



Confined Space Safety

Chapter 6



Confined Space Program

29 CFR 1910.146

Purpose

The Confined Space Entry Program is provided to protect authorized employees that will enter confined spaces and may be exposed to hazardous atmospheres, engulfment in materials, conditions which may trap or asphyxiate due to converging or sloping walls, or contains any other safety or health hazards.

Reference: *OSHA-Permit-Required Confined Spaces* (29 CFR 1910.146)

Responsibilities

Management

- Ensure proper training for entry & rescue teams
- Provide proper equipment for entry & rescue teams
- Ensure confined space assessments have been conducted
- Ensure all permit required confined spaces are posted
- Annually review this program and all Entry Permits
- Evaluate Rescue Teams/Service to ensure they are adequately trained and prepared
- Ensure rescue team at access during entry into spaces with IDLH atmospheres

Employees

- Follow program requirements
- Report any previously un-identified hazards associated with confined spaces

Entry Supervisor

Entry supervisors are responsible for the overall permit space entry and must coordinate all entry procedures, tests, permits, equipment and other relevant activities. The following entry supervisor duties are required:

- Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure



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- Verifies, by checking that the appropriate entries have been made on the permit, all tests specified by the permit have been conducted and that all procedures and equipment specified by the permit are in place before endorsing the permit and allowing entry to begin
- Terminate the entry and cancel the permit when the entry is complete and there is a need for terminating the permit
- Verify that rescue services are available and that the means for summoning them are operable
- Remove unauthorized persons who enter or attempt to enter the space during entry operations
- Determine whenever responsibility for a permit space entry operation is transferred and at intervals dictated by the hazards and operations performed within the space that entry operations remain consistent with the permit terms and that acceptable entry conditions are maintained.

Entry Attendants

At least one attendant is required outside the permit space into which entry is authorized for the duration of the entry operation. Responsibilities include:

- To know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure
- To be aware of possible behavioral effects of hazard exposure on entrants
- To continuously maintain an accurate count of entrants in the permit space and ensures a means to accurately identify authorized entrants
- To remain outside the permit space during entry operations until relieved by another attendant (once properly relieved, they may participate in other permit space activities, including rescue if they are properly trained and equipped).
- To communicate with entrants as necessary to monitor entrant status and alert entrants of the need to evacuate.
- To monitor activities inside and outside the space to determine if it is safe for entrants to remain in the space and orders the entrants to immediately evacuate if: the attendant detects a prohibited condition, detects entrant behavioral effects of hazard exposure, detects a situation outside the space that could endanger the entrants; or if the attendant cannot effectively and safely perform all the attendant duties.
- To summon rescue and other emergency services as soon as the attendant determines the entrants need assistance to escape the permit space hazards.
- To perform non-entry rescues as specified by that rescue procedure and entry supervisor



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- Not to perform duties that might interfere with the attendants' primary duty to monitor and protect the entrants.
- To take the following action when unauthorized persons approach or enter a permit space while entry is under way:
 1. Warn the unauthorized persons that they must stay away from the permit space,
 2. Advise unauthorized persons that they must exit immediately if they have entered the space, and
 3. Inform the authorized entrants and the entry supervisor if unauthorized persons have entered the permit space.

Entrants

All entrants must be authorized by the entry supervisor to enter permit spaces, have received the required training, used the proper equipment, and observed the entry procedures and permit. The following entrant duties are required:

- Know the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;
- Properly use the equipment required for safe entry;
- Communicate with the attendant as necessary to enable the attendant to monitor the status of the entrants and to enable the attendant to alert the entrants of the need to evacuate the space if necessary;
- Alert the attendant whenever the entrant recognizes any warning signs or symptoms of exposure to a dangerous situation, or any prohibited condition is detected; and
- Exit the permit space as quickly as possible whenever the attendant or entry supervisor gives an order to evacuate the permit space, the entrant recognizes any warning signs or symptoms of exposure to a dangerous situation, the entrant detects a prohibited condition, or an evacuation alarm activated.

Hazards

- Explosive / Flammable Atmospheres
- Toxic Atmospheres
- Engulfment
- Asphyxiation
- Entrapment



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- Slips & Falls
- Chemical Exposure
- Electric Shock
- Thermal / Chemical Burns
- Noise & Vibration

Hazard Control

Engineering Controls

- Locked entry points
- Temporary ventilation
- Temporary lighting

Administrative Controls

- Signs
- Controlling External Hazards
- Employee training
- Entry procedures
- Atmospheric monitoring
- Rescue procedures
- Use of prescribed PPE

Definitions

Confined space:

Is large enough or so configured that an employee can bodily enter and perform work.

Has limited or restricted means for entry or exit (i.e. tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry).

Is not designed for continuous employee occupancy.

Permit required confined space (“permit space”), is a confined space that has one or more of the following characteristics:

1. Contains or has a potential to contain a hazardous atmosphere.
2. Contains a material that has the potential for engulfing an entrant.



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3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly covering walls or by a floor which slopes downward and tapers to a smaller cross-section.
 4. Contains any other recognized serious safety or health hazard.
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5. Each Permit-Required Confined Space will be marked with the following placard (or equivalent):



Standard Operating Procedures for Entry

A Standard Operating Procedure (SOP) has been developed for each space to standardize the entry procedure. The SOP outlines:

- Hazards
- Hazard Control & Abatement
- Acceptable Entry Conditions
- Means of Entry
- Entry Equipment Required
- Emergency Procedures
-

Permit Required Confined Space Entry General Rules

During all Confined Space entries, the following Safety Rules must be strictly enforced:

1. Only Authorized and Trained Employees may enter a Confined Space or act as the Entry Attendant.
2. No Smoking is permitted in a Confined Space or near entrance/exit area.



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3. During Confined Space Entries, an Entry Attendant must be present at all times.
4. Constant visual or voice communication will be maintained between the Entry Attendant and Employees entering a Confined Space.
5. No bottom or side entry will be made or work conducted below the level anyhanging material or material which could cause engulfment.
6. Air and Oxygen Monitoring is required before entering any Permit-Required Confined Space. Oxygen levels in a Confined Space must be between 19.5 and 23.5 percent. Levels above or below will require the use of an SCBA or other approved air supplied respirator. Additional ventilation and Oxygen Level Monitoring is required when welding is performed. The monitoring will check Oxygen Levels, Explosive Gas Levels and Carbon Monoxide Levels. Entry will not be permitted if explosive gas is detected above one-half the Lower Explosive Limit (LEL).



This is an example of a confined space gas meter. This unit has a probe attachment which can be lowered down into a confined space for remote readings.

7. To prevent injuries to others, all openings to Confined Spaces will be protected by a barricade when covers are removed.
8. To protect the confined space entrants from external hazards (such as traffic, pedestrians, vehicles, etc.), a traffic-style barricade will be utilized around the entire perimeter of the space and will be set a minimum of 5' from the opening of the space. An example of this traffic-style barricade is shown below:



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Confined Space Entry Procedures

Each employee who enters or is involved in the entry must:

1. Understand the procedures for confined Space Entry
2. Know the Hazards of the specific space
3. Review the specific procedures for each entry
4. Understand how to use entry and rescue equipment

Confined Space Entry Permits

Confined Space Entry Permits must be completed before any Employee enters a Permit-Required Confined Space. The Permit must be completed and signed by an Authorized Member of Management before entry.

- Permits will expire before the completion of the shift or if any pre-entry conditions change. Permits will be maintained on file for 12 months.
- **ATTACHMENT: A sample of our company's ENTRY PERMIT is attached to this document.**

Contractor Entry

All work by non-company employees that involves the entry into confined spaces will follow the procedures of this program. The information of this program and specific hazards of the confined spaces to be entered will be provided to Contractor Management prior to commencing entry or work.

Training

Training for Confined Space Entry includes:



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1. Duties of Entry Supervisor, Entrant and Attendants
2. Confined Space Entry permits
3. Hazards of Confined Spaces
4. Use of Air Monitoring Equipment
5. First Aid and CPR Training
6. Emergency Action & Rescue Procedures
7. Confined Space Entry & Rescue Equipment
8. Rescue training, including entry and removal from representative spaces

Confined Space Hazards

Flammable Atmospheres

A flammable atmosphere generally arises from enriched oxygen atmospheres, vaporization of flammable liquids, byproducts of work, chemical reactions, concentrations of combustible dusts, and desorption of chemical from inner surfaces of the confined space.

An atmosphere becomes flammable when the ratio of oxygen to combustible material in the air is neither too rich nor too lean for combustion to occur. Combustible gases or vapors will accumulate when there is inadequate ventilation in areas such as a confined space. Flammable gases such as acetylene, butane, propane, hydrogen, methane, natural or manufactured gases or vapors from liquid hydrocarbons can be trapped in confined spaces, and since many gases are heavier than air, they will seek lower levels as in pits, sewers, and various types of storage tanks and vessels. In a closed top tank, it should also be noted that lighter than air gases may rise and develop a flammable concentration if trapped above the opening.

The byproducts of work procedures can generate flammable or explosive conditions within a confined space. Specific kinds of work such as spray painting can result in the release of explosive gases or vapors. Welding in a confined space is a major cause of explosions in areas that contain combustible gas.

Chemical reactions forming flammable atmospheres occur when surfaces are initially exposed to the atmosphere, or when chemicals combine to form flammable gases. This condition arises when dilute sulfuric acid reacts with iron to form hydrogen or when calcium carbide makes contact with water to form acetylene. Other examples of spontaneous chemical reactions that may produce explosions from small amounts of unstable compounds are acetylene-metal compounds, peroxides, and nitrates. In a dry state, these compounds have the potential to explode upon percussion or exposure to increased temperature. Another class of chemical reactions that form flammable atmospheres arises from deposits of pyrophoric substances (carbon, ferrous oxide, ferrous sulfate, iron, etc.) that can be found in tanks used by the chemical and petroleum industry. These tanks containing flammable deposits will spontaneously ignite upon exposure to air.



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Combustible dust concentrations are usually found during the process of loading, unloading, and conveying grain products, nitrated fertilizers, finely ground chemical products, and any other combustible material. High charges of static electricity, which rapidly accumulate during periods of relatively low humidity (below 50%), can cause certain substances to accumulate electrostatic charges of sufficient energy to produce sparks and ignite a flammable atmosphere. These sparks may also cause explosions when the right air or oxygen to dust or gas mixture is present.

Toxic Atmospheres

The substances to be regarded as toxic in a confined space can cover the entire spectrum of gases, vapors, and finely-divided airborne dust in industry. The sources of toxic atmospheres encountered may arise from the following:

1. The manufacturing process (for example, in producing polyvinyl chloride, hydrogen chloride is used as well as vinyl chloride monomer, which is carcinogenic).
2. The product stored [removing decomposed organic material from a tank can liberate toxic substances, such as hydrogen sulfide (H_2S)].
3. The operation performed in the confined space (for example, welding or brazing with metals capable of producing toxic fumes).

During loading, unloading, formulation, and production, mechanical and/or human error may also produce toxic gases which are not part of the planned operation.

Carbon monoxide (CO) is a hazardous gas that may build up in a confined space. This odorless, colorless gas that has approximately the same density as air is formed from incomplete combustion of organic materials such as wood, coal, gas, oil, and gasoline; it can be formed from microbial decomposition of organic matter in sewers, silos, and fermentation tanks.

Carbon monoxide is an insidious toxic gas because of its poor warning properties. Early stages of CO intoxication are nausea and headache. Carbon monoxide may be fatal at 1000 ppm in air, and is considered dangerous at 200 ppm, because it forms carboxyhemoglobin in the blood which prevents the distribution of oxygen in the body.

Carbon monoxide is a relatively abundant colorless, odorless gas; therefore, any untested atmosphere must be suspect. It must also be noted that a safe reading on a combustible gas indicator does not ensure that CO is not present. Carbon monoxide must be tested for specifically. The formation of CO may result from chemical reactions or work activities, therefore fatalities due to CO poisoning are not confined to any particular industry. There have been fatal accidents in sewage treatment plants due to decomposition products and lack of ventilation in confined spaces. Another area where CO results as a product of decomposition is



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in the formation of silo gas in grain storage elevators. In another area, the paint industry, varnish is manufactured by introducing the various ingredients into a kettle, and heating them in an inert atmosphere, usually town gas, which is a mixture of carbon dioxide and nitrogen.

In welding operations, oxides of nitrogen and ozone are gases of major toxicologic importance, and incomplete oxidation may occur and carbon monoxide can form as a byproduct.

Another poor work practice, which has led to fatalities, is the recirculation of diesel exhaust emissions. Increased CO levels can be prevented by strict control of the ventilation and the use of catalytic converters.

Irritant (Corrosive) Atmospheres

Irritant or corrosive atmospheres can be divided into primary and secondary groups. The primary irritants exert no systemic toxic effects (effects on the entire body). Examples of primary irritants are chlorine, ozone, hydrochloric acid, hydrofluoric acid, sulfuric acid, nitrogen dioxide, ammonia, and sulfur dioxide. A secondary irritant is one that may produce systemic toxic effects in addition to surface irritation. Examples of secondary irritants include benzene, carbon tetrachloride, ethyl chloride, trichloroethane, trichloroethylene, and chloropropene.

Irritant gases vary widely among all areas of industrial activity. They can be found in plastics plants, chemical plants, the petroleum industry, tanneries, refrigeration industries, paint manufacturing, and mining operations.

Prolonged exposure at irritant or corrosive concentrations in a confined space may produce little or no evidence of irritation. This may result in a general weakening of the defense reflexes from changes in sensitivity. The danger in this situation is that the worker is usually not aware of any increase in his/her exposure to toxic substances.

Asphyxiating Atmospheres

The normal atmosphere is composed approximately of 20.9% oxygen and 78.1% nitrogen, and 1% argon with small amounts of various other gases. Reduction of oxygen in a confined space may be the result of either consumption or displacement.

The consumption of oxygen takes place during combustion of flammable substances, as in welding, heating, cutting, and brazing. A more subtle consumption of oxygen occurs during bacterial action, as in the fermentation process. Oxygen may also be consumed during chemical reactions as in the formation of rust on the exposed surface of the confined space (iron oxide). The number of people working in a confined space and the amount of their physical activity will also influence the oxygen consumption rate.

A second factor in oxygen deficiency is displacement by another gas. Examples of gases that are used to displace air, and therefore reduce the oxygen level are helium, argon, and nitrogen.



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Carbon dioxide may also be used to displace air and can occur naturally in sewers, storage bins, wells, tunnels, wine vats, and grain elevators. Aside from the natural development of these gases, or their use in the chemical process, certain gases are also used as inerting agents to displace flammable substances and retard pyrophoric reactions. Gases such as nitrogen, argon, helium, and carbon dioxide, are frequently referred to as non-toxic inert gases but have claimed many lives. The use of nitrogen to inert a confined space has claimed more lives than carbon dioxide. The total displacement of oxygen by nitrogen will cause immediate collapse and death. Carbon dioxide and argon, with specific gravities greater than air, may lie in a tank or manhole for hours or days after opening. Since these gases are colorless and odorless, they pose an immediate hazard to health unless appropriate oxygen measurements and ventilation are adequately carried out.

Oxygen deprivation is one form of asphyxiation. While it is desirable to maintain the atmospheric oxygen level at 21% by volume, the body can tolerate deviation from this ideal. When the oxygen level falls to 17%, the first sign of hypoxia is deterioration to night vision which is not noticeable until a normal oxygen concentration is restored. Physiologic effects are increased breathing volume and accelerated heartbeat. Between 14-16% physiologic effects are increased breathing volume, accelerated heartbeat, very poor muscular coordination, rapid fatigue, and intermittent respiration. Between 6-10% the effects are nausea, vomiting, inability to perform, and unconsciousness. Less than 6%, spasmodic breathing, convulsive movements, and death in minutes.

Mechanical Hazards

If activation of electrical or mechanical equipment would cause injury, each piece of equipment should be manually isolated to prevent inadvertent activation before workers enter or while they work in a confined space. The interplay of hazards associated with a confined space, such as the potential of flammable vapors or gases being present, and the build-up of static charge due to mechanical cleaning, such as abrasive blasting, all influence the precautions which must be taken.

To prevent vapor leaks, flashbacks, and other hazards, workers should completely isolate the space. To completely isolate a confined space, the closing of valves is not sufficient. All pipes must be physically disconnected or isolation blanks bolted in place. Other special precautions must be taken in cases where flammable liquids or vapors may re-contaminate the confined space. The pipes blanked or disconnected should be inspected and tested for leakage to check the effectiveness of the procedure. Other areas of concern are steam valves, pressure lines, and chemical transfer pipes. A less apparent hazard is the space referred to as a void, such as double walled vessels, which must be given special consideration in blanking off and inerting.

Thermal Effects

Four factors influence the interchange of heat between people and their environment. They are: (1) air temperature, (2) air velocity, (3) moisture contained in the air, and (4) radiant heat. Because of the nature and design of most confined spaces, moisture content and radiant heat



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are difficult to control. As the body temperature rises progressively, workers will continue to function until the body temperature reaches approximately 102°F. When this body temperature is exceeded, the workers are less efficient, and are prone to heat exhaustion, heat cramps, or heat stroke. In a cold environment, certain physiologic mechanisms come into play, which tend to limit heat loss and increase heat production. The most severe strain in cold conditions is chilling of the extremities so that activity is restricted. Special precautions must be taken in cold environments to prevent frostbite, trench foot, and general hypothermia.

Protective insulated clothing for both hot and cold environments will add additional bulk to the worker and must be considered in allowing for movement in the confined space and exit time. Therefore, air temperature of the environment becomes an important consideration when evaluating working conditions in confined spaces.

Noise

Noise problems are usually intensified in confined spaces because the interior tends to cause sound to reverberate and thus expose the worker to higher sound levels than those found in an open environment. This intensified noise increases the risk of hearing damage to workers which could result in temporary or permanent loss of hearing. Noise in a confined space which may not be intense enough to cause hearing damage may still disrupt verbal communication with the emergency standby person on the exterior of the confined space. If the workers inside are not able to hear commands or danger signals due to excessive noise, the probability of severe accidents can increase.

Vibration

Whole body vibration may affect multiple body parts and organs depending upon the vibration characteristics. Segmental vibration, unlike whole body vibration, appears to be more localized in creating injury to the fingers and hands of workers using tools, such as pneumatic hammers, rotary grinders or other hand tools which cause vibration.

Other Hazards

Some physical hazards cannot be eliminated because of the nature of the confined space or the work to be performed. These hazards include such items as scaffolding, surface residues, and structural hazards. The use of scaffolding in confined spaces has contributed too many accidents caused by workers or materials falling, improper use of guard rails, and lack of maintenance to insure worker safety. The choice of material used for scaffolding depends upon the type of work to be performed, the calculated weight to be supported, the surface on which the scaffolding is placed, and the substance previously stored in the confined space.

Surface residues in confined spaces can increase the already hazardous conditions of electrical shock, reaction of incompatible materials, liberation of toxic substances, and bodily injury due to slips and falls. Without protective clothing, additional hazards to health may arise due to surface residues.



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Structural hazards within a confined space such as baffles in horizontal tanks, trays in vertical towers, bends in tunnels, overhead structural members, or scaffolding installed for maintenance constitute physical hazards, which are exacerbated by the physical surroundings. In dealing with structural hazards, workers must review and enforce safety precautions to assure safety.

ATTACHMENT 1 CONFINED SPACE ENTRY PERMIT

Confined Space Entry Permit

Date and Time Issued: _____/_____/_____ Date and Time Expires: _____/_____/_____

Job site/Space I.D.: _____

Equipment to be worked on: _____

Work to be performed: _____

Entry Supervisor: 1) _____

Entrant(s): 1) _____

2) _____

3) _____

Attendant: 1) _____

1. Atmospheric Testing

Time _____:____AM/PM

Oxygen _____%

Explosive _____% L.F.L.

Toxic _____PPM



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2. Tested by (Signature of Tester): _____

3. Are there any energy sources present that could create a hazard to the entrants?
If YES, list each below:

4. Ventilation Modification: N/A Yes No
Mechanical () () ()
Natural Ventilation only () () ()

5. Atmospheric check after Isolation and Ventilation (if applicable):

Oxygen _____% >19.5% and <23.5%

Explosive _____% L.F.L. <10%

Toxic _____PPM <10 PPM H₂S

Time ____:____AM/PM Testers signature: _____

6. Communication procedures: Radios/Phones (circle one)

7. Rescue procedures: **Contact Local Fire Department – Dial 911**

8. Entrant(s), Attendant, and Entry Supervisor have all successfully completed required training? Yes()
No() Is training current? Yes() No()

9. Equipment

Direct reading gas monitor (Name of unit):

10. Periodic atmospheric tests:

Oxygen _____% Time _____ Oxygen _____% Time _____

Explosive _____% Time _____ Explosive _____% Time _____

Toxic _____% Time _____ Toxic _____% Time _____

Are there any safety concerns or potential hazards that could impact the entrants which have not been isolated and verified as having been properly addressed? Yes() No()

Permit Prepared By: _____

Approved By (Entry Supervisor): _____

Reviewed By (Operations Personnel):

(printed name)

(signature)



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This permit shall be posted at or near the entrance to the permit required confined space.

When the confined space project is completed, this permit shall be returned to the safety department immediately.

The safety department shall keep this cancelled permit on file for a minimum of twelve (12) months from the date of the project completion.