



Goal

This program is designed to help develop a general industry training program for safety in permit-required confined spaces.

Objective

At the end of this program, employees should be able to demonstrate general knowledge of the hazards of working in confined spaces and of appropriate measures to take to prevent injuries and illnesses.

Characteristics of Confined Spaces

Confined spaces are dangerous because they may contain harmful substances, affect breathing, increase fire hazards, be unsafe in design, or limit an employee's ability to enter and exit safely.

Generally speaking, a confined space is an area that:

- Is large enough and configured so that an employee can physically enter and perform required work
- Has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, or pits may have limited means of entry)
- Is not designed for continuous employee occupancy

A permit-required confined space (PRCS) is an even more dangerous area that has one or more of the following additional characteristics:

- Contains or has the potential to contain a hazardous atmosphere
- Contains a material that could engulf an employee
- Has an internal configuration, such as inwardly converging walls or a floor that slopes downward and tapers to a smaller cross-section, which could trap or asphyxiate an employee
- Contains any other recognized serious safety or health hazard

Employers must inform employees of the locations and hazards of PRCS's. This is often done by posting signs around the space that state "DANGER – PERMIT-REQUIRED CONFINED SPACE – AUTHORIZED ENTRANTS ONLY." Only authorized

and trained personnel with a permit from the entry supervisor may enter a PRCS.

Under certain circumstances, employees may enter a confined space without a permit, such as if:

- All hazards can be removed by isolating the space
- The only hazard is atmospheric, and the hazard can be controlled by ventilation. In this instance, the employer must perform pre-entry atmospheric testing and provide continuous atmospheric monitoring thereafter.

Atmospheric Hazards

Oxygen-Deficient Atmospheres

Normal air contains about 20.8% oxygen by volume. Oxygen-deficient atmospheres have less than 19.5% oxygen by volume. Changes in normal concentrations are a serious hazard in confined spaces. Oxygen levels can decrease as a result of:

- Welding, cutting, or brazing
- Chemical reactions (rusting)
- Bacterial action (fermentation)
- Displacement by other gases, such as carbon dioxide or nitrogen

Oxygen-Enriched Atmospheres

Oxygen-enriched atmospheres occur when oxygen levels exceed 23.5% by volume. At that point, the atmosphere becomes flammable, and materials such as clothing or hair will burn rapidly if ignited. Unattended or leaking oxygen lines or cylinders can increase oxygen concentration to an unsafe level.

Toxic Atmospheres

Toxic atmospheres can be caused by any of the following:

- Products stored in the space have been absorbed into the walls and give off toxic gases during removal
- Work performed in the space, such as welding, sanding, or degreasing
- Hazardous toxicants produced in areas near the confined space accumulate, such as liquids, vapors, mists, solid materials and dusts

Toxic Gases

Toxic gases can irritate the skin, eyes, nose, and throat. Some can prevent the body from using oxygen effectively, and all of them can injure or kill. Some of the most common toxic gases found in confined spaces are:

- Carbon monoxide – a colorless, tasteless, and odorless byproduct of combustion
- Hydrogen sulfide – a colorless gas with the distinct smell of rotten eggs

Before employees begin work, employers should investigate any confined space to determine whether any of these conditions exist and take proper precautions to safeguard employees.

Atmospheric Testing

Hazardous gases can be found at the top, middle, or bottom of a confined space and can vary in density. To accurately determine which gases are present, atmospheric testing must be performed at all three levels. If a toxic or combustible gas or an oxygen-deficient or enriched atmosphere is present, employees must wear the proper respiratory protection for the detected contaminants.

Ventilation

Several methods exist for ventilating a confined space. The method and equipment chosen depend on the size of the confined space openings, the gases to be removed, and the source of replacement air.

Under certain conditions where flammable gases or vapors have displaced the oxygen level but are too rich to burn, forced air ventilation may dilute the gases until they are capable of exploding. The same is true if inert gases (e.g., carbon dioxide, nitrogen, or argon) exist in the confined space. Ventilate and retest the space before allowing entry.

Ventilation should be continuous where possible because in many confined spaces the hazardous atmosphere will form again when the airflow is stopped.

Respiratory Protection

Three types of respirators help employees to breathe safely without inhaling toxic gases or particles:

1. Air-purifying respirators (APR's) use a filter or sorbent to remove airborne contaminants from the air before they are inhaled. However, there are some disadvantages to using APR's:
 - They require that wearers expend additional effort to breathe, and they require medical surveillance to ensure that employees are medically fit to wear them. If there is room inside the confined space, powered air-purifying respirators (PAPR's), which use a fan to draw air through filters, can be used.
 - They do not supply oxygen; therefore, they cannot be used in oxygen-deficient atmospheres.
 - The filter media must be designed specifically to absorb or counteract the contaminants that are present.
 - If overused, respirators may become saturated with particles or other contaminants and cause additional breathing difficulties until masks or filters are changed. Employers must develop and follow cartridge or mask change schedules.
 - They are best used with gases or vapors that can be detected by odor, taste, or irritation.
2. Supplied-air respirators (SAR's) supply air to the user from a source such as a compressor or compressed air cylinder. Some disadvantages to using SAR's are:
 - They have a maximum allowable hose length of 300 feet.
 - The hose can become twisted and tangled.
 - The employee has only one path of entry and exit.
3. Self-contained breathing apparatuses (SCBA's) use a tank of breathable air carried by the employee. Although the SCBA has a limited wear time and may be heavy and bulky, it provides the highest level of respiratory protection available and may allow the employee greater mobility while performing the job. If there is room to use one, this is the best type of respirator to use in a confined space.

Isolation

Isolation of a confined space is a process for removing the space from service by:

- Locking out electrical sources, preferably at disconnect switches remote from the equipment
- Blanking and bleeding pneumatic and hydraulic lines
- Disconnecting belt and chain drives and mechanical linkages on shaft-driven equipment where possible
- Securing mechanical moving parts within confined spaces with latches, chains, chocks, blocks, or other devices

General and Physical Hazards

Employers should consider the following when evaluating a confined space:

- Temperature extremes can be harmful to employees. For example, if a space has been steam-cleaned, it must cool before any employees enter.
- Engulfment hazards such as loose material (grain, sand, coal, etc.) can crust over in a bin, break loose under an employee's weight and trap employees during entry.
- Noise can become excessive in a confined space and can not only damage hearing, but also affect communication and cause warnings to go unheeded.
- Slick or wet surfaces can cause slips and falls and increase the chances of electric shock in a confined space.

Fall protection is needed when employees are working at 4 feet or more above a lower level.

Written Program

An employer that allows employees to enter PRCS's must develop and implement a written program. The program should include these key provisions:

1. Measures to prevent unauthorized entry
2. Hazards of permitted spaces
3. Procedures and practices for safe entry into permitted spaces:
 - Create acceptable entry conditions

- Allow authorized personnel to observe the monitoring process
 - Isolate permitted spaces
 - Eliminate or control atmospheric hazards
 - Provide barriers to protect entrants from external hazards
 - Continuously verify that conditions are acceptable
4. Equipment needed for PRCS's:
 - Testing and monitoring equipment
 - Ventilation equipment
 - Communications equipment
 - Personal protective equipment
 - Lighting equipment
 - Barriers or shields
 - Equipment needed for safe ingress and egress
 - Any other needed equipment
 5. Explanation of how permitted spaces will be evaluated
 6. Assignments for attendants, supervisors, and rescuers
 7. Designations and definitions of roles of attendants, supervisors, and rescuers
 8. Rescue procedures
 9. Description of the process for issuing, using, and cancelling PRCS permits

Communication

Communication is the primary key to safety in confined space work. To work safely in a confined space, the entrant must be able to communicate with the attendant on duty outside the space. A system of communication must be set up prior to beginning work.

The following personnel are involved in this process:

- **Entrant** – a person who enters the space to perform the work
- **Attendant** – the person on duty outside the space whose only function is to monitor the space while entrants are working inside. The attendant must always be aware of what is going on inside the space so they can react in the event of an emergency.
- **Entry Supervisor** – the person in charge of confined space entry and ultimately responsible for all activities.

- **Rescuers** – personnel who must be able to either rescue the entrant by remote means (such as a winch) or to enter the space with sufficient equipment (including personal protective equipment) to do the job safely.

Training

- Train entrants, attendants, entry supervisors, and rescuers in their duties before attempting a confined space entry. The employer must ensure that all affected employees understand and can perform their tasks fully. Rescuers must be trained in the hazards they are likely to encounter in the employer's confined spaces. Additional training is required if job duties change, new PCRS's are identified, or if affected employees show a lack of understanding or proficiency.
- Train rescuers in first aid and cardiopulmonary resuscitation (CPR).
- Perform practical rescue exercises with rescuers at least annually.
- Document all training and maintain training records.

Use of Fire Department Rescue Squads

There are no regulations prohibiting the use of fire department rescue teams, however, employers must take certain precautions:

- The employer must evaluate the fire department rescue truck and personnel to determine that the rescue squad is properly trained and equipped to undertake a confined space rescue in the employer's PCRS.
- The employer must determine that the fire department rescue squad can respond and deploy in a timely manner.
- Before commencing a PCRS entry, the employer must determine that the rescue squad is available to respond if needed, and be prepared to abort the entry if the rescue personnel go out on another call.

Entry Permits

The entry supervisor must sign all entry permits and post them at all entrances to the confined space, or otherwise make them available to entrants before anyone enters the space. Permits must confirm that all pre-entry preparations have been completed. The permit must contain a time limit that does not exceed the time needed to do the task inside the confined space.

Entry permits must include:

- The name of the PCRS to be entered, the names of the entry supervisor and all entrants and attendants involved
- Test results
- The tester's initials or signature
- The entry supervisor's signature
- The purpose of entry and known hazards
- Measures taken to isolate the space and to eliminate or control hazards
- The names and phone numbers of rescue and emergency personnel
- The date and authorized duration of entry
- Acceptable entry conditions
- Communication procedures and equipment to ensure communication during entry
- Additional permits (such as hot work permits) that authorize specific work in the confined space
- Special equipment and procedures needed for the entry
- Any other information needed to ensure employee safety

The entry supervisor must cancel the permit when the work is complete or new conditions arise. New conditions must be noted on the permit and used to revise the confined space entry program. Permits must be kept on file for at least one year.

Review Questions

1. What is the best respirator for use in confined space operations (assuming it will fit in the space)?
 - a. Supplied-air respirators (SAR's)
 - b. Self-contained breathing apparatuses (SCBA's)
 - c. Air-purifying respirators (APR's)
2. Oxygen-deficient atmospheres have less than [how much] oxygen available?
 - a. 20.6%
 - b. 18.7%
 - c. 19.5%
 - d. 21.7%
3. Carbon monoxide is colorless and odorless but leaves a distinct taste of rotten eggs in your mouth.
 - a. True
 - b. False
4. Atmospheric testing must be done at the top and bottom of the space only since gases tend to only rise to the top or sink to the bottom.
 - a. True
 - b. False
5. The attendant is the person responsible for the confined space entry and is ultimately responsible for all activities.
 - a. True
 - b. False
6. Entry permits are issued by:
 - a. Entrants
 - b. Attendants
 - c. Entry supervisor
 - d. The fire department rescue captain
7. If the designated rescuers are the fire department rescue squad members, the confined-space entry must be aborted if the rescue truck leaves to respond to an emergency.
 - a. True
 - b. False

Answers

1. B
2. C
3. False – hydrogen sulfide smells like rotten eggs, carbon monoxide has no color, taste or smell
4. False – to accurately determine which gases are present, atmospheric testing must be performed at all levels, top, middle, and bottom
5. False – entry supervisor
6. C
7. True

For more information on confined space entry and other topics see the Service Lloyds website. In Risk Control's Training Materials section, we have additional resources including:

- Confined Space Program – Sample Safety Program
- Parlay Handouts:
 - What is a Confined Space?
 - Confined Space Hazards
 - Confined Space Roles & Responsibilities
 - Confined Space Atmospheric Controls

Remember to practice Safety; don't learn it by accident.

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