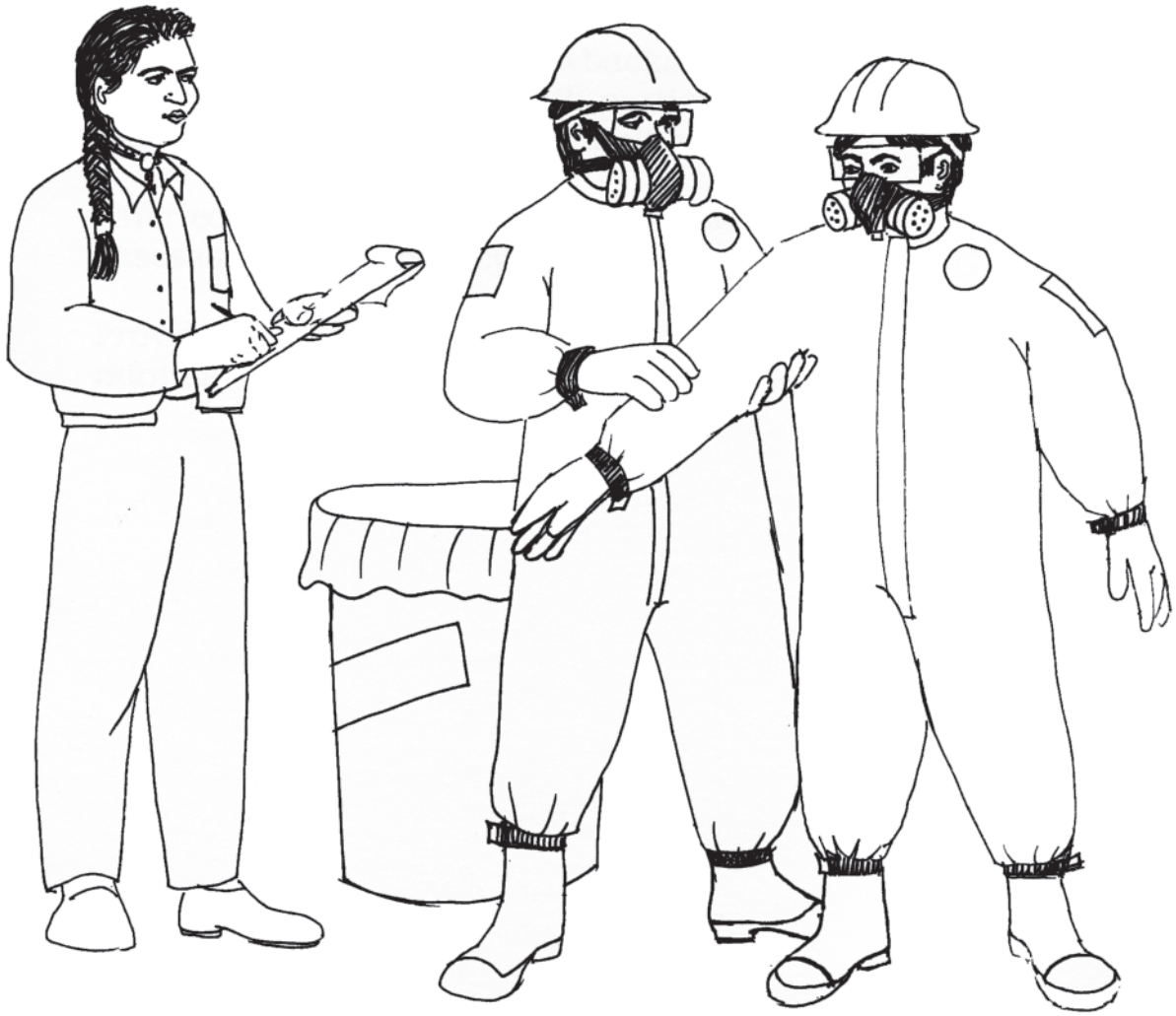
7

Working Safely in Confined Spaces



Outline

1. Identifying Confined Spaces

    - Limited openings for entry and exit
    - Unfavorable natural ventilation
    - Not designed for continuous worker occupancy

2. The Hazards of Entering and Working in Confined Spaces

    - Oxygen deficient atmospheres
    - Flammable atmospheres
    - Toxic atmospheres
    - General physical hazards
    - Standby and rescue

3. Methods for Safe Confined Space Entry

    - Written entry permit
    - Air monitoring
    - Ventilation
    - Isolation (Lookout/Tagout)
    - Respiratory protection
    - Rescue plan

4. The Importance of Permits in Confined Space Work

    - What information should be on a work permit?
    - Review of a sample permit

5. The Cal/OSHA Standard

    - How does the standard protect confined space workers?

Objectives

Participants will be able to:

1. Define the elements of confined spaces.

2. Describe ways confined spaces present hazardous occupational conditions.

3. Describe preliminary steps for safe entry.

4. Identify the protection OSHA offers to confined space workers.

5. List components of a good confined spaces training program.

Confined Spaces

As many as 1.6 million U.S. workers are required to enter confined spaces, such as tanks or trenches, each year to do construction, maintenance, or repair work. More than 50 of these workers die and 5,000 of them are injured each year. *60% of these deaths are rescuers*. These deaths and injuries can be prevented simply by recognizing the hazards and implementing proper controls before entry.

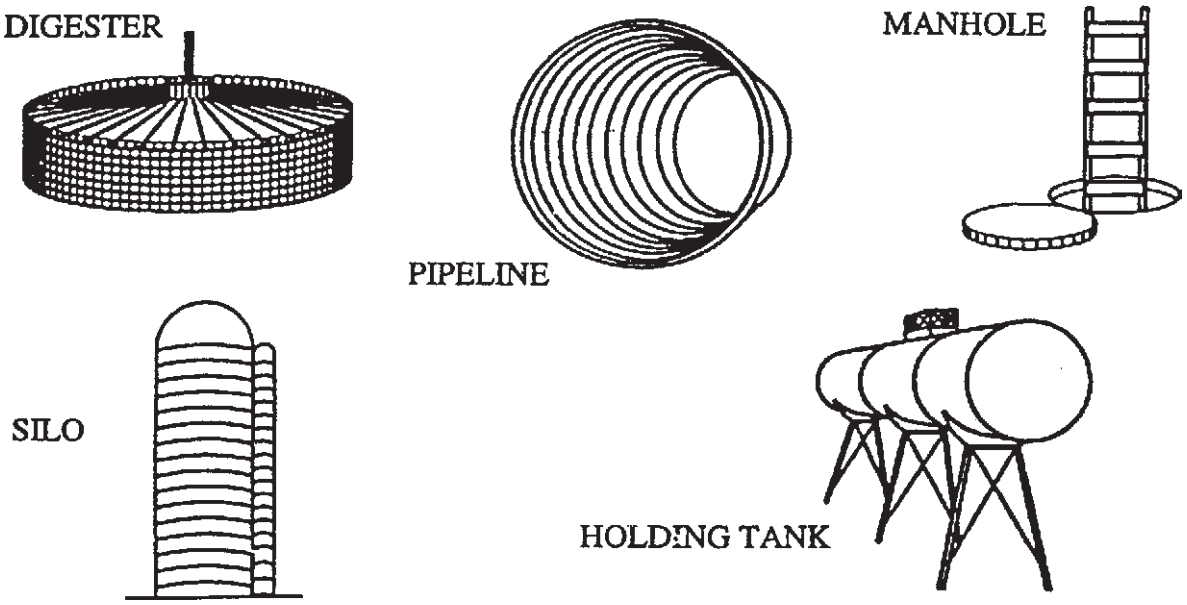
OSHA has promulgated a standard for confined spaces. It requires the development of entry permit systems whenever workers will be entering a confined space. The standard does not apply to construction workers unless they are conducting activities that might occur in general industry, such as cutting inside a tank. The requirements of the standard suggest safety-oriented practice for all confined space entry. This chapter describes the hazards of confined spaces and the means for controlling those hazards as they are laid out by OSHA.

What Is a Confined Space?

A confined space is defined by OSHA as a space that:

- Is large enough for a worker to enter and perform work;
- Has limited or restricted entrances or exits; and
- Is not designed for continuous employee occupancy.

Some examples:



from: *Basic Health and Safety Course for Hazardous Waste Site Personnel*, New England Consortium.

Definition of a Confined Space

The National Institute for Occupational Safety and Health (NIOSH) defines a confined space as an area having one or more of the following characteristics:

1. Poor natural ventilation:

Air in a confined space does not move in and out freely. Therefore, the atmosphere inside a confined space can be very different from the atmosphere outside.

Dangerous gases may be trapped inside a confined space, especially if the space is used to store or process chemical or organic materials, which may decompose.

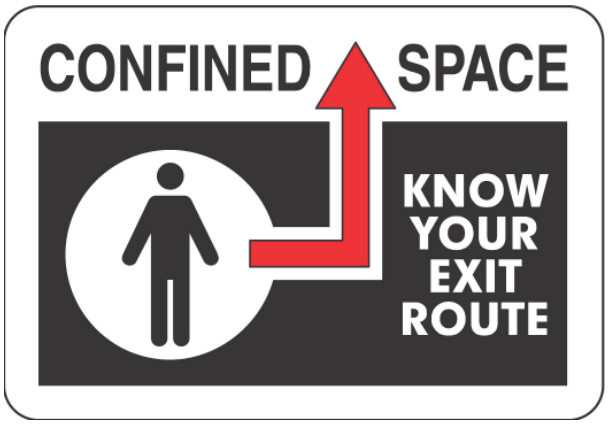
There may not be enough **oxygen** inside a confined space to support life. Or, the air could have so much oxygen that it is likely to increase the chance of fire or explosion if a source of ignition is present (a cigarette, for example).

2. Limited opening for entry and exit:

Confined space openings are usually small in size. For example, they may be as small as 18 inches in diameter. They are difficult to move through easily. Small openings make it difficult to get work equipment in or out of the spaces.

It is also difficult to get protective equipment, such as respirators, and life-saving equipment into these spaces.

In some cases, confined space openings may be very large, for example open-topped containers such as tanks or degreasers. You may have to use ladders, hoists, or other equipment to enter or exit these spaces. Escape from such areas may be very difficult in an emergency.



3. Not designed for continuous worker occupancy:

Most confined spaces are not designed for workers to enter and work in on a routine basis. They are designed to store a product, enclose materials and processes, or transport products.

Therefore, occasional worker entry for inspection, maintenance, repair, cleanup, or similar tasks is often difficult and dangerous due to chemical or physical hazards within the space.

Cal/OSHA however, defines a confined space as an area with poor ventilation and limited openings for entry and exit.

A confined space in the workplace may have a combination of these three characteristics, which can complicate working in and around these spaces as well as rescue operations during emergencies.

Exemptions to the Rules for Confined Space Entry

A confined space may only be considered a permit-required confine space because of an actual or potential hazardous atmosphere. If continuous ventilation of such a space is sufficient to control the hazard, then the employer is not subject to all of the requirements in the standard. Instead, the employer can choose to follow these alternative requirements for entry.

- Eliminate any condition that makes it unsafe to remove an entrance cover before the cover is removed.
- Guard entrances with a barrier to prevent accidental falls into the space.
- Test the atmosphere for oxygen content, flammable gases and vapors, and potential toxic contaminants.
- Prohibit employee entrance into space with a hazardous atmosphere before and throughout an entry.
- Test the space periodically to ensure that a hazardous atmosphere has not developed.
- If a hazardous atmosphere develops, employees must leave the space.
- Measures must be taken to protect employees before re-entry.
- There must be written certification that the space is safe for entry.

from: *Basic Health and Safety Course for Hazardous Waste Site Personnel*, New England Consortium.

The Hazards in Confined Spaces

Oxygen-Deficient Atmospheres

An oxygen-deficient atmosphere has less than 19.5% available oxygen (O_2). You should **not** enter any atmosphere having less than 19.5% oxygen without wearing an approved self-contained breathing apparatus (SCBA).

The oxygen level in a confined space can decrease because of work being done, such as welding, cutting, or brazing; or it can be decreased by certain chemical reactions (for example, rusting) or through fermentation. The oxygen level also decreases if another gas, such as carbon dioxide or nitrogen, displaces it. Total displacement of oxygen by another gas will result in unconsciousness, followed by death.

The Health Effects of Different Levels of Oxygen

Level of Oxygen	Result
21%	Plenty of oxygen
19.5%	Enough oxygen to enter a confined space
16%	Tire rapidly; cannot think clearly
14%	Not enough oxygen; difficult to breathe
6%	Cannot breathe; death

Flammable Atmospheres

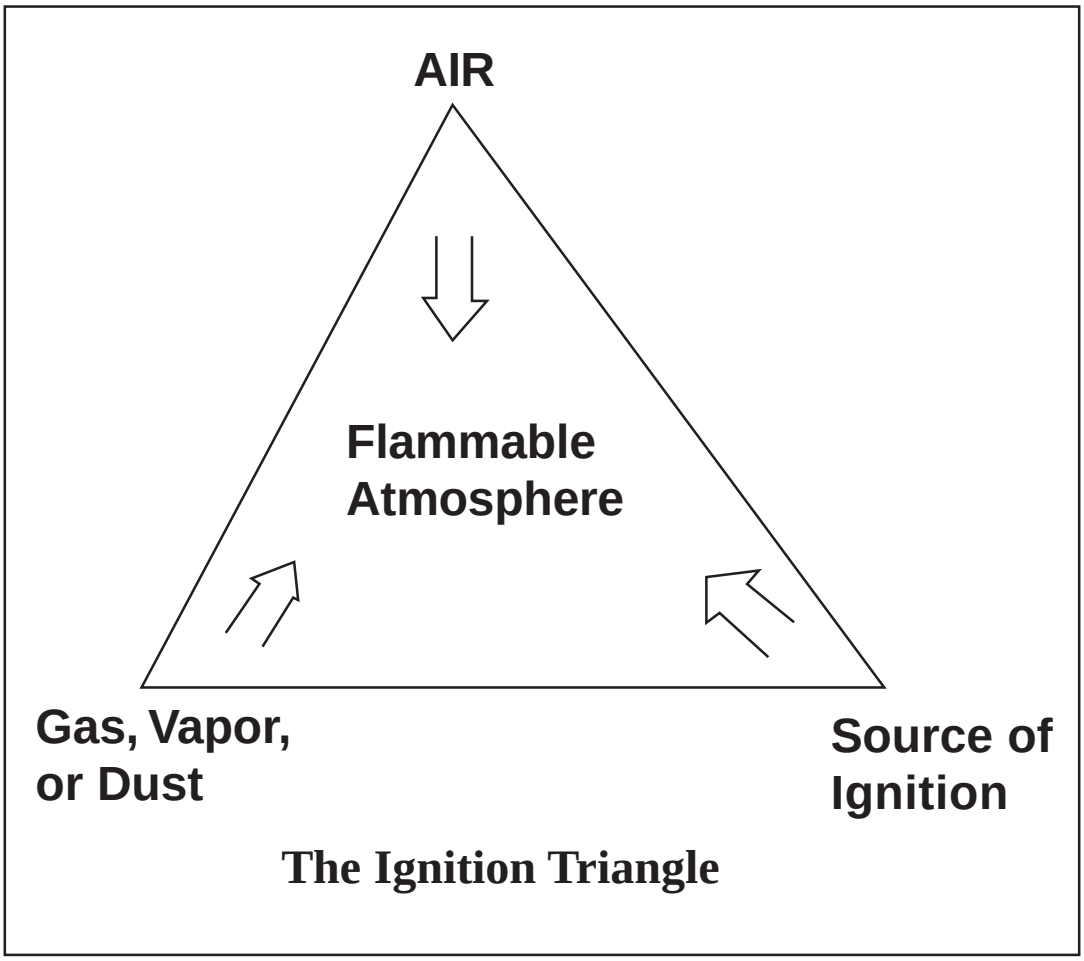
Two things make an atmosphere flammable:

- the amount of oxygen in the air; and
- a specific mixture of flammable gas, vapor, or dust.

If a source of ignition (for example, a sparking or electrical tool) is used in a space containing a flammable atmosphere, an explosion will result.

If the air in a confined space is rich in oxygen (above 21 %), flammable materials, such as clothing and hair, will burn quickly when ignited. Therefore, **never use pure oxygen to ventilate a confined space**. Ventilate with normal air.

If the LEL of the CHEM is 10% or greater, workers shall evaluate the tank until these conditions can be lowered.



The Ignition Triangle

Toxic Atmospheres

Most liquids, vapors, gases, mists, solids, and dusts that you work with should be considered hazardous in a confined space. Toxic materials can come from:

- Products stored in a confined space

  Products stored in a confined space can be absorbed into the walls and give off toxic gases. When cleaning the walls, toxic gases can give off gas. For example, in the removal of sludge from a tank, decomposed material can give off deadly hydrogen gas.

- **Work in and around confined spaces**

Toxic atmospheres are created in many processes. Examples include welding, cutting, brazing, painting, scraping, sanding and degreasing. Many of the industrial cleaning solvents are very toxic in a confined space.

Toxic materials produced by work near a confined space can also enter and build up in a confined space.

General Physical Hazards

In addition to hazardous atmospheres, confined spaces may also contain potential hazards such as electrical shock, radiation machinery and other hazards as:

Extreme Temperatures:
Extremely hot or cold temperatures can be a problem for workers in a confined space. For example, if the space has been steam cleaned, it should be allowed to cool before any entry is made.

Noise:
Noise within a confined space can be amplified because of the design and acoustic properties of the space. This can damage hearing and interfere with communication, causing a shouted warning to go unheard.

Slick/wet Surfaces:
Slips and falls can occur on a wet surface causing injury or death to workers. Also, a wet surface will increase the chance of injury from electric shock in areas where electrical circuits, equipment, and tools are used.

Falling Objects:
Workers in confined spaces should be careful of the possibility of falling objects, especially in spaces, which have topside openings for entry, and where work is being done above the worker.

Engulfment Hazards:
Loose, granular material (such as grain, sand, coal, or similar material), stored in bins and hoppers, or liquid (such as chemicals water, or beer) can engulf and suffocate a worker. By crusting or bridging over in a bin appearing to be a firm surface, break loose under the weight of a worker (see figure below).

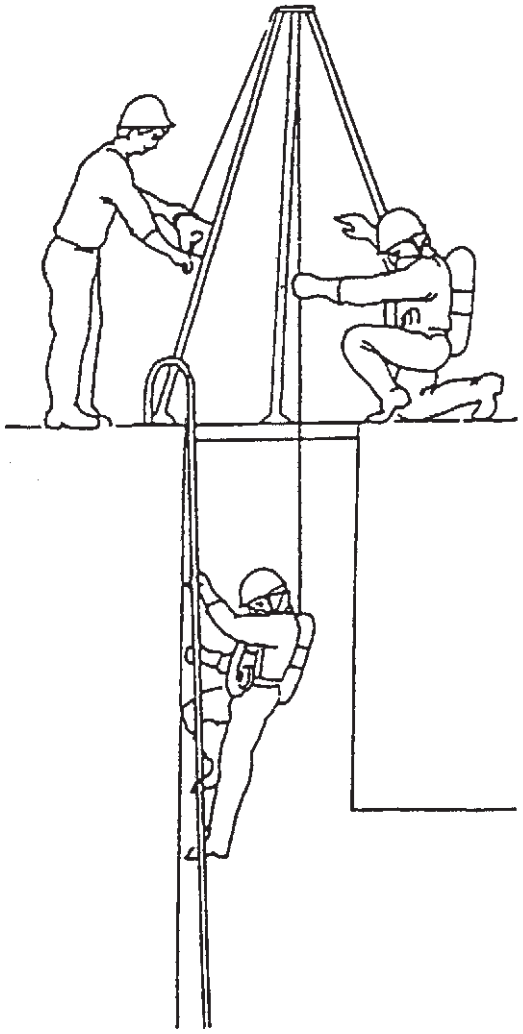
Standby and Rescue

A standby person should be assigned to remain on the outside of the confined space and be in constant contact (visual or speech) with the workers inside. The standby person should not have any other duties but to serve as standby and know who should be notified in case of emergency. Standby personnel should not enter a confined space until help arrives, and then only with proper protective equipment, life lines, and respirators.

Over 50% of the workers who die in confined spaces are attempting to rescue other workers. Rescuers must be trained in and follow established emergency procedures and use appropriate equipment and techniques (lifelines, respiratory protection, standby persons, etc.). Steps for safe rescue should be included in all confined space entry procedures.

Rescue should be well planned and drills should be frequently conducted on emergency procedures.

Unplanned rescue, such as when someone instinctively rushes in to help a downed co-worker, can easily result in a double fatality, or even multiple fatalities if there are more than one would-be rescuers.



Entry with Hoist and Standby Personnel

REMEMBER, AN UNPLANNED RESCUE WILL PROBABLY BE YOUR LAST!

CONFINED SPACE EXPLOSION

An employee in Arizona entered a solvent storage tank to remove toluene residues. The tank was 20 feet tall and 10 feet in diameter. The employer had rented a self-contained breathing apparatus for this entry and showed the employee how to use it. However, the tank atmosphere had not been tested, nor had any provisions for rescue been made. The employee could not fit through the tank's opening while wearing the SCBA. The employer decided that the SCBA would be loosely strapped to th worker so it could be lowered over his head.

However, the worker, who did not speak English well, misunderstood and entered without the SCBA. When the supervisor realized what happened he tried unsuccessfully to het the worker to climb out. He lowered the SCBA, but the worker was already unconscious. A call for help was sent to the city fire department. Because of the small opening, firefighters who responded to the rescue call could not enter the tank while wearing SCBA's. They decided that only by cutting open the side of the tank could they possibly rescue the victim. To reduce the possibility of sparking, water was sprayed into the tank. This failed. The toluene vapor in the tank ignited. The tank exploded, killing one firefighter and injuring 16 others.

It was later determined that the entrant was already dead before the explosion occurred due to toxic effects of toluene and lack of oxygen.

* Source: *Worker Deaths in Confined Spaces*, NIOSH, 1994

Methods for a Safe Confined Space Entry

Employers should make available to employees a list of all confined spaces. Workers should be trained to identify confined spaces and the hazards that may be found in them. This training should stress that death is the likely outcome if the following precautions are not taken **before entry** is made:

Written Entry Permit (Safe Work Permit)

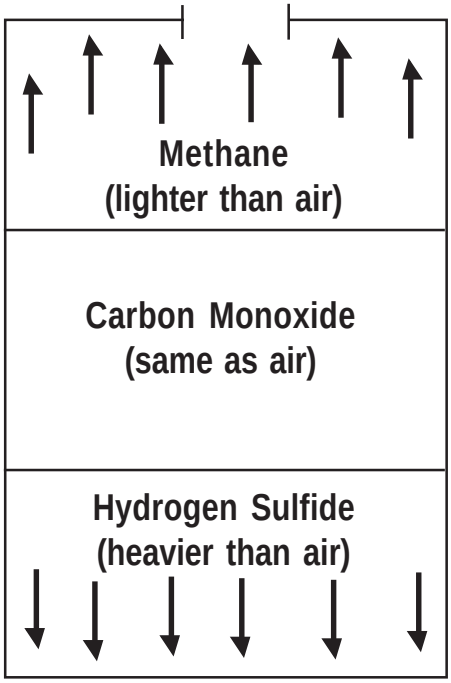
A set of established written work procedures that explains how jobs in each confined space shall be done, posted at the jobsite entry.

Air Monitoring

Remember that some gases or vapors are "heavier" than air and will settle to the bottom of a confined space.

Also, some gases are "lighter" than air and will be found around the top of the confined space.

Therefore, it is very important that a qualified person monitor all areas (top, middle, bottom) of a confined space for toxic gases and vapors before anyone enters it. Monitoring for oxygen level, flammability, and known or suspected toxic materials should all be conducted.



If testing reveals oxygen deficiency, toxic gases and vapors, or flammable gases and vapors, the space must be ventilated and re-tested before workers enter. If ventilation is not possible and entry is necessary (for emergency rescue, for example), workers must have appropriate respiratory protections.

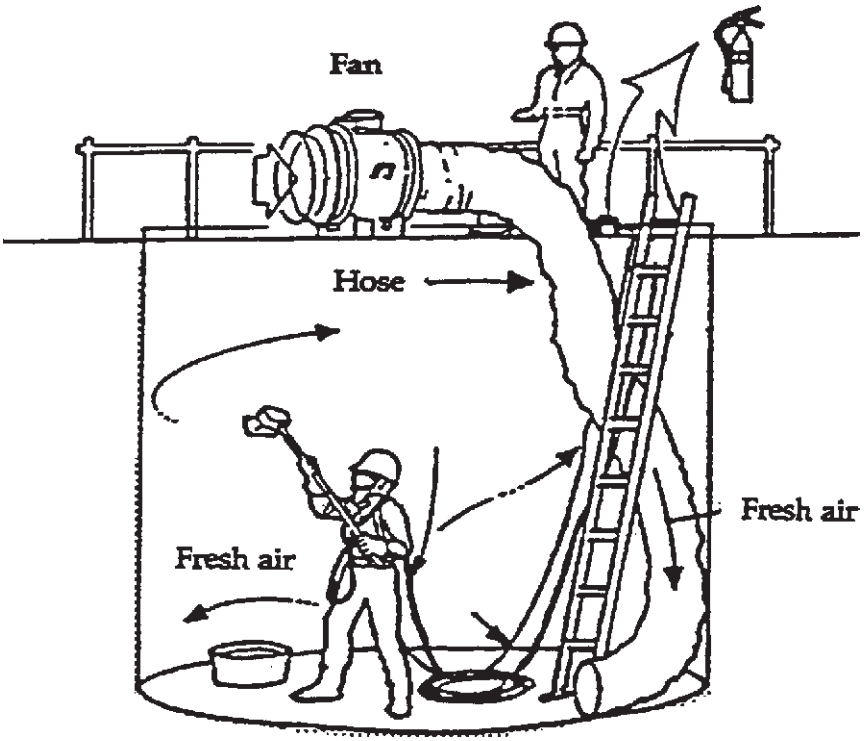
Never trust your senses to determine if the air in a confined space is safe! You can **not** see or smell many toxic or flammable gases and vapors, nor can you determine the level of oxygen present. A confined space should be monitored continuously to determine whether the atmosphere has changed due to the work being done.

Ventilation

Ventilation by a blower or fan may be necessary to remove harmful gases and vapors from a confined space. The method and equipment to use depend on:

- the size of the confined space openings,
- the gases to be ventilated out (for example, are they flammable?),
- the source of the fresh air (the air that is blown into the confined space).

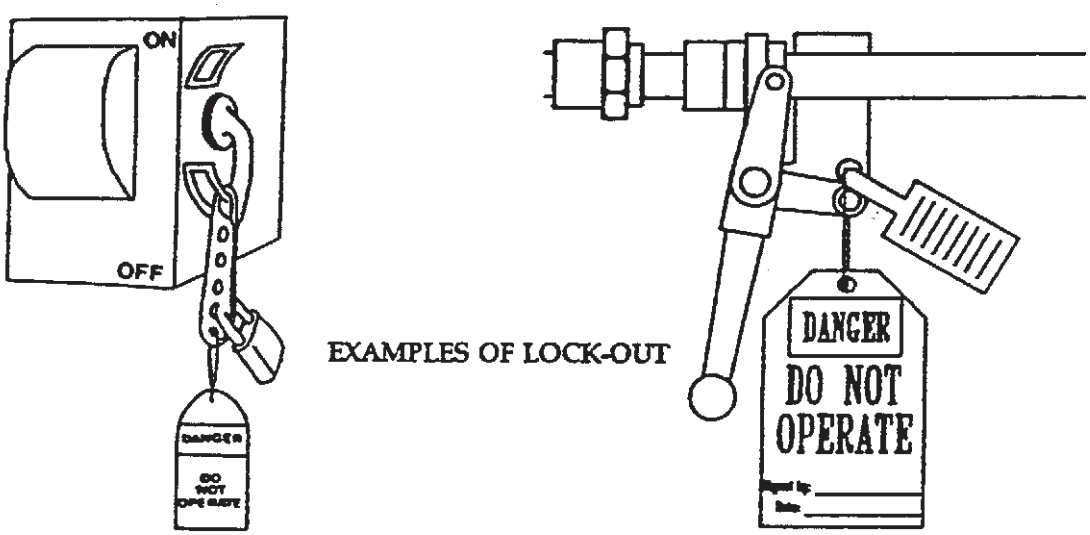
A common method of ventilation requires a large hose with one end attached to a fan and the other lowered into a manhole or opening. For example, in a manhole the ventilating hose would run to the bottom to blow out all harmful gases and vapors (see figure below). The fan should be placed in an area that will draw in fresh air only. Ventilation should be continuous where possible, because in many confined spaces the hazardous atmosphere will form again when the flow of air is stopped.



Isolation

Isolation is the process of putting an area out of service. Whenever the safety of a confined space entry cannot be ensured, the space should be isolated. There are several methods to remove a confined space from service:

- **Lock-out** of electrical sources, preferably with the use of disconnect switches far from the equipment;
- **Blanking and bleeding** of 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.



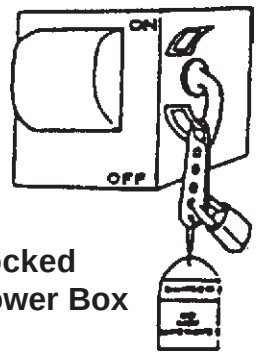
EXAMPLES OF LOCK-OUT

How To Establish An Effective Lockout Program

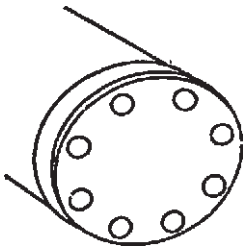
The only “fail-safe” plan is to achieve a zero energy state. This means neutralizing all energy sources before maintenance, set-up, or service work is attempted. A complete lockout procedure must include the following:

1. A clear commitment from higher management.
2. A comprehensive survey of energy sources.
3. A written plan that addresses all energy sources and strives for zero energy states.
4. Training of all personnel, not only those actually using lock out, since anyone could come by and activate the machinery while it is being worked on.
5. Provision of a sturdy lock and a unique key to all personnel who will need them.
6. Regular review and adjustment of the program.

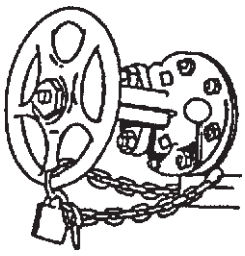
Methods of Lockout



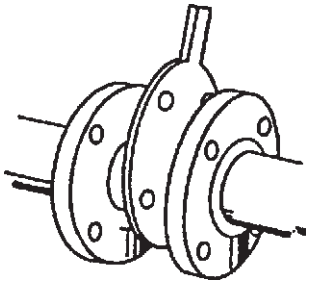
Locked Power Box



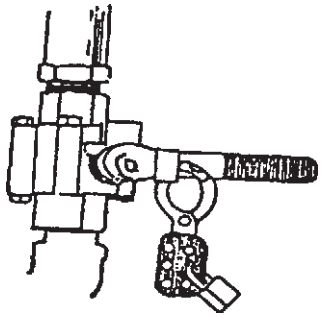
End Pipe Block



Chained and Locked Valve



Blocking Device for Flanged Pipe



Flow Valve Lockout

from: *Basic Health and Safety Course for Hazardous Waste Site Personnel*, New England Consortium.

A Sample Lockout Procedure

A good lockout procedure, at a minimum, should contain the following parts:

1. All maintenance personnel will be provided with a good lock. The lock will have the individual worker's name and other identification on it. Each worker will have the only key to the lock.

2. BEFORE turning off the power, the worker should check to be sure that no one is operating the machinery. The machine operator will be informed before the power is turned off. Sudden loss of power could cause an accident.

3. Steam, air, and hydraulic lines will be bled, drained, and cleaned out. There should be no pressure in the lines or in reservoir tanks. In some cases, such as pipelines, complete draining is not possible and the pipes are "blanked" instead. This involves inserting a circular disk into the line to block flow, and then draining the blocked off portion.

4. Any mechanism under tension or pressure, such as springs, will be released and blocked.

5. Each person working on the machinery will put a lock on the machine's lockout device(s). Each lock will remain on the machine until the work is completed.

6. All energy sources which could activate the machine will be locked out.

7. The main valve or main electrical disconnect will be tested to be sure that the power to the machine is off.

8. Electrical circuits will be checked with proper and calibrated electrical testing equipment. An electrical failure could energize the equipment even if the switch is in the off position. Stored energy in electrical capacitors should be safely discharged.

9. When working on machinery such as power presses and welding presses that have a ram which could fall, the ram will be supported with safety blocks or pins. Fully interlocked safety blocks are the safest.

from: *Basic Health and Safety Course for Hazardous Waste Site Personnel*, New England Consortium.

What About Tags?

Tags are sometimes used in place of locks to prevent accidental start up of machinery. This is a risky approach and should not be relied upon except for very brief periods, or when a locking mechanism is absolutely impossible. OSHA says a “Do Not Start” tag on power equipment shall be used for a few moments or a very short time until the switch in the system can be locked out.

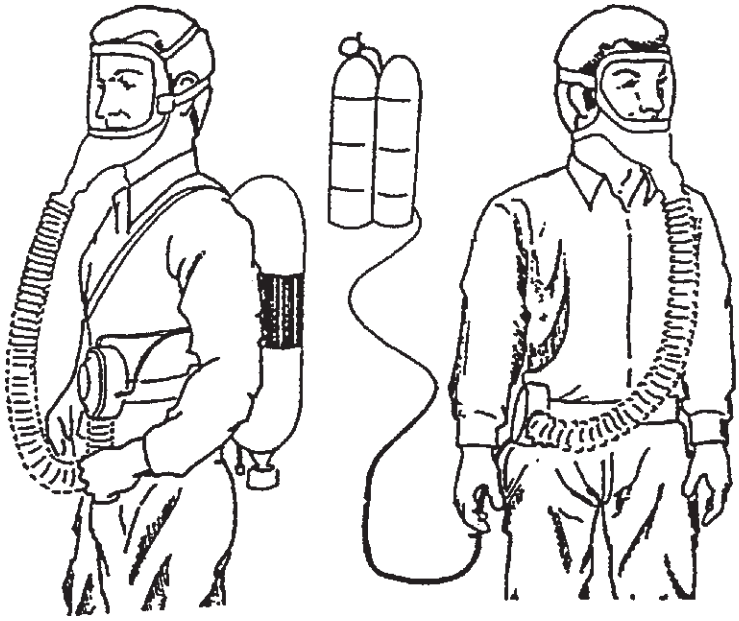
For the rare instances where tags are used, they must be highly visible and placed in a conspicuous location that effectively stops people from operating the starting mechanism. All personnel must be trained in the meanings of any tags used and the serious hazards resulting from not heeding the warnings.

Respiratory Protection

Respirators allow you to breathe safely without inhaling toxic gases or particles. (For a review of air-purifying and air-supplying respirators see modules 7c-7e). Use only air-supplying respirators in confined spaces where there is not enough oxygen.

AIR-SUPPLIED RESPIRATORS

Self-Contained Breathing Apparatus SCBA



Supplied Air Respirator with Auxiliary Escape SCBA

AIR PURIFYING RESPIRATORS

(Do **not** use these in oxygen-deficient atmospheres)

Half-mask

Full-face

COMMUNICATION

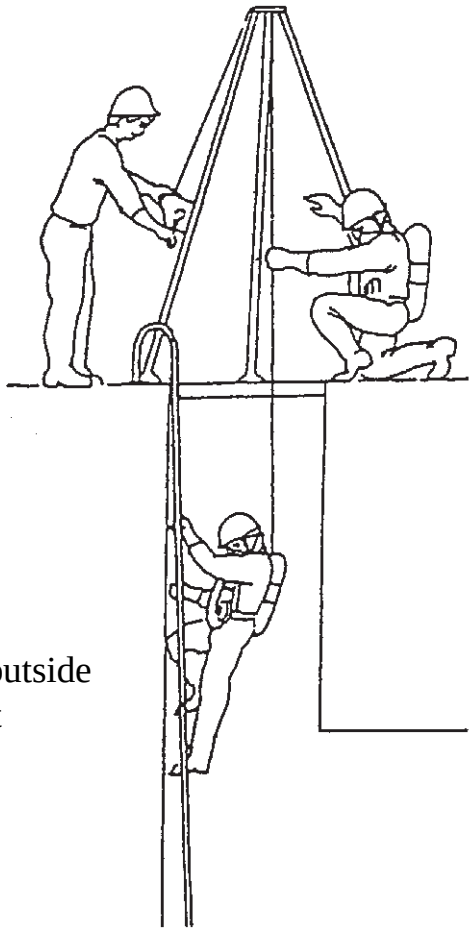
Due to work conditions, workers may not be able to communicate. Alternative communications should be available for emergencies such as horns, ropes, or intrinsically safe electronic communication.

Rescue Plan

Over 60% of workers who die in confined spaces are trying to rescue other workers.

Therefore, an appropriate standby and rescue plan is especially important for anyone working in a confined space.

Rescuers must be trained in and follow established emergency procedures. They must also use proper equipment such as respiratory protection.



Steps for a safe rescue should be:

- included in all confined space entry procedures.
- established **before entry**.
- specific for each type of confined space.
- well planned and practiced often enough to ensure an efficient and calm response to any emergency. Unplanned rescue such as when someone rushes in without thinking, can easily result in another death.

A standby person is someone assigned to remain on the outside of the confined space. The standby should be in constant contact (through sight or speech) with the workers inside.

The standby person should:

- not have any other duties but to serve as standby.
- be equipped with rescue equipment including a safety line attached to the worker in the confined space, SCBA, protective clothing, boots, etc.
- know who to notify in case of emergency.
- the standby person may enter a confined space in case of emergency but must alert at least one additional employee outside of the confined space of the emergency and of his/her intent to enter the confined space.

Remember: An unplanned rescue will probably be your last!

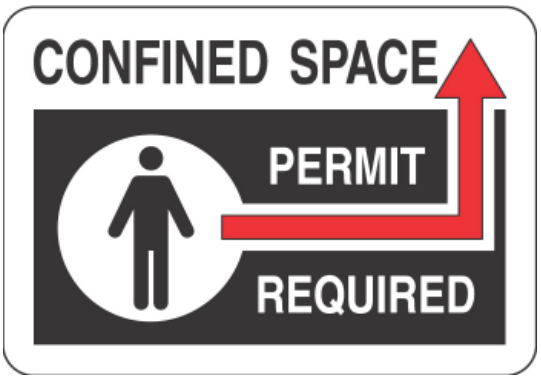
Entry Permit System

Entry permits provide documentation that the appropriate procedures for safe entry have been followed. Whenever a worker is required to enter a confined space, an entry supervisor must sign an entry permit to authorize entry. The permit must be made available to all entry personnel. It is valid only for the amount of time it takes to complete the task specified on the permit, but for no longer than one shift. It must be cancelled on completion of the job. Permits must be kept on record for at least one year.

What Is on an Entry Permit?

Entry permits must include the following information.

- The identification of the space to be entered
- Hazard control measures
- The purpose of entry
- Conditions acceptable for entry
- The date and duration of the permit
- Results of initial and periodic monitoring
- The names of authorized entrants
- Rescue and emergency numbers
- The names of attendants
- Communication between entrants and attendants
- The name of the entry supervisor
- Equipment to be used for safe entry
- The hazards of the space
- Any other information specific to the space being entered



Examples of confined spaces permits are in Appendix A at the back of the Cal/ OSHSA standard.

The Cal/OSHA Confined Spaces Standard

Both private and public sector workers in California are covered by a set of Confined Spaces standards: GISO 5156, 5157 and 5158.

Cal-OSHA requires employers to:

- evaluate the workplace to identify any confined spaces requiring a permit
- conduct air monitoring
- provide respirators and safety equipment (harnesses, belts)
- follow specified operating procedures
- provide employee training
- develop written procedures for confined spaces entry—with clearly designated duties for entrants, attendants and supervisors
- designate outside attendants & rescuers, with PPE
- develop and follow emergency and rescue procedures
- develop and use a written permit system

Make sure your employer is following the revised 1994 Cal-OSHA standards and the 1999 federal OSHA requirements to provide greater worker participation.

A copy of the Cal-OSHA Confined Spaces standards is in Appendix A; it contains sample entry permit forms. The three related standards were created in 1994 to replace and update an earlier standard, GISO 5156. In addition, federal OSHA revised its confined spaces standard in 1999 to require employers to share information and involve workers more in the development of the written confined space permit program. See next page for more details.

Changes in the Federal OSHA Permit-Required Confined Spaces Standard (29 CFR 1910.146)

Topic	Old Standard	New Standard
Clarification of the need to provide authorized representatives with information required by the standard	The written program, which contains the employer's procedures and policies for implementing that program, is to be available for inspection and copying by employees and their authorized representatives	Additional clarification of the Agency's intent for authorized representative(s) of the employees to have access to any information provided to employees under the standard
Observation of pre-entry entry atmospheric testing	No provisions	Employers whose employees enter permit spaces are required to allow employees or their authorized representative(s) an opportunity to observe both the testing of the space during pre-entry and the periodic testing
Evaluation of selection of rescue and emergency services	Specific requirements are required for in-house teams employed by the employer without containing equally explicit requirements for outside rescue teams	Clarification of an employer's obligations to select a rescue service that is trained, equipped, and available to respond during confined space entries. It includes factors that an employer must consider in selecting a rescue team and a non-mandatory Appendix F to provide employers with additional assistance in evaluation
Employee Participation	None	A new paragraph is added to ensure employee involvement in permit space program development and implementation