Workplace Health and Safety Queensland

A guide to working safely in confined spaces

Queensland Government
Department of Industrial Relations

Contents

Part 1: Introduction

1.1 What is this guide about?

This industry guide is aimed at employers, workers and self-employed persons who carry out work associated with confined spaces. It provides practical guidance towards minimising health and safety risks associated with confined spaces, and outlines the necessary actions required to meet compliance with the *Workplace Health and Safety Regulation 1997* (*Part 15 - Confined Spaces*). It is also a useful resource for anyone carrying out work in confined spaces.

1.2 What is a confined space?

A 'confined space' means an enclosed or partially enclosed space that
(a) is at atmospheric pressure when anyone is in the space; and
(b) is not intended or designed primarily as a workplace; and
(c) could have restricted entry to, or exit from, the place; and
(d) is, or is likely to be entered by a person to work; and
(e) at any time, contains, or is likely to contain, any of the following -
  (i) an atmosphere that has potentially harmful levels of a contaminant;
  (ii) an atmosphere that does not have a safe oxygen level;
  (iii) anything that could cause engulfment.

Examples of confined spaces include:
- storage tanks, tank cars, process vessels, pressure vessels, boilers, silos and other tank-like compartments;
- pits and degreasers;
- pipes, sewers, sewer pump stations including wet and dry wells, shafts and ducts; and
- shipboard spaces entered through small hatchways or access points, cargo tanks, cellular double bottom tanks, duct keels, ballast or oil tanks and void spaces.

However, many other types of structures may also meet the definition of a confined space.

1.3 Confined spaces can be fatal

Each year in Australia, people are killed in a wide range of confined spaces, from storage vessels, to complex industrial equipment. Many of these fatalities occur when attempting to rescue another person in a confined space. Additionally, people can be seriously injured from other hazards found within confined spaces.

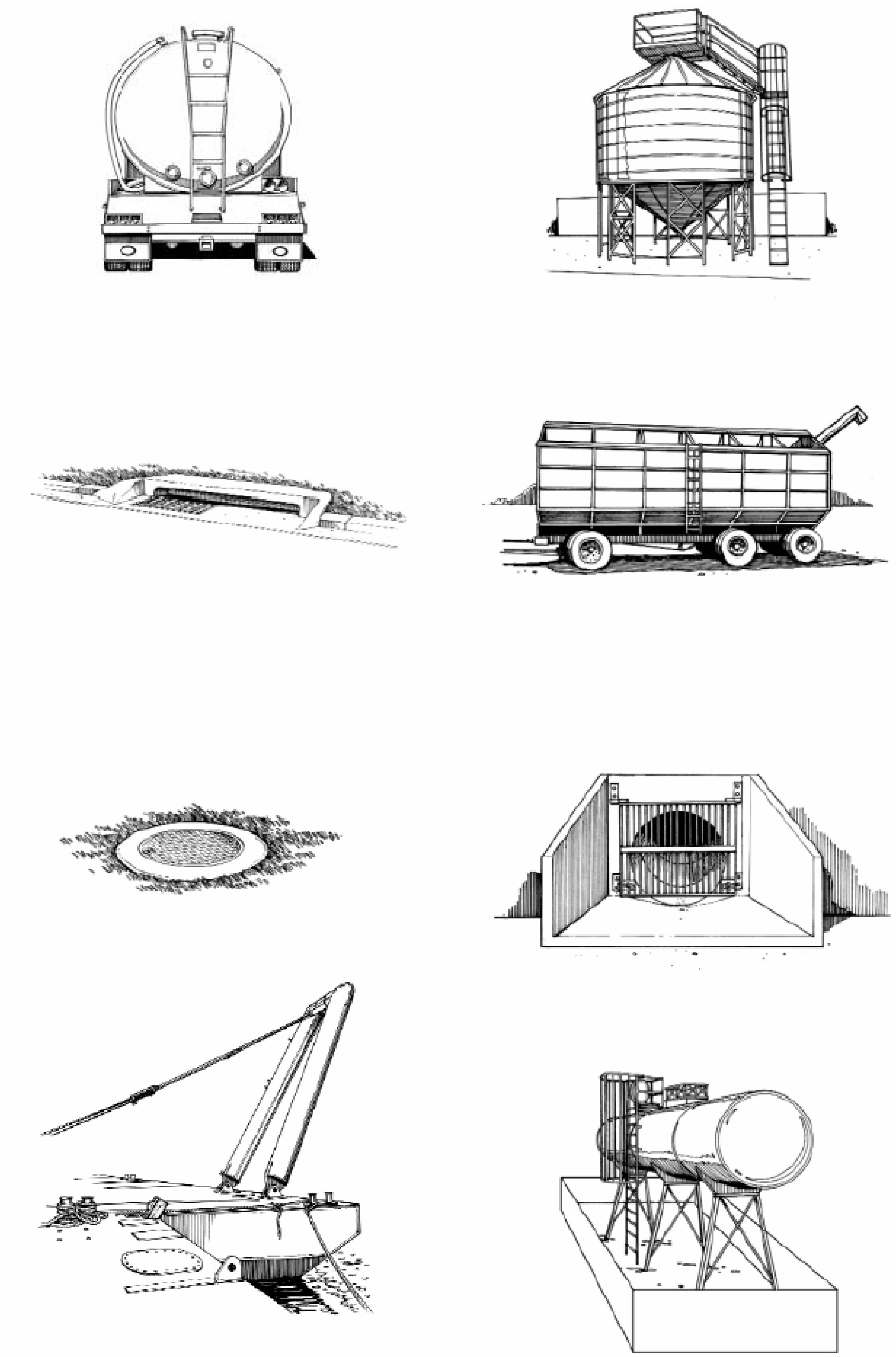


Figure 1: *Some examples of confined spaces*

1.4 Why people enter confined spaces

Confined spaces are normally entered to perform necessary industrial tasks. The list below represents some typical reasons for entering confined spaces.

- Cleaning to remove waste or sludge
- Physical inspection of plant or equipment
- Installing pumps, motors or other equipment
- Maintenance work painting, sand blasting or applying surface coatings
- Reading of meters, gauges or dials
- Repair work (e.g. welding or cutting)
- Installing, repairing or inspecting cables (e.g. telephone, electrical or fibre optic)
- Tapping, coating or testing of piping systems (e.g. steam, water or sewage)
- Constructing a confined space (e.g. industrial boiler)
- Rescuing people who are injured or overcome by fumes

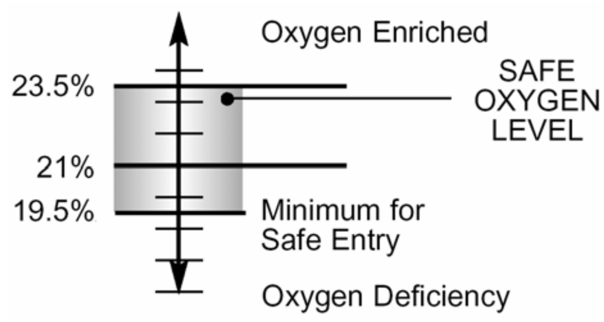
Yet regardless of why confined spaces are entered, all hazards should be thoroughly assessed prior to any persons entering.

The work activities undertaken in a confined space are often indicative of the hazards which may be present. For example, the use of hazardous substances can bring about hazards such as oxygen deficiency, atmospheric contaminants or flammable atmospheres. Similarly, hazards may arise from work processes being carried out, storage of substances, process by-products or the effect of external environments. Some of the hazards that may be associated with confined spaces are as follows. A summary list of confined space hazards are is provided in Appendix C.

Part 2: Confined spaces - why are they hazardous?

2.1 Unsafe oxygen level

The air we breathe consists mostly of nitrogen (78%), oxygen (21%) and small amounts of other assorted gasses including argon, carbon dioxide and hydrogen. In order to function normally, the oxygen we breathe must fall within a 'safe' range of no less than 19.5% and no more than 23.5%. The health effects of oxygen deficient atmospheres are extensive, ranging from poor respiration and fatigue, to cardiac arrest and death. An abundance of oxygen in the air will make combustible materials easier to ignite and burn.



2.1.1 Oxygen deficiency

Oxygen levels inside a confined space may fall below a 'safe' level (19.5%) due to chemical or biological reactions. Situations which may bring these reactions, and thus oxygen deficiency, include:

- combustion of flammable substances (such as welding, heating or cutting);
- slow bacterial reactions of organic substances (eg. the contents of a sewerage pit or a fermenting wine vat);
- reaction of inorganic substances (e.g. rust forming on the inside of a ship or pontoon);
- oxygen being absorbed by materials (e.g. grain in silos);
- displacing oxygen with another gas (e.g. nitrogen used to remove flammable or toxic fumes); and
- high oxygen consumption rate (e.g. many people working in a small confined space).

Simple asphyxiants are gases which when present in an atmosphere in high concentrations, lead to a reduction of oxygen by displacement or dilution. Most simple asphyxiants are odourless and include gases such as acetylene, hydrogen, methane, propane, helium and nitrogen.

Low oxygen levels can cause asphyxiation. Symptoms of asphyxiation include increased breathing and pulse rate, faulty judgement, fatigue, nausea and vomiting, loss of consciousness and death. At concentrations below 6% oxygen, death will occur in minutes.

2.1.2 Oxygen enrichment

A major cause of oxygen-enriched atmospheres relates to poorly designed or maintained oxygen storage equipment. Leakage can occur from oxygen lines, pipes, and fittings and thus, inadvertently enrich the atmosphere. Some industrial processes can also bring about excess oxygen, such as improper use of oxy-propane welding equipment.

High oxygen levels support combustion. In conjunction with combustible or explosive materials, the risk of fire and explosion is increased in oxygen enriched atmospheres.

Marine craft incident case study

Workers were instructed to inspect the voids of the company's service pontoon. The workers entered a void space that had been sealed for some years. Upon entry, the first worker immediately collapsed to the bottom of the void. The second worker, who was acting as lookout, entered the void to try and assist, and he collapsed too. Both workers had died before rescuers could safely reach them.

The void had been sealed for some years. The rusting of the inside metal surfaces consumed the oxygen in the atmosphere to below 2%; a level that is immediately dangerous to life. At these levels, death occurs in less than two minutes.

2.2 Flammable and explosive atmospheres

An atmosphere becomes flammable and explosive when a mixture of oxygen and flammable material is present in the proper proportions. If an ignition source is also present combustion (burning) of the atmosphere occurs. Some circumstances which lead to explosive and flammable atmospheres are listed below.

2.2.1 Flammable gases and vapours

In order for a gas or vapour to become flammable, its concentration must fall within its particular 'explosive range.' For example, the explosive range of methane is 5% to 15% in air. This means that below 5% (its lower explosive limit, LEL) the methane/air mixture is too lean to explode. Similarly, concentrations above 15% (its upper explosive limit, UEL) are too rich to support combustion. See Figure 2.

In confined spaces, a common source of explosive atmospheres is residue left over in "empty" tanks or containers. Although the container may appear to be completely empty, small quantities of flammable liquid can become trapped and evaporate to form an explosive air-vapour mix. Even if the tank is open-topped, vapours which are heavier than air (such as petrol) can sink to the bottom and create an explosive atmosphere. Other processes that can form an explosive air-vapour mix in confined spaces include:

- spray painting;
- cleaning with solvents or liquids;
- applying some surface coatings;
- leaking material from pipes, fittings or valves; and
- chemical reactions which produce flammable gases or vapours.

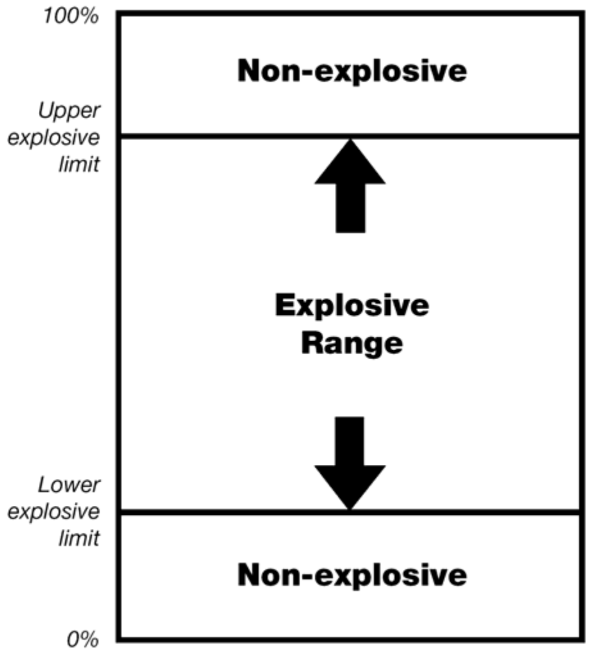


Figure 2: *Upper and lower explosive limits.*

2.2.2 Combustible dusts

Combustible dusts can often be found in a variety of confined spaces including storage bins, process hoppers and grain silos. Normally, the dust will form during the processing of this material or the loading and unloading of it. Should the dust be of sufficient concentration, an explosive atmosphere could be formed.

2.2.3 Ignition sources

Ignition sources provide enough heat energy to ignite a flammable or explosive atmosphere. An ignition source can be a spark, a flame or just a hot surface. Ignition sources commonly found, or introduced, into confined spaces include:

- open flames, such as welding torches or cigarette lighters;
- electrical arcing from incorrectly installed wires or electrically overloaded fittings;
- hot surfaces, such as steam lines, heaters or exposed light bulbs;
- static electricity sparks (e.g. as generated by synthetic clothing);
- frictional sparks (e.g. a metal tool striking another object);
- a spark or heat produced by non-intrinsically safe electrical equipment (e.g. a mobile phone, radio, flashlight, wristwatch or pager).

Welding explosion case study

A welder was welding close to two 200L paint drums. The drums were empty and the rubber bungs in the top of the drums had been removed. A spark from the welding process fell into one of the drums and it exploded. The force of the explosion caused the lid to blow off the drum, hitting the welder in the face. He suffered facial injuries and hearing damage. Even though the drum was empty, the flammable fumes from the paint it previously contained, caused an explosive atmosphere.

2.3 Substances hazardous to health

2.3.1 Sources of substances hazardous to health

Substances of a hazardous nature may be present in a confined space. These substances may be introduced for use in the confined space or generated by a process being conducted in or near the confined space. If a substance being used is classified as a hazardous substance, the substance's material safety data sheet (MSDS) must be available and should be referred to for safe use of the substance.

Substances may be present in a confined space in various forms including dusts, vapours, gases, fumes and mists. Substances of a hazardous nature in a confined space can arise from:

- the work processes being undertaken (e.g. the use of solvents, adhesives, and degreasing agents may produce vapours; welding producing fumes and gases; use of acid cleaning solutions or spray painting producing mists; or a process which disturbs solid materials may produce dusts);
- the storage or transfer of materials in a confined space, such as sewerage or grain;
- spills or leakage from pipes, fittings or machinery, including those from adjacent or underground sources releasing toxic or flammable gases;
- disturbing materials such as sludge;
- chemical reactions between substances present in the confined space atmosphere;
- exhaust gases from pumps or other machinery used in or near confined spaces;
- gasses in sewers and stormwater drains.

2.3.2 How might we be exposed to these substances?

The principal route of exposure to a substance hazardous to health in a confined space is likely to be through inhalation of atmospheric contaminants. However, ingestion of a substance through hand to mouth contact and absorption of the substance through the skin contact is also possible.

Because of the limited ventilation in confined spaces, substances tend to build up in the atmosphere more quickly and reach higher concentrations than when in use outside a confined space. For example, the carbon monoxide released from a forklift into the atmosphere of a cold room will build up easily and reach a higher concentration than the same forklift operating in an outside distribution yard. Therefore, the risk of injury and illness is significantly increased when using or producing substances in confined spaces.

2.3.3 Exposure standards for hazardous substances

The National Occupational Health and Safety Commission (NOHSC) in their document *Exposure Standards for Atmospheric Contaminants in the Occupational Environment*, set out levels of exposure to atmospheric contaminants above which adverse health effects are expected. The exposure standards are expressed as time weighted averages (TWA), short-term exposure limits (STEL) and peak exposure limits (PEAK).

TWA:	The average concentration of a substance when calculated over a normal eight-hour day, for a five-day working week.
STEL:	The airborne concentration of a substance averaged over a fifteen-minute period. It should not be exceeded at any time or for more than four periods during a normal eight-hour day. A minimum of sixty minutes should be allowed between successive exposures.
PEAK:	The maximum concentration a worker should be exposed to.

People at work must not be exposed to atmospheric concentrations greater than the exposure standard for that substance. However, because of the increased risk of injury and illness in a confined space, exposure to all atmospheric contaminants should be reduced to as low as reasonably practicable, even if they are already below the exposure standard.

A person's senses do not provide a reliable indication of concentration of atmospheric contaminants. As an example, carbon monoxide is a colourless, odourless and tasteless gas and exposure to high concentrations can be fatal.

Most simple asphyxiants, such as methane and nitrogen do not have exposure standards. This is because they present a risk to health by displacement or dilution of oxygen, rather than from exposure to the substance. This does not apply to carbon dioxide, which can have toxic effects at concentrations that do not cause asphyxiation.

Carbon monoxide poisoning case study

Two brothers were pumping water out of an underground tank. As the level of water in the tank decreased they lowered the petrol driven motor into the tank by a rope to reach the water. When the tank was nearly empty one brother got into the tank. He collapsed and the other brother climbed in to attempt to rescue him, but he collapsed also. By the time the brothers were rescued they had both died from carbon monoxide poisoning. The carbon monoxide produced by the petrol driven motor reached a lethal concentration a short time after being lowered into the tank. Because carbon monoxide is a colourless, odourless and tasteless gas the brothers were not able to detect it when entering the tank.

2.4 Engulfment

Materials stored in or around confined spaces (e.g. sawdust, grains or soil) can surround, trap and engulf a person within seconds. Often the victim is unaware of this hazard, when a seemingly solid surface gives way under their weight. As the person tries to escape, their movement only draws them deeper into the material. Once engulfed, the pressure exerted on the person's body makes breathing difficult or impossible. Once this supply of oxygen is cut off, death can occur within four minutes. See figure 3.

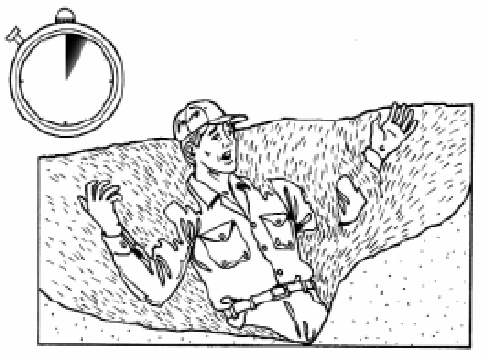


Figure 3: *Within seconds the victim may be completely engulfed.*

A specific type of engulfment hazard occurs when material is being drawn out from the bottom of a storage bin. As the material flows from the bottom outlet, a funnel-like depression forms throughout the material. Should a person be trapped in this depression, engulfment and complete burial may occur within seconds. See Figure 4.

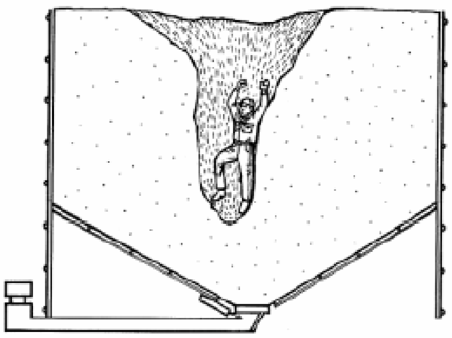


Figure 4: *As material is emptied from the bottom of a confined space, a person may be trapped in a funnel-like depression.*

A similar type of engulfment hazard is known as bridging. This hazard occurs when storing moist or powdery materials such as agricultural products or cement. Over time, a hard crust can build up on top of confined spaces such as silos, hoppers or storage bins. When material is emptied from the bottom of the space, the bridge can easily give way under a person's weight without warning. See Figure 5.

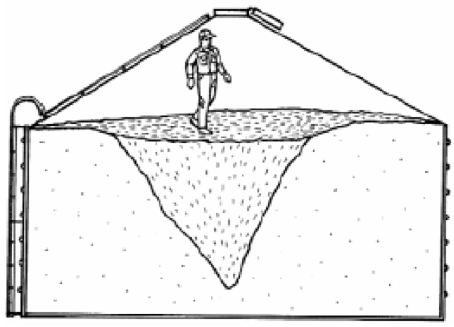


Figure 5: *Bridging crust can give way under a person's weight.*

Engulfment may also occur if a cavity forms within the material. See Figure 6.

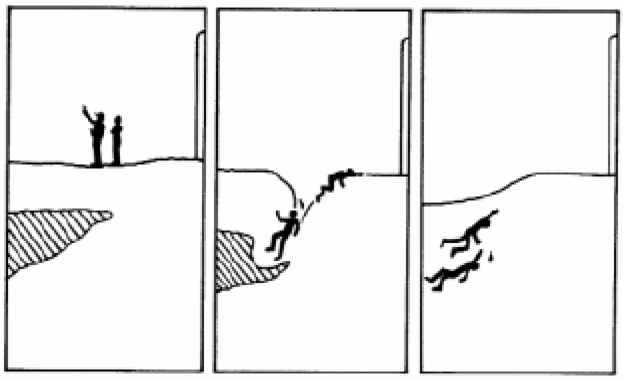


Figure 6: *Cavity gives way under people's weight.*

Engulfment case study

Three workers were transferring wheat grain from a silo to a truck for transportation. The majority of the grain was transferred via a hole in the floor of the silo. However, the grain reached an angle that would not continue to gravity feed and the workers were instructed to remove the grain with a suction device. The remaining grain was approximately four metres high. Two workers entered the silo with a suction device and the third worker remained outside the silo as a stand-by person. The two workers lost control of the suction device and it sucked its way to the bottom of the silo. The third worker entered the silo to help retrieve the device. As the device sucked the grain from the bottom of the silo, the grain at the top of the pile was flowing downwards towards the suction point in a funnel formation. The third worker was standing in the funnel of downwards flowing grain and within seconds he was completely buried under the surface of the grain. He suffocated before he could be rescued.

2.5 Electrical hazards

Contact with electrical sources can result in a variety of adverse health effects including:
- burns and scalds as heat passes through body tissue;
- involuntary muscle contraction - when a person cannot let go of the object until the energy source is cut;
- ventricular fibrillation - when the body receives a severe electric shock, the heart muscles begin to quiver and fail to pump blood throughout the body;
- cardiac arrest - full stoppage of the heart; and
- pulmonary arrest - when nerves in the brain controlling breathing are damaged, causing inability to breathe.

In addition to the above health effects, electrical contact within a confined space presents other unique hazards. For example, should a person experience a sudden jolt from an electric shock, they could be easily injured from contact with a wall or other object within the confined space. When working on ladders, scaffolding or elevated work platforms, electric shocks can also lead to a serious fall.

2.6 Other hazards

Plant and machinery hazards
- Plant and mechanical equipment, such as augers, conveyers and pumps, are commonly found in confined spaces. Such machinery presents the risk to workers of entanglement, cutting, crushing or other acute injuries if not adequately guarded.

Isolation of power supply to plant hazards
- Power supply to plant which could adversely affect the health or safety of workers inside a confined space must be isolated before anyone enters the confined space. For example, a sweep auger which could become energised, or machinery to dispense grain into a silo, must be isolated before entry to the silo.

Thermal hazards
- Thermal stress - working in hot environments can adversely affect workers through the onset of heat related illness such as cramps, exhaustion and heat stroke. For example, steam cleaning the inside of a confined space will increase the risk of heat stress. At the other extreme, low temperature confined spaces can lead to reduced mental alertness, hypothermia and frostbite.

Noise hazards

- Noise levels can be amplified within a confined space. This can increase a person's exposure, reducing the length of time they are able to work without hearing protection. Further, noise can inhibit communication between people working in a confined space.

Physical hazards

- Falling objects present a hazard, particularly to people working in open topped spaces or when work is carried out above people. In a silo, grain or other material may have stuck to the wall, and may become dislodged in a solid mass, potentially injuring anyone working inside the confined space.

- When working in access holes located in roadways or footpaths there is a risk of pedestrians falling into the hole, items being thrown into the hole and motorists colliding with people working in and around access holes.

- The lighting levels within a confined space may not be adequate to work safely.

- Awkward or vertical entry points may introduce hazards such as falling from height. Small or awkward spaces may restrict movement and encourage sustained and awkward postures. This risk may be increased if equipment or machinery is to be used in the confined space.

Biological hazards

- People working in confined spaces may be exposed to biological hazards (e.g. grain silos can harbour bacteria and fungi that can cause adverse health effects).

- There may be a risk of exposure to zoonotic diseases from animals living in confined spaces (e.g. psittacosis from pigeon droppings).

- Infectious diseases may also be present in the contents of confined spaces (e.g. exposure to sewage carries the risk of hepatitis A, leptospirosis, tetanus and gastroenteritis).

Psychological hazards

- Any one or combination of the above hazards when working in a confined space can induce psychological factors such as stress and claustrophobia.

In Queensland, the *Workplace Health and Safety Regulation 1997* (the Regulation), *Part 15 - Confined Spaces* requires employers, self-employed people and others (e.g. designers) to take suitable precautions to minimise the risks from exposure to confined space hazards and prevent death and injury.

Part 3: What does the law say about working in confined spaces?

3.1 The requirements for employers and self-employed persons

Part 15 of the Regulation references *Australian/New Zealand Standard 2865 - Safe Working in a Confined Space*. The Standard provides detailed information on meeting minimum safety requirements for entering and working in a confined space. More specifically, employers and self-employed persons must comply with the following sections of *AS/NZS 2865*:

a) Hazard identification (section 8.1)
b) Risk assessment (sections 9.1 and 9.2)
c) Control measures (sections 10.1, 10.5, 10.11, 10.22, 10.30, 10.41 and 10.46 to 10.48)
d) Training and competence (sections 11.1, 11.3, 11.6, 11.9)
e) Emergency response (sections 12.1 and 12.2)
f) Record keeping (section 13)

The risk management approach is designed to reduce the incidence of death, injury, and illness and it plays an important role in the management of confined space hazards.

The Regulation states a risk assessment must be completed and recorded when conducting work associated with confined spaces. The risk assessment must take into account at least the following:

- the nature and inherent hazards of the confined space;
- the work required to be done, including the need to enter the confined space;
- the range of methods by which the work can be done;
- the hazards and risks associated with the work method and equipment to be used;
- emergency response procedures; and
- the competence of the persons to undertake the work.

Appendix A provides a sample risk management form to record this information.

Part 4: A risk management approach for confined spaces

The *Workplace Health and Safety Act 1995* describes a five step risk management process by which hazards can be managed. The process entails:

Step 1: **Identify** hazards
Step 2: **Assess** risks associated with the hazard
Step 3: **Decide** on control measures to prevent or minimize the level of risk
Step 4: **Implement** the control measures
Step 5: **Monitor** and **review** the effectiveness of the control measures

There are many processes available to complete *Step 2 - Assess risks* of the risk management process. The process discussed here is taken from the *Risk Management Advisory Standard*. Other risk assessment processes may also be suitable.

Hazards and risks are not the same. A hazard is something with the potential to cause harm. Risk is the likelihood that death, injury or illness may result because of the hazard. For example, a **confined space is a hazard** but the **risk** is the likelihood of death, injury or illness from say, **exposure to an oxygen deficient atmosphere**.

The following risk assessment process is slightly different from the one outlined in *AS/NZS 2865*. However, the principle and possible outcomes are the same and both processes are acceptable.

Step 1: Identify the hazards

Many types of hazards associated with confined spaces have the potential to cause death, injury or illness. Some of these were outlined in section 2.0. Determining why the space needs to be entered (if at all) will provide a frame of reference for possible hazards. For example, spray painting will introduce contaminants into the atmosphere, whereas checking a water meter may not. Other methods which help identify confined space hazards include:

- analysing injury and incident records;
- talking with workers about their experience or problems which may arise;
- conducting a task analysis;
- consultation with designers, manufacturers and suppliers of confined spaces;
- obtaining advice from occupational health and safety specialists, engineers or occupational hygienists;
- consultation with unions, employer associations, professional bodies or government associations (such as the Division of Workplace Health and Safety); and
- using scientific or technical information (e.g. atmospheric testing, reports, safety alerts or journals).

Step 2: Assess the risks

Once the hazards have been identified, the associated risks for each hazard should be assessed. There are two major factors to consider when assessing the risk of hazards—the likelihood of an incident occurring and the consequences.

(a) Determine the likelihood
The descriptive scale below can be used to nominate the likelihood of an incident occurring. When assessing this likelihood, bear in mind the effectiveness of existing control measures.

Likelihood:	Very likely – could happen frequently Likely – could happen occasionally Unlikely – could happen, but rarely Very unlikely – could happen, but probably never will

(b) Determine the consequences
Use the following descriptive scale to nominate the consequences of an incident occurring.

Consequences:	Extreme – death or permanent disablement Major – serious bodily injury Moderate – casualty treatment Minor – first aid only, no lost work time

(c) Rate each risk
The level of risk or "risk score" is determined by the relationship between likelihood and consequence. The matrix below can be used to estimate the level of risk by referring to the "risk score". Further, these scores can then be used to prioritise addressing risks by referring to the following table.

LIKELIHOOD How likely could it happen?	**CONSEQUENCES : How severely could it hurt someone?**			
	EXTREME - death, permanent disablement	MAJOR - serious bodily injury	MODERATE - casualty treatment	MINOR - first aid only, no lost time
VERY LIKELY - could happen frequently	**1**	**2**	**3**	**4**
LIKELY - could happen occasionally	**2**	**3**	**4**	**5**
UNLIKELY - could happen, but rare	**3**	**4**	**5**	**6**
VERY UNLIKELY - could happen, probably never will	**4**	**5**	**6**	**7**

N.B. It is important to consider that both likelihood and severity of confined space hazards may change at any time. For example, a leaking water pipe may disturb the content of a confined space and thus release new contaminants into the atmosphere.

The scores (1-7) in the risk priority chart indicate how important it is to do something about each risk.

Score	**Action**
1, 2 or 3	Do something about these risks immediately
4 or 5	Do something about these risks as soon as possible
6 or 7	These risks may not need immediate attention

A case study example of identifying and assessing a confined space risk

An employer operates a business emptying and carting waste from septic tanks and other waste producing operations. He uses a truck with a tank on it to transport the waste to the treatment plant. Once a week the employer, or his worker, has to clean the accumulated residue from the tank. Cleaning involves opening the tank and using water pressure to discharge the accumulation and entering the tank to manually dislodge settled accumulations. Upon conducting the risk assessment for this process the employer determines that:

- even after emptying the contents of the tank on normal discharge, the tank accumulates sludge and residues;
- the manual cleaning task cannot be eliminated and the worker must enter the tank to clean it effectively;
- the atmosphere in the tank could contain toxic contaminants;
- the accumulated sludge in the tank could be sufficiently bioactive to convert oxygen to carbon dioxide, thus creating an oxygen deficient atmosphere;
- the length of time between last emptying the tank, its temperature and state of ventilation of the tank are all likely to impact on the risk of producing an atmosphere deficient in oxygen and containing other atmospheric contaminants; and
- currently no measures are taken to test the atmosphere for adequacy of oxygen content or other contaminants for safe entry to the tank, and the tank is not ventilated as a precaution prior to entry.

Based on this information, the likelihood of an incident occurring while cleaning out the tank is ***Very Likely*** and the consequence of an incident would be ***Extreme*** as death could easily occur. Therefore, the ***risk priority score is 1*** suggesting this risk needs to be addressed immediately.

Step 3: Deciding on control measures

When the hazard cannot be eliminated measures must be taken to control the risk of death, injury or illness.

The hierarchy of control presents control measures in an order of priority. The higher order controls provide a greater level of protection against a risk.

See Section 5 of this document for some possible control measures for risks associated with confined spaces. They are presented in accordance with the hierarchy of control.

Step 4: Implement and review control measures

Since the extent of risks may not be fully known before entering the space, a full range of appropriate control measures should be implemented prior to any persons entering.

In many cases it may be necessary to implement more than one control measure and sometimes lower order control measures may be implemented immediately, prior to implementing higher order control measures.

For example, an employer may find it necessary to isolate service lines, substitute hazardous chemicals and implement appropriate administrative controls and personal protective equipment. In order for these controls to work effectively, other work procedures should be introduced including:

- providing training and instructions on what the control measures are, how they work, any changes to the controls (including why the changes need to be made);
- adequate supervision to ensure that the controls are being used correctly;
- maintenance procedures – for example, releasing a pressure valve on a service line.
- communication procedures between staff and supervisors – for example, monitoring controls or when new problems/situations arise; and
- Measuring the effectiveness of controls, such as:
    - have the chosen controls been implemented as planned?
    - are the control measures being used, and used correctly?
    - are the control measures working effectively (if not, why not)?
    - are there any new conditions, situations or changes that have arisen?
    - do the changes require new control measures?

Once the confined space work has finished, the information and experiences gained can then be used for future reference. In particular, difficult situations or incidents should be investigated, reviewed and planned for in the risk management process.

Part 5: Control measures for confined spaces

The following control measures can be used to effectively manage the risks associated with confined spaces. Other controls may be needed to manage risks in specific circumstances.

Elimination

The ideal solution would be to eliminate the confined space hazard altogether, by eliminating the need to enter the space. Examples of eliminating the need to enter the confined space may be achieved by:

- initial design of the confined space that eliminates the need for entry;
- performing the task or process from outside the confined space (e.g. if a meter or gauge needs to be read, can it be relocated outside the confined space?);
- retrieving an object with long handled tools;
- cleaning walls through side and top access points;
- using internal vibrators to minimize packing and crusting in silos.

Substitution

Substitution involves replacing a hazard or work process with a less hazardous one. Examples of controlling risks associated with confined spaces through substitution include:

- cleaning walls or surfaces without chemicals (e.g. high pressure water);
- using non-toxic substances instead of toxic ones;
- applying paints, solvents or surface coatings with brushes, rather than aerosols; and
- replacing flammable substances with non-flammable ones.

Isolation and engineering

When eliminating a less hazardous one or substituting a hazard is not achievable, the next most preferred method is to engineer out the hazard. This involves modifying the workplace, plant or process to physically distance the worker from the hazard. Isolating the worker from the hazard can also be effective. Examples of engineering and isolation include:

- blocking service lines such as electrical cables, water pipes, airlines etc;
- guarding or securing moving machinery parts such as agitators, fans or blenders;
- enclosing machinery to reduce noise;
- thoroughly ventilating the space to ensure a safe oxygen level (e.g. in most confined spaces, mechanical ventilation using fans and blowers will be needed to disperse contaminants to a safe level);
- purging contaminants from the space (e.g. using nitrogen to disperse flammable contaminants).

Atmospheric testing

Atmospheric testing and monitoring shall be carried out consistent with the hazards identified and the risk assessment. For example, if it has been identified that the confined space contains, or previously contained, sewage or rust has formed on the inside of a sealed confined space, then atmospheric testing and monitoring must be conducted.

Atmospheric testing and monitoring may need to be conducted to identify a hazard or as a control measure to ensure the atmosphere is maintained at a safe level.

Atmospheric testing is usually performed during the risk assessment process to determine the level of risk. However, when the risk assessment has been conducted with reliance on knowledge and experience, atmospheric monitoring should be conducted as a control measure to confirm expectations about the atmosphere.

Never trust your senses to determine if the air in a confined space is safe. You cannot see or smell many toxic or flammable gases and vapours, or sense the level of oxygen or combustible contaminants.

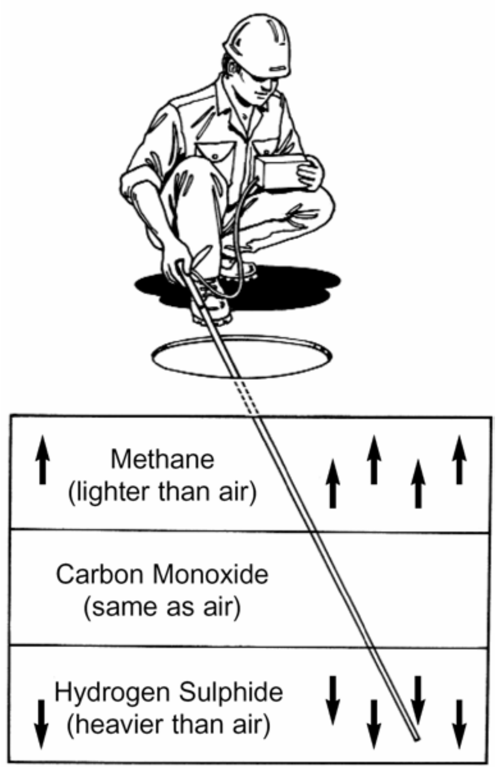


Figure 7: *Monitoring of the atmosphere can be conducted from outside the confined space and during occupancy of the space with a continuous monitoring device, which usually has audible and/or visual alarms.*

The oxygen content, flammability (percentage of LEL and UEL) and any possible atmospheric contaminants should be tested. Initially, testing should be performed from outside the confined space. The point in the confined space where testing is performed will depend on the type of contaminant likely to be present (remembering some contaminants are denser or lighter than air) and the areas that need to be accessed. See Figure 7.

Direct reading gas detectors are used to test the atmosphere of a confined space. They must be operated by a competent person and calibrated and maintained. The supplier of the device should be able to provide training and information on calibration and maintenance.

There are two types of direct reading gas detectors; multi-gas and single gas. The multi-gas detectors will typically analyse the oxygen level, carbon dioxide and flammability of an atmosphere in one device. The single gas detector is designed to monitor for only one gas or contaminant, for example hydrogen sulphide. See figure 7.

After entry of the confined space, retesting and monitoring of the atmosphere may be necessary. The intervals of retest should take into account the likelihood of a change of conditions. Continuous gas detection devices with alarms can be used.

Atmospheric monitoring must determine that:

- oxygen levels fall within a "safe" zone of between 19.5% and 23.5%. Levels below the minimum can impair function and cause death, while levels above the maximum increase the flammability of combustible materials.
- any contaminants in the confined space must be below their relevant exposure standard (see Material Safety Data Sheet –MSDS).
- flammable contaminants must be below 5% of its lower explosive limit (LEL) prior to entry.
- if continuous monitoring equipment is used, workers may remain in the confined space at concentrations up to 10% of the contaminant's LEL, provided the air quality is maintained or supplied and breathing apparatus is used.

Written authority

Written authority, such as an entry permit, must be prepared by a competent person prior to anyone entering the confined space. The permit outlines the range of control measures and other procedures needed to minimise risks identified in the risk assessment. It should be displayed near the confined space entry and all persons entering the confined space must fully understand and comply with the requirements of the permit. Some general considerations that form the basis of a written authorisation include (but are not limited to):

- purpose of entry and nature of work;
- persons authorized to enter the confined space;
- description of physical conditions and hazards such as noise, heat, contaminants, restricted movement etc;
- working procedures and control measures;
- results of atmospheric testing/circumstances requiring further testing or ventilation;
- services which are isolated;
- special equipment required;
- communication arrangements;
- emergency precautions and first aid equipment;
- other precautions such as public protection and signage;
- personal protective equipment; and

A sample written authority format is contained in Appendix D.

A **"competent person"** is likely to be someone who has successfully completed an adequate training course with a recognised training provider. They should be able to demonstrate knowledge in identifying and managing confined space hazards. They should have skills and abilities in correctly completing risk assessments, written authorities and emergency procedures. They should also have experience in working with confined spaces and regularly undergo refresher courses.

Stand-by person

Where the risk assessment indicates a risk to health and safety, the control measures shall require a stand-by person or persons to be outside the confined space while it is occupied.

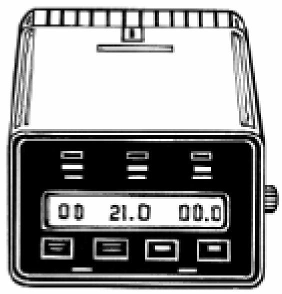
As a guide, if the implemented control measures cannot ensure the following, then a stand-by person may be required.

a) a safe oxygen range can be continuously maintained;
b) no atmospheric contaminants are present, or likely to be present, above the exposure standard;
c) there can be no risk fire or explosion;
d) there can be no risk of entrapment or engulfment;
e) the work to be performed cannot generate a risk to health and safety;
f) equipment, or conditions, outside the confined space cannot control or monitor conditions within the confined space to ensure health and safety (e.g. ventilation, air supplied respiratory equipment, vehicles and weather); and
g) there can be no other risks to the health and safety of persons entering the confined space.

Hot work

Hot work is welding, thermal or oxygen cutting, heating, including fire-producing or spark-producing operations that may increase the risk of fire or explosion. Such processes in a confined space may introduce the risk of:

a) fire and explosion;
b) reduced oxygen level; and
c) release of hazardous substances into the atmosphere.

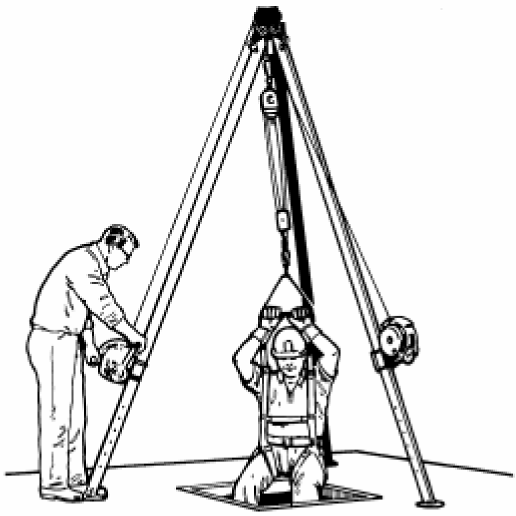


Hot work in or around a confined space should not be commenced until a hot work permit has been issued. The hot work permit should be an integral part of the written authority to enter the confined space, and also be addressed in the risk assessment.

Appendix F of *AS/NZS 2865: 2001* and the Welding Technology Institute of Australia's *Technical Note 7 - Health and Safety in Welding*, provide guidance on hazards to assess and control when conducting hot work.

Emergency response

Appropriate emergency response and first aid procedures and provisions must be planned, established, rehearsed and followed at all times. Appropriate rescue equipment such as harnesses and radios should also be present. A rescuer must resist the immediate reaction to enter a confined space in an emergency situation, as this may lead to death or serious injury of the rescuer. Any person involved in an emergency response must be made aware of the conditions of the confined space.



Training and competence

Any person performing any of the following activities must be trained and assessed as competent to carry these out:

- performing work in or on confined spaces;
- performing confined space assessments, (e.g. risk assessments and testing and monitoring the atmosphere;
- issuing written authorities (e.g. work permits)
- designing and laying out the workplace;
- managing or maintaining responsibility for the direct control of the work in confined spaces;
- maintaining equipment used for ensuring the safety of persons in the confined space, providing, fitting, wearing and maintaining personal protective equipment;
- performing stand-by; or
- are involved in emergency response and first aid procedures.

Training for these persons shall include at least the following:

- the hazards of confined spaces;
- assessment procedures, such as how to monitor and test an atmosphere, what to monitor and test for and how to assess the risks associated with confined spaces;
- control measures to be used, such as how the space is to be ventilated;
- emergency procedures, such as which respiratory equipment to wear in the event of a rescue, which emergency services to contact and how to administer first aid;
- the selection, use and maintenance of equipment, such as tripods and harnesses, monitoring equipment and personal protective equipment;
- legislative requirements, which include the sections of *AS/NZS 2865* as called up in the Regulation; and
- training for breathing apparatus it is going to be used.

A record must be kept of any training conducted.

Record keeping

The employer must maintain the following records. These records must be made available to workers and inspectors of regulatory authorities.

- Work authorities (for one month).

- risk assessments for work in confined spaces (for five years from their time of validity).
- training records (for the term of the employee's employment).

Personal protective equipment (PPE)

Personal protective equipment such as hard hats, glasses, gloves, chemical suits, boots and respiratory protective equipment should only be considered as a control measure when exposure to the risk cannot be reduced in any other way. Ideally, risks should be controlled through higher order controls such as elimination, substitution, isolation or engineering. Personal protective equipment can be used effectively in conjunction with other control measures. In some cases PPE may be the only control option. For example, if the atmosphere of a confined space has a high concentration of contaminants, which cannot be ventilated or purged, air-supplied respiratory protection may have to be used. When using any form of PPE, ensure that:

- the risk assessment identifies the correct type of PPE needed for the job;
- personal protective equipment complies with Australian Standards and is of a high quality. Personal protective equipment which is comfortable is also more likely to be worn by workers;
- people required to wear PPE are trained on why it is necessary and how to use it correctly; and
- all PPE is inspected, maintained and repaired as necessary (e.g. look for punctures, tears, cracks, abrasions, discolouration, flaking or peeling, corrosion, foreign materials etc.).

Signs and barriers

Prior to entering, and during occupancy of a confined space, appropriate signs and protective barriers must be erected to prevent entry of persons not involved in the work.

Undertaking pro-active initiatives will further assist obligation holders comply with confined space regulations and general duties of care. In the photograph, participants are attending a confined space training course. The course is based on AS/NZS 2865, and consists of classroom theory and practical work. In particular, the course modules include hazard identification and assessment; atmospheric monitoring; and rescue procedures. Training in the use of breathing apparatus will be required if this is likely to be needed in performing work in or around a confined space.

Appendix A: Completed risk management example

Background: A contractor is required to replace a motor located within a sewage pit. He is unsure whether the atmosphere of the sewer is safe to enter and work. *(Note: this example only applies to atmospheric hazards – many other hazards may also apply.)*

Step 1: Identify the hazard: The contractor visually inspects the pit through a side mounted inspection hole. The pit does not appear to have any raw contents in it. Discussions with the owner of the facility reveal that the contents were drained three days ago when the motor broke. Consultation with an occupational hygienist reveals that sewage often gives off hydrogen sulphide gas, which is colourless and toxic. The owner also informs the contractor that another contractor was overcome by gases when a similar job was performed four years ago.

Step 2: Assess the risk: The sewage pit contains no ventilation holes and is only entered to carry out periodic maintenance. Although the contents of the pit were emptied some three days ago, the contractor believes that an unsafe level of hydrogen sulphide could still be present. He concludes that under these circumstances, is it **likely** an incident could occur if he entered the pit.

The contractor knows from previous experience that hydrogen sulphide (or rotten egg gas) can often be fatal when a person is exposed to it in high concentrations. He has a hydrogen sulphide direct reading gas monitor and he lowers this into the pit on a rope. The monitor shows the hydrogen sulphide levels exceed the safe exposure level. He concludes that the consequence of entering the pit would be **extreme**. By checking these scores against a risk matrix, he concludes that the risk is of a high priority and must be attended to before entry.

Step 3: Decide on control measures: After doing some research, the contractor considers the following control measures in accordance with the hierarchy of control.

- the need to enter the confined space cannot be eliminated. He has to enter the sewage pit to access the motor. However, he has discussed with the owner to relocate the motor outside the sewage pit to eliminate the need to enter the space in the future.
- he isolates sewage pipes entering the pit by manually closing the valves and locking them closed. He arranges for the remaining sewage to be removed by a waste disposal company.
- he also electrically isolates the motor and places a tag on the switch.
- to ventilate the sewage pit the contractor hires a push/pull extraction system which introduces fresh air into the space and extracts potential pollutants. He calculates the number of air changes required per hour and for how long the system must run with the help of an Occupational Hygienist.
- while ventilating the space he places physical barriers around the entry point and signs stating 'DO NOT ENTER CONFINED SPACE' and 'CONTAMINATED ATMOSPHERE'.
- he then retests the atmosphere by lowering a calibrated multi-gas detector into the confined space at staged intervals. The monitor tests for oxygen level, carbon monoxide, hydrogen sulphide and the LEL of methane and determines they are all at a safe level.
- with his worker as a stand-by person, he enters the confined space wearing disposable gloves and overalls to retrieve the motor.
- he wears the multi-gas detector around his neck while in the confined space to warn of atmospheric changes.

The contractor has also prepared an emergency procedure and written authority which he signs each time he enters and exits the confined space. Both he and his worker have undergone training with a recognised training provider, and been assessed as competent in working with confined spaces. They update their knowledge by attending refresher courses 12 monthly. The contractor also trains his worker in emergency procedures, the risk assessment and written authority for each confined space they work with. He has copies of his risk assessment, training records, emergency procedures and written authority with him on site.

Step 4: Implement and evaluate: The contractor finds that the job is taking longer than expected. Throughout the day, heat builds up within the confined space making the worker feel uncomfortable, dehydrated and exhausted. He exits the pit and consults the entry permit which states that heat stress can be reduced through regular rest breaks, drinking cool water and using ventilation fans. These controls are adopted and the job is finished without further incident.

Appendix B: Blank risk assessment form

(Adapted from AS/NZS 2865)

<table>
<tr><td colspan="5">Description of plant:</td></tr>
<tr><td colspan="5">Description of work:</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5">Range of possible methods:</td></tr>
<tr><td colspan="5">Method (a):</td></tr>
<tr><td colspan="5">Method (b):</td></tr>
<tr><td colspan="5">Method (c):</td></tr>
<tr><td colspan="2">Risk assessment conducted by:</td><td colspan="2">Date:</td><td>Time:</td></tr>
<tr><td>HAZARD</td><td>ASSOCIATED RISK</td><td>LEVEL OF RISK (RISK SCORE)</td><td colspan="2">CONTROL MEASURES</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="5">Emergency response procedures:</td></tr>
</table>

Appendix C: Potential confined space hazards

Mechanical hazards Agitators Augers Blenders Mixers Conveyers	**Ignition hazards** Open flames Heat sources Frictional sparks Welding & cutting Riveting / forging Electrical equipment Grinding / chipping Sandblasting Incorrect lighting (non-intrinsic)
Environmental hazards Heat / cold stress Wet, damp or humid environments Insects, animals Slippery surfaces	**Electrical** Lines / cables Transformers / capacitors Relays / switches Exposed terminals
Engulfing materials Agricultural products Wood chips / saw dust Coal products Plastics / chemicals Grains Sand / soil	**Chemicals** Acids Alkalis Solvents / cleaning fluids Other skin irritants Fumigant residue, e.g. phosphine
Noise Ambient noise levels Noise from plant, machinery Other people / operations in the space	**Traffic hazards** Pedestrians Vehicles / foreign objects
Atmospheric hazards Oxygen deficiency Oxygen enrichment Combustible materials Toxic air contaminants	

Appendix D: Sample written authority format

(Adapted from AS/NZS 2865)

GENERAL

Location of work:……………………………………………………………………………………
………

Description of work:……………………………………………………………………………..
………
………..
………
………..

CONTROL MEASURES

Isolation

Space needs to be isolated from:
Location/method
Water/gas/steam/chemicals…………………………
Mechanical/electrical drives…………………………
Auto fire extinguishing systems……………………..
Hydraulic/electric/gas/power…..……………………
Sludge/deposits/wastes……………………………..
Locks and/or tags have been fixed to isolation points………………………………………….yes/no

Personal protective equipment (PPE)

The following PPE shall be worn:
Specify type
Respiratory protection……………………………..
Harness/lifelines……………………………………
Eye protection………………………………………
Hand protection…………………………………….
Footwear…………………………………………….
Protective clothing………………………………….
Hearing protection………………………………….
Safety helmet……………………………………….
Communication equipment…………………………..
Other………………………………………………...
………………………………………………………….

Atmosphere

The atmosphere in the confined space has been tested……………………………………….….yes/no
Results of test:
Oxygen…………………………………………%
Flammable gases…………………………….% LEL
…………………………….% UEL
Other gases
…………..………………………ppm (<….ppm)
……………………………………..ppm (<….ppm)
Other atmospheric contaminants:
………………………………………………………….
………………………………………………………….
………………………………………………………….
The conditions for entry are as follows:
a) Air supplied respiratory protection…….yes/no
b) Other respiratory protection……………yes/no
c) Escape unit………………………………yes/no

Other precautions

Warning notices/barricades………………….yes/no
Smoking prohibited…………………………..…yes/no
All persons have been trained………………yes/no
Ventilation requirements……………………………..
………………………………………………………….
…………………………………………………………..

Emergency response

A plan has been developed………………….yes/no
The plan has been rehearsed……………….yes/no
Emergency equipment is available…………yes/no
Procedures and equipment:…………………………
…………………………………………………………..
………………………………………………………….
…………………………………………………………..

Hot work

Area clear of all combustibles including the atmosphere……………………………………yes/no
Type of appropriate fire prevention equipment available……………………………………..…yes/no
Suitable access and exit……………………..yes/no
Hot work is permitted…………………………yes/no

Stand-by personnel

Stand-by person/s……………………………………
…………………………………………………………..
…………………………………………………………...
Stand-by person requirements………………………
…………………………………………………………...
…………………………………………………………...
…...……………………………………………………

AUTHORITY TO ENTER

The control measures and precautions appropriate for the safe entry and execution of the work in the confined space have been implemented and the persons required to work in the confined space have been advised of and understand the requirements of this written authority.
Signed……………………………………(person in direct control)
Date……..………Time……………….

Signed …………………………………..(person working in confined space)
Date……..………Time………………..

The written authority is valid until………………………..(date)…………………………(time)

PERSONS REQUIRED TO ENTER CONFINED SPACE

I have been advised of and understand the control measures and precautions to be observed with the entry and work in the confined space.

ENTRY			EXIT		
Name	**Date**	**Time**	**Name**	**Date**	**Time**

WITHDRAWAL OF WRITTEN AUTHORITY

All persons and equipment accounted for……………………………………………………yes/no
Equipment checked and restored correctly……………………………………………..…yes/no
Signed……………………………………(Person in direct control) Date…………Time……….
Remarks or comments about the work…………………………………………………………..
……………………………………………………………………………………………………..
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