Safety Training Program

Confined Spaces

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 easily. The Occupational Safety and Health Administration (OSHA) outlines confined space safety requirements for general industry in 29 Code of Federal Regulations (CFR) 1910.124, 146, 261, 262, 268, and 272. Separate requirements for construction are found in 29 CFR 1926.1201-1213, and those for shipyards are found in 29 CFR 1915 Subpart B.

Generally speaking, a confined space is an area that

- is large enough and configured so that an employee can bodily enter and perform assigned work;
- has limited or restricted means for entry or exit (for example: tanks, vessels, silos, storage bins, hoppers, vaults, or pits may have limited means of entry); and
- is not designed for continuous employee occupancy.

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

- contains or has a 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; or
- contains any other recognized serious safety or health hazard.

Employers must inform employees of the locations and hazards of PRCSs. 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:

- all hazards can be removed by isolating the space; or
- 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 percent oxygen by volume. Oxygen-deficient atmospheres have less than 19.5 percent oxygen by volume. Changes in normal concentrations are a serious hazard in confined spaces (Table 1). Oxygen levels decrease as a result of

- welding, cutting, or brazing;
- chemical reactions (rusting);
- bacterial action (fermentation); or
- displacement by other gases, such as carbon dioxide (Table 2) or nitrogen.

Oxygen-Enriched Atmospheres

Oxygen-enriched atmospheres occur when oxygen levels exceed 23.5 percent by volume. At that point, the atmosphere becomes flammable, and materials such as clothing or hair will burn rapidly when 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 that have been absorbed into the walls and give off toxic gases during removal;

- work performed in the space, such as welding, sanding, or degreasing; and
- hazardous toxicants produced in areas near the confined space that can enter the space and 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; and
- 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, employers must ventilate and retest the confined space before permitting entry. If ventilation is impossible and entry is necessary, 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 (for example 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 allow employees to breathe safely without inhaling toxic gases or particles:

1. **Air-purifying respirators** (APRs) use a filter or sorbent to remove airborne contaminants from the air before it is inhaled. However, some disadvantages exist to using APR:
   - 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 (PAPRs), which use a fan to draw air through the 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** (SARs) supply air to the user from a source such as a compressor or compressed air cylinder. The following are disadvantages to using SARs.
   - They have a maximum allowable hose length of 300 feet.
   - The airline can become twisted and tangled.
   - The employee has only one path of entry and exit.
3. **Self-contained breathing apparatus** (SCBA) uses 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. This is the best type of respirator to use in a confined space if there is room to use one.

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; and

- 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.
- Falling objects are a danger if work is being done above the entrant 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 PRCSs 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; and
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, and
   - verify that conditions are acceptable throughout an authorized entry.
4. equipment needed for PRCS:
   - testing and monitoring equipment,
   - ventilation equipment,
   - communications equipment,
   - personal protective equipment,
   - lighting equipment,
   - barriers or shields,
   - equipment needed for safe ingress and egress, and
   - 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; and
9. description of the process for issuing, using, and cancelling PRCS permits.

Communication

Communication is the primary key to safety in confined space 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 as long as there are entrants working inside. The attendant must always be aware of what is going on inside the space to be able to react in event of an emergency.
- Entry Supervisor – the person in charge of confined space entry and ultimately responsible for all activities. 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.
- 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 PRCSs 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

The 29 CFR 1910.146 standard does not prohibit an employer from using a fire department rescue team for confined space rescue. 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 PRCS.
- The employer must determine that the fire department rescue squad can respond and deploy in a timely manner.
- Before commencing a PRCS 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 PRCS to be entered; and the names of the entry supervisor, 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 used 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; and
- 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)
   b. Self-contained breathing apparatus (SCBA)
   c. Air-purifying respirators (APR)

2. Oxygen-deficient atmospheres have less than [how much] oxygen available?

   a. 20.6 percent
   b. 18.7 percent
   c. 19.5 percent
   d. 21.7 percent

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. b (false) – Hydrogen sulfide smells like rotten eggs.

4. b (false) – To accurately determine which gases are present, atmospheric testing must be performed at all levels.

5. b (false) – Entry supervisor

6. c

7. a (true)

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Table 1 - Effects of Oxygen-Enriched and Oxygen-Deficient Atmospheres

Oxygen Percent by Volume	Resulting Condition/Effect on Humans
23.5% and Above	**Oxygen enriched, extreme fire hazard**
21%	Normal oxygen concentration of air
19.5%	Minimum "Safe Level" (OSHA, NIOSH*)
15-19%	Decreased ability to work strenuously. May impair coordination and may induce early symptoms in persons with coronary, pulmonary, or circulatory problems.
12-14%	Respiration increased in exertion, pulse up, impaired coordination, perception, judgment
10-12%	Respiration further increases in rate and depth, poor judgment, lips blue
8-10%	Mental failure, fainting, unconsciousness, ashen face, blueness of lips, nausea, and vomiting
6-8%	8 minutes, 100% fatal; 6 minutes, 50% fatal; 4-5 minutes, recovery with treatment
4-6%	Coma in 40 seconds, convulsions, respiration ceases, death

These values are approximate, and effects can vary based on an individual's health and on physical activities performed.
*Source: *National Institute of Occupational Safety and Health (NIOSH)*

Table 2 - Effects of Carbon Monoxide (CO) Levels

CO Level in PPM*	Resulting Condition/Effect on Humans
35	Permissible exposure level, 8 hours (OSHA)
200	Possible mild frontal headache in 2 to 3 hours
400	Frontal headache and nausea after 1 to 2 hours. Occipital (back of the head or skull) after 2-1/2 to 3-1/2 hours
800	Headache, dizziness, and nausea in 45 minutes. Collapse and possibly death in 2 hours
1,600	Headache, dizziness, and nausea in 20 minutes. Collapse and possibly death in 2 hours
3,200	Headache and dizziness in 5 to 10 minutes. Unconsciousness and danger of death in 30 minutes
6,400	Headache and dizziness in 1 to 2 minutes. Unconsciousness and danger of death in 10-15 minutes
12,800	Immediate effect is unconsciousness. Danger of death in 1 to 3 minutes

** Parts per million, 10,000 PPM – 1 percent by volume*

All values are approximate, and effects can vary based on an individual's health and physical activities performed.
Source: American Industrial Hygiene Association