# Confined spaces in the chemical industry – Where no two jobs are the same

Cleaning and maintenance work in confined spaces present particular challenges for safety officers in the chemical industry. This document outlines five basic rules for working safely and efficiently.

The cleaning, maintenance and repair of columns, tanks, and silos are part of the frequent, yet anything but routine, activities in the industry. For example, tanks and silos must be cleaned of sludge, decontaminated and reconditioned during batch changes. Maintenance cycles must be complied with and regular inspections must be performed.

## Accidents in confined spaces often result in death

In spaces which are difficult to access and are poorly ventilated such as columns, tanks and silos, mechanical incidents may occur or dangerous gas clouds may form unexpectedly and undergo spontaneous combustion. There is a risk of injury due to lack of oxygen, toxic and explosive gases, harmful particles and mechanical impact. Accidents in confined spaces and containers often result in death and normally affect several persons at once. There is a lack of official statistics which detail these accidents as well as the precise extent of their impact – such as the types of injuries, the degree of injury, delayed effects and deaths. There are, however, scientific studies which publish precise numbers related to isolated regional cases. A 2012 study published by the University of Berkeley in California, USA shows that 530 workers were killed in 431 accidents by toxic gases or due to lack of oxygen while working in confined spaces in the USA between 1990 and 2005. This number equates to an average of 29 accidents and 36 deaths annually – in the USA alone. According to the study, the activities which most frequently lead to accidents are repair and maintenance work (24 percent of the examined cases) followed by cleaning activities (12 percent) and inspections (11 percent).[1]

### COMMON INJURIES IN CONFINED SPACES

- Loss of consciousness or asphyxiation due to lack of oxygen
- Poisoning and chemical burns caused by hazardous substances
- Electric shocks
- Contusions and limited mobility due to mechanical impact or solids

### WHAT ARE FREQUENT CAUSES OF ACCIDENTS?

There are several diverse causes of accidents. These include the following:

- Missing or insufficient hazard identification and risk assessment
- Insufficient threat awareness,
- No selection or the incorrect selection of gas detection instruments
- The use of unsuitable personal protective equipment or
- The lack of training of workers who are designated for Confi ned Space Entry.

Some accidents occur purely due to a lack of knowledge and competence. For example, if international teams are provided with training and instructions in English, non-native speakers of English may misunderstand some parts of the instruction given. This then results in the incomplete and incorrect application of the relevant instructions by the executing personnel.

Other possible causes of accidents include cases of negligence such as failure to disconnect the space from the energy supply, from sources of heat or other mechanical or chemical influencers. The concentration of gases (oxygen content – OX, explosion hazard – EX, risk of intoxication – TOX) within tanks is often underestimated. Workers are also often unaware of chemical reactions which may be in progress or the condition of possible tank contents

(material, temperature, strength, etc.). Another hazard is the introduction of ignition sources, such as electric tools which are not EX protected and can trigger sparks. Entry to confined spaces is always associated with increased risks, as it is impossible to predict with 100% accuracy which conditions will be found in interiors despite appropriate precautionary measures.

## Identifying and assessing risks

Work in confined spaces and containers must be coupled with thorough risk assessment by the plant operator. Workers must be provided with operating instructions which inform them of the specific conditions as well as potential dangers. Tank cleaning not only requires formal qualifications (e.g. occupational medical examination for work with respiratory protection), it also requires a wealth of experience, practice and physical and mental strength. In the event of an incident, the supervisor must be able to introduce adequate rescue measures within the shortest possible time. For this reason, proper certification of tank cleaning personnel is obligatory. This also applies to the use of gas detectors, personal protective equipment and respiratory protective devices.

The internationally recognised term “Confined Space Entry” is used for work in confined spaces. Due to the high risks associated with Confined Space Entry, special safety standards apply, such as the OSHA Standard 1910.146 “Permit-required Confined Space Entry” in the USA .[2]

**According to OSHA, a permit-required Confined Space Entry is present if a confined space also**

- Has a (potentially) dangerous atmosphere
- Contains substances that may envelope the person entering the area
- May constrict the person entering the area, or lead to asphyxiation, due to its design and
- Contains recognised, serious dangers to safety and health.

**A non-permit Confined Space Entry is defined as follows:**

- The space is large enough for the worker to operate in
- Entry and exit are restricted
- It is not suitable as a permanent workplace.

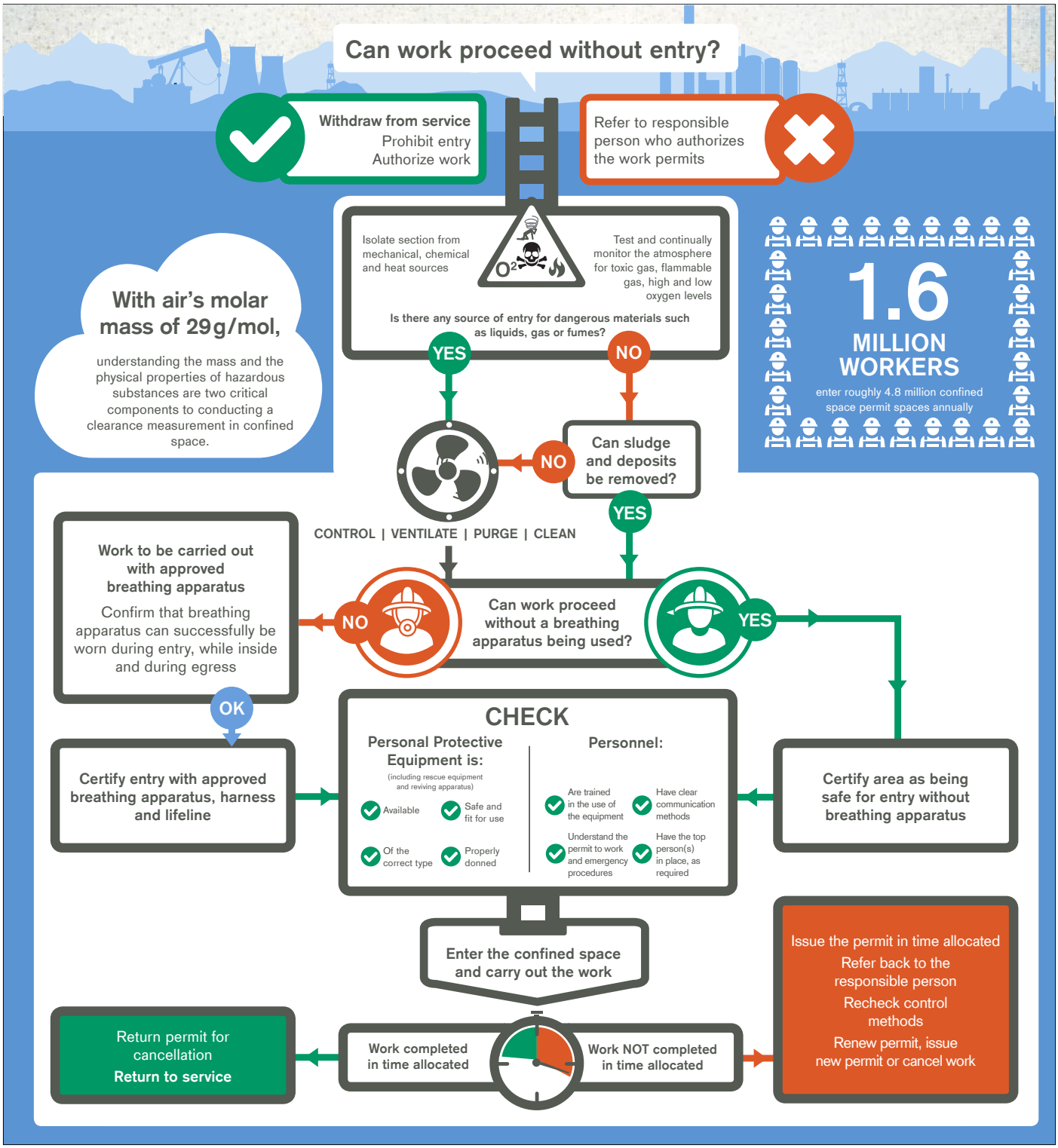
In practice, the risk assessment decides which category the planned Confined Space Entry is to be allocated to. According to OSHA USA, the employer is also obliged to install warning signs that point out the particular danger of a permit-required Confined Space Entry as well as implement an explicit permit-required confined space programme. Despite all the safety regulations and organisational precautions, entry to confined spaces remains a high-risk job.

## How to ensure proper clearance measurements

Many accident investigations reveal that knowledge, skills and experience are often lacking when it comes to testing the atmosphere inside of a container before entering it. The selection of the right gas detector and its correct operation are vital for minimising risks. When it comes to so-called clearance measurements, miscalculations are common as a result of measurements being taken in the wrong places. Often the wrong sensor technology is also used. For example, an EX sensor only measures whether gas is present in an explosive concentration but does not detect any toxic substances which may also be contained in the atmosphere. Some toxic concentrations are so low that they are not displayed by the EX sensor reading, even though a risk of intoxication is present. An EX sensor generally only measures volume percent, allowing it to detect a risk of explosion but not a possible intoxication, which may already be in the ppm range (ppm: parts per million). For this there are special photoionisation detectors (PID sensors) which can detect harmful substances in the ppm range.

EX sensors are also cross sensitive, which can lead to incorrect measurements, especially of difficult to detect substances like toluene, xylene and hexane. All of these vital aspects can, however, only be observed by someone who has already addressed such issues on several occasions. Proper knowledge, experience and training is essential.

## Working Properly in Confined Spaces



## Why are rescue attempts so risky?

A large proportion of fatal accidents in confined spaces occur during rescue attempts. Colleagues respond impulsively without having properly assessed the situation in advance. Rescuers are often injured or killed due to the same causes which originally endangered the colleague in the confined space. If a colleague has lost consciousness due to gas in the container, the rescuer will also be affected if he or she enters the space without a proper respiratory protective device.

If there is an accident, the limitations associated with confined spaces also complicate rescue work. Access openings may be too tight, visibility may be limited and proper equipment is often missing. Every second is vital during the rescue of injured persons in confined spaces, especially when dealing with a toxic or oxygen deficient atmosphere.

## Be aware of rescue concepts from the very start

There are often no specific emergency plans provided in workplaces, or workers are not aware that such emergency plans exist. A safe workplace must include a suitable emergency concept and rescue plan which is based on special basic conditions so that workers are prepared to respond professionally should an emergency arise.

It must be taken into consideration that external rescue teams may not always be adequately trained to rescue injured persons from confined spaces, requiring them to first take time-consuming preparatory measures. This can significantly delay rescue measures, as shown by this example from California, USA. "[...] firefighters typically arrive at an emergency within five to seven minutes of a 911 call, but it can take one to three hours for someone to be extricated from a confined space because these are 'low-frequency, high-risk' operations in which crews avoid rushing into a dangerous situation."

But speed can save lives. Especially when it comes to work in confined spaces, it is extremely important to have a plan for how to respond in "what if" situations and to have a well-trained rescue team standing by which can move in with respiratory protective devices and other equipment.

## A maintenance project – An entry permit

In order to ensure that the risk-prevention measures stipulated in the operating instructions are adhered to when workers enter containers, the safety officer creates a temporary permit in the form of a protocol. This protocol addresses exact, project-specific tasks and basic conditions. The supervisor adheres to the specified measurement

techniques, intervals and devices as well as the measurement results, the required personal protective equipment and the measures to be taken in case of an emergency. The schema on page 4 illustrates the ideal procedure for working safely in an enclosed space.

## How can accidents be avoided?

Proper training is an important prerequisite for avoiding accidents during work in confined spaces. Training sessions simulate a real work scenario and start, for example, by demonstrating the correct way to take clearance measurements and the use of personal protective equipment followed by entry and exit exercises. Participants are also trained in how to respond in stressful situations and low visibility in interiors as well as in the evacuation of unconscious and injured persons.

It is normally the task of the workplace safety teams belonging to the plant to present and practice specific rescue scenarios with plant personnel before work is started. The rescue concept varies from plant to plant depending on varying basic conditions. One plant may have its own rescue team which is trained to respond to accidents in confined spaces. Another plant may rely on a regional fire brigade which regularly performs confined space rescue exercises together with plant employees.

5 TIPS FOR CSE ACCIDENT PREVENTION

1) Check the following before beginning work: Are the national or regional CSE regulations fulfilled? For example, entry into a container or a confined space requires operating instructions and a permit in Germany as stipulated in BGR (117). Operating instructions alone are also sufficient in some cases involving activities which are performed on a regular basis and which always carry the same risks and protective measures.

2) Have clear responsibilities been established? Who does what? Is there a supervisor, and does everyone know that the supervisor is the contact person for all questions regarding safety?

3) When it comes to clearance measurements, are the necessary operating instructions also available? Are certified workers and proper devices available?

4) Have the workers on site been trained regarding the individual activities? Have they been trained regarding the use of personal protective equipment, rescue belts, rescue winches, etc.?

5) Is there an alarm and rescue plan? Have the recommended measures been consistently thought through?

## Raising awareness through professional consultation

Information and consultation is also a very important topic. Some companies are not even aware that their plants include confined spaces. This means that there is no risk assessment because a hazard has not been recognised. The devil is in the details. Tripping hazards, gases, electric currents and mechanical equipment such as mixers or hydraulic flaps are all aspects which can, when considered individually, represent calculable risks. However, when they are combined with strong walls and poor ventilation, the risk multiplies. A joint inspection with an experienced safety expert and a detailed risk assessment can reveal that even a supposedly “harmless” shaft, a large basin, hollow sections in shell construction or cavities for maintenance access can all be classified as confined spaces.

## NFPA presents new CSE manual

It is a fact that, despite all of the existing regulations by liability insurance associations, government authorities such as the OSHA and other relevant institutions, serious and even fatal accidents still occur on a regular basis. This is why the National Fire Protection Association (NFPA), which has its headquarters in Quincy, Massachusetts in the USA, has summarised important aspects in its latest handbook “NFPA 350; Guide for Safe Confined Space Entry and Work”.

This practice-oriented approach provides relevant tips regarding aspects such as the selection and use of personal protective equipment, clearance measurements before and during entry to a confined space and for the development of individual emergency plans. The industry-spanning approach of the NFPA is an important step towards reducing the number of accidents in confined spaces worldwide.

## REFERENCES


1 *http://news.berkeley.edu/2012/02/13/confined-spaces/; Date of access: June 03, 2016*

2 *OSHA – Occupational Safety & Health Administration, source: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9797&p_t table=STANDARDS, Date of access: June 01, 2016*

3 *OSHA – Occupational Safety & Health Administration, source: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9797&p_ table=STANDARDS; Date of access: June 01, 2016*

4 *››[…] 60 percent of deaths in confined spaces result from would-be rescuers entering to help a fallen buddy.‹‹ http://www.huffingtonpost.com/2012/05/24/ca-workplace-fatalities_n_1542829.html?goback=.gmp_2246751.gde_2246751_member_260516403#!, Date of access: June 03, 2016*

5 *http://www.huffingtonpost.com/2012/05/24/ca-workplace-fatalities_n_1542829.html?view=print&comm_ref=false, Date of access: 03/06/2016*

6 *http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=350; Date of access June 03, 2016*



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