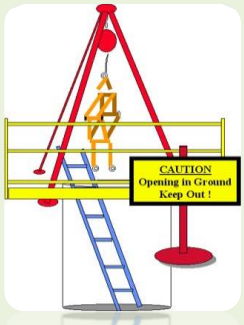
Confined Space Safety



A number of people are killed or seriously injured in confined spaces each year around the world. This happens in a wide range of industries, from those involving complex plant to simple storage vessels. Those killed include people working in the confined space and those who try to rescue them without proper training and equipment.

Many workplaces contain spaces that are considered "confined" because their configurations hinder the activities of employees who must enter, work in, and exit them. A confined space has limited or restricted means for entry or exit, and it is not designed for continuous employee occupancy. Confined spaces include, but are not limited to underground vaults, tanks, storage bins, manholes, pits, silos, process vessels, and pipelines.

Confined space can be any space of an enclosed nature where there is a risk of death or serious injury from hazardous substances or dangerous conditions (e.g. lack of oxygen).means a space that has any of the following characteristics:

— limited openings for entry and exit;
— unfavourable natural ventilation;
— not designed for continuous worker occupancy.

Some confined spaces are fairly easy to identify, e.g. enclosures with limited openings:
storage tanks; silos; reaction vessels; enclosed drains; sewers.
Others may be less obvious, but can be equally dangerous, for example:
open-topped chambers; vats; combustion chambers in furnaces etc; ductwork; unventilated or poorly ventilated rooms.

It is not possible to provide a comprehensive list of confined spaces. Some places may become confined spaces when work is carried out, or during their construction, fabrication or subsequent modification.
In general ,it includes, but is not limited to, boilers, pressure vessels, cargo holds, cargo tanks, ballast tanks, double bottoms, double hull spaces, fuel oil, lube oil, sewage-tanks, pump-rooms, compressor rooms, cofferdams, void spaces, duct keels, inter-barrier spaces and engine crankcases.

Dangers of confined spaces

A lack of oxygen.

- This can occur:
  - where there is a reaction between some soils and the oxygen in the atmosphere;
  - following the action of groundwater on chalk and limestone which can produce carbon dioxide and displace normal air;
  - in ships' holds, freight containers, lorries etc as a result of the cargo reacting with oxygen inside the space;
  - inside steel tanks and vessels when rust forms.
- Poisonous gas, fume or vapour. These can:
  - build-up in sewers and manholes and in pits connected to the system;
  - enter tanks or vessels from connecting pipes;
  - leak into trenches and pits in contaminated land, such as old refuse tips and old gas works.
- Liquids and solids which can suddenly fill the space, or release gases into it, when disturbed. Free-flowing solids such as grain can also partially solidify or 'bridge' in silos, causing blockages which can collapse unexpectedly.
- Fire and explosions (e.g. from flammable vapours, excess oxygen etc).
- Residues left in tanks, vessels etc, or remaining on internal surfaces, which can give off gas, fume or vapour.
- Dust present in high concentrations, e.g. in flour silos.
- Hot conditions leading to a dangerous increase in body temperature.

Some of the above conditions may already be present in the confined space. However, some may arise from the work being carried out, or because of ineffective isolation of plant nearby, eg leakage from a pipe connected to the confined space. The enclosure and working space may increase other dangers arising from the work being carried out, for example:

- machinery being used may require special precautions, such as provision of dust extraction for a portable grinder, or special precautions against electric shock;
- if access to the space is through a restricted entrance, such as a manhole, escape or in an emergency will be more difficult
- gas, fume or vapour can arise from welding, or by use of volatile and often flammable solvents, adhesives etc;

Safe systems of work

If you cannot avoid entry into a confined space, make sure that a safe system for working is in place before work proceeds inside the confined space. Use the results of risk assessment to help identify the precautions you need to take to reduce the risk of injury. These will depend on the nature of the confined space, the associated risk and the work involved.
Make sure that the safe system of work, including the precautions identified, is developed and put into practice. Everyone involved will need to be properly trained and instructed to make sure they know what to do and how to do it safely.
The below mentioned are required and includes many of the essential elements to help prepare a safe system of work.

Responsible supervisor

Supervisors should be given responsibility to make sure that the necessary precautions are taken, to check safety at each stage and may need to remain present while work is underway.

People suitable for the work

Do they have sufficient experience of the type of work to be carried out, and what training have they received? Where risk assessment highlights exceptional constraints as a result of the physical layout, are individuals of suitable build? The competent person may need to consider other factors, e.g. concerning claustrophobia or fitness to wear breathing apparatus, and may need to seek medical advice on an individual's suitability.

Isolation

Mechanical and electrical isolation of equipment is essential if it could otherwise operate, or be operated, inadvertently. If gas, fume or vapour could enter the confined space, you need to isolate the pipe work. In all cases, a check should be made to ensure isolation is effective.

Cleaning before entry

This may be necessary to ensure fumes do not develop from residues etc while the work is done.

Check the size of the entrance

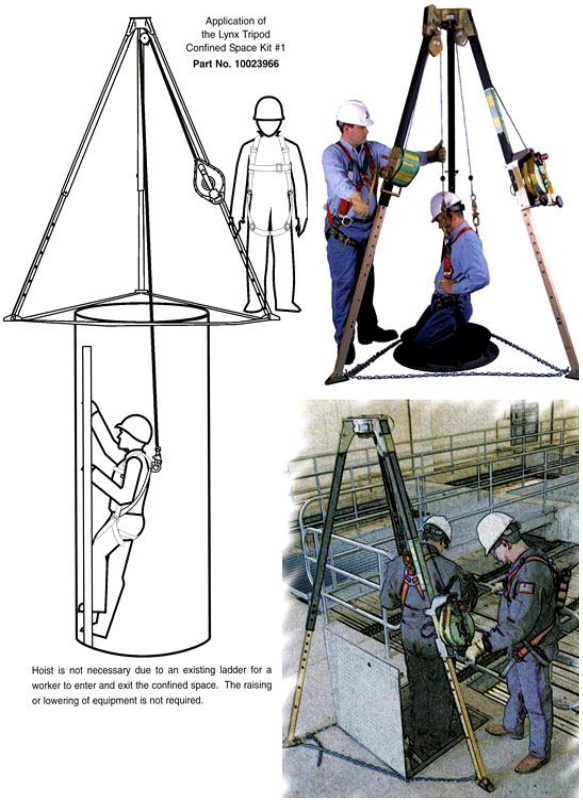
Is it big enough to allow workers wearing all the necessary equipment to climb in and out easily, and provide ready access and exit in an emergency? For example, the size of the opening may mean choosing air-line breathing apparatus in place of self-contained equipment which is more bulky and therefore likely to restrict ready passage.

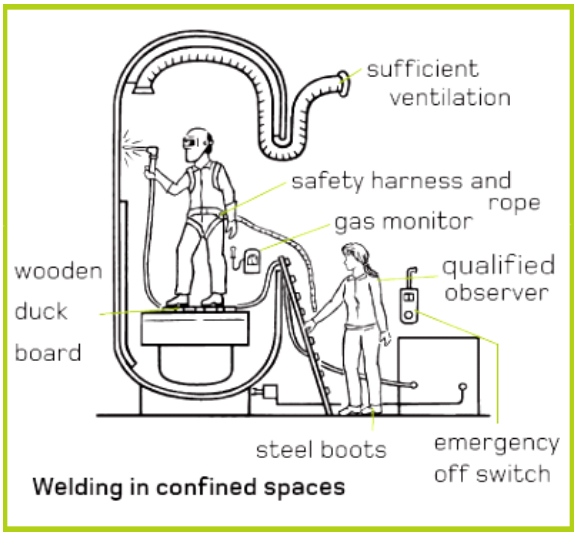
Provision of ventilation

You may be able to increase the number of openings and therefore improve ventilation. Mechanical ventilation may be needed to make sure there is an adequate supply of fresh air. This is essential where portable gas cylinders and diesel-fuelled equipment are used inside the space because of the dangers from build-up of engine exhaust. Warning: carbon monoxide in the exhaust from petrol-fuelled engines is so dangerous that

Testing the air

Testing the air may be necessary to check that it is free from both toxic and flammable vapours and that it is fit to breathe. Testing should be carried out by a competent person using a suitable gas detector which is correctly calibrated. Where the risk assessment indicates that conditions may change, or as a further precaution, continuous monitoring of the air may be needed.





Provision of special tools and lighting

Non-sparking tools and specially protected lighting are essential where flammable or potentially explosive atmospheres are likely. In certain confined spaces (e.g. inside metal tanks) suitable precautions to prevent electric shock include use of extra low voltage equipment (typically less than 25 V) and, where necessary, residual current devices.

Provision of breathing apparatus

Breathing apparatus is essential if the air inside the space cannot be made fit to breathe because of gas, fume or vapour present, or lack of oxygen. Never try to 'sweeten' the air in a confined space with oxygen as this can greatly increase the risk of a fire or explosion.

Preparation of emergency arrangements (will be discussed in detail later)

Emergency arrangements will need to cover the necessary equipment, training and practice drills.

Provision of rescue harnesses

Lifelines attached to harnesses should run back to a point outside the confined space.

Communications

An adequate communications system is needed to enable communication between people inside and outside the confined space and to summon help in an emergency.

Check how the alarm is raised

Do you need to position someone outside to keep watch and to communicate with anyone inside, raise the alarm quickly in an emergency, and take charge of the rescue procedures?

Is a 'permit-to-work' necessary?

A permit-to-work ensures a formal check is undertaken to make sure all the elements of a safe system of work are in place before people are allowed to enter or work in the confined space. It is also a means of communication between site management, supervisors, and those carrying out the hazardous work.

Essential features of a permit-to-work are:

- clear identification of who may authorise particular jobs (and any limits to
  - their authority) and who is responsible for specifying the necessary
  - precautions (e.g. isolation, air testing, emergency arrangements etc);
- making sure that contractors engaged to carry out work are included;
- training and instruction in the issue of permits;
- monitoring and auditing to make sure that the system works as intended

Emergency procedures

When things go wrong, people may be exposed to serious and immediate danger. Effective arrangements for raising the alarm and carrying out rescue operations in an emergency are essential.

Contingency plans will depend on the nature of the confined space, the risks identified and consequently the likely nature of an emergency rescue.

Emergency arrangements will depend on the risks. You should consider communications and rescue and resuscitation equipment.

Communications

How can an emergency be communicated from inside the confined space to people outside so that rescue procedures can start? Don't forget night and shift work, weekends and times when the premises are closed, e.g. holidays. Also, consider what might happen and how the alarm can be raised.

Rescue and resuscitation equipment

Providing suitable rescue and resuscitation equipment will depend on the likely emergencies identified. Where such equipment is provided for rescuers to use, training in correct operation is essential.

Injuries and fatalities in Confined Space

Injuries and fatalities involving confined spaces are frequent and often involve successive fatalities when would-be rescuers succumb to the same problem as the initial victim. Approximately 60% of fatalities involve would-be rescuers and more than 30% of fatalities occur in a space that has been tested and found to be safe to enter. One example was in 2006 at the decommissioned Sullivan Mine in British Columbia, Canada when one initial victim and then three rescuers all died.

Accidents in confined spaces present unique challenges and are often catastrophic, such as the Xcel Energy Cabin Creek Fire in 2007.

In 1999, North West OHS released a study of confined space fatalities based on reports from the Occupational Safety and Health Administration (OSHA), National Institute of Occupational Safety Health (NIOSH) and the Mines Safety and Health Administration (MHSA) with a breakdown of their causes. Researchers believe that the following numbers are only a fraction of the fatal confined space accidents that actually occurred as many locations are not initially identified as confined spaces

Report	Year	Incidents	Fatalities
Fire and Explosion (OSHA 1982a)	1974 to 1979	50	76
Lockout-tagout (OSHA 1982b)	1974 to 1980	83	83
Grain Handling (OSHA 1983)	1977 to 1981	126	105
Toxic and Asphyxiating Atmospheres (OSHA 1985)	1974 to 1982	122	173
Welding and Cutting (OSHA 1988)	1974 to 1985	217	262
Shipbuilding & Repair (OSHA 1990)	1974 to 1984	151	176
Mining (MSHA Report 1988)	1980 to 1986	38	44

Source: Wikipedia/ confined space safety

Capabilities of rescuers

Rescuers need to be properly trained people, sufficiently fit to carry out their task, ready at hand, and capable of using any equipment provided for rescue, e.g. breathing apparatus, lifelines and fire-fighting equipment. Rescuers also need to be protected against the cause of the emergency.

Shut down

It may be necessary to shut down adjacent plant before attempting emergency rescue.

First-aid procedures

Trained first aiders need to be available to make proper use of any necessary first-aid equipment provided.

Local emergency services

How are the local emergency services (e.g., Fire and Rescue Service) made aware of an incident? What information about the particular dangers in the confined space is given to them on their arrival?

Display IMPORTANT Numbers

All the important numbers such as supervisor, safety, project management, police ,Civil Defense and other considerable numbers should be on display at a prominent place , easily visible

Personal Protection Equipment (PPE)

PPE is traditionally regarded as the last line of protection with the emphasis being placed on avoidance and appropriate managerial control methods. However, the potentially hazardous nature and isolated position of those entering a confined space means that, for the confined space worker, PPE may be the first line of protection. Each confined space will present different hazards and degrees of risk to health and safety, the final provision of PPE should therefore be based on an assessment of risk. As a general rule the following guidance is offered. Basic PPE should include:

- Body protection (hard wearing overalls with suitable pockets for notebook, etc);
- Foot protection (steel toecaps (200 joules), steel midsoles, good grip, oil resistant);
- Head protection (hard hat with chinstraps);
- Hand protection (hard wearing gloves);
- Eye protection (protective glasses, goggles);
- Ear protection (ear defenders or ear plugs – worn subject to communication system);
- Gas meter - multi-gas meter for measuring of HC, H2S, CO, O2 is recommended;
- Lighting (hand held with lanyard and appropriate beam width).
- Full Body Harness with attached lifeline
- Communication radio.

Atmospheric hazards

The most common hazard seen in confined spaces is that of atmospheric hazards. These affect air quality and present immediate hazards to health or life. Acceptable atmospheric conditions must be verified before entry, and must be monitored continuously while the space is occupied. The oxygen concentration, the presence of toxic gases, and flammable material are the three conditions that must be monitored.

Oxygen concentration is considered safe if it is between 19.5% and 23.5% of the total atmosphere. To protect against toxic gases, contaminants have permissible exposure limits (PELs),. Work also cannot continue if the concentration of a material reaches or exceeds 10% of its lower explosive limit. Even if a tank or similar vessel initially is tested and found to contain breathable air, a hazard can develop during operations inside the tank if residues inside the tank can release toxic gas or vapor when disturbed or if accidentally ignited. Steel water tanks may have dangerously low oxygen concentration when the

Standby / rescue

Standby...

A standby person should be assigned to remain on the outside of the confined space and be in constant contact (visual or two-way voice communication e.g. walkie-talkie) with the survey team inside. Routines for communication intervals with the survey team should be established. The standby person:

- should not have any other duties than to serve as standby and know who should be notified in case of emergency;
- should never leave his post even after help has arrived and is a key communication link to others onboard;
- should be able to communicate sufficiently in a relevant common language.

Communication between watch personnel (Bridge, Cargo Control Room or Engine Control Room) and standby person should be established.

Rescue...

Rescuers must be trained in and follow established emergency procedures and use appropriate equipment and techniques (such as lifelines, respiratory protection, standby persons).

Emergency and evacuation procedures should be agreed and understood by all parties involved in a potential rescue operation.

Steps for safe rescue should be included in all confined space entry procedures. Rescue should be well planned and evidence should be made available that indicates drills have been frequently conducted on emergency procedures.

Testing of the atmosphere Testing

General

Initial testing should be carried out by a certified "Marine Chemist" or a "Competent person" or similar accredited person who will issue a certificate stating whether the space is 'safe for man' and/or work, and if any special conditions are to be observed. On a vessel this may be the Chief Officer, or other competent person onboard. If in doubt of the officer's qualification, documentation is required to be shown. In no case should the class surveyor be considered to be a "Competent Person" – even if he is equipped with his own personal testing equipment. Ventilation should be stopped about 10 minutes before tests are made and not restarted until the tests are completed. The testing should be carried out in the following sequence

- Oxygen-deficient or -enriched atmospheres
- Flammable atmospheres
- Toxic atmospheres when considered necessary

To evaluate the measurements taken, the following limit values should be used.

Testing for oxygen

Any atmosphere with less than 20.8% (± 0.2%) oxygen by volume should *not* be entered. Oxygen measurements should be carried out by, or under supervision of, the surveyor immediately before entry into the confined space.

Testing for flammable atmosphere

A space with an atmosphere with more than 1% of the "Lower Flammable Limit" (LFL) or "Lower Explosive Limit" (LEL), on a combustible gas indicator should not be entered. The Flammability indicator shows the percent within a safety range of 0-10% of the Lower Explosive Limit (LEL) and, ideally, should read 0%. Combustible gas detectors have normally two measuring ranges 0-100% LEL and 0-10% LEL.

Testing for toxic atmospheres

Toxins are measured in parts per million (PPM). Under no circumstances should the surveyor enter a confined space exceeding the limits specified below. Different testing bodies throughout the world may, however, have different acceptance limits.

For vessels with inert gas systems, trace amounts of various toxic gases may increase the hazard of exposure for personnel. Normally, a steady 21% by volume of oxygen reading will be sufficient to dilute these gases to below their "Threshold Limit Value" (TLV).

Gas	Limit 8 Hour work shift [ppm]	Limit 15 min working [ppm]
Benzene (C6H6)	1	5
Hydrogen Sulphide (H2S)	5	20
Carbon Dioxide (CO2)	5	30
Carbon Monoxide (CO)	25	50
Nitrogen Dioxide (NO2)	1	3
Nitrogen Monoxide (NO)	25	50
Sulphur Dioxide (SO2)	2	5

ppm- parts per million

Be aware that some chemicals have a lower TLV value than odour value. Gases from these substances will not be traceable by smell before they are dangerous to health.

Never trust one's own senses to determine if the air in a confined space is safe! Many toxic gases and vapours can neither be seen nor smelled, nor can the level of oxygen present be determined.

Reference

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