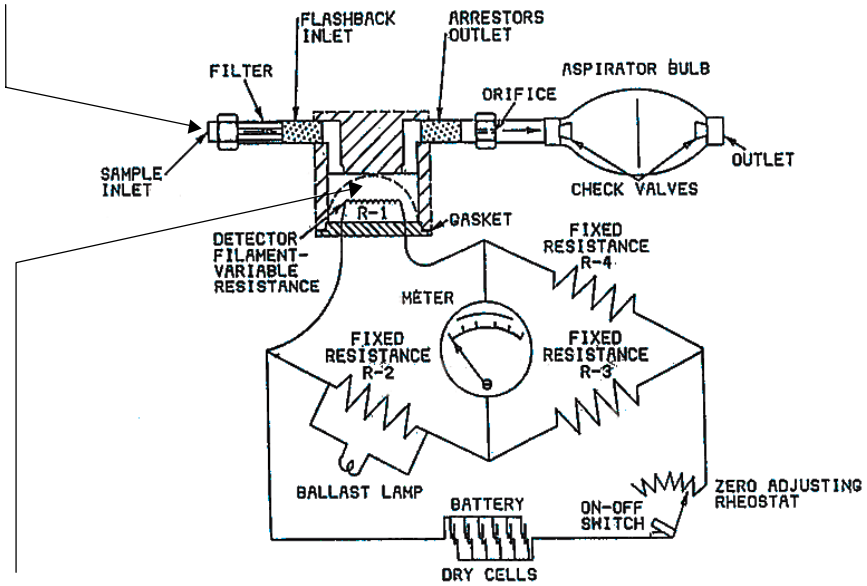
Whenever an oxygen level of less than 20.0% is detected it must be investigated further. (Either the analyser is reading wrongly or there is some contamination of the air.)

Performing Gas Tests

3.4 Gas Testing for Flammable Vapours

Most portable LEL detectors are catalytic-type detectors as described below.

Must have air/oxygen in sample!



Controlled combustion takes place here:
Oxygen + Flammable gases => CO_2 + H_2O + Heat

Typical Catalytic Explosimeter

Working Principle

The Wheatstone bridge is balanced under zero explosive conditions at ambient temperature. Air is flushed several times through the instrument which is then adjusted to zero using a single rheostat which adjusts the circuit balance and detector current simultaneously. This is done **every time before a test is performed.**

The sample is drawn into the cell by pumping the aspirator bulb (flame arrestors must be in place to prevent flame propagation). Heat is developed as the flammable mixture in the sample burns on a heated catalytic platinum filament forming part of the bridge. The filament temperature is raised; hence the resistance is raised in proportion to the heat of combustion in the sample,

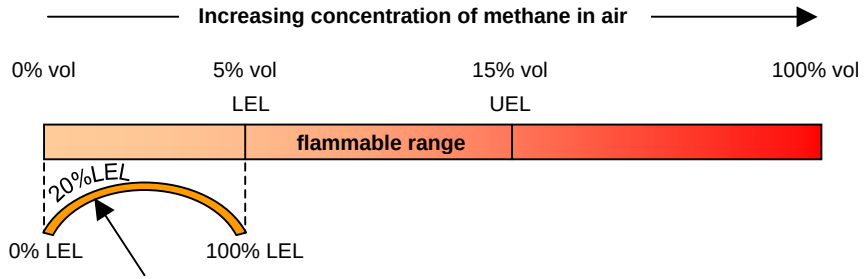
which is directly dependent upon the concentration of combustibles. A bridge imbalance occurs, the meter is deflected on a scale calibrated directly as % Lower Explosive Limit (LEL).

Pumping is continued until a **maximum** reading is obtained. After each determination the apparatus must be **flushed out with air by at least five pumps**.

Precautions / Limitations

- Appropriate concentration of oxygen (~20.8%) must be present in the sample to ensure combustion in the typical explosimeter. Hence, never use an explosimeter in an inert atmosphere unless the instrument incorporates an additional valve and arrangement to introduce air, such as special "Gas-scope / Tank-scope" instrument. Always undertake an oxygen reading first.

- Remember this instrument measures the % LEL. It does not measure the true concentrations of the flammables. It does not measure the concentration beyond LEL. For vapour above the LEL, the instrument will flick over and then return to zero, giving false sense of safety. However, your oxygen results from earlier measurement should give you an indication of how much flammable material there is.



The measurement range for most flammable gas detectors is only a fraction of the LEL. For instance, the flammable range of methane is between 5% (LEL) and 15% (UEL) by volume, but only the first 5% is monitored by most detectors.

- The instrument may become poisoned or inhibited by certain substances, thus affecting its accuracy. Some of the potential problems are shown below:
    - o halogenated compounds such as BCF fire extinguishers can cause poisoning of the filament
    - o the presence of anti-knock agents such as tetraethyl lead (TEL) & tetramethyl lead (TML) can cause permanent loss of sensitivity
    - o volatile compounds of sulphur, lead or mercury do irreversible damage to the catalytic platinum filament
    - o copper parts not recommended for acetylene
    - o silicones can coat the filament and cause insensitivity

- Use only **extension tubes** recommended by the manufacturers. Others e.g., plastics and natural rubber may absorb hydrocarbons from the gas sample.

- Calibration. If the explosimeter is calibrated on pentane, the reading may be 70% - 80% too high in the case of H_2 or CO, and 50% too low in the case of xylene.

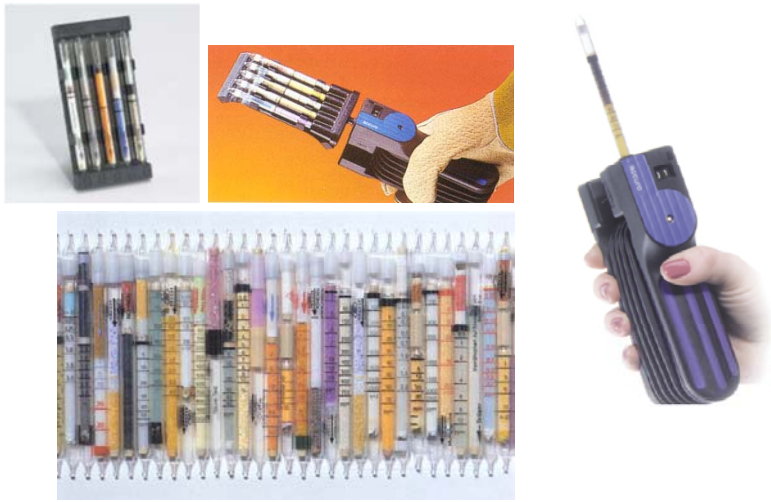
- Temperature Variation. Ethyl alcohol easily evaporates at atmospheric conditions, resulting in cooling effect that causes concentration equivalent of LEL to give only 66% LEL on a conventional explosimeter.

- High flash point materials such as lubricating oil, diesel oil or fuel oil is often heated **during** maintenance / repair work, giving rise to flammable atmosphere. This will be undetected if gas test is only done before the work starts, not continuously. If gas testing is carried out during the work, the explosimeter may not be able to detect heated vapours of high flash point materials because condensation will occur in the sampling tube. It is uncommon to obtain an "explosive" reading of a vapour with a flashpoint above ambient temperature. Cutting up oil drums with 1/10th pint oil left in them will form an explosive mixture as the oil is vapourised. Testing devices are not always entirely reliable. Visual inspection is essential.

- Leakage of air into the instrument through loose connections will cause a dilution effect and give lower readings.

If you have purged a flammable atmosphere with nitrogen, do not use a catalytic explosimeter to check for presence of flammable gas as it needs oxygen to operate. Use IR detectors for such tests.

3.5 Gas Testing for Toxic Vapours



Draeger Tubes

Working Principle

The equipment consists essentially of a hand-held bellow pump and a detector tube appropriate to the toxic compound to be measured. It is a convenient sampling system and makes use of specific chemical colorimetric reactions.

Method:

- Break fused tips of tube
- Insert tube in pump – arrow points towards the pump
- Draw in air with bellow pump – one stroke samples 100 ml of air
- Note number of strokes
- Two ways to assess results; an instruction sheet with each tube gives the method to be used.
    1. Do 'N' strokes to get a stain. Check its length against prior calibration.
    2. Do 'X' strokes to get a standard length of stain. 'X' is then related to concentration.

Advantages

Its main advantages are its convenience, speed of response and rapidity in terms of obtaining a quantitative answer.

Limitations

- Accuracy is in the range of +/- 20%. Hence:
- It is best to use a 'Go / No–Go' test. Negative results will usually be recorded as less than the detection limit, where entry is permitted. Positive results indicate that entry is not permitted.
- Store in cold. Each tube has specific instructions including storage life, which is usually two years, although stock turnover of not more than six months is preferable.

Other Types of Gas Detectors

- ***Electrochemical*** - Gas molecules from the sample are adsorbed on an electrocatalytic sensing electrode, after passing through a diffusion medium, and are electrochemically reacted at an appropriate sensing electrode potential. This reaction generates an electric current directly proportional to the gas concentration.
- ***Infrared*** - Infra-red instruments shine a "tuned" beam of light through the gas sample. If the target gas is present, a portion of the beams light spectrum is absorbed in proportion to the concentration of the gas.
- ***Papertape*** - Chemically-impregnated tape is used for very accurate and specific detection of toxic gases. Much like litmus paper, the tape changes colour when exposed to a given gas; the colour change is detected by a photocell, analyzed, and translated into concentration value.

Various fixed and portable gas detectors with visual, audible and/or vibrator alarms

There is a large range of fixed and portable toxic gas detectors available for use in detecting the full range of typical gases; H_2S, CO, CO_2, benzene, etc. In order to be effective, these devices need to be maintained and calibrated regularly to provide adequate assurance. The sensors are often sensitive and can be easily damaged.

3.6 Calibration and Maintenance

All gas testing instruments and apparatus should be registered and periodically calibrated and inspected in accordance with the manufacturer's instructions to ensure their integrity.

Calibration due dates must be indicated on each detector and records kept.

3.7 Taking Gas Measurements

Prior to any entry, tests of the atmosphere at appropriate places within the confined space should be carried out by an Authorised Gas Tester.

Where the vessel, equipment or system is large, multiple gas tests must be made.

Duration of testing should be at least the minimum response time of the test instrument specified by the manufacturer.

Initial gas testing should be performed from outside the space by inserting a probe or piece of flexible tubing.

Always sample through a pick-hole, or open the cover slightly on the downwind side (while personnel standing on upwind side), before opening the cover completely.

However, ensure that the contractor or employee performing gas testing is adequately protected with breathing apparatus if necessary and accompanied by a second person.

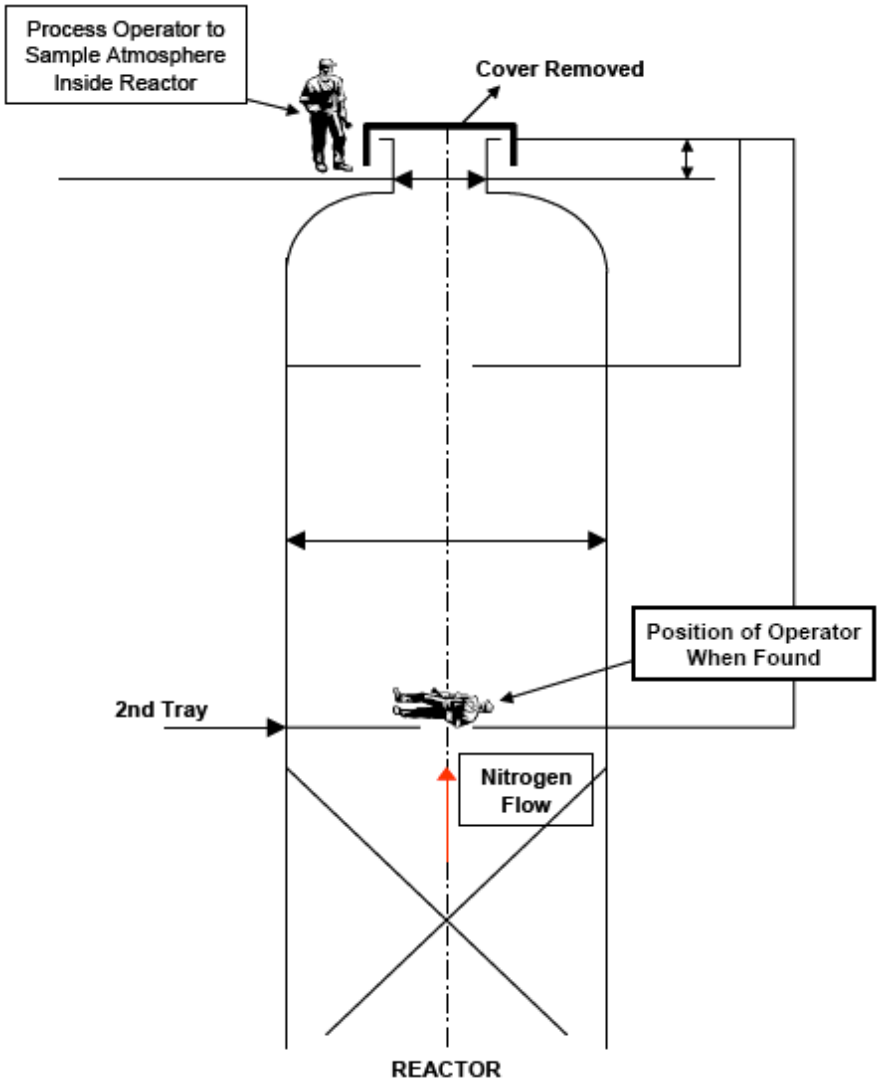
Accident

Gas Testing / Sampling can be Hazardous !!!

While in the process of taking a sample of the atmosphere from a reactor under nitrogen purge, the unaccompanied process operator removed the top manhole cover completely and became asphyxiated and fell to his death through the open manhole. The operator was not warned of an oxygen deficient atmosphere prior to sampling and the necessity to wear breathing apparatus in an area that could be deficient in oxygen. There was inadequate assessment of needs and risks associated with taking sample of the atmosphere inside the reactor. See the diagram on the next page.

- Have you adequately identified potentially hazardous jobs and reinforced critical safe behaviours in their procedures?
- Gas testing must be performed by a trained and certified authorised Gas Tester wearing the appropriate breathing apparatus.

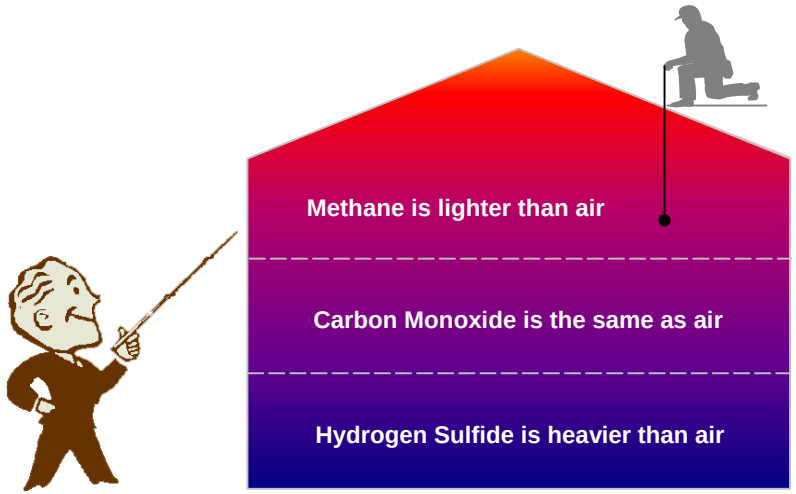
Nitrogen purge from bottom to top of reactor created an inert atmosphere outside the manhole that overcame an operator who removed the temporary plywood cover completely to take gas samples without any respiratory protection.



Testing Stratified Atmospheres

When monitoring for entry involving a descent into an atmosphere that may be stratified, the atmospheric envelope should be tested a distance of approximately 4 feet (1.22 m) in the direction of travel and to each side. If a sampling probe is used, the entrant's rate of progress should be slowed to accommodate the sampling speed and detector response.

Some vapors or gases are heavier than air and will settle to the bottom of a confined space. Other gases are lighter than air and will be found around the top of the confined space. Because of the different densities of various toxic gases, you must test all areas (**top**, **middle**, **bottom**) of a confined space.



Accident ***Have you gas tested at all levels and in all areas?***

A vertical reactor vessel (7.6m / 25 ft high) had been safely shutdown, the catalyst removed, water washed twice, ventilated, inspected, gas tested and approved for entry. Then, the vessel was left idle for 5 days with no mechanical ventilation. Gas testing was carried out again in preparation for entry but was done only in the area around 2.4m (8ft) from the top manhole. The reactor was then approved for entry by operations. The contractor went down the ladder with an employee at the top manhole who lowered an explosimeter / gas sentinel simultaneously with the entrant. No mechanical ventilation was installed for this entry. Halfway down the vessel, the gas sentinel alarmed due to a high LEL. The entrant immediately ascended the ladder and exited the vessel. He felt a headache and was sent to the hospital.

This incident could have resulted in a fatality or serious injury to the entrant from a flash fire or being exposed to toxic levels of hydrocarbons. Although no visible liquid hydrocarbon was detected in the vessel, hydrocarbon vapour was likely released from residues trapped behind the metallic reactor shroud or absorbed into the refractory liner. Gas testing at the manhole was definitely not representative of the entire internal working space. This incident clearly highlights why it is important to perform gas testing for **top**, **middle**, **and bottom** of confined spaces. Remember to gas test **at all levels and in all areas**.

Comment

An Authorized Gas Tester/Test Person is a person nominated by local management to undertake gas tests of confined spaces. Such a person will have received training in the use of the particular gas measuring instruments. However the responsibility for “WHAT” and “WHERE” to test for contaminants remains with the Confined Space Entry Permit Issuing Authority, who may also be the nominated authorized gas tester.

Other Precautions

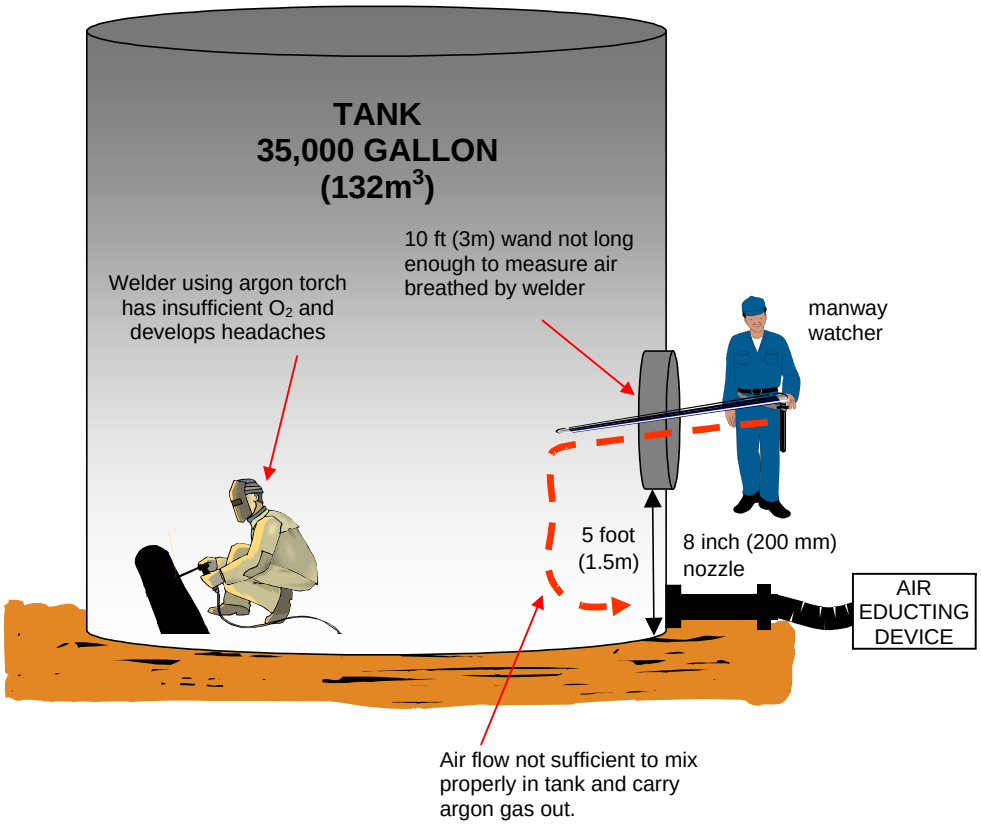
- Combustion (welding, heating, cutting, brazing, gasoline or diesel engines) and oxidation (rusting) can cause hazards in confined spaces. These processes can consume oxygen or displace oxygen by the combustion products, creating oxygen deficient atmospheres.
- Cutting cadmium plated bolts with a torch releases a toxic vapour.
- Once work begins, sample frequently or continuously. Conditions can change. As work progresses, a once-safe atmosphere can become hazardous due to leaks, combustion, cleaning processes or other factors.
- Even after an empty tank has been purged, toxic or flammable gases can desorb from porous walls or be liberated from sludge, cleaning solvents or produced by chemical reaction between sludge and solvents or other materials.

Accident ***Argon Arc Welding in Confined Space Causes Oxygen Deficiency!!!***

A welder suffered headaches after a day inside a tank using argon to weld repair titanium. It was discovered that there was a rapid decrease of oxygen in the area where he was working due to a poor ventilation arrangement. Furthermore, a manway watch attendant was monitoring the oxygen content in the tank at all times, but the 10ft (3m) wand he was using was not long enough to monitor the air where the welder was working (see figure below).

Local exhaust ventilation is required for welding work in a confined space.

The minimum safe level of oxygen in the air for working is 19.5% (which is not far below the normal level in the air of 21%). Refer to Process Safety Booklet No.10, "Hazards of Nitrogen and Catalyst Handling' for more details on the dangers of inert gas atmospheres and working in confined spaces.



Arrangement Set-up for Argon Arc Welding in Tank

3.8 Respiratory Protection

Respiratory protection of workers entering into Confined Spaces should be determined based upon the following principles and specific risk assessment guidelines.

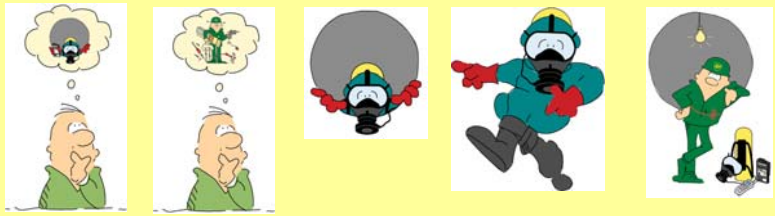
	OXYGEN	FLAMMABLE	TOXIC
ENTRY WITHOUT BREATHING APPARATUS	**20.8%**	**< 1% LEL**	**< 10% OEL**
SPECIFIC RISK ASSESSMENT	19.5 - 23.5%	up to 20% LEL*	up to STEL
UNSAFE - TOO HIGH FOR NORMAL BA	< 19.5% or > 23.5%	> 20% LEL	> STEL

Entry Dispensation Limits

Oxygen	Flammable	Toxic	Entry without Breathing Apparatus	Specific Risk Assessment	Unsafe Too High for normal BA
20.8%	< 1% LEL	<10% OEL	✓ **		
		upto STEL		✓	
		> STEL			✓
	upto 20% LEL*	<10% OEL		✓	
		upto STEL		✓	
		> STEL			✓
	> 20% LEL	<10% OEL			✓
		upto STEL			✓
		> STEL			✓
19.5% - 23.5%	< 1% LEL	<10% OEL		✓	
		upto STEL		✓	
		> STEL			✓
	upto 20% LEL*	<10% OEL		✓	
		upto STEL		✓	
		> STEL			✓
	> 20% LEL	<10% OEL			✓
		upto STEL			✓
		> STEL			✓
> 23.5% or < 19.5%	< 1% LEL	<10% OEL			✓
		upto STEL			✓
		> STEL			✓
	upto 20% LEL*	<10% OEL			✓
		upto STEL			✓
		> STEL			✓
	> 20% LEL	<10% OEL			✓
		upto STEL			✓
		> STEL			✓

Note: * Concentration below 10% LEL should be considered as an entry criteria, while 20% LEL used as an exit criteria where work should stop and persons be withdrawn from the confined space. ** Provided hazardous atmosphere is not generated by cleaning solvents, removal of sludge, hot work, etc.

Table showing Authorisation Requirement for Confined Space Entry against various levels of Gas Concentrations.

Types of Atmosphere	Characteristics and Guidelines	Entry Requirement
Safe Atmosphere	• oxygen content the same as atmospheric air, i.e. 20.8% • flammable gas concentration < 1% LEL • toxic gas concentration <10% OEL • adequate ventilation is provided to maintain atmospheric conditions • the space has been thoroughly cleaned of sludge, scale and any other material likely to give off harmful gases or vapours if disturbed • work inside the confined space, or on equipment connected to it and within the isolation envelope, cannot give rise to hazardous gases or vapours • work being carried out in the area outside the confined space cannot give rise to harmful gases or vapours which can enter the confined space through openings such as manways, disconnected piping or removed stirrers, • conditions are not expected to change	• Safe entry without respiratory protection • With adequate mechanical ventilation • Standby person • Gas testing after a break of >30 minutes If in doubt – use breathing apparatus during entry. 
Hazardous Atmosphere	• oxygen content should be in the range 19.5% to 23.5% volume • flammable gas concentration should be below 10% LEL (this should be considered as an entry criteria, with 20% LEL used as an exit criteria where work should stop and persons be withdrawn from the confined space) • toxic gas concentration at or below the STEL • where conditions are considered **likely to change** from safe atmosphere, e.g. entry is required to removed sludge, scale and any other material likely to give off hazardous gases or vapours	• Competent person to determine the degree of respiratory protection required based on risk assessment of the measured concentrations of gases / dusts within the space and the work to be carried out • Standby person 
Life-threatening Atmosphere	• the oxygen content is below 19.5% or above 23.5% • concentrations of flammable gas or vapour are above 20% LEL • concentrations of toxic gases or vapours are above short term exposure values (STEL)	• Strictly No Entry! See Note 1*.  Strictly No Entry!

*Note 1: Only specialist workers with recognised expertise, training, special respiratory protective equipment and work practices should be allowed to enter a life threatening atmosphere in confined space for rescue or to work under inert conditions. Special dispensation from senior site management should be sought whenever carrying out inert entry work, except for rescue which should only be carried out by personnel trained by a recognised emergency services organisation.

Breathing Air Supply Cut Off !!!

While cleaning the inside of a separator, the primary (and only) breathing air supply to the worker was cut off. The worker scurried out of the separator with the help of the standby attendant. In the worst case scenario, the worker could have died from lack of oxygen or being overcome by toxic fumes from the cleaning fluid. It was found that the wrong type and size of air compressor generator was used, which caused the air compressor to overheat and shutoff. Also, the air compressor plug connected to the generator was not the proper lock / explosion proof. This incident highlights the need to specify proper and adequate requirements for equipment used in confined space entry.

- Do not rely on contractors to decide correct equipment.
- Do not accept improper or sub-standard equipment.
- A secondary air supply, e.g. a 5-minute escape bottle is required.

Picture of the separator after the incident, with inadequate physical barrier and lack of signage.

Breathing Air Supply Running on Empty !!!

A contract worker was working 8m (26ft) inside an amine contactor tower using air supplied breathing apparatus when the air supply ceased because the external air bottle was exhausted. The labourer put in charge of monitoring and operating the air bottle system was ordered by a supervisor to perform other duties away from the air bottles. The worker was alert and quickly exited the tower. Two lessons can be learned here: (1) air bottles supplying air to breathing apparatus should be continuously monitored; (2) warning devices for low breathing air pressure should be installed and tested prior to the commencement of work.

3.9 Protective Clothing

Additional protection requirements for persons entering confined spaces can include:

- Hearing protection against excessive noise
- Specialised protective clothing and equipment for specific tasks such as shot/grit blasting, cutting and welding, etc.
- Special precautions against specific materials such as asbestos and radioactive materials

3.10 Common Mistakes and Pitfalls

- Inadequate gas testing
- No gas testing after lunch break
- Failure to interpret gas testing results correctly
- Failure in inspection and maintenance regime
- Inadequate respiratory protection
- Unauthorised person sneaking into confined space

4.0 EMERGENCY RESCUE

4.1 Rescue and Emergency Services

The site should have a procedure describing the means of rescue and allocation of resources (internal and/or external) to affect a confined space rescue, and the means of raising the alarm.

Rescue should always be considered when planning for Confined Space Entry work. In all cases of entry into confined spaces the methods of rescue of persons from inside the equipment must be agreed upon in advance with the appropriate emergency services function, irrespective of whether breathing apparatus is worn.

The hazards that may be faced during entry including information on the mode of exposure, signs or symptoms, and consequences of exposure shall be communicated to the entrants and standby person.

All entrants should exit from a permit required confined space as quickly as possible whenever:

a) An order to evacuate is given by the standby person or the entry supervisor;

b) The entrant recognizes any warning signs or symptoms of exposure to a dangerous situation; and

c) The entrant detects a prohibited condition, e.g. toxic level exceeds STEL.

For the rescue and emergency procedures to be sufficient and adequate overall, they should include consideration of:

- Resuscitation techniques
- Raising, and responding to the alarm
- Safeguarding rescuers
- Fire control
- Plant control
- First aid
- On-site, and off-site, emergency services
- Training

4.2 Rescue Team

The employer shall ensure that

- Each member of the rescue team is provided with, and is trained to properly use, the personal protective equipment and rescue equipment necessary for making rescues from confined spaces.

- Each member of the rescue team shall be trained to perform the assigned rescue duties. Each member of the rescue team shall also receive the training required of authorized entrants.

- Each member of the rescue team shall practice making confined space rescues at least once every 12 months, by means of simulated rescue operations in which they remove dummies, mannequins, or actual persons from the actual confined spaces, or from representative confined spaces. Representative permit spaces shall, with respect to opening size, configuration, and accessibility, simulate the types of confined spaces from which rescue is to be performed.

- Each member of the rescue team shall be trained in basic first-aid and in cardiopulmonary resuscitation (CPR). At least one member of the rescue team holding current certification in first aid and in CPR shall be available.

4.3 Design of Vessels to Facilitate Ease of Rescue

Rescue from a confined space is a specialized and difficult activity. New plant and equipment should, wherever possible, specify a minimum access way size of 24 inch (600 mm). It is virtually impossible to effect a confined space rescue using a breathing air apparatus with an 18 inch (450 mm) access way!

4.4 Lifeline

- When entry is made wearing breathing apparatus, all entrants must also wear a full body harness and lifeline that extends outside the confined space.

- The lifeline must be securely fastened to a proper support and with an arrangement to provide mechanical aid for the rescue of the person from confined space. The best choice will depend on the shape of the assess port(s). The person outside the equipment should be able to pull an affected man out of the confined space using the lifeline alone.

- When entry is authorised without breathing apparatus the wearing of full body harness and lifeline may still be advisable if access inside the confined space is particularly hazardous e.g. rope ladder extending over a substantial vertical height.

- Account should be taken of any internal equipment inside the confined space that might interfere with rescue by lifeline e.g. by "fouling" the lifeline and preventing rescue of, or even injuring, persons inside the confined space.

Entry into confined space with access ladder, safety harness with attached lifeline that extends out of confined space and secured to a proper support.

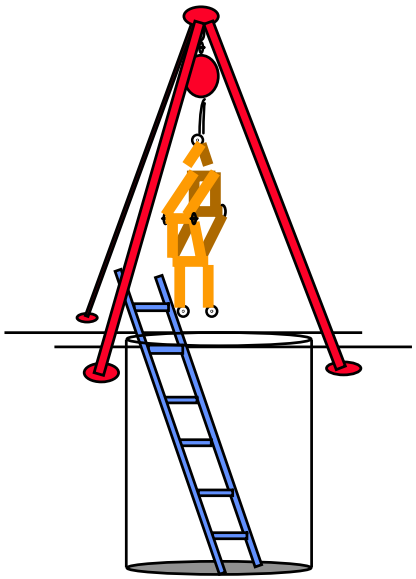
The preferred method of rescue is external (non-entry) confined space rescue, even though it may not be feasible on all occasions. The rule of thumb is that if external rescue via a tripod, winch, retrieval line, and body harness cannot be made, then the confined space entry should not be made in the first place. When such retrieval systems are used, they shall meet the following requirements.

- Each authorized entrant shall use a chest or full body harness, with a retrieval line attached at the center of the entrant's back near shoulder level, or above the entrant's head. Wrist harness may be preferable to a full body harness in the case of a closed vessel provided with one or more manholes.

- The other end of the retrieval line shall be attached to a mechanical device (such as a tripod and winch assembly) or fixed point outside the permit space in such a manner that rescue can begin as soon as the rescuer becomes aware that rescue is necessary.

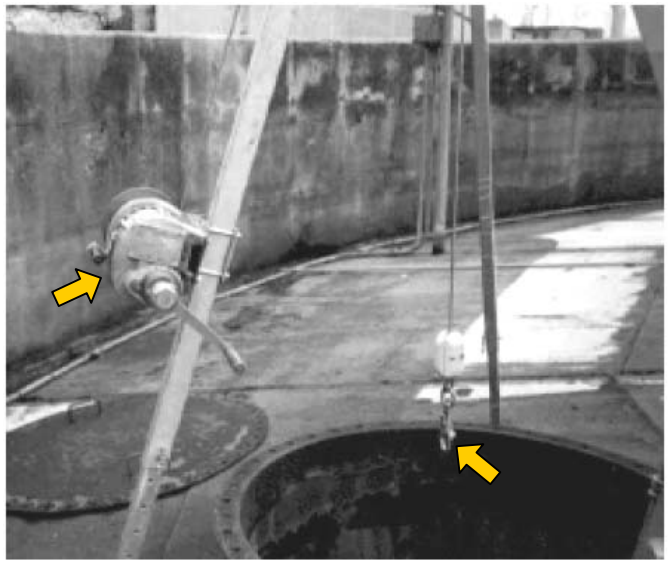
In the event of a rescue where the entrant is exposed to a hazardous material for which a Material Data Safety Sheet (MSDS) or other similar written information is required to be kept at the worksite, that MSDS or written information must be made available to the medical facility treating the exposed entrant.

A means must be provided for both safe normal entry or exit, and emergency extrication. Ladders may be used for ordinary entry and exit. ***Tripods with hoist, lifeline, and full body harness*** *are often used for emergency rescue and recovery.*



Entrant in full body harness making a correct entry into a confined space.

Manual winch and hook used to rescue entrant when required.



Accident

Botched Rescue !!!

Work was carried out on a tank containing residual toluene at a petroleum storage plant. It was a welded steel, cone roof tank approximately 20 ft (6 m) high by 9½ ft (3 m) in diameter. The only access to the tank interior was via a small opening (16 in / 0.41 m diameter) on the roof, since the tank was not fitted with a bottom entrance.

Two workers went to the roof of the tank, bringing along a single 30-minute self-contained breathing apparatus and a spare cylinder, a nylon rope, a squeegee mop and paper towels. The rope was tied at mid-length around the relief vent at the top of the cone roof, and one end was lowered into the tank. The intention was to lower the worker to the bottom of the tank and then have the breathing apparatus lowered to him. He had removed his shoes and left them on the roof prior to making entry, barefoot and without protective clothing or respiratory protection.

The victim was disabled very quickly after entering the tank. He was on the floor of the tank, overcome by lack of oxygen and the presence of toluene vapours. The other worker on the roof raised the alarm to other employees.

The local fire department responded to the rescue call promptly. There was some confusion about what material was inside the tank and its properties. A decision was made to cut into the tank based on an assessment that this approach would reach the victim more rapidly than any other and could be accomplished safely. During the rescue operations that utilised a gasoline engine-driven power saw an explosion occurred inside the tank resulting in the death of one fire-fighter and injury to 14 other fire-fighters. During the autopsy, it was estimated that the worker died of asphyxiation and inhalation of toluene vapours within 10 minutes of entry.

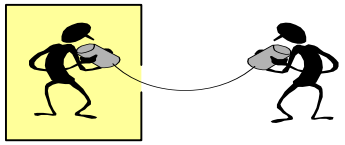
This incident highlights the severe consequences of an inadequate rescue arrangement (rescue procedures and equipment i.e. safety harness, lifeline, tripod with hoist, and drills with external assistance) prior to commencing a confined space entry.

4.5 Standby Person

In all cases a Standby Person / Attendant must be posted outside the confined space when work is performed, and must remain on duty throughout the duration of the entry, unless relieved by another person of equivalent experience and training, and knowledge of the job. This individual should be provided with an equivalent level of protection worn by those within the confined space so that he can look into the vessel.

The specific duties of a Standby Person should include the following:

- Maintain an accurate count of all persons within the confined space,
- Monitor activities inside and outside the confined space to determine whether it remains safe for the entrants to remain inside the space,



- Maintain effective and continuous contact with the persons working inside the confined space, if needed using radio, agreed hand signals, horn, lights, etc.

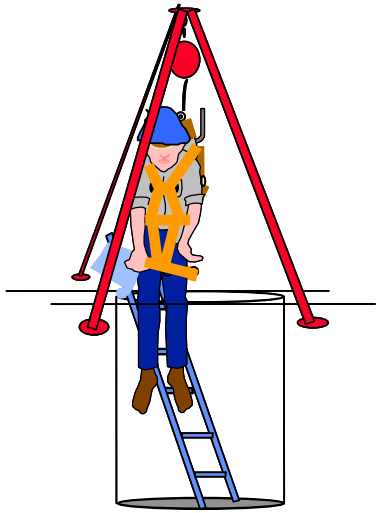
- Prevent entry of unauthorised persons,
- Order evacuation of the confined space if conditions change or any situation occurs which could endanger entrants,

- Raise the alarm and summon rescue services in an emergency,
- Assist the rescue services as necessary **without** entering the confined space.

Should conditions develop which require extrication, and the entrants cannot get out of the confined space on their own, the **standby person must call for emergency assistance at once!**

The standby person should attempt to remove the entrant from the confined space using tripods, hoist, and lifelines. **The Standby Person must NEVER enter confined spaces**. Lethal hazards may be present within the confined space. Only properly equipped and trained emergency rescue personnel may enter confined spaces to make rescues.

The Standby Person must NEVER enter confined spaces to attempt rescue.



Accident ***Additional Three Die in Fatal Rescue !!!***

Four men were assigned to work inside an empty sewage tank. One man entered the tank with a safety harness, but no lifeline. When he uncoupled a hose that was used to drain off the tank's contents, residual sewage and gases in the line flowed back into the tank. The mixture of methane and hydrogen sulfide overcame the man inside the tank, and he lost consciousness. One by one, his co-workers (who were observing the operation from outside the tank) entered the tank to attempt a rescue. All were overcome within a minute. They drowned in sewage.

This story is tragic, but all too familiar. Just how often does this occur? Refer to annual statistics provided by the National Safety Council and the Bureau of Labor Statistics, USA on fatalities that occur in the workplace. In 1996, approximately 60 fatalities occurred from confined space entries. Out of this number, over 60% of the victims were rescuers!

Over 60% of workers who die in confined spaces are would-be rescuers.

Accident ***Fatalities due to Solvent Spraying and Rescue !!!***

Three workers were killed while cleaning an above ground 8,000-gallon (30 m^3) storage tank used to store clear vinyl coating. A contractor was applying the solvent cyclohexanone from a hatch on the tank's roof with a pressurised wand. At some point, he entered the confined space of the tank. The safety manager and a co-worker died while trying to rescue him. The deaths were caused by chemical exposure and lack of oxygen. The spraying of solvents can itself be hazardous and needs to be assessed before permission is given to do so e.g. toxic risks, static ignition if a flammable solvent is used, etc. Rescue attempts must not be made, unless competent rescuers are provided with and wearing appropriate protection – e.g. breathing apparatus, protective clothings, rescue lines, etc.

5.0 POINTS TO REMEMBER AT TOOL BOX MEETINGS

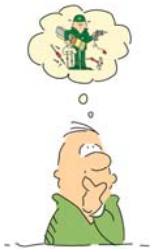
! Take care when planning or performing a job to ensure that all types of hazards have been identified and that confined spaces are not inadvertently introduced.

! Perform gas tests after vacating any confined space for a period of time, e.g. for a break, to ensure that safe working conditions are still present.

! Never store compressed gas cylinders/tanks in a confined space, regardless of its contents.

! Check your Material Safety Data Sheets (MSDSs) for information on the toxicity and flammability of chemicals where exposure potential exists. Plan your actions accordingly and ensure that the appropriate protective measures are in place.

! When authorising entry to confined spaces, remember to consider what is to be taken into the confined space by the workers, e.g., paints, coatings, solvents, burning gas, and inerts for weld shielding. Consider also the consumption of oxygen by metal spraying processes and generation of welding/burning fumes.



! Watch out for sources of static electricity within a confined space. Remember to earth/ground static generating devices to prevent static accumulation.

! Keep pyrophoric scale *wet* to avoid ignition and fire.

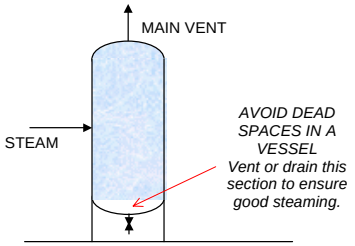
! The Confined Space Entry Permit is only for entry! In order to perform work within the space, a Hot Work or Cold Work Permit is also required.

! The Confined Space Entry Permit is declared void when:

a) Conditions change, making the job unsafe
b) Work is delayed or work is stopped for more than two (2) hours
c) An alarm to exit the space is activated
d) An order is given to exit the space

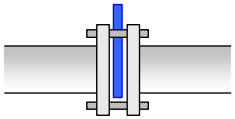
! Access to confined spaces must be physically barricaded and locked at all times when a valid permit is not issued. In this case, use of keys must be controlled.

! Can the confined space be modified so that entry is not necessary? Can the work be done from outside (for example flushing or water jetting blockages, using long-handled paint brushes or other tools, using remote cameras, or other means)? Examine the advantages and disadvantages of alternative methods before deciding.



! Plan steam out procedures well to avoid overpressure, vacuum or dead spaces (that get little or no steam) in a vessel.

! Perform isolation as close as possible to towers and vessels being prepared for confined space entry. Where this is not possible, prohibit entry into the space while hot work is taking place on connected lines or vessels.



! "Gas free" does not mean "flammable free".

! Deposits or residue material can give out toxic or flammable vapours under certain conditions (e.g. heating). Testing and inspection must encompass checks for these materials.

! Watch out for unidentified residual or stored energy sources within a confined space after the isolation process.

! Never authorize a Confined Space Entry Permit without being absolutely certain that the area is safe for entry.

! There is no substitute for walking around the isolated equipment to check each connection and verify positive isolation.

! Ensure that the selected means of isolation has been designed to withstand subjected pressures.

! When venting toxic, inert, or flammable gases, make sure the venting area is far away from the work area, roads, etc. and cordon it off.

! If the confined space fails the gas test, take time to examine the situation and perform proper planning before repeating preparation steps.

! Check that the lighting provided is certified for use in the location and is in good condition before starting work.

Explosion-proof drop light

! Installed ladders must be inspected on a periodic basis to ensure that they are safe for use. It is important to also check the devices holding the ladder, e.g. attachment bolts and screws.

! Ensure that winching and hoisting devices used for entry into a confined space never leaves the entry/exit point when the confined space is occupied to provide a ready means of retrieval.

! Do not enter a confined space unless every precaution specified in the entry permit is fulfilled.

! Double check against the work order and entry permit that the correct equipment is to be entered.

! Where a change in the atmosphere inside a confined space may be expected (e.g. oxygen deficiency/excess, build up of flammable or toxic gases due to disturbance of sludge), continuous monitoring of the atmosphere must be carried out.

! The Confined Space Entry Permit is withdrawn once conditions deviate from the safe levels recorded on the permit. Exit the space immediately and do not reenter until the permit has been reissued.

! Avoid deviating from work instructions as new actions would not have been properly risk assessed.

! Adequate air supply and ventilation should always be ensured when toxic vapours are expected. If ventilation is insufficient, self-contained breathing apparatus (SCBA) must be used.

! Locate machinery and equipment that present ignition sources or give off toxic fumes outside the confined space. (e.g. pumps, engines.)

! The permit, by itself, does not make entry safe. Workplace safety depends on people factors!

! Effective communication and cooperation between Permit Issuing and Work Performing Authorities are essential for a successful Confined Space Entry Permit Program.

! Authorised entrants, standby attendants, gas testers, and entry supervisors must be adequately trained before assuming assigned responsibilities.

! NEVER trust your senses to determine if the air in a confined space is safe!

! You CANNOT see or smell many toxic or combustible gases and vapours, nor can you determine the level of oxygen present.

! Perform gas testing in this order:

1. Oxygen
2. Flammables
3. Toxics

! Whenever an oxygen level of less than 20.0% is detected it must be investigated further. (Either the analyser is reading wrongly or there is some contamination of the air.)

! If you have purged a flammable atmosphere with nitrogen, do not use a catalytic explosimeter to check for presence of flammable gas as it needs oxygen to operate.

! Local exhaust ventilation is required for welding work in a confined space.

! The Standby Person must NEVER enter confined spaces to attempt rescue.

! Over 60% of workers who die in confined spaces are would-be rescuers.

6.0 TEST YOURSELF

Confined Spaces

1 **One of the first questions that should be answered before planning entry into a confined space is "can this job/task be accomplished without entering the space?"**

True ❍ False ❍

2 **The Permit-Required Confined Space Entry program requires the employer to initially evaluate the workplace to determine if there are any confined spaces.**

True ❍ False ❍

3 **A confined space is an equipment that stands apart from an operation's main facility.**

True ❍ False ❍

4 **A confined space has limited or restricted means for entry and exit.**

True ❍ False ❍

5 **An underground office where authorised personnel spend most of their 40-hour workweeks is considered a confined space.**

True ❍ False ❍

6 **An open trench more than 4ft (1.2m) deep is a confined space.**

True ❍ False ❍

7 **A worker can access the roof of an empty floating roof tank (20ft / 6m of height) without confined space entry permit because there is no product in the tank.**

True ❍ False ❍

Confined Space Entry Program

8 **Entry into a permit-required confined space is considered to have occurred only when the whole body of entrant is fully inside the confined space.**

True ❍ False ❍

9 **The most deadly hazards associated with confined spaces are hazardous atmospheric conditions and engulfment.**

True ❍ False ❍

10 **If an employer decides that he/she will contract out all confined space work, then the employer does not need to develop an effective Confined Space Entry program.**

True ❍ False ❍

11 **A written Confined Space Entry Permit program requires that the employer develop a system to prepare, issue, and cancel entry permits.**

True ❍ False ❍

12 **The following actions are essential parts of a Permit-Required Confined Space program: a) permit must include the purpose, date, and duration of entry; b) listing all residual hazards and necessary precautions on the permit is compulsory; c) rescue plan is devised and attached to the permit.**

True ❍ False ❍

13 **The type of ventilation methods to be used for confined space entry is determined by the configuration and contents of the confined space, and the tasks to be performed inside it.**

True ❍ False ❍

14 **Hot work is going to be performed in a solvent reactor vessel that is 12ft (3.7m) high and 8ft (2.5m) in diameter. After cleaning and purging the vessel, the worker can enter it without a confined space entry permit.**

True ❍ False ❍

15 **Local exhaust ventilation is not required for welding work in a confined space.**

True ❍ False ❍

16 **Ladders in confined spaces should be inspected periodically because corrosion often occurs.**

True ❍ False ❍

17 **When contracting out all confined space work, the employer does not need to ensure that the contractor has a proper rescue plan.**

True ❍ False ❍

18 **Training of all employees whose work is regulated by the Permit-Required Confined Space standard shall only be provided when the employer believes that there are inadequacies in the employee's knowledge of the company's confined space procedures.**

True ❍ False ❍

19 **The following must be included in employee training for confined spaces: a) precise locations of all permit-required confined spaces at the worksite; b) proper use of the worksite's pre-entry checklist; c) written evaluation and certification of each trained employee; d) refresher training when job duties change.**

True ❍ False ❍

Gas Testing

20 **The proper gas testing sequence for confined spaces is the following: Toxics, Flammables, Oxygen.**

True ❍ False ❍

21 **The principal of operation of most combustible gas meters / explosimeters used for permit entry testing is catalytic combustion.**

True ❍ False ❍

22 **When you use a combustible gas meter / explosimeter to test an atmosphere with a mixture of 2% by volume methane with a balance of nitrogen, the reading is zero.**

True ❍ False ❍

23 **Combustible gas meters / explosimeters should be used to detect toxic gases because they can measure all types of gases.**

True ❍ False ❍

24 **Toxic gases in confined spaces can result from: products stored in the space and the manufacturing process, work being performed inside the space or in adjacent areas, desorption from porous walls and decomposing organic matter.**

True ❍ False ❍

25 **It is the duty of the standby attendant to continually test the level of toxic chemicals in the confined space.**

True ❍ False ❍

Standby Attendant

26 **A standby attendant is a person with no other duties assigned other than to remain immediately outside the entrance to the confined space and who may render assistance as needed to personnel inside the space. The attendant never enters the confined space and never leaves the space unattended while personnel are within the space.**

True ❍ False ❍

27 **A standby attendant watches over a confined space while other employees are in it and only leaves if he or she must use the restroom.**

True ❍ False ❍

28 **A standby attendant is a person who runs to the nearest food store to buy refreshments for the crew inside the confined space.**

True ❍ False ❍

29 **It is standby attendant's responsibility to issue confined space entry permits.**

True ❍ False ❍

30 **Standby attendants can enter the space to rescue a worker but only when wearing a SCBA and connected to a life line.**

True ❍ False ❍

Rescue Team

31 **During most confined space incidents, outside personnel tend to risk personal safety to rescue others affected inside the confined space.**

True ❍ False ❍

32 **The employer shall provide trained confined space rescue personnel for each confined space entry effected.**

True ❍ False ❍

33 **The rescue personnel must be on site, must be aware that confined space entry is being performed, and must be immediately available to perform rescue.**

True ❍ False ❍

34 **Each member of the rescue team will practice making rescues at least once every year.**

True ❍ False ❍

35 **Each member of the rescue team need not be trained in basic first-aid and cardiac-pulmonary resuscitation (CPR).**

True ❍ False ❍

ANSWERS

1T / 2T / 3F / 4T / 5F
6T / 7F / 8F / 9T / 10F
11T / 12T / 13T / 14F / 15F
16T / 17F / 18F / 19T / 20F
21T / 22T / 23F / 24T / 25F
26T / 27F / 28F / 29F / 30F
31T / 32T / 33T / 34T / 35F

7.0 GLOSSARY

LEL	Lower Explosive Limit
UEL	Upper Explosive Limit
OEL	Occupational Exposure Limit
STEL	Short Term Exposure Limit
MSDS	Material Safety Data Sheet
MTBE	Methyl Tertiary Butyl Ether
OSHA	Occupational Safety and Health Administration
JSA/JHA	Job Safety/Hazard Analysis
THA	Task Hazard Analysis
LOTO	Lock-out and Tag-out
N_2	Nitrogen
O_2	Oxygen
CO	Carbon Monoxide
CO_2	Carbon Dioxide
H_2	Hydrogen
H_2S	Hydrogen Sulphide
GFCI	Ground Fault Circuit Interrupters
SCBA	Self-Contained Breathing Apparatus
PPE	Personal Protective Equipment
BCF	Bromochlorodifluoromethane
TEL	Tetraethyl lead
TML	Tetramethyl lead
CPR	Cardiopulmonary resuscitation

8.0 LIST OF REFERENCES

ANSI Z117.1 Safety Requirements for Confined Spaces

API 2217 Guidelines for Work in Inert Confined Spaces in the Petroleum Industry

API 2015 Safe Entry & Cleaning of Petroleum Storage Tanks

OSHA 29 CFR 1910.46; 94 & 252
1926.651
1915.12; 13; 14 & 15

UK HSE Approved Code of Practice, Regulations and Guidance “Safe Work in Confined Spaces” ISBN 0-7176-1405-0

http://www.hse.gov.uk/spd/spdconf.htm

Complete Confined Spaces Handbook; John F Rekus ISBN 0-87371-487-3

Introduction to Safety Management (Lesson 6: Confined Space Entry); ABS Consulting, Government Institutes Division

Occupational Medicine, Third Edition; Carl Zenz, O. Bruce Dickerson, Bruce P. Horvath, Jr.

IP Guidance on the Declassification of Tanks Previously in Leaded Gasoline Service, The Institute of Petroleum, London, 1998

Safe Work in Confined Spaces, HSE Leaflet, ISBN 7176 1442 5

Loss Prevention Bulletin, No. 154, August 2000, Special Issue on Confined Space Entry, Institution of Chemical Engineers, Rugby, U.K.

PAST INCIDENTS RECORDED IN QSB

(Tear-away Sheet)

INCIDENTS	YEAR/QUARTER
Fatal Accident during Inspection of Tanks	1971/1Q
Man Affected by Cleaning Fluid Vapour	1973/2Q
Office Fire	1973/4Q
Gassing Incidents	1977/4Q
Two Men are Asphyxiated During Removal of Catalyst from a Vessel Under Nitrogen Cover	1978/4Q
Gassing Incident Onboard a Ship	1979/4Q
Welder Asphyxiated	1980/1Q
Three Men Killed During Tank Cleaning Operations	1981/1Q
Toluene Tank Explosion with Fatalities	1986/1Q
Europe – Fatalities During Cleaning Operations of Crude Oil Rail Car	1986/23Q
Gassing Incident	1988/34Q
Worker Exposed to Toxic Fumes	1989/1Q
Contractor Fatality During Construction Work	1992/1Q
Three Killed by Hazardous Vapours	1992/3Q
A Partially Enclosed Space	1993/4Q
Fire and Fatalities at Crude Unit	1994/4Q
Contractor Fatality	1995/4Q
Confined Space: Contractor Fatality	1996/2Q
Refractory Explosion – RVI	1996/3Q
Incident During Chemical Cleaning	1996/4Q
Contractor Fatalities During Maintenance	1997/1Q
Vessel Entry Incident	1997/3Q
Fatality from a Temporary Confined Space	1998/2Q
Confined Space Entry – A Near Miss	1998/4Q
Nitrogen Gassing Incident	1998/4Q
Confined Space Fatality	1999/4Q
Nitrogen Asphyxiation	2000/1Q
Breathing Air Supply Failure	2000/1Q
Fatality During Removal of Catalyst Under Nitrogen Cover	2001/2Q
Inert Gas Entry Fatality	2001/3Q
Technician Overcome by Oxygen Deficient Environment	2001/4Q
Confined Space Entry “Near Miss”	2002/1Q
Multiple Fatalities due to Hydrogen Sulphide Released from Molecular Sieves After Contact with Water	2002/2Q
Argon Arc Welding in Confined Space Causes Oxygen Deficiency	2002/4Q
Uncontrolled Temporary Confined Space	2002/4Q