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ABSTRACT

This student module on working safely in confined spaces in one of 50 modules concerned with job safety and health. This module explains how to recognize potential hazards in confined spaces, how to deal with these hazards, and how planning can prevent accidents. Following the introduction, 17 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., Identify the three major hazards associated with confined spaces and five possible sources of these hazards). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

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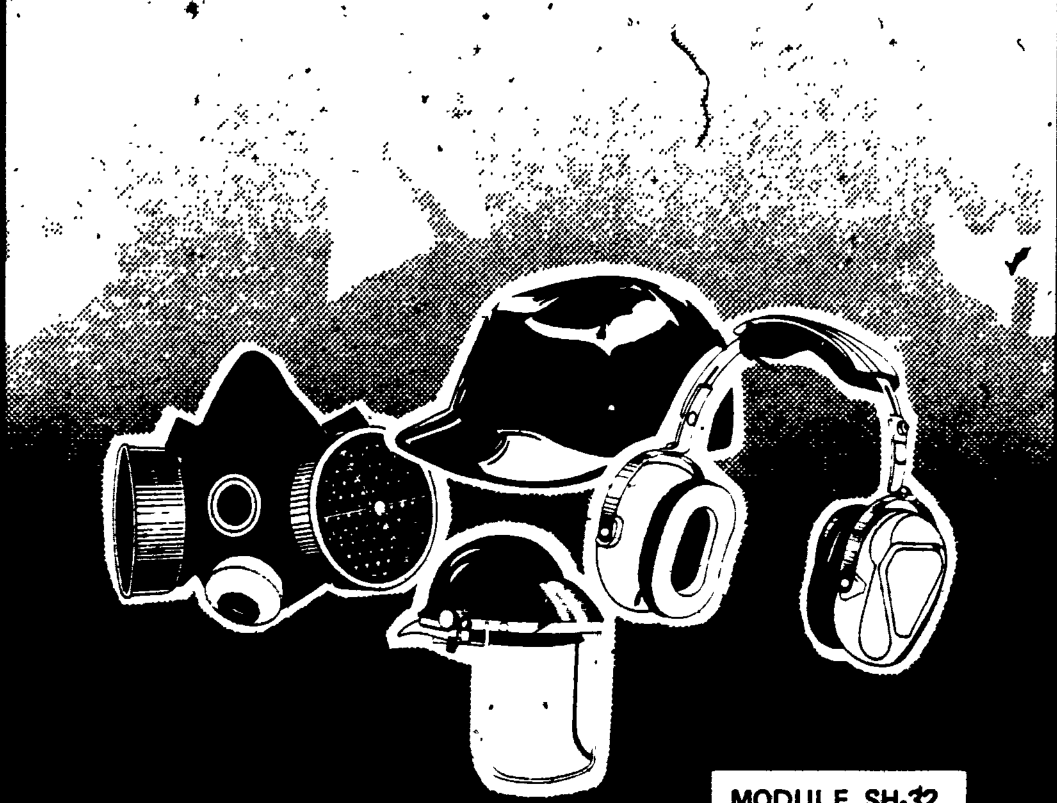
SAFETY AND HEALTH

WORKING SAFELY IN CONFINED SPACES



MODULE SH-32

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INTRODUCTION

Each industry and each situation has its own specific problems and dangers. Prevention of injuries to the life and health of workers requires that they be properly trained and well equipped to recognize, understand, and control the hazards they could encounter. The danger of hazards that are not easily seen, smelled, heard, or felt can represent deadly risks to people who work in confined areas. When a person works in a confined area or space - one in which dangerous air contamination cannot be prevented or removed by natural ventilation - the chance always exists that the oxygen level may be low, or combustible or toxic gases may be present.

Before entry is made into a confined area, a comprehensive written entry procedure should be followed. Next, it should always be assumed that a hazard is present and the environment should be measured before entry. If a hazard exists or could exist, then the environment should be tested or monitored for hazards before entry is made and periodically during work in the confined space or area. Ability to identify and to deal with the hazard, once it is recognized, should result in careful planning and control of all work in confined spaces.

This module explains how to recognize potential hazards in confined spaces, how to deal with these hazards, and the kinds of planning and control that is necessary to prevent confined space accidents.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. Identify the three major hazards associated with confined spaces and five possible sources of these hazards. (Page 3)
2. Describe the effects of lack of oxygen on human beings and cite the minimum exposure level established by OSHA. (Page 4)
3. Discuss the different ways in which exposure to toxic substances in confined spaces may affect the worker. (Page 6)

4. List two preventive measures that may be taken to safeguard against flammable or explosive atmospheres in confined spaces. (Page 8)
5. List seven problems that must be considered before engaging in any work within a confined space or vessel. (Page 10)
6. Compare the differences between Class, A, B, and C confined spaces. (Page 15)
7. Describe the entry permit system for working in confined spaces. (Page 16)
8. Contrast the medical exam requirements for workers in Class A and B confined areas. (Page 19)
9. Discuss the first-aid provisions and training requirements necessary for confined space work. (Page 20)
10. Discuss the testing, monitoring and environmental control procedures for confined spaces. (Page 22)
11. Discuss the requirements for labeling, posting, and working safely, and providing protective equipment for work in confined spaces. (Page 29)
12. Describe isolating, locking out, and tagging of Class A and B confined spaces. (Page 35)
13. List the cleaning and housekeeping procedures for confined spaces. (Page 38)
14. Describe the equipment and tools used in Class A, B, and C confined working spaces. (Page 39)
15. State the special precautions to be taken when working in confined spaces with hazardous atmospheres. (Page 40)
16. Describe the types of records that must be kept for Class A and B confined space working areas. (Page 42)
17. Explain the precaution steps performed on boilers before entry is made. (Page 43)

OBJECTIVE 1: Identify the three major hazards associated with confined spaces, and list five possible sources of these hazards.

Most people who have died or been seriously injured during work in confined spaces either had little knowledge of the inherent dangers or failed to take the necessary precautions, including using proper personal protective equipment and the "buddy system." The three major hazards associated with confined spaces are oxygen deficiency, flammable atmospheres, and toxic concentrations of airborne contaminants.

Hazards are usually related to the substance previously stored in the space. In most cases, the potential problem can be grouped under one or more of the three major types of hazards. Other sources of contamination besides the previous contents of the vessel are vapors of flammable or toxic substances used for treating or cleaning the storage area, fuel gases used within the vessel, and gases from fermentation of organic matter. Combustion by-products from engine exhaust, welding, or explosions created within the storage area are potentially hazardous, too.

ACTIVITY 1:

The hazard in a confined space is always related to the material previously stored in that space. (Circle one.)

True False

*Answers to Activities begin on Page 45.

OBJECTIVE 2: Describe the effects of lack of oxygen on human beings, and cite the minimum exposure level established by OSHA.

Lack of oxygen is the primary cause of illness and death in and around confined spaces. The normal concentration of oxygen in the air is 21%. The Occupational Safety and Health Aministration (OSHA) standards have established a minimum oxygen level of 19.5 percent as being permissible in a work environment. Exposure to an atmosphere containing less than 19.5 percent oxygen is considered hazardous.

Serious accidents often result when a person assumes that changes in the atmospheric concentrations of various substances can be detected by the senses. Many of the contaminants encountered in confined spaces have a narcotic effect and actually dull the senses. In addition, the effects of exposures to some contaminants may not arouse much concern. For instance, the first symptoms of the lack of oxygen (anoxia) are ringing in the ears and labored breathing. These symptoms would not necessarily alarm a worker; therefore human senses may be misleading.

If exposure to an oxygen-deficient atmosphere continues, the worker loses coordination and judgment is impaired. Drowsiness, lack of will to work, and euphoria (a feeling of no concern) often sets in. When the amount of oxygen in the atmosphere falls below 16 percent, more serious symptoms of anoxia begin to appear, as the following table shows:

TABLE 1. HUMAN RESPONSE TO BREATHING AIR DEFICIENT IN OXYGEN.

Stage	Oxygen Volume Percent	Symptoms
1	12 - 16	Increased breathing and pulse rate; slightly disturbed muscular coordination.
2	10 - 14	Continued consciousness; emotional upsets; abnormal fatigue upon exertion; disturbed respiration.

3	6 - 10	Nausea and vomiting; inability to move freely; loss of consciousness may occur; may collapse and although aware of circumstances, be unable to move or cry out.
4	Below 6	Convulsive movement; gasping respiration; respiration stops and a few minutes later heart action ceases.

The following example describes one of the possible effects of lack of oxygen in a confined space:

> An underground oil storage tank that required cleaning had been used to store nitrogen. The man assigned to clean the tank dropped an air hose into the tank before entering. As he reached the bottom of the ladder, he passed out. His helper outside the tank went in to help and, feeling faint, left without getting the man out. He went to get assistance from a nearby maintenance shop. Three men came to the tank and climbed down and all were overcome. Finally, after almost 20 minutes, all men were recovered with the help of the fire department. The only reason that there were no fatalities was that the airline in the tank was blowing air in the vicinity of the fallen workers.

Several safety precautions were overlooked in the situation cited above. No attempt was made to test the air after the air hose was dropped into the tank. Very little time elapsed between the dropping of the air hose and the workers climbing into the tank. No rescue gear was present, and no rescue procedure had been planned. These preliminary steps and other precautions for work in confined spaces will be described in greater detail later in this module.

ACTIVITY 2:

(Choose the best answer.)

1. The minimum acceptable level of oxygen in the workers environment as determined by OSHA is:

   a. 16%.

   b. 21.5%.

   c. 19.5%.

   d. 12%.

2. Which of the following symptoms of anoxia would manifest itself first?
   a. Drowsiness, lack of will to work, euphoria.
   b. Slightly disturbed muscular coordination.
   c. Nausea and vomiting.
   d. Ringing in the ears and labored breathing.

OBJECTIVE 3: Discuss the different ways in which exposure to toxic substances in confined spaces may affect the worker.

One of the major hazards associated with confined space is toxic substances. Toxic substances may be classified by their physiological effect. The degree of the resulting effect depends on the degree of toxicity and atmospheric concentration of the substance. Toxic substances may affect the worker in a confined space in several ways - as an irritant, asphyxiant, anesthetic, narcotic, systemic poison, or disabling respirable particulate matter, such as fibrosis-producing dusts and bacteria. The higher the concentration, the worse the effect.

Toxicity in a confined space is also relative to the size and type of space involved. It is not absolute. A substance considered nontoxic under normal conditions can be lethal in a confined space.

The extent of the effects may vary considerably. Severe poisoning may occur. Very short exposures to high concentrations of a material such as hydrogen sulfide (sewer gas), a substance that paralyzes the respiratory system, may be fatal. Chronic exposure (exposure over a period of time) to low concentrations of this same substance may result in eye irritation, skin irritation, or general discomfort. The long term effects of chronic, low level exposure are unknown at this time.

Many toxic substances are colorless, odorless, and tasteless. This further complicates their detection and essentially eliminates human sensory recognition. Some materials produce a symptom known as olfactory fatigue, which is the inability to detect the presence of a substance by its odor after an initial exposure. The timeworn consolation, "Oh, you get used to the smell quickly," in many cases is actually a result of olfactory fatigue and the worker may be unaware, after a whiff or two, that the exposure to a toxic substance is continuing or even increasing.

The following account illustrates the potential severity of toxic substances in confined spaces:

> Employees of a local utility were repairing a water meter in an underground vault 18 feet x 6 feet x 5 feet with an opening 24 inches in diameter. To make the repairs, it was necessary to cut 26 cadmium-plated bolts with an oxygen propane torch. Two men worked in the vault with one man cutting and the other standing beside him. Neither man wore a respirator and no ventilation was provided. Two other men remained on the surface. During the cutting of the bolts with the oxygen propane torch, a "heavy blue smoke" filled the vault. This smoke was exhausted after the cutting was completed.
>
> The 56-year-old man who had cut the bolts died 17 days after exposure. He became nauseated shortly after the job and was seen by his family physician the next day for fever (102°-103°F), chest pain, cough, and sore throat. On the 4th day following the incident he was in greater distress and was hospitalized. Death occurred in 2 weeks and was attributed to massive coronary infraction and corpulmonale. The 29-year-old assistant complained of chills, nausea, cough, and difficulty in breathing. He was treated for pneumonia and made a slow recovery. A reenactment of the work demonstrated that the exposure to cadmium was well above the threshold limit value of "0.1 mg/m^3." Symptoms attributed to cadmium poisoning include: severe labored breathing and wheezing, chest pain, persistent cough, weakness and malaise, and loss of appetite. The clinical course is similar in most cases. The injured frequently are well enough to work the day after exposure, but their conditions deteriorate until approximately the 5th day. At this point the exposed worker will either get much worse or begin to improve.

In the previous case, no attempt was made to anticipate the possible health hazards of the cutting procedure, and no safety measures were taken. A few simple precautions would have saved a life.

ACTIVITY 3:

(Fill in the blanks.)

1. The inability to detect the presence of a substance by its odor after initial exposure is known as

   ____________________.

2. The extent of the effects of a toxic substance on a person is often dependent upon the ______________ of the toxic substance in the atmosphere.

OBJECTIVE 4: List two preventive measures that may be taken to safeguard against flammable or explosive atmospheres in confined spaces.

When flammable liquids and vapors reach a certain concentration in air, they will flame or explode. The minimum concentration of vapor in air below which flame or explosion does not occur is known as the lower explosive limit (LEL). There is also an upper explosive limit (UEL). When the concentration of vapor in air reaches the upper explosive limit, propagation of flame or explosion does not occur.

When the concentration of a flammable liquid, vapor, or combustible particulate in air falls between the lower explosive limit and the upper explosive limit, a very critical condition exists. Any ignition source (flame, spark, or temperature above the auto-ignition point) in an area containing concentrations within the explosive range will cause a flash fire or explosion.

The most obvious protections against these conditions are cleaning, purging of the confined space (drawing out of the contaminated air with a suction device), or a combination of the two. Further precautions must be utilized to prevent ignition should a combustible atmosphere develop.

The following example illustrates the potential for tragic consequences when safeguards are not provided.

Two men entered a newly constructed tank to repair a bulge which had formed after the flange of the manhole was welded to the tank. The planned repair procedure was to have two men enter the tank with a jack to force the flange of the manhole into place while a third worker heated the bulge from the outside. To accomplish this procedure the men had to close the manhole. To improve the air within the tank, oxygen used for welding was blown in through an opening. A worker on the outside noticed through the opening that the hair of one of the workmen inside was on fire. The cover was immediately removed and one of the worker managed to escape. His clothing was burning rapidly; the second worker had collapsed and remained unconscious inside. It became necessary to invert the tank to remove the unconscious workman. Both workmen who were doing work inside suffered serious burns. One died a short time later; the second was hospitalized for several months. A rescuer in the operation was burned on the hands.

Investigation of the accident revealed that the use of oxygen in place of normal air greatly hazard of fire. Enriching the atmosphere with only a small amount of oxygen above 21% will cause a dramatic increase in the ability of air to support combustion; hair as well as clothing will absorb the oxygen and burn violently. Enriched oxygen atmospheres could be the result of improper blanking off of oxygen lines, chemical reactions which liberate oxygen, or inadvertently purging the space with oxygen in place.

In this instance, proper purging of the atmosphere inside the tank was bypassed; a "quick method" of improving the atmosphere by dropping in an oxygen line was used instead. The tragic results were predictable and preventable.

ACTIVITY 4:

1. List two preventive measures that may be taken to safeguard against flammable or explosive atmospheres in confined spaces.

   a. ______________________________

   b. ______________________________

2. Define these terms.

   a. LEL ______________________________

   b. UEL ______________________________

OBJECTIVE 5: List seven problems that must be considered before engaging in any work within a confined space or vessel.

There are a host of problems that must be considered before engaging in any work within a confined space or vessel. Such problems include, but are not limited to, the areas outlined below.

MECHANICAL

If activation of any piece of electrical or mechanical equipment would cause injury to a person working in a confined space, then the piece of equipment should be manually isolated to prevent inadvertent activation before workers enter or while they work in the confined area. 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 area. To completely isolate a confined space the closing of valves is not sufficient. All pipes must be physically disconnected or isolated, blanked or bolted in place. Other special precautions must be taken in case the flammable liquids or vapors may recontaminate 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 created by any space referred to as a void, such as double-walled vessels, that must be given special consideration in blanking off and inerting.

COMMUNICATION

Communication between the worker inside and the standby person outside is of utmost importance. If the worker inside should suddenly have a problem and not be able to summon help, an injury could become a fatality. Frequently, the body positions that must be assumed in a confined space make it difficult for the standby person to detect that the worker is unconscious. When visual monitoring of the inside worker is not possible because of the design of the confined space or the location of the entry hatch, a voice or alarm-activated explosion-proof type of communication system will be necessary.

ENTRY AND EXIT

One of the potential hazards of a confined space is the time required to enter and exit. The extent of the precautions taken and the standby equipment needed to maintain a safe work area will be determined in part by the ease or difficulty required for rescue attempts. The following should be considered when equipping a confined area for emergencies: type of confined space to be entered, access to the entrance, number and size of openings, barriers within the space, the occupancy load, and the time requirement for exiting in the event of fire or dangerous levels of toxic vapor, and the time required to rescue injured workers.

THERMAL EFFECTS

Four factors influence the interchange of heat between humans and their environment: (1) air temperature, (2) air velocity, (3) moisture contained in the air, and (4) radiant heat. The moisture content and temperature of the air in which one is working affects efficiency; it may also endanger the worker's life. Because of the nature and design of most confined spaces, moisture content and radiant heat are difficult to control. As the body temperature rises progressively, a worker will continue to function until the body temperature reaches 38.3-39.4°C. When this body temperature is exceeded, the worker is less efficient and prone to heat exhaustion, heat cramps, or heat stroke. The most severe strain in cold conditions is chilling of the body's extremities so that activity is restricted. Special precautions must be taken in cold environments to prevent frostbite, trench foot, and general hypothermia.

Insulated clothing for both hot and cold environments will usually protect the worker, but it will also add additional bulk and must be considered in allowing for movement in the confined space and in allowing for exit time. Air temperature of the environment then becomes an important consideration when evaluating working conditions in confined spaces.

NOISE

Noise problems are usually intensified in confined spaces. Because the structure often causes sound to reverberate, the worker is exposed to higher sound levels than in an open environment. This intensified noise increases the risk of hearing damage that could result in temporary or permanent loss of hearing. Noise in a confined space that may not be intense enough to cause hearing damage may still disrupt verbal communication with the emergency standby person outside 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 is increased.

VIBRATION

Vibration is another hazard often encountered in a confined space. Vibration may affect the whole body, or it may be limited to only one area. Whole body vibration may be regarded as a "generalized stressor" and 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 that cause vibration.

GENERAL

Some physical hazards cannot be eliminated because of the nature of the confined space or the work to be performed. These hazards relate to such items as scaffolding, surface residues, and structural hazards. The use of scaffolding in confined spaces has contributed to many accidents caused by workers or materials falling, improper use of guard rails, and lack of maintenance to ensure 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 potentials for electrical shock, reaction of incompatible materials, liberation of toxic substances, and bodily injury due to slips and falls.

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 are examples of physical hazards. In dealing with structural hazards, workers must review and enforce safety precautions to assure safety.

Rescue procedures may require withdrawal of an injured or unconscious person which means that all possible problems of working in a confined space must be considered. Careful planning must be given to the way in which a worker may be removed. If the worker is above the exit opening, the emergency system must include a rescue arrangement operated from outside the confined space, if possible, by which the employee can be lowered and removed without injury.

If any special problems are anticipated or encountered, specialists should be consulted before any employees are exposed (see Figure 1).

Training and retraining is essential to the success of confined spaces work.

Use of the "Buddy System" or a standby person is also most important. At no time should an employee enter a confined space without proper authorization, monitoring, training, equipment, and a well trained buddy or standby person outside the confined space.

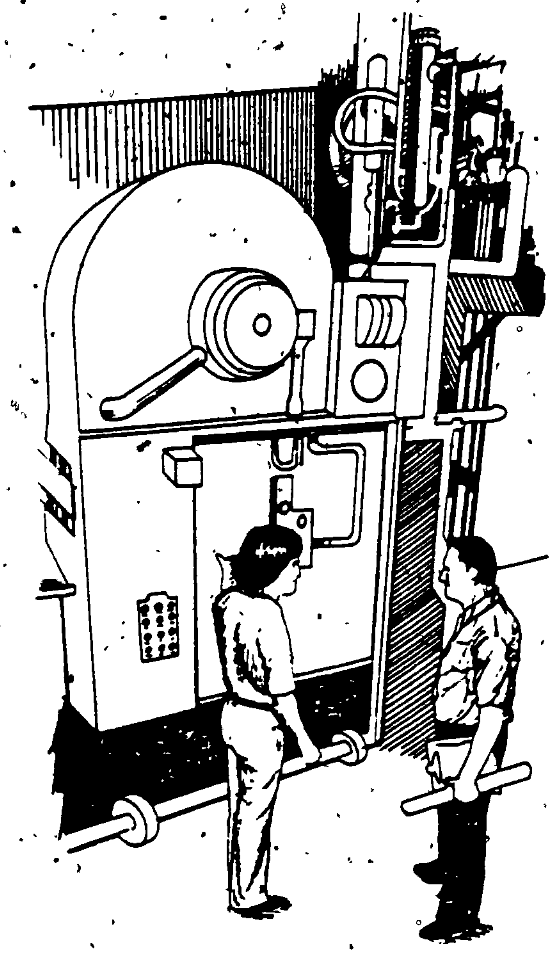


Figure 1. Special problems should be discussed before entry.

ACTIVITY 5:

List seven problems that must be considered before engaging in any work within a confined space or vessel.

1. ______
2. ______
3. ______
4. ______
5. ______
6. ______
7. ______

> **OBJECTIVE 6:** Compare the difference between Class A, B, and C confined spaces.

There are three classes of confined spaces. Each class is representative of a different level of risk to workers, Class A being the category of highest risk.

A Class A confined space is immediately dangerous to life. Rescue procedures require the entry of at least one extra individual who is fully equipped with life-support equipment. Maintenance of communication requires an additional standby person stationed within the confined space.

A Class B environment is dangerous, but not immediately life threatening. Rescue procedures require the entry of no more than one individual fully equipped with life-support equipment. Indirect visual or auditory communication with workers must be maintained.

A Class C space is considered a potential hazard area but one which requires no basic modification of work procedures. Standard rescue procedures apply; direct communication with workers may be maintained from outside the confined space.

Table 2 shows the oxygen levels, flammability characteristics, and toxicity levels of the three classes.

TABLE 2. CLASSES OF CONFINED SPACES.

HAZARD	CLASS A	CLASS B	CLASS C
Oxygen	16% or less *(122 mm Hg) or greater than 25% *(190 mm Hg)	16.1% to 19.4% *(122-147 mm Hg) or 21.5% to 25% *(163-190 mm Hg)	19.5% - 21.4% *(148-163 mm Hg)
Flammability Characteristics	20% or greater of LFL (Lower Flammable Limits)	19% - 19% LFL (Lower Flammable Limits)	10% LFL or less (Lower Flammable Limits)

Toxicity Level	**IDLH	Greater than contamination level, referenced in 29 CFR Part 1910 Subpart 2 - less than **IDLH	Less than contamination level referenced in 29 CFR Part 1910 Subpart 2

*Based upon a total atmospheric pressure of 760 mm of Mercury (Hg) at sea level.
**Immediately Dangerous to Life or Health as referenced in NIOSH Registry of Toxic and Chemical Substances, Manufacturing Chemists data sheets, industrial hygiene guides or other recognized authorities.

ACTIVITY 6:

(Fill in the blanks.)

The confined space category of highest risk is ________.

OBJECTIVE 7: Describe the entry permit system for working in confined spaces.

Entry to confined spaces or vessels must be strictly limited to authorized personnel. All equipment, work practices, procedures, and work time-periods must receive careful review and confirmation. Authorization is officially granted only through the use of a vessel entry permit signed by the responsible supervisor. (This supervisor should be one appointed by management who is trained in all aspects of confined space entry and knowledgeable as to specific problems and hazards possible in the supervised areas.) This permit must include:

1. A location and description of the work.
2. A checklist to ensure that proper vessel preparation and atmospheric tests have been accomplished.
3. A guarantee that these procedures will be maintained throughout the period specified for workers to be inside the vessel.

The permit must carry an expiration time and date and not be used through a shift change. Essential items which should be included on any permit are the following (suggested guidelines from the Kingston Plant of DuPont):

1. Signatures of second line supervisor (of area), supervisor of personnel, as well as personnel entering tank or confined space.

2. Requirements for special clothing and equipment.

   a. Nonsparking tools.

   b. Safety harness (belt) and lifeline.

   c. Breathing apparatus (respirators).

   d. Gloves, boots, goggles, etc.

3. Environmental analysis of confined space.

   a. Air analysis frequency.

   b. Explosive limit check frequency.

   c. Radiation level check frequency.

   d. Concentrations of toxic substances.

4. Reminder to display permit prominently and to post sign showing confined space work in progress.

An example of a confined space entry permit is shown here in Table 3.

TABLE 3. EXAMPLE OF AN ENTRY PERMIT.

VESSEL ENTRY PERMIT*

Department ______________________ Date __________ Time ______

Name of Vessel Being Entered ______________________

Permit Issued on ______ 7-3 Shift ______ 3-11 Shift ______ 11-7 Shift

Checklist:	Check if Required	Check when Completed
Atmosphere Tests (Record Results in Completed Column)		
1. Oxygen (O2) more than 19.5%		
2. Sulfur dioxide (SO2) less than 6 ppm		
3. Hydrogen sulfide (H2S) less than 21 ppm		
4. Chlorine (Cl2) less than 2 ppm		
5. Chlorine dioxide (ClO2) less than 0.2 ppm		
6. Flammable vapors – below 20% LFL		
7. Temperature less than 120°F		
Lockout and/or Blind Flange (Indicate Total Number Required)		
Observer		
Does Observer Know:		
1. Location of nearest phone?		
2. Location of nearest persons for HELP?		
3. Location of nearest air masks?		
Harness and life line		
Low voltage of battery powered lights or ground fault		
Protective clothing		
Vessel has been flushed out		
Ladder or scaffolding		
Ventilation (blowers, air movers, etc.)		

All personnel entering vessel, observer and supervisors must sign below. This form is for the purpose of helping ensure the safety of all employees and is not a waiver of any rights.

We have received instructions on the safety procedure and hazards (if any) of the job.

Supervisor of People Entering Vessel

Operating Department Superintendent

In the event that toxic gases in a vessel cannot be reduced below the acceptable level as posted on the procedure, no one shall enter except in an emergency where life is in danger. If such an emergency arises, either self-contained breathing apparatus or an air line respirator with egress cylinder must be worn at all times.

*Sample from Nekoosa Paper, Inc.

ACTIVITY 7:

(Choose the best answer.)

The confined space entry permit system requires:

a. A checklist to ensure proper vessel preparation and atmospheric testing.

b. An expiration time and date which prevents the entry permit from being used through the change of shift.

c. The signature of the responsible supervisor and also of the second level supervisor and employees entering the confined space.

d. All of the above.

OBJECTIVE 8: Contrast the medical exam requirements for workers in Class A and B confined areas.

Workers who enter a Class A or B confined space must have a preplacement physical examination which the employer makes available to them. The employer must provide the physician performing or responsible for the medical surveillance program information such as the type of confined space the employee may be required to enter, the type of substances the employee may encounter, and a description of any protective devices or equipment the employee may be required to use. The physical examination must include:

- A demonstration of the worker's ability to use negative and positive pressure respirators as cited in OSHA Standard 29 CFR 1919.134.
- A demonstration of the worker's ability to see and hear warnings, such as flashing lights, buzzers, or sirens.
- The examination should place emphasis on general evaluations of the employee's ability to carry out his assigned duties and the detection of any disease or abnormalities which may make it difficult for the employee to work within confined spaces.

Following completion of the examinations, the physician must give the employer a written statement specifying any condition or abnormality found that would increase the risk to the employee's health by working in confined spaces.

Results of periodic medical examinations must be made available, upon completion and on request to employees required to work in Class A or B confined spaces.

Records of exposure to known health hazards must be included in the employee's medical record. These records must be made available to the designated medical representatives of the Department of Health and Human Resources, the Secretary of Labor, the employer, and the employee or former employee. Records must be kept for 20 years or longer. Keeping these records allows researchers to examine procedures used and provide examples of proper and improper procedures.

ACTIVITY 8:

Medical exams for entry into Class A confined spaces are more rigid than those for Class B confined space entry. (Circle one.)

True False

OBJECTIVE 9: Discuss the first aid provisions and training requirements necessary for confined space work.

Working or being present in confined space often requires certain training or knowledge. For Class A and B entry there must always be someone readily available in the area of the confined space who holds a current verifiable certificate in cardiopulmonary resuscitation (CPR) and basic first aid procedures.

Employees must be aware of the location of the nearest first aid equipment and must know how to obtain emergency assistance and medical attention. An adequate supply of first aid equipment must be made within easy access of the confined space.

The serious nature of the hazards encountered in a confined space requires careful structuring of an effective training program that will result in safe work practices and techniques. The training program should deal with the specific hazards to be encountered, be approved by a trained industrial hygienist or safety person, and be given to all individuals who will perform the work or may be assigned as standby or rescue persons. It is essential that the person in charge of training know the relevant aspects of safety as they relate to confined spaces.

The medical needs of confined space personnel are likely to be specialized. For example, a fire, explosion, or superheated air in a confined space will result in burns of the respiratory tract, with or without immediate symptoms. Any worker subjected to such an experience should be observed in a hospital emergency room.

The training method and approach will be determined by the previous experience and skills of the employee, with the exception of a newly hired person who should receive a complete and thorough safety orientation. Basic types of prescribed training are:

- Orientation of all new employees - This type of training would consist of classroom sessions along with a walk-through of the physical plant layout to give the trainee a basic understanding of the industrial activity.
- On-the-job training - This would be a second phase of training. After classroom sessions and after the trainee has gained a basic understanding of the operation and hazards involved, on-the-job instruction should include observation and closely supervised participation in actual work practices or simulated conditions.
- Retraining - This should be performed periodically and as frequently as needed. Many industrial activities are quite complex and operations are frequently updated to keep up with modern innovations. It is necessary, therefore, for a formal training program to be planned so that all personnel concerned may be kept abreast of changes. Retraining should also be considered necessary if a supervisor notices a weakness in employee performance.

The following are recommended areas that should be covered thoroughly in training:

- The types of confined spaces that are found in the industrial complex.
- Physical and chemical hazards involved.
- Atmospheric testing of the confined space.
- Cleaning and purging of the space.
- Ventilation of the space by mechanical methods to reduce or eliminate toxic airborne contaminants.

- Isolation and lockout of the confined space.
- Safety equipment and clothing - A major subject in this section will be the use of respirators: the types required, their use, quantitative fit (test), respirator cleaning procedures, and proper storage. It should be emphasized that different type respirators are required for different atmospheres and that there are dangers involved when the wrong type is used.
- Buddy system and use of a standby person(s).
- Communication systems and emergency signals.
- Rescue procedures.
- Permit system which is used by the employer.
- Documentation of Training. Satisfactory completion of this safety training, and refresher courses, should be entered into the employee's permanent record.

ACTIVITY 9:

List at least six areas that should be covered in a training program on safe work practices in confined spaces.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________

OBJECTIVE 10: Discuss testing, monitoring, and controlling the environment in confined spaces.

Strict procedures must be followed in testing, monitoring, and controlling the environment in a confined space. Taking air samples in confined spaces and interpretation of results should be done by an industrial hygienist or professional safety engineer. If this is not possible, a person should be specially trained by an industrial hygienist or should attend a short course providing the necessary training. In either event, all workers who expect to be working in or around confined spaces should be aware of the various potential hazards that may be encountered in such spaces. These workers should know how to use testing and monitoring equipment and the limitations of such equipment.

The presence of dangerous air contaminants can be checked by using various types of instruments. An employee should initially attempt to use these instruments in the confined space to check for contaminants, but there is a chance that upon entering a confined space, the person checking could be overexposed to dangerous air contaminants, or the instrumentation could ignite flammable vapors. Because of this danger the correct procedure is to remain outside the confined space and bring samples of the atmosphere to the testing instruments with sampling lines or containers. Those sampling lines or containers must be able to reach the bottom of the confined space. Instruments taken into untested atmospheres must be approved by a recognized testing agency for such use, and the employee must wear the necessary respiratory equipment (self-contained breathing apparatus or hose mask with blower), since lethal doses of various substances (carbon monoxide, sewer gas, etc.) may be encountered before any actual testing can take place.

Before a worker enters, the atmosphere must be tested for oxygen deficiency, toxicity, and flammability. These tests must be continuous or periodic while the worker is in the confined space.

Oxygen deficiency may occur for any of the following reasons:

- Rusting tank walls.
- Gases or vapors which have displaced the air.
- Fire.
- Plant growth.
- Workers in the area consuming oxygen.
- Chemical reactions.

Oxygen indicators (O_2 meters) usually have a range of zero to 25 percent of oxygen and can be used with a sampling line. (See Figure 2.) The test can be easily and quickly repeated. If tests indicate an oxygen deficiency, the confined space must be purged until the atmosphere contains at least 19.5 percent oxygen. Continuous ventilation must be provided and oxygen deficiency tests must be continued while workers are in the confined space. If the oxygen content cannot be raised to 19.5 percent, each worker must wear a self-contained breathing apparatus in addition to all other required protective equipment.

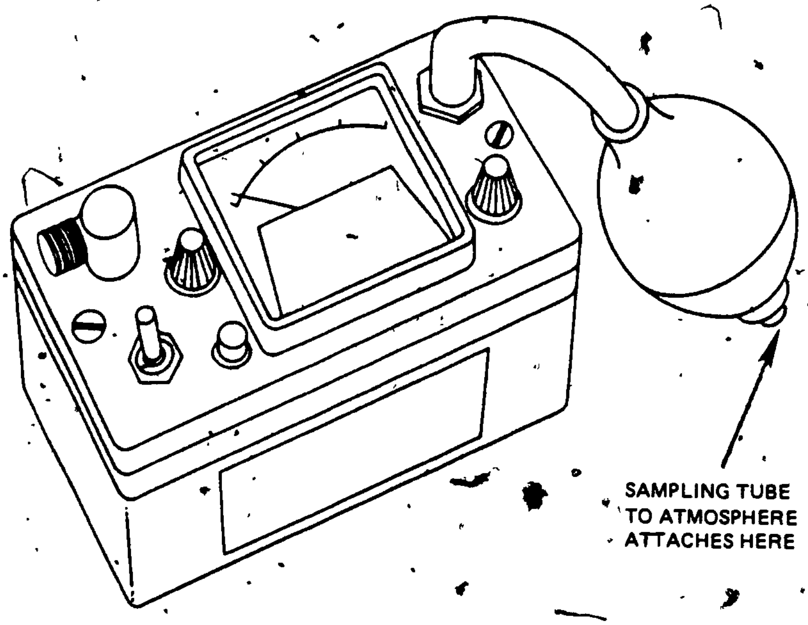


Figure 2. Oxygen deficiency indicator.

A flammable atmosphere should be assumed to be present in any tank or vessel that contains or has ever contained flammable liquids or vapors. Subsequent tests must be made before entering and periodically afterwards during any continued operations. The atmosphere may be tested for flammable vapor-air mixtures by using a combustible gas indicator. (See Figure 3.) This instrument should be used only by trained persons and must be calibrated before use.

Operating instructions must be read and followed and are usually printed on the instrument case. These include essential directions for adjusting the voltage and zeroing the direct reading instruments. Calibration (a mandatory activity performed prior to actual operation) consists of checking the accuracy of the instrument against a known standard quality of a gas such as methane. Calibration gas is supplied by the instrument manufacturer.

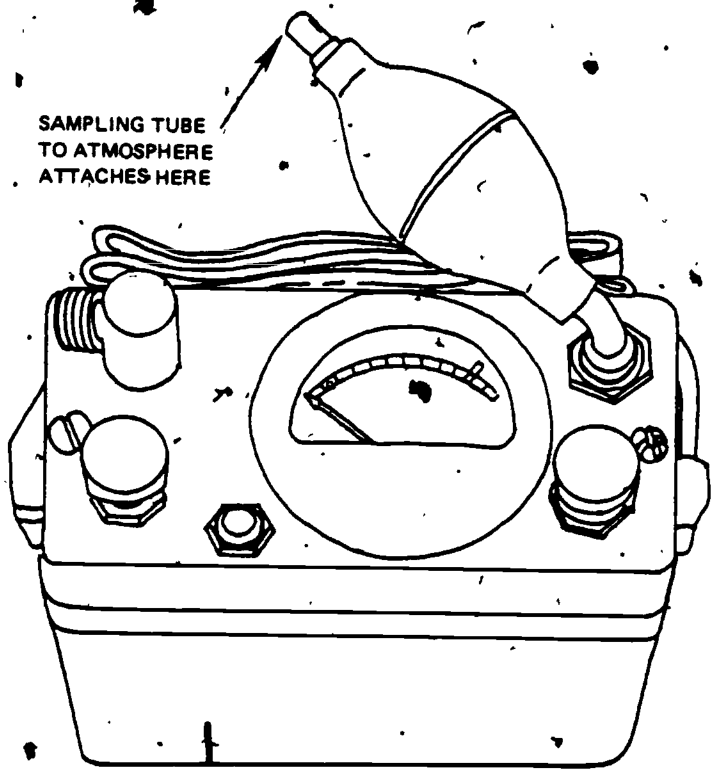


Figure 3. Combustible gas indicator.

Combustible gas indicators normally are calibrated to indicate the percent of the lower explosive limit (LEL) of a gas or vapor in the air being tested. Good judgment must be used in interpreting the meter reading because the instrument does not always respond in the same manner to different flammable materials. Because the responses may vary, the tester must (1) compare test results with calibrated curves furnished by the test instrument manufacturer and (2) calibrate the instrument for the gas or vapor in question for the tests to be valid.

Oxygen content should be checked prior to testing for flammable mixtures because gas indicators will not function properly in oxygen-deficient atmospheres. Only explosion-proof equipment should be brought into areas where there is any likelihood of flammable or explosive mixtures. The combustible gas indicator must have a sampling tube that can be lowered into the atmosphere to be tested. If tests indicate that the flammable vapor content of the atmosphere is greater than 20 percent of the lower explosive limit (LEL), the vessel must undergo additional purging. Mechanical ventilation should also be continuous to prevent further build-up of flammable mixtures.

All confined spaces must also be tested before entry for the level of toxic substances in the atmosphere. Gases and vapors can be detected by direct reading instruments, colorimetric and stain length instruments, and samples collected for subsequent laboratory analysis. Particulates, fumes, and mists are normally determined by collecting samples for subsequent laboratory analysis.

If tests indicate that employees would be exposed to substances in excess of the threshold limit value(TLV), the confined space must be purged until the atmosphere is safe. Continuous ventilation must be provided and tests for toxic substances must be made continuously or periodically until work ceases in the space.

If the atmosphere cannot be made safe, an approved respirator must be worn. If the atmosphere is hazardous to life, the exposed worker must wear a self-contained breathing apparatus in addition to all other protective equipment. Types of respirators to be worn when a person is exposed to toxic materials in excess of the threshold limit value (which are not immediately hazardous to life) must be determined on an individual basis by competent personnel.

Air temperatures in manholes or tunnels, particularly those providing access to steam pipes, may reach 200 degrees Fahrenheit. According to methods in use throughout the world, such a condition alone (although usually coupled with high humidity and little natural air movement) would rapidly result in excessive heat exposure. Any of several excessive heat exposure ailments could likely occur unless the worker is adequately protected by appropriate clothing or cooled by forced air.

It should not be assumed that any one instrument will determine all harmful concentrations of oxygen deficiency, flammable vapors, toxic substances, and excessive heat. Unfortunately, there is no universal device that will detect all of these harmful atmospheric conditions; therefore extra care is necessary to ensure worker safety.

A routine schedule of proper maintenance and calibration is necessary for all testing instruments. Deficiencies and inaccuracies in the instruments may be caused by improper maintenance, component unreliability, lack of calibration, poisoning of the catalysts by interfering substances in the atmosphere, changes in airflow rates and volumes, age of test cells, and weak batteries.

Accurate testing will detect environmental problems that must be controlled. The most common methods for control of the environment within vessels and confined spaces are outlined in the following paragraphs. The most appropriate method for any given situation will vary, depending on tank configuration and contents. A careful selection of the appropriate method is essential.

There are several ways to prepare confined spaces or containers for personnel entry by using mechanical ventilating equipment. These include the following:

- A duct or large flexible tube is lowered from a suitable fan at a top access port to draw the heavy vapors from the bottom of the space or container. Fresh air is allowed to enter through another opening in the top of the enclosure.
- A large fan is placed in a top opening or port and exhausting started at low speed. A lower access is opened, and the fan speed is increased to its maximum, allowing exhausting of vapors through the top while fresh air is drawn into the lower.
- A fan is placed in the lower vessel opening, the top port is opened, and the fan forces fresh air in at the bottom of the enclosure with vapor escaping at the top.

In all these cases, if flammable vapors are involved, the fan must have nonferrous blades, be electrically bonded to the container or vessel, and be approved electrically for the conditions. All toxic and flammable vapors must be exhausted to a safe location where they will not create additional hazards. All such ventilation and accompanying atmosphere tests must be performed by a trained and qualified individual and records kept of procedures and results.

The simplest but often possibly the least efficient method of freeing or purging a confined space of vapor is through natural ventilation. This method consists of opening two or more portals and letting natural air currents remove the vapors inside. Due to the lack of control over air currents, extreme care must be exercised to eliminate sources of ignition from the area of potential flammable vapors, and to protect personnel from potential toxic vapors areas. Regular testing will determine when safe levels exists. In all cases, personnel must be thoroughly instructed in the hazards, the precautions, the procedures of the operation, and the materials involved.

Where adequate pressure is available and time is not a factor, steam may be used for vapor freeing confined spaces. A steam nozzle, electrically bonded to the vessel or enclosure, is used to introduce low pressure near the bottom of the space, with a top port or access open. This method can be continued until the surface temperature of the vessel reaches about 1700 degrees Fahrenheit. Following steam, the vessel or space should be thoroughly flushed with water. The steam method should not be used for vapor freeing where the steam might damage valves, gaskets, controls, or safety devices.

In special situations and instances where entry into the confined space is not required or can be achieved with the use of self-contained breathing equipment, and there is a need for purging the space of flammable or other hazardous residue or vapors, one of the two following methods may be applied:

- Water may be used for direct displacement of vapors by filling the vessel or container and allowing the vapors to escape through openings to the top. The water should be allowed to overflow until no traces of flammable or toxic materials are detected. Depending on the necessary operations, the water may be left in the container or drained out. If the water is drained out, then tests must be conducted to ensure that residual vapors do not exist at a hazardous level.
- Similarly, inert gas (a gas that is not toxic and will not explode or burn easily) may be used for displacement of vapors. The inert gas is introduced into either the top or bottom of the confined space (depending on the relative specific gravities involved) and the vapor is expelled through the appropriate ports. The inert gas may be left in the space or removed as required. It is important to remember that the inert gas will also displace oxygen.

ACTIVITY 10:

(Choose the best answer.)

1. Combustible gas indicators must be:
   a. used only by trained persons.
   b. calibrated before using.
   c. used only before entering the confined space and not during operations.
   d. a and b.
   e. a, b, and c.
2. If flammable vapors are present where mechanical ventilation is to be employed, then these precautions must be taken:
   a. the fan must be approved electrically for the conditions.
   b. the fan must have nonferrous blades.
   c. the fan must be bonded to the container.
   d. a and b.
   e. a, b, and c.

OBJECTIVE 11: Discuss the requirements for using labels, posting signs, and using safety and personal protective equipment for work in confined spaces.

All labeling and posting should be according to standards. All warning signs must be printed both in English and in the predominant language of non-English reading workers. Where established symbols exist, they must also be used. Workers unable to read labels and posted signs shall receive information regarding hazardous areas and must be informed of the instructions printed on the signs.

All entrances to any confined space must be posted. Signs must include, but are not necessarily be limited to, the following information:

DANGER

CONFINED SPACE

ENTRY BY PERMIT ONLY

When a specific work practice is performed or specific safety equipment is necessary, statements to that effect must be added, in large letters, to the warning sign:

HOT WORK PERMITTED	RESPIRATOR REQUIRED FOR ENTRY	NO HOT WORK

Emergency procedures, including phone numbers of fire department and emergency medical services, must be posted conspicuously within the immediate area of the confined space, or at the telephone from which help would be summoned.

Personal protective equipment must be considered only as a last line of defense for employees against occupational injury or illness. Engineering controls must be utilized when feasible to eliminate hazardous exposures. Confined space cleaning, purging, and ventilation are required to provide a safe atmosphere. Frequently, additional safeguards are necessary to ensure employee safety. Unique problems often arise in utilizing such equipment in confined spaces. Such problems, along with the generally high degree of hazard inherent in work in confined spaces, mandates effective personal protective equipment policies.

Once a confined space has been tested and found clean, it should be continuously sampled during any work periods during which conditions change because of occupancy and work. In addition to manual sampling, there are automatic sampling devices that are set to warn if the oxygen goes below a certain level, the carbon monoxide content of the atmosphere reaches a hazardous levelor the LEL (lower explosive limit) of a gas is reached, or a preset level of other specific materials is reached. There are also badges that may be worn that change color when certain limits are reached. However, these should be viewed as additional protection and should not take the place of continued monitoring of the atmosphere by trained personnel. In one or another of the various types of confined spaces, it is likely that a worker will encounter a hazard that can and should be controlled, (on an immediate basis at least) by using any of the various items of face or body protection. In fact, virtually any piece of personal protective equipment may be needed according to the task and the hazard. Included are eye protectors, hard hats, gloves, coveralls or aprons, foot protectors, safety belts (harness, lifeline), ear protectors, and life jackets. Any entry permit devised by the employer should list all required protective equipment. Respirators may be required when entering a confined space because of toxic contaminants or oxygen deficiency. Although minimizing exposure to the worker, respirators are generally intended only for intermittent or emergency use. They constitute the "last resort" and should only be used when ventilation will not make the atmosphere safe. If respiratory protective equipment is relied on for confined space entry, the following pitfalls must be avoided:

1. The proper type may not be provided.
2. The employee may not wear it.
3. Respirators may not be properly cleaned and serviced.
4. Facepiece fit may be poor, permitting unfiltered air to enter.
5. Chemical cartridge respirators or gas masks may be worn without regard to the danger of oxygen deficiency.

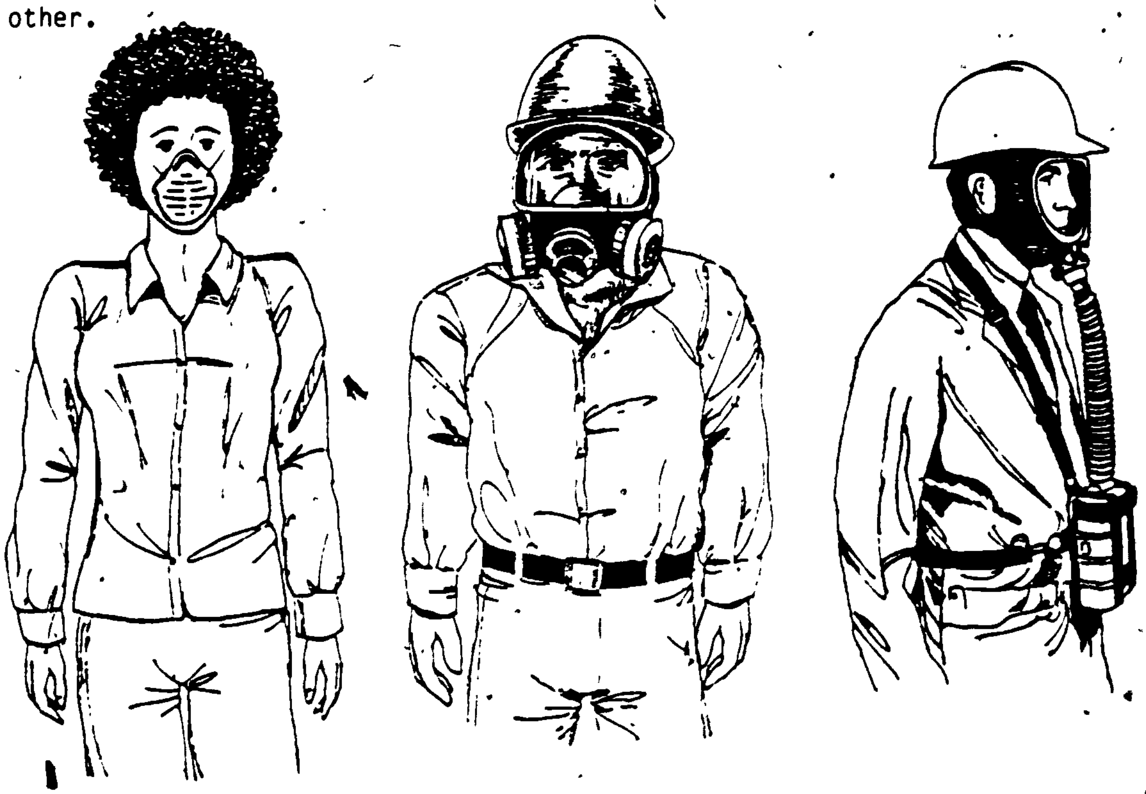
espiratory devices remove contaminants from the atmosphere and can be used only in atmospheres which are not oxygen deficient (less than 19.5 percent oxygen at sea level) and within specified concentration limitations (shown on cartridge or canister label). The useful life of an air purifying device is dependent upon the concentration of the contaminants, the breathing volume of the wearer, and the capacity of the air purifying medium.

There are three basic types of air purifying devices:

- Mechanical filter respirators (see Figure 4a) - These provide respiratory protection against particulate matter such as dusts, fumes, and mists. Selection of the appropriate respirator is based on the type, toxicity, and particulate size of the particulate matter.

- Chemical cartridge respirators (see Figure 4b) - These respirators provide protection against specified gases and vapors in concentrations not in excess of 0.1 percent (by volume). Where exposure is both gaseous and particulate, a combination chemical cartridge and mechanical cartridge and mechanical filter respirator may be used.
- Gas masks (Figure 4c) - These provide respiratory protection against certain specific gases and vapors in concentrations up to two percent volume (or as specified on the canister label) and against particulate matter.

Air-purifying devices can aid in the delivery of contaminant-free, nontoxic breathing air to the wearer's facepiece within the limits of each device. Only hose masks and/or self-contained breathing apparatus are suitable for use in atmospheres immediately dangerous to life (Class A). Specific conditions of use will usually prove one of these types more suitable over the other.



a. b. c.

Figure 4. Air-purifying devices.

The basic types of supplied air respirators are:

- Air line respirators (see Figure 5) - These respirators should be used only in atmospheres not immediately harmful to life or from which the wearer can escape without the use of the respirator. This limitation is necessary because the air supply is not carried by the wearer of the respirator.
- If a compressor is used for supplying air, suitable inline air purifying sorbent beds and filters must be installed to assure acceptable breathing air quality. If an oil lubricated compressor is used, it must have either a high temperature or carbon monoxide alarm, or both. If only a high temperature alarm is used, the air from the compressor must be frequently tested for carbon monoxide. It is also advisable to check the location of the compressor to ensure that other toxic substances are not picked up by the compressor and to ensure that other toxic substances are not picked up by the compressor's air intake.
- Hose masks - In these masks, outside air is supplied directly to the wearer. They are available either with or without blowers. Approved hose masks with blowers can be used in any atmosphere regardless of the degree of contamination or oxygen deficiency, providing clean, breathable air can be reached within the maximum allowable hose length (300 ft). Hose masks are not recommended for use in immediately dangerous atmospheres.
- Self-contained breathing apparatus (see Figure 6) - These provide complete respiratory protection in toxic atmospheres that are

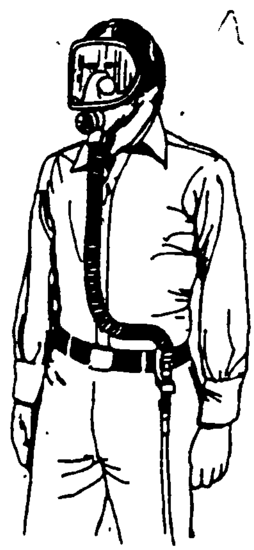


Figure 5. Air-line respirator.

Figure 6. Self-contained breathing apparatus.

life-threatening and where there is oxygen deficiency. The four basic types are: oxygen cylinder rebreathing, self-generating, demand, and pressure demand.

The minimum requirements for an effective respirator program are listed below:

- Written standard operating procedures governing the selection and use of respirators must be established and available for all concerned.
- Respirators must be selected on the basis of the hazards to which the worker could be exposed.
- The user must be instructed and trained in the proper use of respirators and their limitations.
- Where practicable, the respirators should be assigned to individual workers for their exclusive use.
- Respirators must be regularly cleaned and disinfected. Those issued for the exclusive use of one worker should be cleaned after each day's use or more often, if necesary.
- Respirators must be stored in a convenient, clean, and sanitary location.
- Respirators used routinely must be inspected during cleaning. Worn or deteriorated parts must be replaced. Respirators for emergency use, such as self-contained devices, must be thoroughly inspected at least once a month and after each use.
- Appropriate surveillance of work area conditions and degree of employee exposure or stress must be maintained.
- Regular inspections and evaluations must be made to determine the continued effectiveness of the program.
- Persons should not be assigned to tasks requiring the use of respirators unless it has been determined that they are physically able to perform the work and use the equipment. A physician must determine what health and physical conditions are pertinent. The respirator user's medical status should be reviewed periodically (for instance, annually).
- Approved or accepted respirators must be used. The respirator furnished must provide adequate respiratory protection against the particular hazard for which it is designed in accordance with standards established by competent authorities.

ACTIVITY 11:

(Fill in the blanks.)

1. Three basic types of air-purifying devices are:

   a. ______________________________

   b. ______________________________

   c. ______________________________

2. The best protection for atmospheres that are life threatening and where there is oxygen deficiency is ______________________________.

OBJECTIVE 12: Describe isolating, locking out and tagging Class A and B confined spaces.

The purpose of locking, tagging, and isolating is to prevent inadvertently activating electrical circuits; mechanical power transmission apparatus; conveyor systems; agitation systems; steam, vapor or liquid transfer systems; or any other operations or processes associated with the vessel or space whose operation may expose employees working within to hazardous conditions. Locking, tagging, and isolating is required in Class A and B confined space areas and is recommended for Class C confined space areas.

The type of equipment used in protecting a space or vessel will depend on the type of equipment that is being locked or isolated or the type of materials being secured or isolated. The following equipment is commonly used for protecting a space or vessel through locking, tagging, or isolating:

- Blanking flanges (with skillet blanks).
- Chains with padlocks.
- Padlocks.
- Lock-out boxes.
- Multiple lock hasps.
- Special keys and wrenches.
- Tags.

Different types of equipment are shown in Figure 7. Proper preparation, employee education, follow-up, and supervision are essential to any successful locking, tagging, and isolating program. Proper employee protection can be ensured only if all power sources and potential exposures from any hazardous materials or systems are positively eliminated.

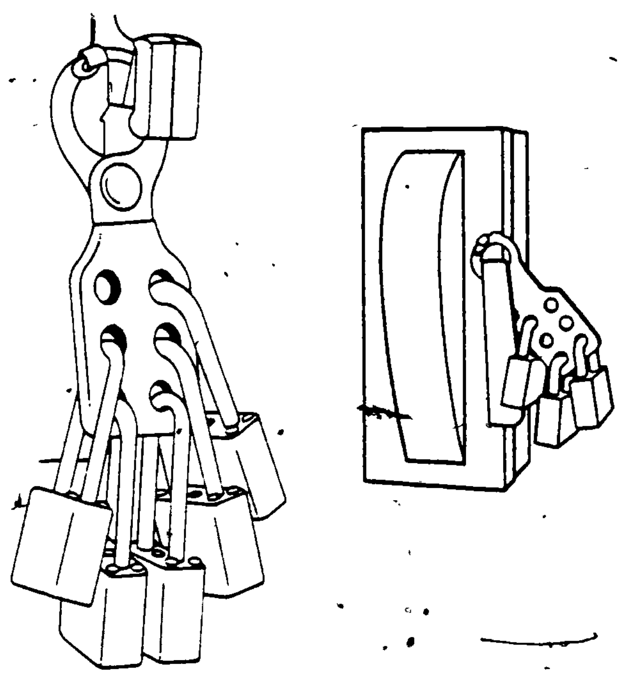


Figure 7. Lock-out devices.

Three basic phases of the system are lock, tag, and try. First, all the systems or equipment that could create a hazardous condition must be identified and positively eliminated through locking and isolation. All electrical apparatus must be shut off and locked in the off position. Mechanical power transmission apparatus and agitators must be mechanically disabled or locked to prevent operation. Valves must be closed and locked in the closed position. Additionally, the piping should be disconnected from the vessel and further disabled by installing blanking flanges or skillet blanks, especially in cases where misalignment is impractical.

Second, signs or tags should be posted stating that the device or system has been deactivated and warning against further use. A checklist and supervisory approval system (with a signed verification form) listing all tagged points is insurance that all systems have been locked-out and isolated.

The final phase involves "trying" activators (buffers, switches, etc.) to verify complete deactivation. Thus, before any employees enter a space or vessel, the start buttons, valves, and other actuating devices should be tried to ensure that they are disabled.

Before removing any locks, tags, and isolation devices, employees and supervisors must verify that the equipment or system locked-out is safe to operate. This is primarily a supervisory responsibility utilizing check lists and verification forms. Assurance of the following conditions is mandatory:

- All personnel are clear of hazardous equipment and spaces.
- All guards are installed.
- All previously exposed electrical wiring and equipment are properly covered.
- All piping systems and open pipes are closed and properly connected.
- All agitators and similar devices are free of loose, unsecured objects.

Lock-out procedures are effective only when religiously followed by both management and employee. The program must be enforced through constant monitoring and strict adherence to the prescribed procedures.

ACTIVITY 12:

List the three basic phases of any lock-out system.

1. ______________________________
2. ______________________________
3. ______________________________

OBJECTIVE 13: List the cleaning and housekeeping procedures for confined spaces.

Cleaning and housekeeping are important in any confined space. Procedures and processes used to clean the inside of a confined space must be reviewed and authorized by the qualified person. The prescribed method is dependent upon the product that is present or that has been present in the space. If the confined space contains a flammable atmosphere above the upper flammable limit, it must be purged with an inert gas to remove the flammable substance before ventilating with air. Initial cleaning must be done from outside the tank if at all possible.

Special procedures should be adopted to handle the hazards created by the cleaning process itself. For example, if the tank is steamed, (1) it must be allowed to cool prior to entry; (2) ventilation must be maintained during neutralization procedures to prevent build-up of toxic materials; (3) steaming must not be used as a cleaning method when the product stored was a liquid with an auto-ignition temperature of 120% or less of the steam temperature, and (4) the pipe or nozzle of the steam hose must be bonded to the tank to decrease the generation of static electricity that could accumulate in tanks during steaming procedures. These and other hazards and controls must be evaluated by the qualified person in charge.

ACTIVITY 13:

(Circle True or False.)

1. The cleaning process creates no hazards itself.

   True False

2. A steamed tank must be allowed to cool prior to entry.

   True False

OBJECTIVE 14: Describe the equipment and tools used in Class A, B, and C confined working areas.

Equipment and tools to be used in a confined space must be carefully inspected and must meet the following requirements:

- Hand tools must be kept clean and in good repair.
- Portable electric tools, equipment, and lighting must be approved in accordance with 29 CFR Part 1910 Subpart S and be equipped with a ground fault circuit interrupter that meets the requirements of 29 CFR 1910.304. All grounds must be checked before electrical equipment is used in a confined space.
- All electrical cords, tools, and equipment must be of heavy duty type with heavy duty insulation, and they must be inspected for visually detectable defects before use in a confined space.
- Air driven power tools must be used when flammable liquids are present. The use of air driven power tools will reduce the risk of explosion, not eliminate it. Explosions can be caused by tools overheating (drilling), sparks produced by striking (percussion), grinding or discharge of accumulated electrostatic charges developed from the flow of compressed air.
- Lighting used in Class A and B confined spaces must be of explosion proof design and, where necessary, equipped with guards. Only equipment listed by the Underwriters Laboratories for use in Division 1, atmospheres of the appropriate class and group, or approved by U.S. Bureau of Mines should be used. Lighting must not be hung by electric cords unless the cords are specifically designed for that purpose. The illumination of the work area must be sufficient to provide for safe work conditions as referenced in the ANSI standard A11.1-1965, or the revision, 1970. Under no circumstances should matches or open flames be used in a confined space for illumination.
- Cylinders of compressed gases must never be taken into a confined space; they must be turned off at the cylinder valve when not in use. Exempt from this rule are cylinders that are part of self-contained breathing apparatus or resuscitation equipment.
- Ladders must be adequately secured or be of a permanent type which provides the same degree of safety as cited in 29 CFR Part 1910 Subpart D.
- Scaffolding and staging must be properly designed to carry the maximum expected load (safety factor of 4), be equipped with traction type planking, and meet the requirements of 29 CFR 1910.28.

- Electrical lines and junctions must be in accordance with National Electrical Code (NEC) and National Fire Code (NFC) as cited in the OSHA regulations, Subpart S.
- Only hose lines and components designed specially for compressed gas and its working pressure can be used, and such systems must have a pressure relief valve outside the confined space.
- All equipment that may be used in a flammable atmosphere must be approved as explosion proof or intrinsically safe for the atmosphere involved. Approval must be by a recognized testing laboratory such as the U.S. Bureau of Mines or MSHA for methane and by the Underwriters Laboratories or by Factory Mutual.

ACTIVITY 14:

Lighting used in Class A and B confined spaces must be:

a. of explosion proof design.

b. listed by Underwriters Lab for use in Division 1 atmospheres or approved by other listed governmental agencies for such use.

c. provide illumination sufficient to provide for safe work conditions as described in ANSI standard A11. 1-1965 or revisions.

d. All of the above.

OBJECTIVE 15: State the special precautions to be taken when working in confined spaces with hazardous atmospheres.

Table 4 provides a checklist of considerations to be reviewed when one is preparing to work in confined spaces.

TABLE 4. CHECKLIST OF CONSIDERATIONS FOR ENTRY, WORKING IN, AND EXITING FROM CONFINED SPACES.

	Item	Class A	Class B	Class C
1.	Permit	X	X	X
2.	Atmospheric testing	X	X	X
3.	Monitoring	X	0	0
4.	Medical surveillance	X	X	0
5.	Training of personnel	X	X	X
6.	Labeling and posting	X	X	X
7.	Preparation			
	Isolate/lockout/tag	X	X	X
	Purge and ventilate	X	X	0
	Cleaning processes	0	0	0
	Requirements for special equipment/tools	X	X	0
8.	Procedures			
	Initial plan	X	X	X
	Standby	X	X	0
	Communications/observation	X	X	X
	Rescue	X	X	X
	Work	X	X	X
9.	Safety equipment and clothing			
	Head protection	0	0	0
	Hearing protection	0	0	0
	Hand protection	0	0	0
	Foot protection	0	0	0
	Body protection	0	0	0
	Respiratory protection	0	0	0
	Safety belts	X	X	
	Life lines, harnesses	X	X	X
10.	Rescue equipment	X	X	X
11.	Recordkeeping/exposure	X	X	

"X" – indicates requirement.

"0" – indicates determination by the qualified person.

ACTIVITY 15:

When working in hazardous atmospheres in confined spaces, which of the following are required?

a. Signed permit.
b. Atmospheric testing and monitoring.
c. Medical surveillance.
d. Labeling and posting.
e. Special preparation and posting.
f. Special personnel training.
g. Safety equipment, clothing, and rescue equipment.
h. Recordkeeping of exposures.
i. a through g of the above.
j. All of the above.

OBJECTIVE 16: Describe the types of records that must be kept for Class A and B confined space working areas.

Certain records that relate to Class A and B space must be kept by the employer. The employer must maintain a written record of training including safety drills, inspections, tests, and maintenance. The records must be retained one year after the last date of training, inspection, test, or maintenance. In the event of separation of the employee or disposal of equipment or appliance, records may be disposed of after one year.

Where atmospheric testing indicates the presence of a toxic substance, records must be maintained in accordance with the existing federal regulation(s). These records must include the dates and time of measurements, duties and location of the employees within the confined space, sampling and analytical methods used, number, duration, and results of the samples taken, PEL (Permissible Exposure Level as prescribed by OSHA) concentrations estimated from these samples, type of personal protective equipment used, (see Figure 8) if any, and employees' names. These records must be made available to the designated representatives of the Secretary of Labor, of the

Secretary of the Department of Health and Human Resources, of the employer, and of the employee or former employee.

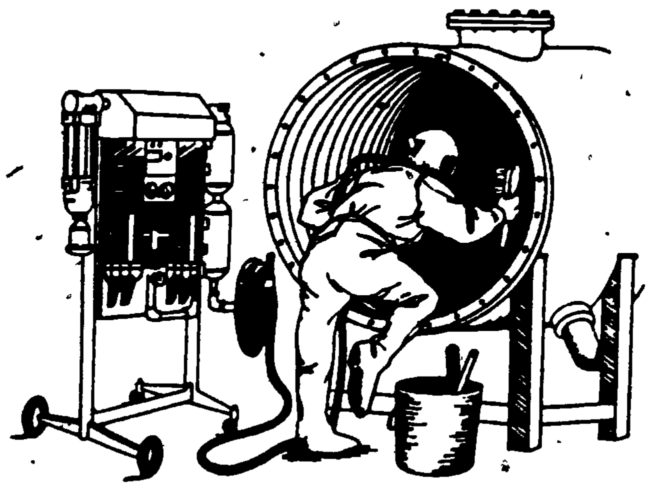


Figure 8. Records must be kept of what kind of protective clothing employees wear in Class A and B spaces.

ACTIVITY 16:

Which of the following records that relate to working in Class A and B confined spaces are not required?

a. Safety ~~drills~~, inspections, tests, maintenance, and other training.

b. Atmospheric testing and monitoring, personal protective equipment used.

c. Payroll records of hazardous pay.

d. Additional records required by this and other governmental regulations.

OBJECTIVE 17: Explain the preparation steps that must be performed on boilers before entry is made.

Toxic materials found in boilers vary depending on the fuel used in the operation of the boiler and the problems encountered. Some common hazards that can be encountered are carbon monoxide, hydrogen sulfide, methane, coal tars, etc. The boiler must be considered a confined space and the atmosphere properly vented and tested before a permit is issued and entry permitted.

As in all confined spaces, the lack of oxygen is an ever present threat, and breathing equipment must be provided: self-contained, air line respirators, or continued ventilation. As in any confined space, the air should be continuously monitored to assure that a correct level of oxygen is present.

All boilers should be cooled to below 100°F before entry is considered.

- The possibility of fire should be minimized by proper ventilation and where necessary, advanced cleaning should be completed prior to entry.
- There should be no hot gases or liquids present as proper forced ventilation and cooling plus draining of the system should be completed before issue of an entry permit or entry is made.
- Inadvertent heating of the vessel should be made impossible by lock-outs of equipment and blanking off of fuel lines prior to entry.

Agitation mechanisms must be locked-out and, if possible, disconnected prior to entry.

Precautions prior to entry into a boiler once it is cooled should be the same as entry into any confined space, including all of the essentials discussed previously such as training, using personal protective gear, testing, monitoring, checklists, etc., but in addition, special attention should be given to the following points:

- All tanks and tubes should be drained, and where appropriate, purged.
- Forced ventilation or an adequate natural ventilation must be carried out to purge the atmosphere and continued to maintain proper oxygen levels.
- Where necessary, the boiler or pressure vessel should be cleaned to remove potential harmful deposits.
- As outlined in the confined spaces requirement for issue of an entry permit, all pipe lines leading into or out of the boiler or vessel must be disconnected and blocked to avoid the possibility of any accidental entry into the boiler or vessel of any gas, liquid, or fuel.
- To avoid the possibility of any power driven equipment being energized, such equipment must be locked out and disconnected.

- Testing of the atmosphere in the confined space (boiler or pressure vessel) for flammable or toxic gases and proper oxygen levels prior to entry is a must as is continued monitoring to assure a continued safe atmosphere.

When the foregoing six points and all of the other requirements for issuing an entry permit are met, then it should be issued and signed by the authorized supervisor, the second level supervisor, and all employees who are assigned to the crew.

ACTIVITY 17:

Which of the following preparation steps may not be needed before entry into a boiler.

a. Isolation/tagout/lockout.

b. Purging and ventilation.

c. Cleaning from the outside.

d. Special equipment/tools.

REFERENCES

National Insitute for Occupational Safety and Health. Criteria for a Recommended Standard: Working in Confined Spaces. (NIOSH Publication Numer: 80-106).

National Safety Council. Accident Prevention Manual for Industrial Operators. 7th ed. Chicago: National Safety Council, 1978.

ANSWERS TO ACTIVITIES

ACTIVITY 1

False.

ACTIVITY 2

1. c. 19.5%.
2. d. Ringing in the ears and labored breathing.

ACTIVITY 3

1. Olfactory fatigue.
2. Concentration or amount.

ACTIVITY 4

1. a. Cleaning.
   b. Purging.
2. a. Lower Explosive Limit.
   b. Upper Explosive Limit.

ACTIVITY 5

(Any seven of these nine.)

1. Mechanical.
2. Communication.
3. Entry and exit.
4. Thermal effects.
5. Noise.
6. Vibration.
7. Saffolding.
8. Surface residues.
9. Rescue procedures.

ACTIVITY 6

Class A.

ACTIVITY 7

d. All of the above.

ACTIVITY 8

False.

ACTIVITY 9

(any six of these eleven.)

1. Types of confined spaces.
2. Physical and chemical hazards.
3. Atmospheric testing.
4. Cleaning and purging.

5. Ventilation.
6. Isolation and lock out.
7. Safety equipment and clothing.
8. Buddy system.
9. Communication.
10. Permit system.
11. Rescue procedures.

ACTIVITY 10

1. d. a and b.
2. e. a, b, and c.

ACTIVITY 11

1. a. Mechanical filter respirators.
   b. Chemical cartridge respirators.
   c. Gas masks.
2. Self-contained breathing apparatus.

ACTIVITY 12

1. Lock.
2. Tag.
3. Try.

ACTIVITY 13

1. False.
2. True.

ACTIVITY 14

d. Listed by Underwriters Lab for use in Division 1 atmospheres or approved by other listed governmental agencies.

ACTIVITY 15

j. All of the above.

ACTIVITY 16

a. Safety drills, inspections, tests, maintenance, and other training.

c. Payroll records of hazardous pay.

ACTIVITY 17

c. Cleaning from the outside.

NA