Recurring accidents: *confined spaces*

Tony Fishwick examines the lessons we should be learning

MUCH work has been done, and many words written, on the subject of repeated accidents. The questions that arise time and again are "why do they recur?" and "how can they be stopped?"

The aim of this article, the first in a series on repeated accidents, is to revisit the safety lessons we should have learned and offer practical guidance on how these can be shared interactively between management, supervisors and those directly involved in the job or process, in a bid to stop similar accidents in the future.

the accidents

The importance of choosing confined spaces as a topic is starkly illustrated by the truly shocking number of deaths that occur while people are working in them. Great Britain's Health and Safety Executive (HSE) reports "several" fatalities each year in the UK alone, with equally saddening figures for Australia, Malaysia and the US (see *the numbers* below).

the general nature of confined spaces

Although the two accidents discussed in detail in this article (see p32 and p33) happened on major industrial plants[1], it would be wrong to conclude that other types of facilities are immune to similar problems. In fact, the potential hazard of confined space working is virtually universal. Accidents of this kind can happen, and have happened, almost anywhere – in the food industry, on board ships, in offices and commercial establishments as well as in a wide range of chemical and petrochemical plants. It follows that the lessons from these accidents are relevant now or will be in the future to the majority of people reading this article.

A confined space can be defined as "*any space of an enclosed nature where there is a risk of death or serious injury from hazardous substances or other dangerous conditions (eg a lack of oxygen).*" Some are easy to define,

the numbers

Each nation has its own methods of categorising and reporting accidents, making it difficult to compare performance directly. It can even be difficult to collect total figures for a single country, as separate agencies can be responsible for one category of accident but not another.

Regardless of this disparity, the standout lesson is that each year workers continue to die in confined spaces. The US Bureau of Statistics records that 350 workers were killed by collapsing trenches between 2000-2009 and in some years there were as many as 50 further fatalities from other confined space causes. Malaysia's Social Security Organisation (SOSCO) reports that in 2010 there were 1,396 industrial accidents in 'confined quarters', resulting in one fatality and 37 permanently disabled workers.

like enclosures with limited openings or access, such as storage tanks, silos, and sewers. Accident 1 is in this category.

Other confined spaces are less obvious, such as open-topped chambers, ducting, open-topped pits, and congested areas with restricted air circulation. Accident 2 is in this category.

It's virtually impossible to compile a comprehensive list of confined spaces, but these examples serve to provide a stimulus for identifying others, as discussed later (see *Practical action,* p34).

the dangers from confined spaces

There are many different types of potential hazards present in confined spaces. The main ones are:

- lack of oxygen (which may arise from a release of toxic gases from sludges; purging with nitrogen; and reactions between oxygen and other materials resulting in oxygen depletion);
- presence of poisonous gases (which can accumulate in sewers, manholes and pits; leak from refuse tips; occur due to fires and explosions, or arise from residues and sludges);
- use of machinery (this may require protection against dust, electric shock or fumes from welding);
- items falling from above or trench walls collapsing;
- restricted escape routes, for example, through a manhole; and
- over-arching all of these, inadequate isolation of the confined space before work begins.

Adequate isolation means: physical breaks in all pipework leading to, or from, the vessel (or at the very least, the insertion of a blank spectacle plate); isolation from sources of electricity, pressure, vacuum, excessive heat or severe cold; and isolation from moving machinery.

the legal section

Countries with extensive, well-regulated industries all have legislation that is similar in principle to that in force in the UK. Factors include the type, and variety, of confined space; the isolation, protective clothing and rescue requirements; and the need to define safe systems of work.

In the UK, the legal requirements for working in confined spaces are contained in the Confined Spaces Regulations, 1997, Statutory Instrument No 1713[2] and the associated code of practice[3]. These, as is the case with all UK health and safety legislation, are underpinned by the Management of Health and Safety at Work Regulations, 1999[4]. The HSE has also produced a guidance note for employers and employees[5] and it is on this document that the following practical guidance is based.

the detailed legal requirements

Using the UK as an example:

A "suitable and sufficient assessment of all the risks for all work activities for the purpose of deciding what measures are necessary for safety" must be carried out in accordance with Reference 4, Regulation 3. For work in confined spaces, this means identifying the hazards present or likely to arise, assessing the risks and determining the precautions to take. The HSE leaflet[6], which is available free of charge, provides a very useful guide to how risk assessment should be done.

The key duties of a risk assessment for work in a confined space are:

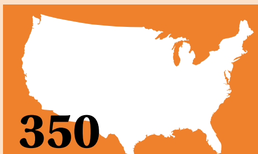
- if possible, avoid entry into the confined space; with careful planning, it is sometimes possible to do the work from outside;
- if entry to the confined space is unavoidable, a safe system of work must be in place and be followed; and
- adequate emergency arrangements must be in place before the work starts.

These key duties are now discussed in more detail.

avoiding confined space entry

Ask yourself and others a few simple questions about how the work could be done differently to avoid entering the confined space. Possible alternatives might include modifying the workspace, clearing blockages by use of vibrators or

A worker was caught in a vortex of grain and suffocated while attempting to clear a blocked drain valve in a grain silo (*Safe Work, Australia*)

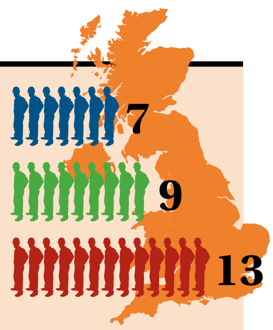


350
US workers killed by collapsing trenches 2000–09

1,396
industrial accidents in confined quarters in Malaysia 2010

8
Australian fatalities in confined spaces 2003–11

UK
Number of workers killed by trench collapse, oxygen depletion and other confined space accidents 2003–11



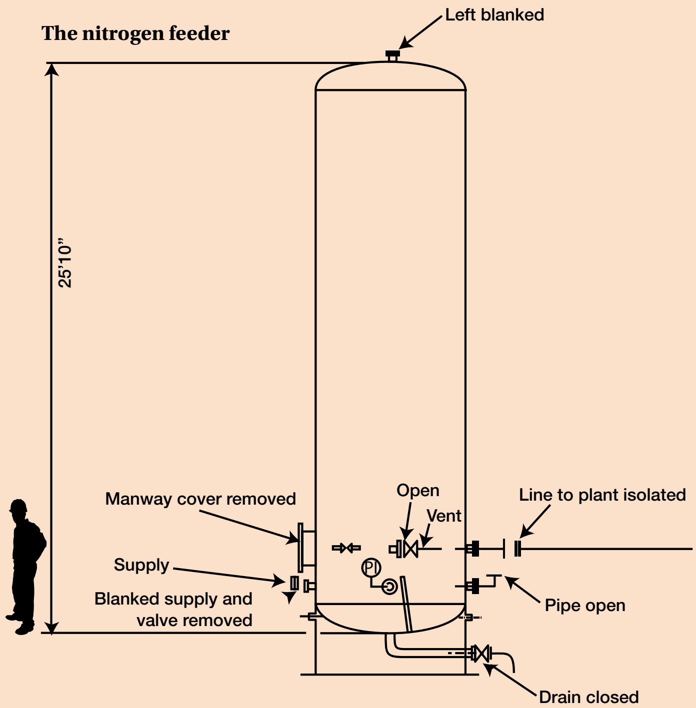
accident 1

vessel inspector overcome by nitrogen

An inspector entered a nitrogen receiver tank via the side manhole. After about 2 mins, he collapsed. The standby man could not get into the receiver because his breathing apparatus was too large to fit through the manhole.

The emergency services attended, rescued the man and took him to hospital. He had a serious head injury but eventually recovered. The investigation found that:

- the receiver tank had not been properly isolated and opened up with the top flange blanked (covered by a bolted on plate to prevent the ingress or egress of gases or other materials);
- the blanked flange prevented full purging of nitrogen so that the top half of the receiver had an oxygen-deficient atmosphere of around 12–16%, compared to a normal atmospheric concentration of about 21% (at 16%, judgement and breathing are impaired and at 12%, consciousness is lost and death follows); and
- the rescue plan was inadequate.



2007
North America

Five workers died in an accident at a hydroelectric plant. They were part of a group of 11 painters working in a tunnel. The flammable solvent in the cleaning product they were using ignited and spread to open buckets of solvent and other flammable material. The five workers were trapped behind the fire and died from smoke inhalation. There had been a lack of planning for hazardous work and an inadequate choice of contractor.

purges, sampling, inspecting and cleaning from outside and using remote cameras. Are any of these practicable with some rearrangement of the work?

safe systems of work

If you cannot avoid entering the confined space then a safe system of work must be put in place. To prepare a safe system of work:

- appoint a job supervisor to check safety and to ensure that the necessary precautions are taken;
- ensure that the persons doing the job have the necessary training and experience and do not have any special restrictions, eg claustrophobia or problems with wearing breathing apparatus;
- ensure the workspace is mechanically and electrically isolated;
- check for physical isolation from toxic gases and liquids or powders, including if possible whether there are any gaps in the pipework through which materials could enter and potentially suffocate workers;
- clean and purge the equipment that workers are entering;
- assess the means of entry and exit and how people can be rescued in an emergency;
- provide ventilation and/or breathing air supplies for use during the work and for emergencies;
- test the atmosphere inside the confined space for toxic or flammable materials and oxygen content;
- consider that the tools the workers will use are suitable for the job (is non-sparking equipment necessary?);
- ensure that rescue harnesses are available (although be aware that when using harnesses with a winch, there is a danger of the person being rescued getting caught on internal hardware and incurring further injury);
- check/ensure you have adequate communications, standby and alarm arrangements; and
- prepare a permit to work, identifying roles and responsibilities (including those of contractors) and the requirements for monitoring the progress of the job.

This is not an exhaustive list.

emergency arrangements

The emergency procedures will depend on the detailed nature of each job and the risks identified. However, a number of factors will be common to most situations. These include:

- communications – a workable intercom system so that persons inside the confined space can contact those outside;
- standby back-up personnel to maintain contact with the workers inside the confined space. This is a vital feature of confined space working;
- adequately-trained rescuers;
- training in first aid;
- means of summoning local emergency services; and
- appropriate drilling and testing of the emergency arrangements.

A worker was asphyxiated by LPG fumes in a pit area while trying to repair a gas leak (*Safe Work, Australia*)

For more information and a sample copy of LPB visit: www.icheme.org/resources/lpb

1983
North America

A worker inside a sewage digester attempted to restart a propane heater. The heater was being used to warm the wall of the digester prior to painting it. The heater exploded and although the man survived to crawl away he entered an area that was deficient in oxygen and died. A co-worker tried to rescue him but also died. Some estimates place the number of deaths of would-be rescuers in confined space accidents at as high as 60% of total deaths.

so why do accidents recur?

Safety leader Trevor Kletz has examined this subject in detail and provides a number of reasons[7]. Principal amongst these, to which I've added some comments of my own, are:

- Organisations fail to record and circulate the lessons learned from past accidents.
- Experience and skills are lost as companies cut permanent staff to save costs.
- Greater use of contractors for non-routine work. There is nothing intrinsically unsafe about using contractors but they need closer supervision and more explicit instructions. Remember, last week they may have been working in a dairy. Today, they are in your plant which handles highly toxic chemicals.
- Hazards are not reassessed often enough. What was safe in the past is not necessarily safe now.
- The supervisor is overloaded. The supervisor is the interface between management and the workforce, and *ensures* that the job is carried out smoothly. Take care not to divert this person with unnecessary tasks and detail, especially those which might divert attention away from safety.
- Change of design can lead to fatal conditions. There should be a formal system for assessment of proposed changes to plant and they should only be implemented after they have met the appropriate criteria;
- An unrecognised hazard, which is particularly relevant to confined spaces.
- Taking a short cut is a readily recognisable human behaviour but it will result in unsafe working practices and conditions.
- Attempting to rescue workers without adequate personal protective clothing. Powerful team and humanitarian instincts come into play in these circumstances but, admirable though these are, they need to be tempered by sound common sense or the number of injuries or fatalities will increase.

avoiding repetitions – ways and means

To prevent repetitions, Kletz provides some helpful techniques that apply to all types of accidents. Eg:

- Describe accidents in safety bulletins emphasising the reasons why the accident happened. These should be internally produced and then submitted to organisations like IChemE and ROSPA for wider circulation.
- Follow up the accident recommendations to ensure that they have been put into effect. The prime responsibility for this is with management but supervisors and operators should be encouraged to take part in the process.
- Never change a procedure until the reason

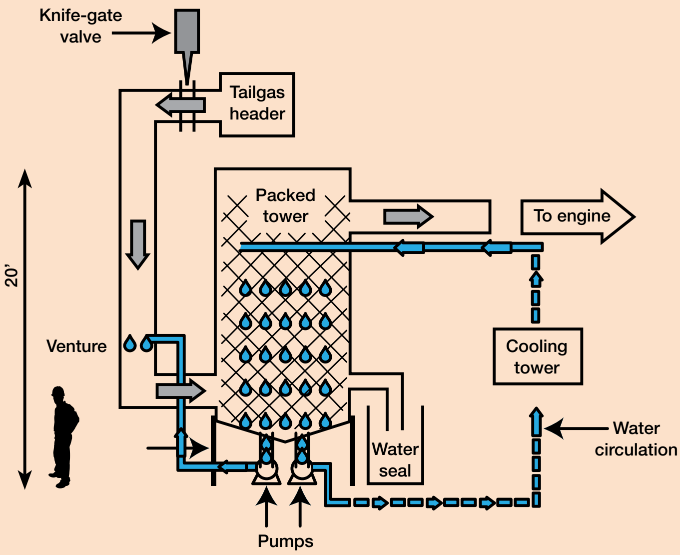
accident 2

waste gas leads to near fatality UK, 1999

An electrician was overcome by fumes while working on a motor on a waste gas tower. The fumes contained dangerous amounts of carbon monoxide, dihydrogen sulphide, hydrogen cyanide and other toxic gases. The waste gas was flammable and was used to run a diesel engine. Fortunately, the electrician had a student with him. They were both inside the skirt underneath the tower. The usual purpose of a skirt is to protect valves, pipework and other equipment from damage from passing objects such as the forks of a forklift truck or large pieces of equipment in transit.

The skirt often has openings in it for access or to prevent build-up of flammable gases. While they were on their hands and knees working, the electrician became motionless and unresponsive. Despite feeling ill himself, the student managed to pull the electrician clear, and he recovered. The investigation found that:

- there had been no risk assessment prior to the job;
- the isolation procedure failed because the vent via the water seal had not been opened. After closure of the knife-gate valve from the tailgas header (to stop gas entering the tower) any leakage was supposed to have vented via the water seal;
- because the vent was shut, the purging was inadequate; and
- there was no specific rescue plan.



Both accidents 1 and 2 had a number of similar causes – or recurring themes. The other very important feature of the second case is that the space inside the skirt was not recognised as a confined space because it had four arched openings in it. However, air circulation was limited and further exacerbated by the fact that the tower was located in a congested area of the plant.

A worker collapsed and later died as a result of fumes while working in a bulk tank (*Safe Work, Australia*)

A worker was overcome by fumes while making repairs to the inside of a boat hull (*Safe Work, Australia*)

for it is fully approved and understood.

- Try to find out about and learn from accidents in other organisations, particularly those that carry out similar work.
- Emphasise the importance of risk assessments and make sure that they are carried out.

The next question is "how to put all this into effective practice?" A range of processes and protocols exist and all have their advantages and disadvantages. These include safety information notes and emails, committee meetings, on- and off-the-job training courses, formal apprenticeships, computerised learning modules, and toolbox talks (TBTs).

TBT (tool box talk)

A TBT (Toolbox talk) is a short (5–30 min) informal way of educating the workforce and getting their views on specific health, safety and environmental topics including accident prevention. Typically, TBTs are presented by the first line supervisor to the work teams in the workplace, although this is not an exclusive protocol. They should be interactive and draw out the views and ideas of the team members. They are a key factor in safety culture and behavioural safety development if done well and can be a very effective accident prevention/repetition tool.

A TBT on confined space working would typically include case studies such as those described in this article; the lessons learned; a discussion of how to prevent recurrences; the legislative and advisory position; and types of confined space and how to make them safe to work in (see *Practical action*).

The TBT can be evolved from in-house experience or from existing sources (available along with good practice guide on TBTs[8]). Successful TBTs include involving everybody included in the job; ensuring that the presenter is well briefed; emphasising the importance of the topic and why; making sure that the group members contribute to the discussion; and ensuring that actions agreed are carried out.

practical action

All of these can be supported by practical measures, for example, simple interactive exercises. At some time not too long after the TBT, the group could be led around the workspace by the supervisor to collectively identify potential confined spaces. These should range from the obvious ones (tanks and reaction vessels) to obscure ones (such as spaces between equipment and a solid wall or open-topped pits). The exercise can be turned into a light-hearted competition with minor rewards – but be careful not to discourage the less successful. Explain that it is not about winning, but to see what everyone has learned.

conclusion

Accidents in confined spaces have long been a source of serious injury and fatality and they continue to be so despite the fact that just about everyone consulted on the subject seems to be aware of the hazards and how to guard against them. The vast majority of jobs in confined spaces are carried out efficiently, safely and without any adverse affect on personnel but the small percentage that do not meet the requirements very often have dire consequences.

Shortage of oxygen, electrocution, exposure to extreme heat or cold, presence of toxic atmospheres are all things which do lead to almost instant death or, if not, are followed by significant, permanent impairment of some vital bodily function. The instinct to help a trapped colleague, however noble, is equally hazardous and must be avoided at all costs unless proper precautions are taken.

The key to avoiding such accidents, having first ensured the safest possible equipment design and operation lies in human behaviour in all its manifold aspects. Education from the highest level of management through to managers and supervisors and most of the entire workforce is absolutely essential. Whatever the value of TBTs, the most important single, simple message to get across to people is: be a 'what if' person, not an 'if only' person. In short, think before you act so as to stay alive and well. **tce**

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references

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