A Guide to Safety in Confined Spaces

by

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control
National Institute for Occupational Safety and Health

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What is NIOSH?

The National Institute for Occupational Safety and Health (NIOSH) was formed in 1971 to conduct research, develop educational and training resources, and develop criteria for recommended standards in the area of occupational safety and health. NIOSH is part of the Centers for Disease Control (CDC), and the Public Health Service under the Department of Health and Human Services in the executive branch of the U.S. Federal Government.

NIOSH employs about 850 administrators, scientists, engineers, technicians, and support staff at its headquarters in Atlanta, Georgia, and its laboratories and offices in Cincinnati, Ohio and Morgantown, West Virginia.

This guide was developed by the NIOSH Division of Safety Research in Morgantown, West Virginia.

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INTRODUCTION

If you are required to construct or work in a:

BOILER, CUPOLA, DEGREASER, FURNACE, PIPELINE, PIT, PUMPING STATION, REACTION OR PROCESS VESSEL, SEPTIC TANK, SEWAGE DIGESTER, SEWER, SILO, STORAGE TANK, SHIP'S HOLD, UTILITY VAULT, VAT, or similar type enclosure,

you are working in a confined space (See examples on page 3).

How Can You Identify a Confined Space?

A confined space is a space which has any one of the following characteristics:

- limited openings for entry and exit
- unfavorable natural ventilation
- not designed for continuous worker occupancy.

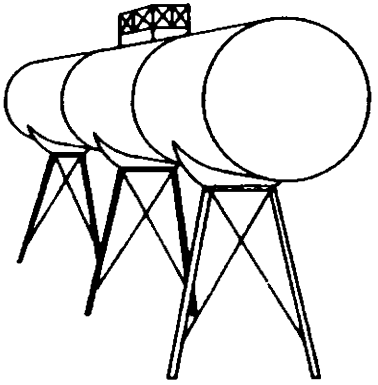
Limited openings for entry and exit:
Confined space openings are limited primarily by size or location. Openings are usually small in size, perhaps as small as 18 inches in diameter, and are difficult to move through easily. Small openings may make it very difficult to get needed equipment in or out of the spaces, especially protective equipment such as respirators needed for entry into spaces with hazardous atmospheres, or life-saving equipment when rescue is needed. However, in some cases openings may be very large, for example open-topped spaces such as pits, degreasers, excavations, and ships' holds. Access to open-topped spaces may require the use of ladders, hoists, or other devices, and escape from such areas may be very difficult in emergency situations.

Unfavorable natural ventilation:
Because air may not move in and out of confined spaces freely due to the design, the atmosphere inside a confined space can be very different from the atmosphere outside. Deadly gases may be trapped inside, particularly if the space is used to store or process chemicals or organic substances which may decompose. There may not be enough oxygen inside the confined space to support life, or the air could be so oxygen-rich that it is likely to increase the chance of fire or explosion if a source of ignition is present.

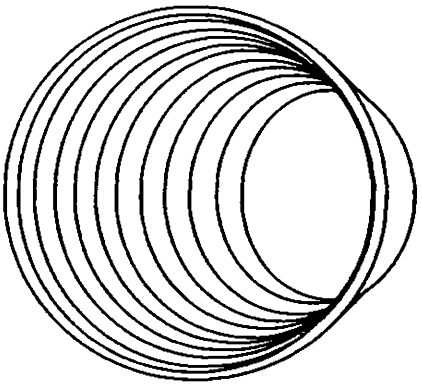
Not designed for continuous worker occupancy:
Most confined spaces are not designed for workers to enter and work in them on a routine basis. They are designed to store a product, enclose materials and processes, or transport products or substances. Therefore, occasional worker entry for inspection, maintenance, repair, cleanup, or similar tasks is often difficult and dangerous due to chemical or physical hazards within the space.

A confined space found 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. If a survey of your working area identifies one or more work spaces with the characteristics listed above,

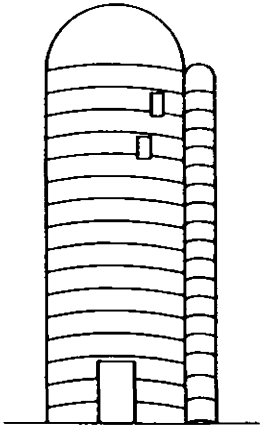
READ THE FOLLOWING INFORMATION - SOMEDAY IT MAY SAVE YOUR LIFE, OR THE LIFE OF A CO-WORKER.



Storage Tank

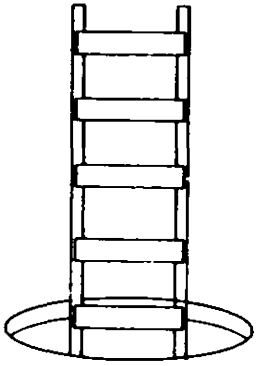


Pipeline

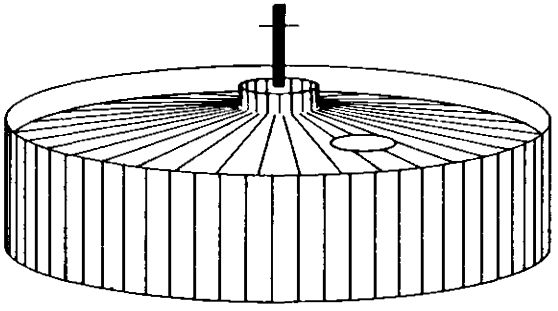


Silo

Examples of Confined Spaces



Manhole



Digester

What are the Hazards Involved in Entering and Working in Confined Spaces?

Hazardous Atmospheres

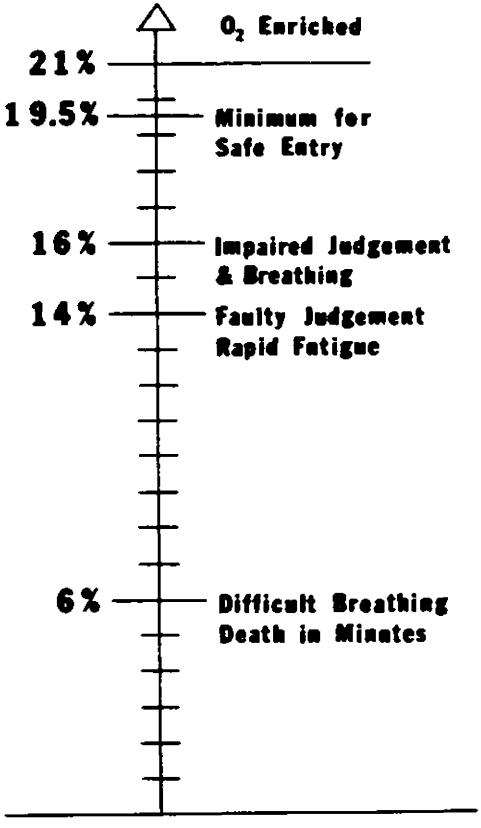
As mentioned, the atmosphere in a confined space may be extremely hazardous because of the lack of natural air movement. This characteristic of confined spaces can result in 1) oxygen-deficient atmospheres, 2) flammable atmospheres, and/or 3) toxic atmospheres.

1. OXYGEN-DEFICIENT ATMOSPHERES:

An oxygen-deficient atmosphere has less than 19.5% available oxygen (O_2). Any atmosphere with less than 19.5% oxygen should not be entered without 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 (rusting) or through bacterial action (fermentation).

The oxygen level is also decreased if oxygen is displaced by another gas, such as carbon dioxide or nitrogen. Total displacement of oxygen by another gas, such as carbon dioxide, will result in unconsciousness, followed by death.

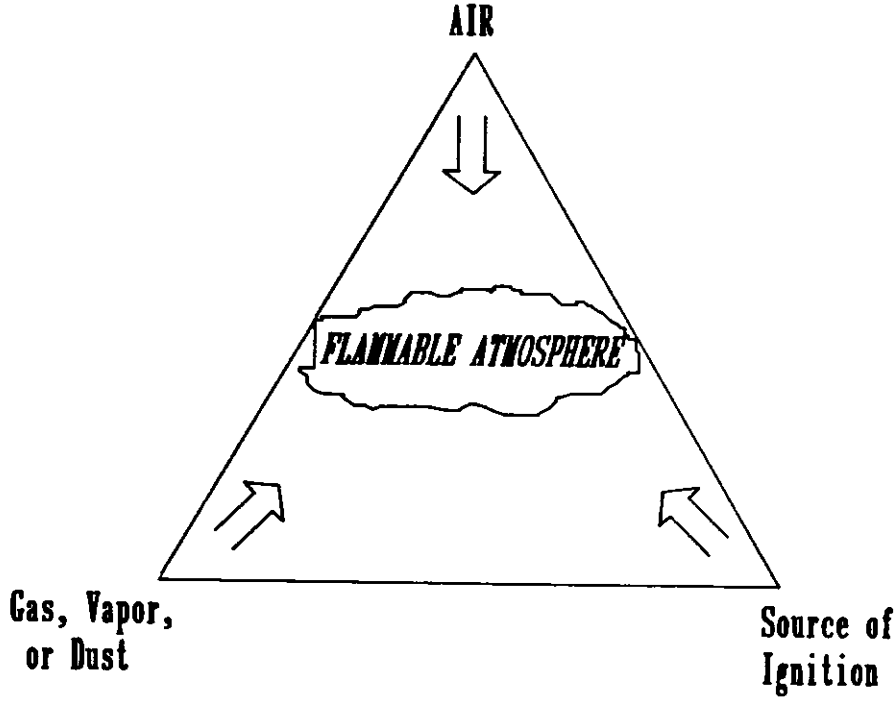


Oxygen Scale

2. FLAMMABLE ATMOSPHERES:

Two things make an atmosphere flammable: 1) the oxygen in air; and 2) a flammable gas, vapor, or dust in the proper mixture. Different gases have different flammable ranges. If a source of ignition (e.g., a sparking or electrical tool) is introduced into a space containing a flammable atmosphere, an explosion will result.

An oxygen-enriched atmosphere (above 21%) will cause flammable materials, such as clothing and hair, to burn violently when ignited. Therefore, never use pure oxygen to ventilate a confined space. Ventilate with normal air.



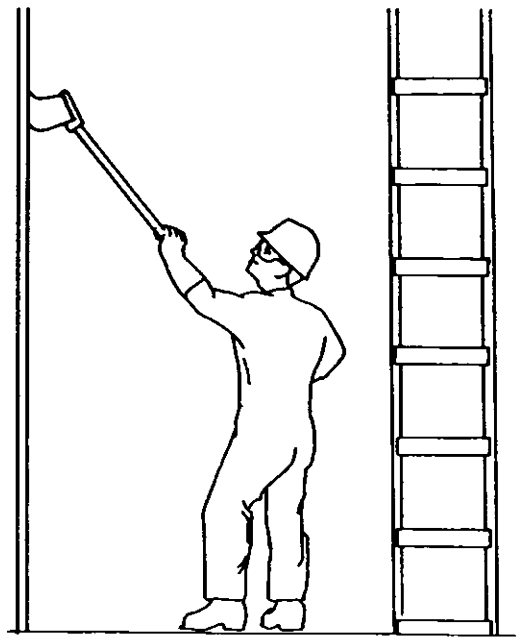
The Ignition Triangle

3. TOXIC ATMOSPHERES:

Most substances (liquids, vapors, gases, mists, solid materials, and dusts) should be considered hazardous in a confined space. Toxic substances can come from the following:

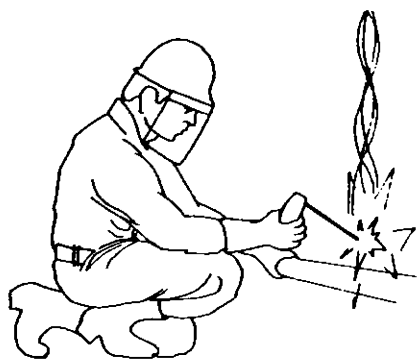
- ***The product stored in the space:***

  The product can be absorbed into the walls and give off toxic gases when removed or when cleaning out the residue of a stored product, toxic gases can be given off. Example: Removal of sludge from a tank - decomposed material can give off deadly hydrogen sulfide gas.



- ***The work being performed in a confined space:***

  Examples of such include welding, cutting, brazing, painting, scraping, sanding, degreasing, etc. Toxic atmospheres are generated in various processes. For example, cleaning solvents are used in many industries for cleaning/degreasing. The vapors from these solvents are very toxic in a confined space.



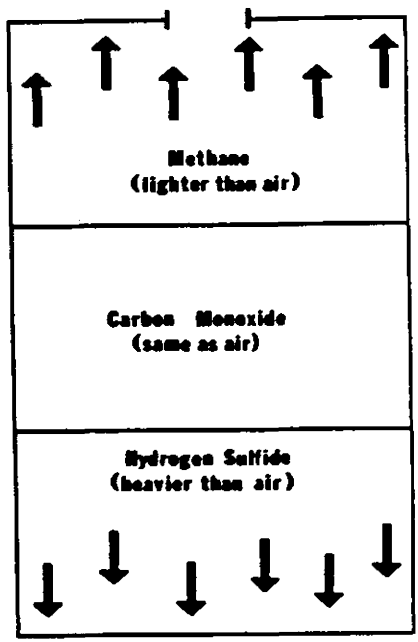
- ***Areas adjacent to the confined space:***

Toxicants produced by work in the <u>area</u> of confined spaces can enter and accumulate in confined spaces.

TESTING THE ATMOSPHERE

It is important to understand 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 necessary to test all areas (top, middle, bottom) of a confined space with properly calibrated testing instruments to determine what gases are present. If testing reveals oxygen-deficiency, or the presence of toxic gases or 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 protection.

NEVER TRUST YOUR SENSES TO DETERMINE IF THE AIR IN A CONFINED SPACE IS SAFE! YOU CAN NOT SEE OR SMELL MANY TOXIC GASES AND VAPORS, NOR CAN YOU DETERMINE THE LEVEL OF OXYGEN PRESENT.



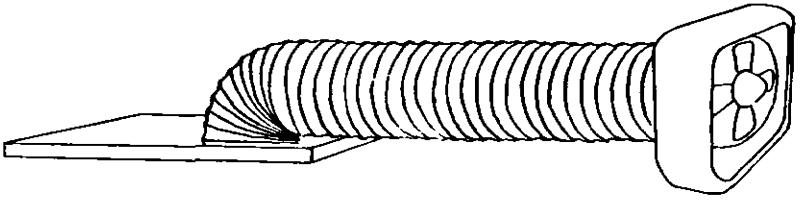
From the Outside, Top to Bottom

VENTILATION

Ventilation by a blower or fan may be necessary to remove harmful gases and vapors from a confined space. There are several methods for ventilating a confined space. The method and equipment chosen are dependent upon the size of the confined space openings, the gases to be exhausted (e.g., are they flammable?), and the source of makeup 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 them until they are within the explosive range. Also, if inert gases (e.g. carbon dioxide, nitrogen, argon) are used in the confined space, the space should be well ventilated and re-tested before a worker may enter.

A common method of ventilation requires a large hose, one end attached to a fan and the other lowered into a manhole or opening. For example, a manhole would have the ventilating hose run to the bottom to blow out all harmful gases and vapors (see diagram). The air intake 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.



Ventilating with Fan and Trunk Hose

ISOLATION

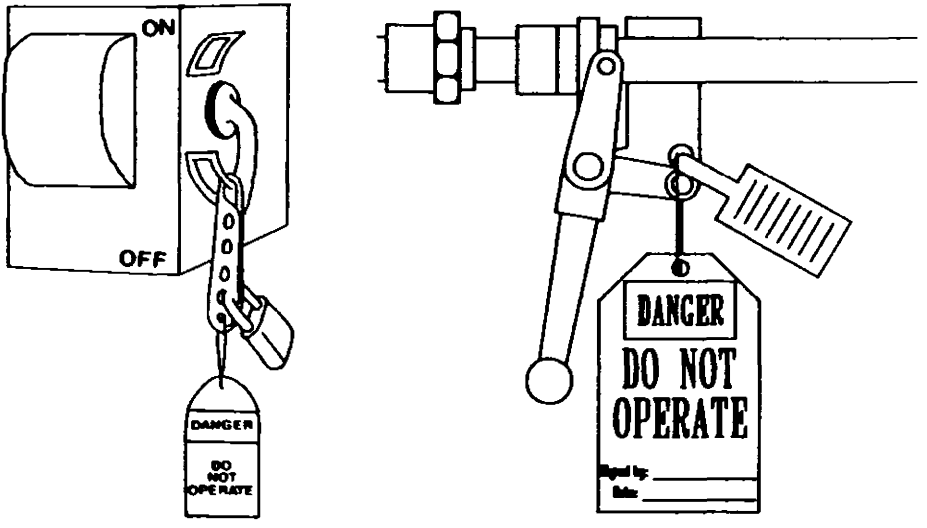
Isolation of a confined space is a process where the space is removed from service by:

- *locking out*
  electrical sources, preferrably at disconnect switches remote from the equipment

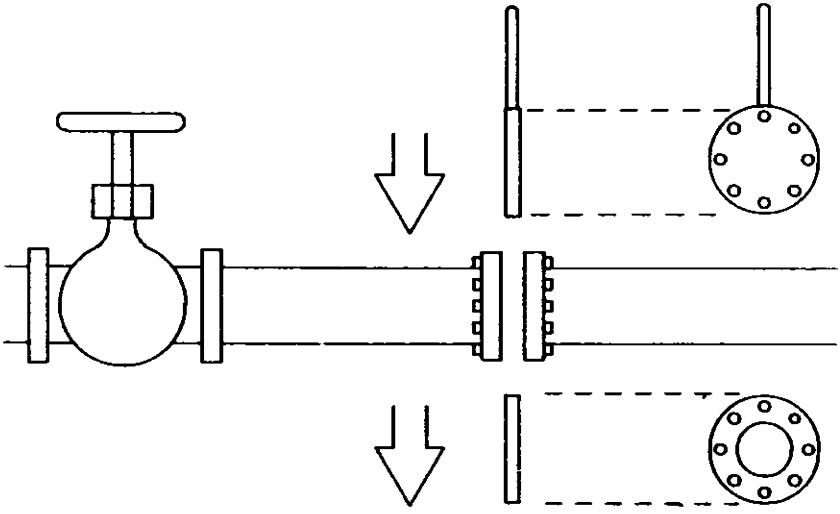
- *blanking and bleeding*
  pneumatic and hydraulic lines

- *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.



Examples of Lockout



Method of Blanking Hydraulic/Pneumatic Lines

RESPIRATORS

Respirators are devices that can allow workers to safely breathe without inhaling toxic gases or particles. Two basic types are air-purifying, which filter dangerous substances from the air; and air-supplying, which deliver a supply of safe breathing air from a tank or an uncontaminated area nearby.

ONLY AIR-SUPPLYING RESPIRATORS SHOULD BE USED IN CONFINED SPACES WHERE THERE IS NOT ENOUGH OXYGEN.

Selecting the proper respirator for the job, the hazard, and the person is very important, as is thorough training in the use and limitations of respirators. Questions regarding the proper selection and use of respirators should be addressed to a certified industrial hygienist, or to the NIOSH Division of Safety Resarch, 944 Chestnut Ridge Rd., Morgantown, West Virginia 26505.

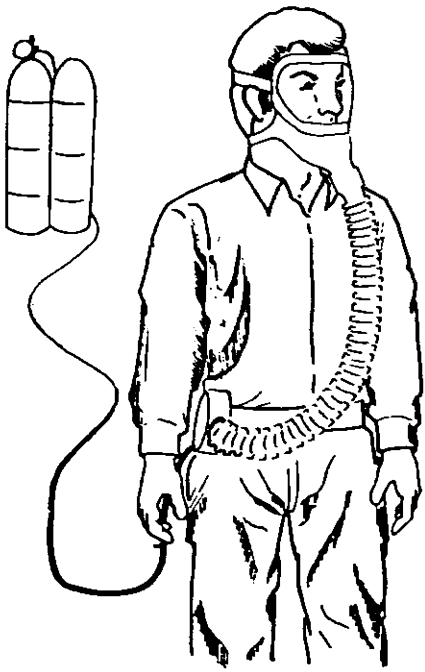
Air-Purifying Respirators

(Do Not Use in Oxygen-Deficient Atmosphere)

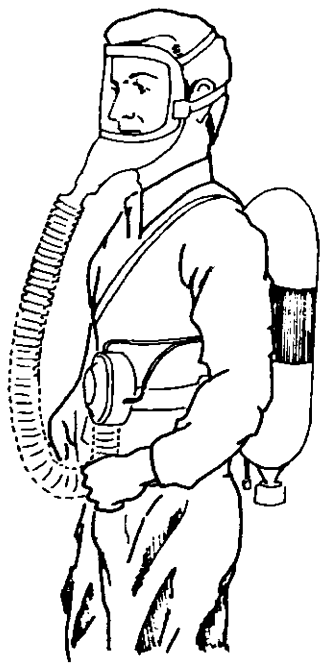
Half-mask

Full-Facepiece

Air-Supplying Respirators



Supplied Air Respirator with Auxiliary, Escape-only SCBA

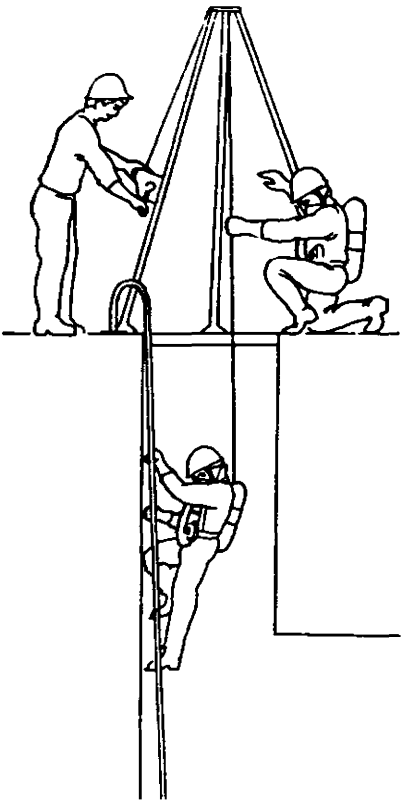


Self-contained Breathing Apparatus (SCBA)

STANDBY/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 <u>LAST</u> .

GENERAL/PHYSICAL HAZARDS

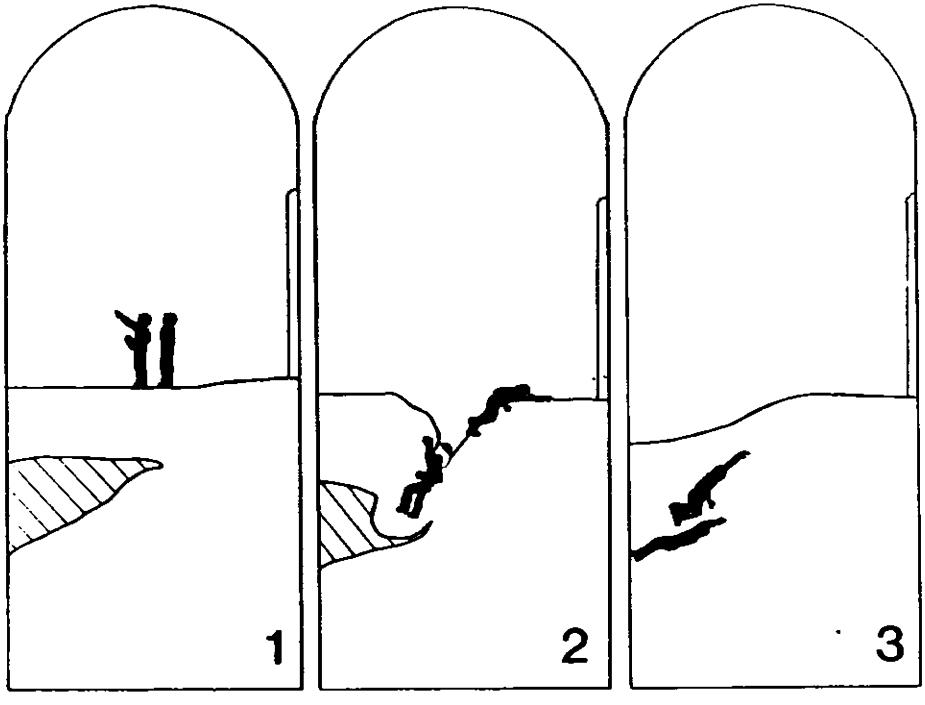
In addition to the areas discussed above, evaluation of a confined space should consider the following potential hazards:

1. TEMPERATURE EXTREMES:

Extremely hot or cold temperatures can present problems for workers. For example, if the space has been steamed, it should be allowed to cool before any entry is made.

2. ENGULFMENT HAZARDS:

Loose, granular material stored in bins and hoppers, such as grain, sand, coal, or similar material, can engulf and suffocate a worker. The loose material can crust or bridge over in a bin and break loose under the weight of a worker.



The Hazard of Engulfment in Unstable Material

3. NOISE:

Noise within a confined space can be amplified because of the design and acoustic properties of the space. Excessive noise can not only damage hearing, but can also affect communication, such as causing a shouted warning to go unheard.

4. 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 likelihood for and effect of electric shock in areas where electrical circuits, equipment, and tools are used.

5. FALLING OBJECTS:

Workers in confined spaces should be mindful of the possibility of falling objects, particularly in spaces which have topside openings for entry, and where work is being done above the worker.

RECOMMENDATIONS FOR SAFE ENTRY: A CHECKLIST

Use the following checklist to evaluate the confined space.

DO NOT ENTER A CONFINED SPACE UNTIL YOU HAVE CONSIDERED EVERY QUESTION, AND HAVE DETERMINED THE SPACE TO BE SAFE.

YES NO

☐ ☐ *Is entry necessary?*

TESTING

☐ ☐ *Are the instruments used in atmospheric testing properly calibrated?*

☐ ☐ *Was the atmosphere in the confined space tested?*

☐ ☐ *Was Oxygen at least 19.5% - not more than 21%?*

☐ ☐ *Were toxic, flammable, or oxygen-displacing gases/vapors present?*

- *Hydrogen Sulfide*
- *Carbon Monoxide*
- *Methane*
- *Carbon Dioxide*
- *Other (list)* _____

_____

YES NO

MONITORING

☐ ☐ *Will the atmosphere in the space be monitored while work is going on?*

☐ ☐ *Continuously?*

☐ ☐ *Periodically? (If yes, give interval:_____)*

REMEMBER - ATMOSPHERIC CHANGES OCCUR DUE TO THE WORK PROCEDURE OR THE PRODUCT STORED. THE ATMOSPHERE MAY BE SAFE WHEN YOU ENTER, BUT CAN CHANGE VERY QUICKLY.

CLEANING

☐ ☐ *Has the space been cleaned before entry is made?*

☐ ☐ *Was the space steamed?*

☐ ☐ *If so, was it allowed to cool?*

VENTILATION

☐ ☐ *Has the space been ventilated before entry?*

☐ ☐ *Will ventilation be continued during entry?*

☐ ☐ *Is the air intake for the ventilation system located in an area that is free of combustible dusts and vapors and toxic substances?*

☐ ☐ *If atmosphere was found unacceptable and then ventilated, was it re-tested before entry?*

YES NO

ISOLATION

☐ ☐ *Has the space been isolated from other systems?*

☐ ☐ *Has electrical equipment been locked out?*

☐ ☐ *Have disconnects been used where possible?*

☐ ☐ *Has mechanical equipment been blocked, chocked, and disengaged where necessary?*

☐ ☐ *Have lines under pressure been blanked and bled?*

CLOTHING/EQUIPMENT

☐ ☐ *Is special clothing required (boots, chemical suits, glasses, etc.)?*

(If so, specify: _____)

☐ ☐ *Is special equipment required (e.g., rescue equipment, communications equipment, etc.)?*

(If so, specify: _____)

☐ ☐ *Are special tools required (e.g., sparkproof)?*

(If so, specify: _____)

RESPIRATORY PROTECTION

☐ ☐ *Are MSHA/NIOSH-approved respirators of the type required available at the worksite?*

☐ ☐ *Is respiratory protection required (e.g., air-purifying, supplied air, self-contained breathing apparatus, etc.)?*

(If so, specify type: _____)

YES NO

☐ ☐ *Can you get through the opening with a respirator on? (If you don't know, find out before you try to enter.)*

TRAINING

☐ ☐ *Have you been trained in proper use of a respirator?*

☐ ☐ *Have you received first aid/CPR training?*

☐ ☐ *Have you been trained in confined space entry and do you know what to look for?*

STANDBY/RESCUE

☐ ☐ *Will there be a standby person on the outside in constant visual or auditory communication with the person on the inside?*

☐ ☐ *Will the standby person be able to see and/or hear the person inside at all times?*

☐ ☐ *Has the standby person(s) been trained in rescue procedures?*

☐ ☐ *Will safety lines and harness be required to remove a person?*

☐ ☐ *Are company rescue procedures available to be followed in the event of an emergency?*

☐ ☐ *Are you familiar with emergency rescue procedures?*

☐ ☐ *Do you know who to notify and how in the event of an emergency?*

YES NO

PERMIT

(The permit is an authorization in writing that states that the space has been tested by a qualified person, that the space is safe for entry; what precautions, equipment, etc. are required; and what work is to be done.)

☐ ☐ *Has a confined space entry permit been issued?*

☐ ☐ *Does the permit include a list of emergency telephone numbers?*

For further information on confined spaces, occupational hazards, safe work practices, and other topics which could affect your wellbeing, write to:

PUBLICATIONS DISSEMINATION
National Institute for Occupational
Safety and Health
Robert A. Taft Laboratories
4676 Columbia Parkway
Cincinnati, OH 45226

Lack of hazard awareness and unplanned rescue attempts led to the following deaths:

On July 23, 1985, a city worker was removing an inspection plate from a sewer line in a 50-foot deep pump station, when the plate blew off allowing raw sewage to enter the room. Two fellow workers and a policeman attempted to rescue the worker from the sludge filled room and were unsuccessful. All four were dead when removed from the pumping station.

On February 21, 1986, a self-employed truck driver died after entering the top of a 22-foot high x 15-foot square sawdust bin. He suffocated when the sawdust inside the bin collapsed and buried him.

On July 5, 1986, a worker entered a chemical degreaser tank to clean out the bottom and collapsed. Two fellow workers noticed the man down and went in to rescue him. All three workers died.

On July 16, 1986, a worker entered a septic tank to clean out the residue at the bottom and collapsed shortly afterward. Two workers on the outside went in to rescue the downed worker. All three were dead when removed from the tank.

On October 10, 1986, a self-employed plumbing contractor entered an underground water line vault to inspect a backflow device. The contractor collapsed shortly after entering the vault. A supervisor noticed the man down, and entered the vault in a rescue attempt. Both men had entered an untested oxygen-deficient atmosphere, and died as a result.

On February 6, 1987, two workers (father and son) at a wastewater plant were working on a digester that was being drained. They went on top of the digester and opened a hatch to check the sludge level. To provide light in the digester, they lowered an extension cord with an exposed 200 watt light bulb into the digester. The light broke and caused the methane gas in the digester to explode, killing both men instantly.

If the guidelines in this pamphlet had been followed, these fatalities would have been prevented.