Permit-Required Confined Space Entry

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Section

PREFACE

PERMIT-REQUIRED CONFINED SPACE ENTRY

Title

HOW TO USE THIS MANUAL

MANUAL OBJECTIVE

The *Permit-Required Confined Space Entry* manual presents training information and other important aspects of what you, as a Laborer, must know to work safely in a permit-required confined space. It will instruct you in:

- Types of confined spaces.
- Health effects and hazards associated with working in confined spaces.
- Safe work practices.
- OSHA regulations 29 CFR 1910.146 (Permit-required confined spaces) and 29 CFR 1910.147 (Control of hazardous energy).

HOW TO USE THIS MANUAL

Each **Section** of the manual covers a major component of working in permit-required confined spaces. Concepts you will learn in each section are listed at the beginning as **Trainee Objectives**. At the end of each section, you will be expected to complete an **Assignment Sheet**.

The **Regulations** section at the back of the manual has copies of the OSHA standards relating to confined spaces for both General Industry and Construction. Besides the standards mentioned above, you will find 29 CFR 1926.21, 29 CFR 1926.352, and 29 CFR 1926.353. Words and acronyms that are italicized in the text are found in the **Glossary** with their definitions.

THANK YOU

Thank you for placing your trust in Laborers-AGC training manuals. We believe this manual will instruct you in the most significant, useful, and up-to-date technical information and safety aspects of your job.

ACKNOWLEDGEMENTS

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INTRODUCTION TO CONFINED SPACES

TRAINEE OBJECTIVES

After completing Section 1, you will be able to:

1. Define a confined space, giving three characteristics.

2. Identify two categories of confined spaces and give examples of each.

3. Identify two factors that lead to fatal injuries in confined spaces.

4. Describe the four characteristics of a permit-required confined space.

INTRODUCTION

The Occupational Safety and Health Administration (*OSHA*) established regulations governing confined spaces in the Permit-Required Confined Space Standard 29 CFR 1910.146. This standard defines a confined space as any area with the following characteristics:

- Adequate size and shape to allow a person to enter
- Limited openings for workers to enter and exit
- Not designed for continuous human occupancy

Confined spaces are found in many different settings, such as steel mills, paper mills, shipyards, farms, public utilities, and the construction industry.

OSHA also addresses confined spaces in construction standards under 1926.21, 1926.352, and 1926.353. This manual focuses on the 1910.146 standard because it is much more protective of worker health and safety. It should be noted that 1910.146 does not apply to confined space entries during new construction work. However, OSHA has stated that the standard does apply to demolition, remodeling, and renovation during construction.

TYPES OF CONFINED SPACES

Because confined spaces are found in many different settings, they come in a wide variety of sizes and shapes (Figure 1-1). To help classify the different types of confined spaces, they are divided into two categories:

1. Open-topped enclosures with depths that restrict the natural movement of air. Examples include:

- Degreasers
- Pits
- Excavations

2. Enclosures with limited openings for entry and exit. Examples include:

- Sewers
- Tanks
- Silos

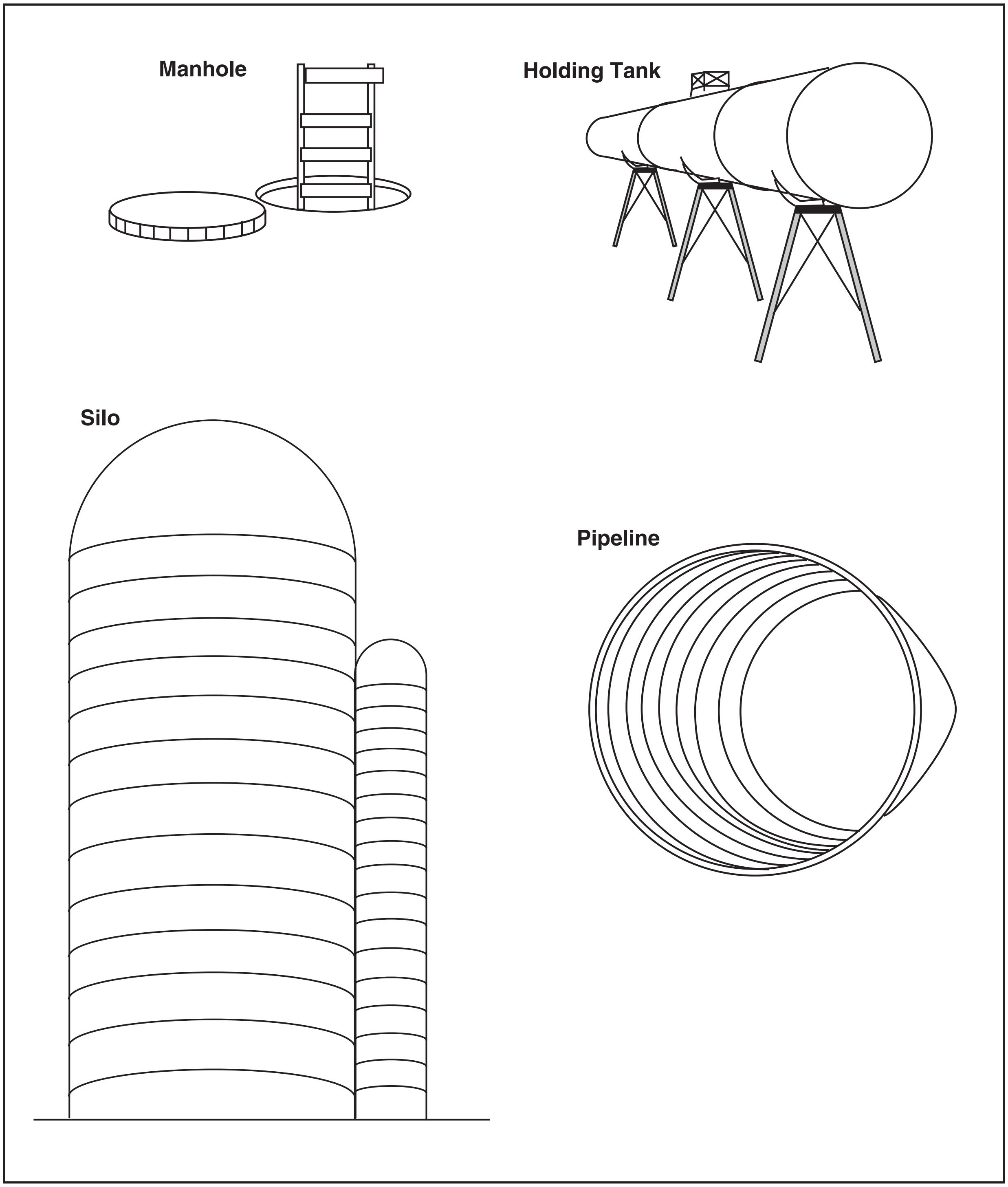

Figure 1-1. Common types of confined spaces.

HAZARDS OF CONFINED SPACE ENTRY

OSHA enacted the 1910.146 standard in 1993. In that year, statistics indicated that more than 5,000 workers received serious injuries while working in confined spaces. Additionally, more than 300 workers died annually.

A more recent study from the Bureau of Labor Statistics (*BLS*) indicates an improvement in these figures. The Census of Fatal Occupational Injuries reported 330 deaths over the five-year period 1993–1997.

The fact is that working in a confined space can be extremely dangerous. An understanding of the hazards in confined spaces is the first step in recognizing their dangers and keeping yourself safe.

There are two major factors that lead to fatal injuries in confined spaces:

1. Failure to recognize and control the hazards associated with confined spaces, such as:

- Asphyxiation
- Electrical shock
- Engulfment
- Falls
- Heat stress

2. Inadequate or incorrect emergency response. Multiple deaths can occur when workers react to an emergency situation, rather than follow an established emergency response plan.

Entry into a confined space occurs when any part of your body breaks the plane of the opening. This would include putting your head inside just to look around.

PERMIT-REQUIRED CONFINED SPACE

Workers are protected from the hazards associated with confined space entry operations by OSHA's Permit-required Confined Space Entry Standard. It requires employers to evaluate the workplace and determine if any spaces must be entered and whether they are *permit-required confined spaces*.

OSHA defines a permit-required confined space to have one or more of the following characteristics:

- Contains, or has the potential to contain, a hazardous atmosphere. This atmosphere can arise from chemicals that have been stored in the space or from activities that are taking place in the space. Such activities include welding, cutting, or using solvents to clean the space.

- Contains a material that has the potential for engulfing the *entrant* (a worker entering the confined space). These materials may be granular (grains or sands), liquids, or sludges.

- Its internal structure is such that an entrant could be trapped or asphyxiated by inwardly converging walls, or by a floor that slopes downward to a smaller cross-section. An example is a grain bin in which the space is shaped like a funnel.

- Contains moving or electrical parts or any other recognized hazard.

Any space that is not classified as a confined space or a permit-required confined space should not be entered until it is classified. Do not assume that a space is safe to enter just because it is not marked.

SECTION 1 - ASSIGNMENT SHEET

1. Define a confined space, giving three characteristics.

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2. Identify two categories of confined spaces and give examples of each.

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3. Identify two factors that lead to fatal injuries in confined spaces.

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4. Describe the four characteristics of a permit-required confined space.

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PERMIT-REQUIRED CONFINED SPACE ENTRY

Section

2

Title

HAZARD RECOGNITION

TRAINEE OBJECTIVES

After completing Section 2, you will be able to:

1. Define and describe the three types of atmospheric hazards found in confined spaces.

2. List the five forms of airborne contaminants.

3. Define exposure guides and list the two most commonly used guides and the organizations that establish them.

4. Describe the six types of physical hazards found in confined spaces.

INTRODUCTION

Construction work of any type can be dangerous. In response, the typical Construction Craft Laborer (*CCL*) develops an ability for spotting hazards on the job. This skill is developed through experience, training, and sharing stories with co-workers.

A *hazard* is defined as any condition, situation, or agent that has the potential to produce an undesirable effect. Workers face a different set of hazards in confined spaces than they would normally see on a construction site. Often, they must deal with situations about which little is known. In addition, wearing *personal protective equipment* (*PPE*) can increase the potential for accidents by:

- Narrowing the field of vision and clarity
- Reducing communication and hearing capabilities
- Increasing heat stress
- Reducing dexterity

Because you are subject to factors in a confined space that reduce your reaction time, you must be able to recognize hazards before they cause injury, illness, or death.

HAZARDOUS ATMOSPHERES

Hazardous atmospheres cause the most deaths and injuries in confined spaces. OSHA divides hazardous atmospheres into three categories:

1. Oxygen-deficient and oxygen-enriched
2. Flammable and explosive
3. Toxic

Oxygen-Deficient and Oxygen-Enriched Atmospheres

The oxygen content of normal breathing air is about 21 percent oxygen by volume. As defined by OSHA, an *oxygen-deficient atmosphere* has an oxygen level below 19.5 percent by volume. An atmosphere containing more than 23.5 percent oxygen is classified as an *oxygen-enriched atmosphere*.

An oxygen-enriched atmosphere presents a serious fire hazard. The high level of oxygen causes flammable and combustible materials to burn more violently and rapidly when ignited.

Oxygen deficient atmospheres are dangerous because asphyxiation can occur when the oxygen content drops low enough. Asphyxiation results in unconsciousness and death. Before these states are reached, physiological effects occur, such as faulty judgement and poor coordination.

Oxygen deficiency is caused by the following:

- Oxygen consumption –
- Oxygen displacement – Other gases push out the breathable air, which includes oxygen.

Oxygen Consumption

Oxygen consumption is the result of chemical reactions or biological processes that use oxygen. A fire is a chemical reaction that uses oxygen. Work such as welding, cutting, or brazing uses up the oxygen in a confined space. A slower form of oxygen consumption is rusting. Rusting, also referred to as oxidation, is a chemical reaction between iron and the oxygen in the air.

Another example of oxygen consumption involves bacteria. Bacteria are living organisms that need oxygen to live. They cause organic matter to decompose (rot). Garbage dumps, landfills, or swampy areas are all places where decomposition occurs. Excavations and manholes near these areas may have low oxygen levels due to the activity of bacteria.

Oxygen Displacement

Oxygen displacement occurs when a gas is introduced into an area, such as a confined space, and pushes the oxygen out to make room for itself. For example, hydrogen sulfide can accumulate in the bottom of manholes or trenches, and will displace oxygen unless a supply of fresh air is introduced.

A *simple asphyxiating atmosphere* is an atmosphere that contains a gas or gases that are nonreactive and nontoxic to the body. However, in sufficient quantity, these gases will displace the oxygen in an area. If enough oxygen is displaced, the atmosphere will not support life. For example, normal breathing air contains about 78 percent nitrogen. No one is harmed by breathing it. But an atmosphere containing 100 percent nitrogen will kill anyone breathing it because no oxygen is present.

Flammable and Explosive Atmospheres

Understanding flammability begins with an understanding of combustion or fire. Fire requires three elements—fuel, oxygen, and heat. If any one of the three elements is removed or missing, a fire is not possible. For example, water puts out a fire by removing the heat, while a fire blanket smothers a fire by removing the oxygen. The fire triangle is used to show the relationship between these elements (Figure 2-1).

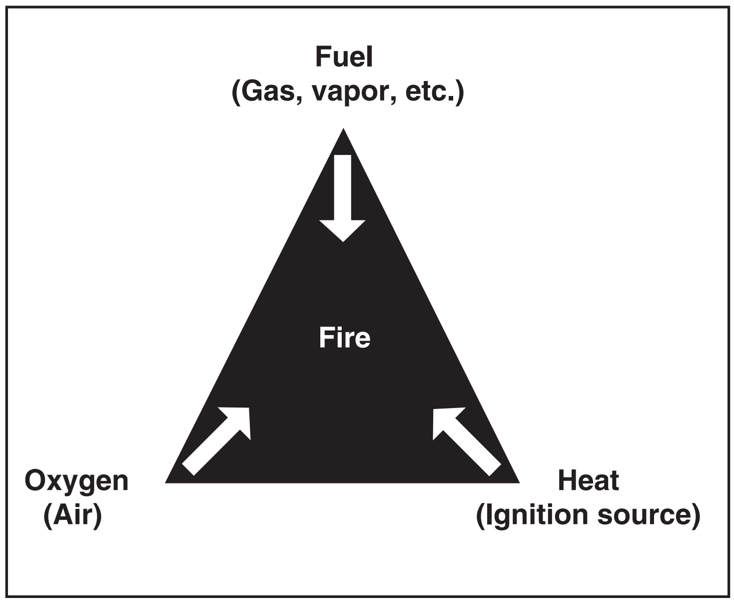


Figure 2-1. Fuel, oxygen and heat must all be present for fire to occur.

In a *flammable* or *explosive atmosphere*, the fuel is the vapors, gases, aerosols, or dusts in the air. The concentration of these vapors, gases, etc., determines whether or not the atmosphere can support combustion. The lowest concentration that can support combustion is called the lower flammable limit (*LFL*). Vapor concentrations lower than the LFL do not contain enough fuel to burn and are said to be too lean. The upper flammable limit (*UFL*) is the highest concentration of vapors that can support a fire. Levels above the UFL are said to be too rich. The fuel displaces the amount of oxygen needed to support a fire.

The concentrations between the LFL and the UFL make up the *flammable range* (Figure 2-2). This range is the concentration of fuel vapor necessary to become flammable in the presence of oxygen and an ignition source.

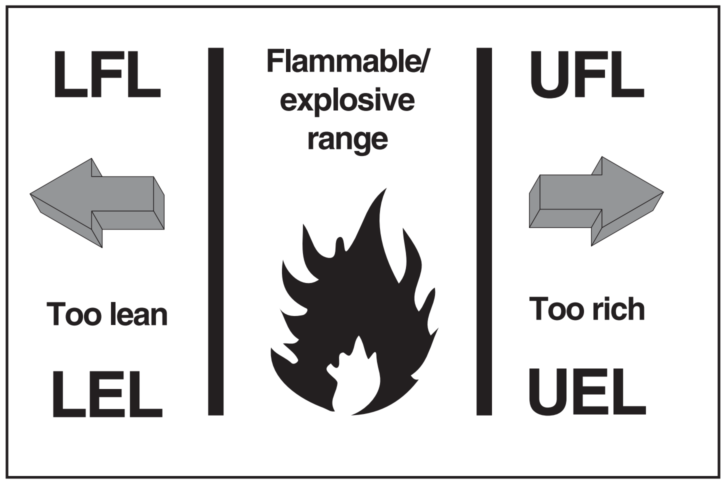


Figure 2-2 Flammable and explosive range.

Explosive range is the same as flammable range. The lower explosive limit (*LEL*) is the same as the LFL, and the upper explosive limit (*UEL*) is the same as the UFL. The difference between the two ranges is that:

- Flammable range refers to materials ignited in open areas.
- Explosive range refers to materials ignited in enclosed areas such as confined spaces.

A flammable material burns in an open area, but it explodes in a confined space. The explosion occurs because energy (heat) is trapped in a confined space and builds up. The buildup goes on until the energy is released suddenly in an explosion.

In a confined space, an atmosphere is considered flammable or explosive when its vapor concentration is greater than 10 percent of the LFL/LEL.

Note: When the vapor concentration is above the UEL in a confined space, and ventilation is started to bring the concentration down, at some point the atmosphere will become flammable/explosive. This is because the ventilation is introducing fresh air into the atmosphere. Eventually it will reduce the vapor concentration below the UEL and into the flammable/ explosive range. Then as the space continues to be ventilated, the vapor concentration will be diluted to the point that it is below the LEL. In these instances, the ventilation equipment must be spark proof to prevent igniting the atmosphere.

Toxic Atmospheres

Toxic atmospheres are characterized by the presence of chemical or biological agents that cause adverse health effects. OSHA defines a toxic atmosphere as any atmosphere having a chemical or biological agent in excess of its *permissible exposure limit* (*PEL*). Chemical agents can be solids, liquids, or gases, and affect specific organs or areas of the body. Toxic materials are of greater concern when they are in the gaseous state because they can be inhaled.

Toxic gases come from several sources:

- Biological or chemical processes occurring inside the confined space. For example, decomposing organic material can create hydrogen sulfide, which can be a deadly gas.

- Work activities performed in the confined space. For example, welding releases nitrogen oxides, ozone, and carbon monoxide.

Some toxic gases are particularly dangerous because they have either poor warning properties or no warning properties at all. For example, carbon monoxide gas is both colorless and odorless, and does not irritate the nose, eyes, throat, or lungs.

EXPOSURE GUIDES

Exposure guides are used to inform workers about exposure limits, and to make decisions about protecting workers from exposures to airborne contaminants.

When both the identity of a contaminant and its airborne concentration are known, specific exposure guides can be applied. The two most common exposure guides used for worker protection are:

1. Permissible exposure limit – Set by OSHA.

2. Threshold limit value – Set by the American Conference of Governmental Industrial Hygienists (*ACGIH*).

Permissible Exposure Limits

Permissible exposure limits (*PEL*s) are legal requirements for airborne concentrations of regulated substances. They set limits on a worker's inhalation exposure, or the amount of substance a worker can safely breathe without suffering adverse effects.

PELs are set by OSHA and are the only legally enforceable limits. This means that by law, employers must keep a worker's exposure below the PEL. PELs are meant to offer the minimum levels of protection—more protective limits are always allowed.

There are three ways to represent PELs:

1. Time weighted average
2. Short-term exposure limit
3. Ceiling limit

Time Weighted Average

Time weighted average (*TWA*) is the average concentration of a substance in an area over an 8-hour work shift of a 40-hour work week. To determine a TWA, exposure levels are collected over a work shift. The exposure levels are averaged out for 8 hours and the results compared with OSHA's PEL lists.

Short-Term Exposure Limits

Short-term exposure limits (*STELs*) are the maximum concentration levels that workers can be exposed to for a short period of time (usually 10 to 15 minutes) without suffering from adverse health effects. These health effects include:

- Irritation
- Chronic or irreversible tissue damage
- Dizziness sufficient to increase the risk of accidents, impair self-rescue, or reduce worker efficiency

STELs should **not** occur more than four times per shift, and there should be at least 60 minutes between exposures. The daily TWA PEL must not be exceeded.

Ceiling Limits

Ceiling limit (*c*) is an exposure level that should **never** be exceeded. However, not all chemicals have assigned ceiling values. If a ceiling limit is not assigned to a substance or chemical, it is generally recommended that exposures never exceed five times the PEL.

Threshold Limit Values

Threshold limit values (*TLV*s) are set by the ACGIH. They are based on the best available information from industrial experience, experimental human studies, and animal studies. The basis on which the values are established may differ from chemical to chemical. TLVs are only advisory and are not legally enforceable. A revised list of TLVs is published each year, which makes them more current than PELs.

Immediately Dangerous to Life and Health Atmosphere

Immediately dangerous to life or health (IDLH) values are set by the National Institute of Occupational Safety and Health (NIOSH). IDLH values identify an exposure level in an environment that is likely to cause death or serious health effects with very brief exposures.

OSHA defines an IDLH atmosphere as an atmosphere that:

- Poses an immediate threat to life
- Would cause irreversible adverse health effects
- Would impair an individual's ability to escape from a dangerous atmosphere

PHYSICAL HAZARDS

Confined spaces can contain physical hazards associated with the following situations or conditions:

- Engulfment
- Temperature extremes
- Noise
- Mechanical, electrical, and hydraulic systems
- Falling objects
- Wet or slick surfaces

Engulfment

Engulfment in loose materials or liquid is one of the leading causes of death from physical hazards in confined spaces. Engulfment and suffocation are hazards associated with storage tanks, bins, silos, hoppers, and sewage treatment plants. These spaces store, handle, or transfer liquids, grains, sand, gravel, or other loose materials.

The movement of such material is unpredictable. Workers can be trapped and buried or drowned in a matter of seconds. When a storage bin is emptied from the bottom, the flow of materials forms a funnel-shaped path over the outlet. As the material empties, it can cause the top surface to act like quicksand, causing unsuspecting workers on the top to be drawn into the material. During a normal unloading operation, the flow rate can be so great that once a worker is drawn into the flow path, escape is virtually impossible.

A condition known as *bridging* can create additional hazardous situations. Bridging occurs when grain, or a similar loose material, clings to the sides of a container or vessel that is being emptied from below. A hollow space is created with a covering of material over it. This bridge of material over the hollow space is unstable and can collapse without warning. Workers standing below or on top of the bridge can become trapped (Figure 2-3).

Bridging can occur in storage bins, silos, and hoppers where dry materials such as grain or cement are stored. It occurs more readily when the diameter of the storage vessel is small and the moisture content of the stored material is high or there is high humidity.

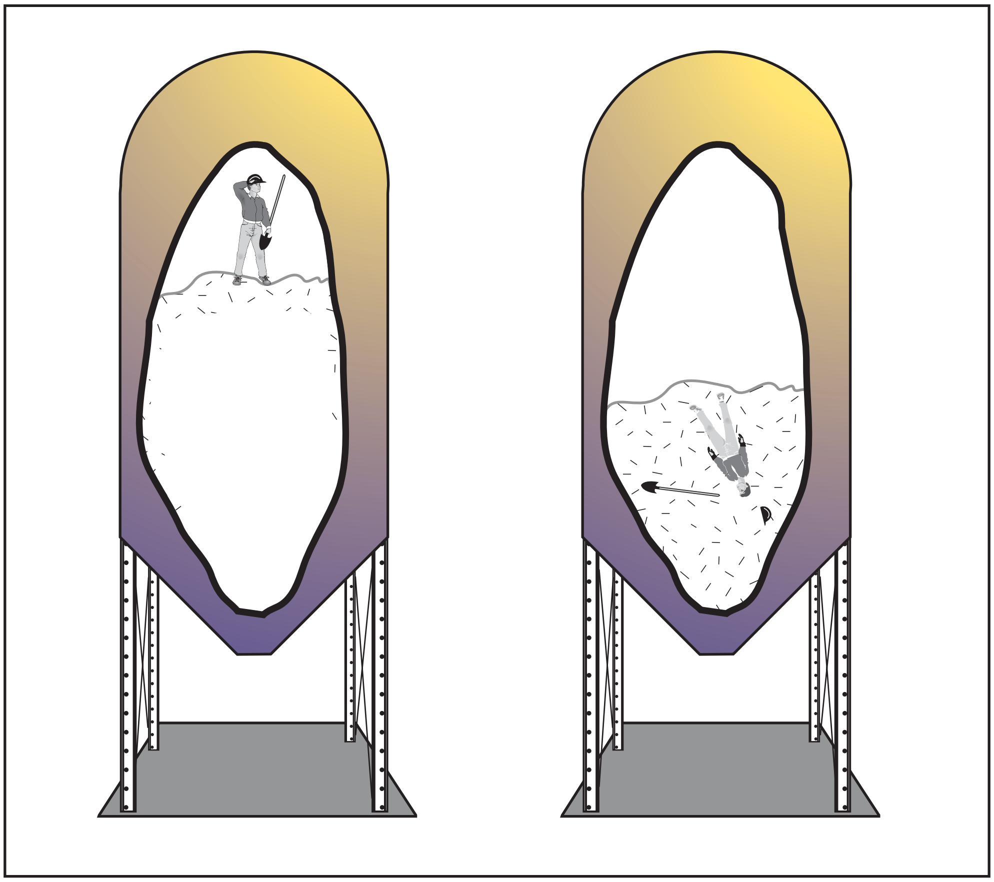


Figure 2-3. When bridging occurs, a hollow space is created under a layer of material.

Temperature Extremes

Extreme temperatures within a confined space can affect the health of workers and their ability to safely perform their tasks. Knowing the signs and symptoms of heat stress and cold stress can help workers prevent injury.

Noise

When working in a confined space, noise can be amplified and cause damage to the ear. It also can affect the health and safety of workers by inhibiting communication.

Noise becomes a hazard when it results in any of the following conditions:

- A temporary or permanent hearing loss
- A physical or mental disturbance
- Any interference with necessary sounds such as voice communication, warnings, or alarms
- The disruption of a job or task

Mechanical, Electrical, and Hydraulic Systems

During confined space work, it may be difficult to separate a worker from hazardous forms of energy, such as powered machinery, electrical energy, and/or hydraulic or pneumatic lines. Activation of electrical or mechanical equipment can cause injury or death to workers in a confined space. Another concern with mechanical or hydraulic systems is the release of material through the lines. A release of material can engulf or drown workers. Control of hazardous energy procedures prevent sudden releases of energy that can harm workers in a confined space.

Falling Objects

Falling objects are a potential hazard in confined spaces, such as when a confined space has a topside opening or work is performed at a height. Tools and other objects may fall and strike a worker.

Wet/Slick Surfaces

Wet or slick surfaces create slipping and tripping hazards. In addition, wet surfaces can provide a grounding path and increase the possibility of electrocution.

ACCIDENTS

An *accident* is an undesirable, unplanned event resulting in physical harm, damage to property, or interruption of business. An accident can result from an unsafe act, such as lighting a match in a flammable atmosphere. An accident may also result from an unsafe condition such as a toxic atmosphere. Situations can be related, since one worker's unsafe act can result in an unsafe condition for another.

Preventing Accidents

The two main approaches to reducing or preventing accidents are eliminating unsafe conditions and reducing unsafe acts.

Eliminate Unsafe Conditions

Workers must be aware of conditions that can contribute to accidents and then act to prevent exposure to these conditions. Examples of prevention are isolating and locking out live electrical circuits or ventilating atmospheres with fresh air. Although eliminating unsafe conditions is the best approach, it is difficult to eliminate all unsafe conditions. It is even more difficult to predict or anticipate where such conditions may exist or develop.

Reduce Unsafe Acts

Each worker must make a conscious effort to work safely despite the hazardous conditions that may exist at any site. A high level of safety awareness must be maintained so that the principles of safety involved in a job become part of the job.

STAYING SAFE

Staying safe is the responsibility of both workers and their employer. When workers and employers work together, a safe entry is more likely to occur.

Worker Responsibilities

Workers are responsible for using knowledge gained in training to effectively deal with hazards, use safety equipment properly, and work safely in confined spaces.

In addition, workers need to remain alert to identify new or additional hazards that may arise as operations progress. Some items to be aware of during confined space entry include:

- Weather changes. When it gets hot or the air is calm, chemical concentrations in the air can increase. This increase may require additional precautions, such as:
  - Exiting the space
  - Upgrading respiratory protection
  - Increasing ventilation
- Wind direction. For example, dust and vapors can be exhausted from a confined space and reenter the space if ventilation is not set up properly.
- Odors that may indicate the presence of chemicals.
- The location of someone who can help if an emergency arises.
- Where and how to exit from every area.

Employer Responsibilities

Employers are responsible for informing workers of the hazards of their jobs during confined space operations, and ensuring a safe environment. They are required to protect workers when they enter and work in confined spaces. Procedures can vary depending on the specific situation.

SECTION 2 - ASSIGNMENT SHEET

1. Define and describe the three types of atmospheric hazards found in confined spaces.

2. List the five forms of airborne contaminants.

3. Define exposure guides and list the two most commonly used guides and the organizations that establish them.

4. Describe the six types of physical hazards found in confined spaces.

PERMIT-REQUIRED CONFINED SPACE ENTRY

Section

3

Title

HEALTH EFFECTS

TRAINEE OBJECTIVES

After completing Section 3, you will be able to:

1. List and describe four types of health effects from toxic chemicals.
2. List and define the three routes of entry for chemicals to enter the body.
3. Describe the two types of asphyxiants and give examples of each.
4. Identify the six physical warning signs of exposure to toxic chemicals.
5. List the four stages of heat stress and identify the symptoms of each.
6. Describe at least two actions that can be taken to prevent heat stress.

INTRODUCTION

Confined spaces may contain hazardous conditions that can cause serious health effects or death if adequate precautions are not taken. Hazardous conditions that can occur in confined space are the result of:

- Chemicals
- Temperature extremes
- Oxygen deficiency

CHEMICALS

Hazardous chemicals cause health effects by upsetting the normal functions of your body. Depending on the chemical, different bodily systems may be affected. For example, many solvents used in construction create health effects when they are inhaled. Once inhaled they can reach the blood and affect internal organs. In many cases, the liver can remove the chemical from the blood stream, but in the process, it may affect the liver's normal functioning, leading to other problems such as cancer.

Types of Health Effects from Chemicals

Health effects that result from chemical exposures can be described as either local or systemic, and prompt or delayed. Local and systemic refer to where the body is affected. Prompt and delayed refer to how fast the effects occur. Whether or not a chemical causes a prompt or delayed effect depends on the chemical and the *dose*. The duration of effects may be short-term or long-term.

Local Effect

A *local effect* occurs when the body is harmed at the point of contact. For example:

- You pick up a rag soaked with benzene with your hand. The skin on your hand becomes dry and irritated.

- You spill battery acid on your arm, and your skin is burned wherever the acid touched it.

A local effect can also occur inside your body. For example:

- You inhale acid vapors through your mouth. The tissues in your mouth and lungs are burned.

Systemic Effect

A *systemic effect* occurs in the body at some place other than the point of contact. For example:

- The solvent benzene has three routes of entry into the body. It can be inhaled into the lungs, absorbed through the skin, or ingested through the mouth. Once inside the body, benzene can affect bone marrow and may cause anemia or leukemia. (Anemia is a low red blood cell count in the blood. Leukemia is a cancer of the bone marrow.)

- Toluene is another solvent that also has three routes of entry. Once inside the body, toluene causes liver damage. The liver is the target organ for toluene. A *target organ* is defined as that organ or system affected by a chemical.

Prompt Effect

A *prompt effect* occurs quickly, usually after exposure to a high concentration of a hazardous material. Most prompt effects are temporary and go away shortly after the exposure is removed. However, permanent damage can occur if exposures are high enough. Examples of chemicals and their prompt effects include the following:

- Carbon tetrachloride – Causes dizziness, nausea, and at higher concentrations, coma and death.

- Acid mists – Cause eye and throat irritation, coughing, sore throat, and chest pain.

Delayed Effect

Delayed effects take a long time to develop. Usually they are the result of repeated exposures to low doses of a substance over a long period of time. Delayed health effects may or may not be reversible. Examples of chemicals and their delayed effects include:

- Carbon tetrachloride – Can cause liver damage or cancer 10 to 40 years after the first low level exposures.

- Asbestos – Can cause asbestosis or cancer of the lung, pleura, stomach, or intestines.

- Acid mists – Can cause chronic bronchitis or emphysema.

Latency Period

The time period between the first exposure and the appearance of disease caused by the exposure is called the *latency period*. Some delayed effects have very long latency periods (10–40 years.) The following are examples of latency periods:

- 10 years – Benzene
- 15 years – Vinyl chloride
- 25 years – Arsenic

The concept of latency is one that you need to fully understand. Exposure to a substance may cause adverse health effects many years after the time of exposure, with little or no effects at the time of exposure. Therefore, it is important to avoid or eliminate all exposures to hazardous substances when possible.

For many chemical agents, the adverse health effects following a single exposure are different from those produced by repeated exposures. For example, the primary prompt effect of benzene is central nervous system symptoms. After repeated exposures, the delayed effect can be leukemia.

Routes of Entry

Chemicals can enter the body in three ways, which are called routes of entry. The three routes of entry are:

1. Inhalation
2. Absorption
3. Ingestion

When a route of entry is identified for any chemical, it refers to the primary way a chemical enters the body. But a chemical may have more than one route of entry. Most chemicals are not equally toxic by all routes of entry.

Inhalation

Inhalation is the most common route of entry for toxic chemicals to enter the body. Chemicals usually do more damage when inhaled because they are absorbed quickly through the lungs. Also, since breathing is always occurring, there is a constant opportunity for exposure. During heavy physical work, both the rate and depth of respiration increase, which means a greater amount of air and chemicals can enter the lungs.

The structure of the lungs allows oxygen to be absorbed quickly into the bloodstream. Some substances are insoluble, which means they cannot be absorbed into the bloodstream. Instead, they are trapped in the lungs for long periods of time, while the body tries to destroy or remove them. These substances may cause adverse health effects, such as inflammation, emphysema, pulmonary edema, and cancer.

Airborne Contaminants

Worker exposures are often the result of airborne contaminants, such as dusts, fumes, gases, mists, or vapors. Each of these contaminants have different actions and physical properties. These contaminants are instrumental in creating respiratory hazards.

Dusts **–** Some dusts have no effect on the body. They do not seem to harm the body or to be changed by the body's chemistry into other harmful substances.

Most harmful dusts cause damage after being inhaled. Others, like cement and arsenic, can also directly affect the skin. Sandblasting is an activity where workers are at high risk of silica exposure.

Pneumoconiosis (pronounced, new-mo-cone-e-o-sis) is a broad term used to describe lung injury caused by the delayed effects of breathing dusts.

Fumes **–** Many fumes irritate the skin and eyes. However, fine particles primarily affect the body when they are inhaled. An inhalation exposure sometimes results in a prompt effect referred to as metal fume fever, especially if the fumes are from metals such as zinc, cadmium, or magnesium.

The small size of the fume particles allows them to reach and irritate the lungs. Their small size and ability to spread out in the lung fluids allow fumes to pass easily from the lungs into the bloodstream, damaging other parts of the body. Many fumes, such as lead fumes, affect the liver, kidneys, and nervous system. They are called systemic poisons.

Gases **-** Toxic gases can directly irritate the skin, throat, eyes, or lungs. They may also pass from the lungs into the bloodstream, damaging other parts of the body.

The body's defenses against some gases include detecting smells, tearing eyes, and coughing. Ammonia's irritating effects and odor warn workers of exposure. However, workers may be exposed to some gases without knowing it, such as carbon monoxide.

Some gases dull the sense of smell after a while. This condition is called *olfactory fatigue*. Hydrogen sulfide with its characteristic rotten egg odor is such a gas. After a short exposure to hydrogen sulfide, a worker is no longer able to smell the gas. Therefore, the sense of smell is a poor way of detecting any type of exposure to hazardous substances, and should not be relied on.

Mists **–** Many mists and fogs damage the body if they are inhaled, or if they make direct contact with the skin and eyes. Like fumes, mists are small enough to by-pass the respiratory system's defenses and get deep inside the lungs. There they pass easily into the bloodstream to other parts of the body. Examples include acid spray mists and paint spray mists.

Vapors **–** Many vapors directly affect the skin causing dermatitis, while some can be absorbed through the skin. When inhaled, most vapors pass through the lungs to the bloodstream and damage other parts of the body. Some of these materials can cause cancer or damage the liver, kidneys, and blood. Solvents are common materials that give off vapors.

Absorption

Absorption is the route of entry into the body through the skin (either broken or unbroken) and sometimes through the eye. The skin is the largest organ of the body, covering about 19 square feet of surface area. Like the lungs, the skin has a large network of blood vessels close to the surface. Chemicals are absorbed or passed through the skin and enter the bloodstream. These chemicals then travel to other organs and cause damage.

Many chemicals, especially solvents, dissolve the oils in the skin. The skin becomes dry and cracked, making it easier for other chemicals to be absorbed through the skin and into the bloodstream.

Most job-related skin conditions are caused by repeated contact with irritants, such as:

- Solvents
- Soaps and detergents
- Particulate dusts
- Oils and grease
- Metal working fluids

The resulting skin irritation is called contact *dermatitis* and has symptoms such as red and itchy skin, swelling, ulcers, and blisters. Dermatitis accounts for 30 percent of all reported occupational illnesses and is the number one occupational disease.

Different parts of the body absorb chemicals at very different rates (Figure 3-1). Serious and even fatal poisonings have occurred from brief skin exposures to highly toxic substances. Abrasions, lacerations, and cuts may greatly increase the absorption, which increases the exposure to toxic chemicals.

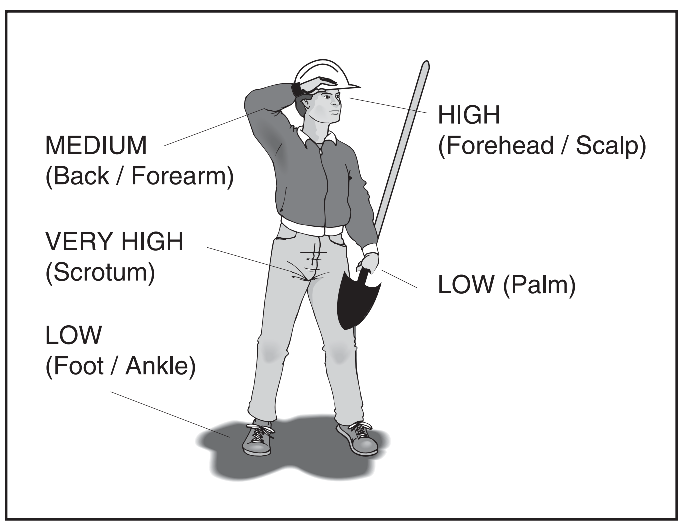


Figure 3-1. Chemical absorption rates for male workers.

Ingestion

Ingestion is the act of taking food or any substance into the body by the mouth (eating or drinking). Many workers on the job site unknowingly ingest harmful toxic chemicals. These toxic chemicals travel to the stomach and then to the intestines. Along the way, they can be absorbed into the bloodstream.

Inhaled toxic dusts can also be swallowed in amounts large enough to cause poisoning. If a toxic material is easily dissolved in digestive fluids, the absorption into the bloodstream is sped up. Ingestion toxicity is normally lower than inhalation toxicity for the same material. The reason is that many chemicals are not easily absorbed from the intestines into the bloodstream.

After absorption from the intestinal tract into the bloodstream, the toxic material generally goes to the liver. The liver detoxifies the material, which means it changes or breaks down the material. But the liver cannot always detoxify a toxic substance. Sometimes the liver breaks down a toxic substance into components that are more toxic than the original. These components may build up in the liver and cause adverse health effects. They may also be transported by the blood to other body organs.

Physical Warning Signs

Physical warning signs are indications that hazardous conditions may exist. Watch for the six physical signs of exposure to toxic chemicals:

1. Breathing difficulties, such as breathing faster or deeper, soreness, a lump in the throat.

2. Dizziness, drowsiness, disorientation, difficulty concentrating.

3. Burning sensation in the eyes or on the skin.

4. Weakness, fatigue, lack of energy.

5. Chills, upset stomach.

6. Odors and/or a strange taste in the mouth.

If any of these signs occur, exit the confined space and immediately report the symptoms to your entry supervisor.

OXYGEN DEFICIENCY

The body requires oxygen to live. Normal breathing air has an oxygen content of about 21 percent. If the oxygen concentration decreases, the body reacts in various ways as shown in Figure 3-2. Death occurs rapidly when the concentration of oxygen in the air falls below 5 percent.

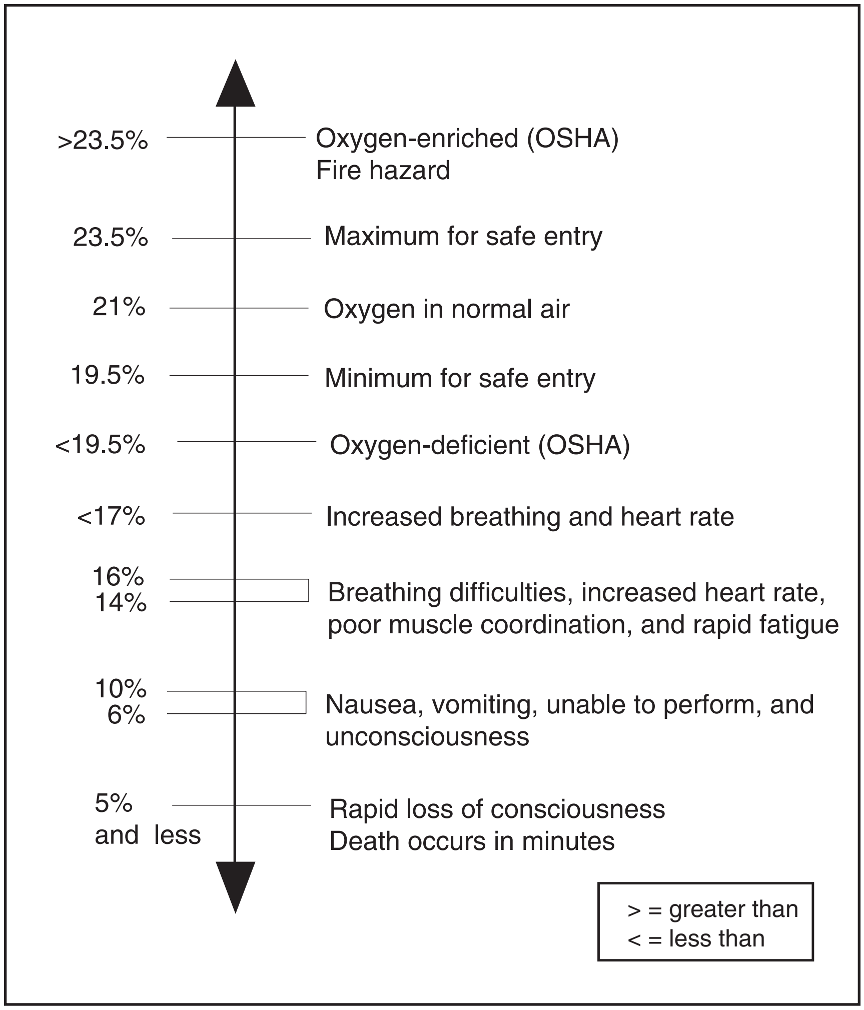


Figure 3-2. Oxygen levels and their effects on the body.

Oxygen deficiency is a major health hazard that can result from an *asphyxiant*. There are two main types of asphyxiants. Both can can cause loss of consciousness, serious injury, and death.

The two types of asphyxiants are:

1. *Simple asphyxiant* – Chemical gas or vapors at such a concentration in a confined space that the oxygen content is below a level that will sustain life.
2. *Chemical asphyxiant* – Substance that reduces or blocks the ability of the blood to carry oxygen.

Simple Asphyxiant

A simple asphyxiant is a gas that when present in high concentrations displaces the oxygen. This creates an atmosphere that cannot support life. A simple asphyxiant has little or no ability to harm the body as a poison. Examples of simple asphyxiants include:

- Methane
- Carbon dioxide
- Natural gas
- Nitrogen
- Helium

Chemical Asphyxiant

A chemical asphyxiant is a gas that reduces or blocks the ability of the body to carry or transfer oxygen. It does this in one of two ways:

1. The chemical binds to the hemoglobin in the red blood cells. (Hemoglobin is the part of the blood cell that carries the oxygen.) Example: carbon monoxide.
2. The chemical interferes with the transfer of oxygen from the lungs to the blood or from the blood to the cells. Examples: hydrogen sulfide, hydrogen cyanide.

Carbon Monoxide

Carbon monoxide binds more easily with hemoglobin than oxygen does. Therefore, when carbon monoxide is present in the blood, it prevents the blood from picking up oxygen and transporting it to the cells of the body. Exposure to carbon monoxide can prevent the body from getting enough oxygen, which severely affects the heart and brain. OSHA's PEL for carbon monoxide is 50 ppm.

Carbon monoxide comes from many sources on the job site, such as the exhaust from heavy equipment, generators, and compressors. It is also a by-product of welding and soldering operations.

People with existing heart conditions are likely to suffer additional heart damage if exposed to carbon monoxide. A burning cigarette produces fairly high carbon monoxide levels. So smokers already have higher than normal levels of carbon monoxide in their bloodstreams. Any additional carbon monoxide from the job increases their exposure.

Table 3-1 lists the signs and symptoms of carbon monoxide exposure at different concentration levels.

Table 3-1. Effects of exposure to carbon monoxide* measured in parts per million (ppm).

Concentration (ppm)	Signs and Symptoms
100	Threshold limit value for no adverse effects even with 6-8 hours exposure
200	Possible mild headache after 2-3 hours
400	Headache and nausea after 1-2 hours
800	Headache, nausea, and dizziness after 45 minutes; collapse and possible unconsciousness after 2 hours
1,000	Loss of consciousness after 1 hour
1,600	Headache, nausea, and dizziness after 20 minutes
3,200	Headache and dizziness after 5-10 minutes; unconsciousness after 30 minutes
6,400	Headache and dizziness after 1-2 minutes; unconsciousness and danger of death after 10-15 minutes
12,800	Immediate physiological effects; unconsciousness and danger of death after 1-3 minutes

* Just how sick people get from carbon monoxide exposure varies greatly from person to person. It depends on age, overall health, concentration of exposure (measured in ppm), and length of exposure.

Source: James H. Meidl, Explosive and Toxic Hazardous Materials, Glencoe Press, 1970, Table 28, p. 293.

Hydrogen Sulfide

At very low concentrations, hydrogen sulfide smells like rotten eggs. At higher concentrations it deadens the sense of smell by paralyzing the olfactory nerves. Just a brief exposure to a very high concentration of hydrogen sulfide can paralyze the lungs, which leads to collapse, coma, and death. Table 3-2 lists the effects caused by exposure to hydrogen sulfide.

OSHA gives hydrogen sulfide a ceiling limit of 20 ppm and a maximum peak above the ceiling limit of 50 ppm for 10 minutes that shall only occur once in an 8-hour work shift and only if there is no other measurable exposure. There is no time-weighted average because hydrogen sulfide is an acute acting substance.

The two most common sources of hydrogen sulfide in confined spaces are:

1. Naturally occurring underground gas deposits
2. Sewer gas

Table 3-2. Effects of exposure to hydrogen sulfide measured in parts per million (ppm).

Concentration (ppm)	Signs and Symptoms
<1	Rotten egg odor detectable. May be smelled at concentrations as low as .13 ppm.
10	Beginning eye irritation.
50–100	Slight conjunctivitis and respiratory tract irritation after 1 hour exposure.
100	Coughing, eye irritation, loss of sense of smell after 2–15 minutes. Altered respiration, pain in the eyes, and drowsiness after 15–30 minutes followed by throat irritation after 1 hour. Several hours exposure results in gradual increase in severity of these symptoms and death may occur within the next 48 hours.
200–300	Marked conjunctivitis and respiratory tract irritation after 1 hour of exposure.
500–700	Loss of consciousness and possible death in 30 minutes to 1 hour.
700–1,000	Rapid unconsciousness, cessation of respiration, and death.
1,000–2,000	Unconsciousness at once, with early cessation of respiration and death in a few minutes. Death may occur even if the individual is removed to fresh air at once.

Source: OSHA Standards Interpretation and Compliance Letters "The appropriate method for assessing hydrogen sulfide peak exposure levels," 9/28/1995 (USA Standard Acceptable Concentrations of Hydrogen Sulfide).

TEMPERATURE EXTREMES

Extreme temperature conditions can affect your health and ability to safely perform tasks. Knowing the signs and symptoms of heat stress and cold stress helps to prevent injury.

Heat Stress

Generally speaking, the more strenuous the job in a hot environment, the greater the chance of heat stress. Heat stress can cause a decrease in mental alertness, a factor that contributes to the increased possibility of accidents in hot environments. Productivity also decreases significantly with increased heat.

The severity of heat stress depends on many factors, including:

- Environmental conditions, such as air temperature, air movement, and relative humidity.
- Age, degree of physical fitness, and obesity.
- Degree of *acclimatization* (e.g. workers in winter are less adapted or acclimated to heat, and thus, more susceptible).
- Type of clothing worn.

The chance of developing heat stress increases with increased humidity, hot environments, and the use of PPE. Regular monitoring and other precautions are essential.

The body maintains a normal temperature (98.6°F/37°C) in a hot environment by sending more blood to the skin and through sweating. Initially the body cools itself by sending more blood to the skin where heat is released. As the blood vessels dilate to allow more blood to go to the skin, the amount of blood available to other parts of the body decreases. This includes the brain and muscles.

Workers in hot environments may feel tired sooner and be less mentally alert. Both these factors, plus the awkwardness from wearing PPE, contribute to an increased number of accidents in the workplace.

As the air temperature increases, the body starts to sweat. Heat is carried away as the sweat evaporates from the skin. If the humidity in the air increases or if the sweat cannot evaporate because of PPE, the body has more difficulty keeping a safe temperature. When individuals are severely stressed by the heat, they may stop sweating. The lack of sweating indicates a breakdown in the ability of the body to regulate temperature. This breakdown can result in the most severe form of heat stress—heat stroke.

Adequate rest periods, drinking large amounts of replacement fluids, and frequent monitoring are essential to prevent the consequences of heat stress.

Individuals at Risk

You are at risk of developing heat stress when you are:

- Working near sources of radiant heat.
- Wearing protective clothing.
- Dehydrated from diarrhea or fever caused by infections.
- Physically unfit or have not worked in a hot environment in the preceding week (not acclimated).
- Living with chronic disease, such as heart disease or diabetes.
- Regularly taking certain medications for depression, nervous conditions, high blood pressure, diabetes, or heart disease.
- Dehydrated from drinking alcohol excessively or using drugs.
- Overweight.

Forms of Heat Stress

There are four forms of heat stress that result from exposure to high temperatures:

1. Heat rash
2. Heat cramps
3. Heat exhaustion
4. Heat stroke

Heat Rash

Heat rash is the mildest form of heat stress. It is caused by heavy sweating where sweat cannot be easily removed by skin evaporation.

Heat Cramps

Heat cramps are due to heavy sweating. Cramps usually occur in the extremities, and generally follow heavy exertion. However, they may also take place hours later. If heat cramps occur, you should rest in a cool place and increase fluid intake.

Heat Exhaustion

Heat exhaustion is the result of dehydration (not drinking enough fluids) or cardiovascular insufficiency. Heat exhaustion resembles shock and can be preceded or followed by heat cramps. There is no increase in body temperature. If heat exhaustion occurs, OSHA recommends the following:

- Move the person to a cool shaded area to rest. Do not leave the person alone. If the person is dizzy or light headed, lay them on their back and raise their legs about 6-8 inches. If the person is sick to their stomach lay them on their side.
- Loosen and remove any heavy clothing.
- Have the person drink some cool water (a small cup every 15 minutes) if they are not feeling sick to their stomach.
- Try to cool the person by fanning them. Cool the skin with a cool spray mist of water or wet cloth.
- If the person does not feel better in a few minutes call for emergency help (Ambulance or Call 911).

Important: If heat exhaustion is not treated, the illness may advance to heat stroke.

Heat Stroke

Heat stroke is the most serious form of heat stress:

- **Heat stroke is a medical emergency**
- **Medical help must be obtained**
- **Heat stroke has a death rate of 30 to 50 percent**

The cause of heat stroke is the failure of the body's ability to regulate temperature. The onset of heat stroke can be gradual, with mental excitement and dryness of mouth and skin, or it can be sudden, with delirium, stupor, or coma.

If you experience any of the symptoms of heat stroke, seek medical attention immediately. If you observe a co-worker exhibiting any heat stroke symptoms, get immediate help for that individual. By the time symptoms of heat stroke are apparent, the worker could be at the stage where he is unable to help himself.

OSHA recommends the following for heat stroke:

- Call for emergency help (Ambulance or Call 911).

- Move the person to a cool shaded area. Do not leave the person alone. Lay them on their back. If the person is having seizures/fits remove any objects close to them so they will not strike against them. If the person is sick to their stomach lay them on their side.

- Remove any heavy and outer clothing.

- Have the person drink some cool water (a small cup every 15 minutes) if they are alert enough to drink anything and not feeling sick to their stomach.

- Try to cool the person by fanning them. Cool the skin with a cool spray mist of water, wet cloth, or wet sheet.

- If ice is available, place ice packs under the arm pits and groin area.

Signs and Symptoms

Table 3-3 summarizes the four forms of heat stress and their signs and symptoms.

Table 3-3. Signs and symptoms of heat stress.

Type of Heat Stress	Cause	Signs/Symptoms
Heat rash	Heavy sweating when sweat is not easily removed by evaporation.	Redness on skin Blisters or a rash
Heat cramps	Heavy sweating with inadequate electrolyte replacement.	Muscle spasms Pain in hands, feet, and abdomen
Heat exhaustion	Increased stress on various body organs and the circulation system. Caused by the inability of the the heart to work properly, and/or dehydration.	Dizziness Nausea Normal to low body temperature Heavy sweating Pale, cool, moist skin Rapid pulse and breathing Fainting
Heat stroke	**The most serious form of heat stress.** Temperature regulation fails. Body temperature rises to critical levels, as high as 108° to 112°F (42° to 44°C). The body **must** be cooled immediately before serious injury or death occurs. **Competent medical help must be obtained. Has a death rate of 30–50%.**	Dizziness, confusion Nausea High fever Little or no sweating Red, hot, usually dry skin Strong, rapid pulse Convulsions Coma Death

Actions Employers Should Take to Prevent Heat Stress

Employers should take the following actions to help prevent heat stress:

- Schedule adequate rest periods
- Provide shaded, and if possible, air-conditioned rest areas
- Provide cool fluids to drink
- Provide medical screening, including vital signs
- Restrict activities
- Provide adequate first-aid facilities for treatment of heat stress illness

Actions Workers Should Take to Prevent Heat Stress

You should take the following actions to prevent heat stress:

- Drink 1 to 1.5 gallons (4–6 liters) of fluids (water or juices) during the day, even when not thirsty. Alcohol, coffee, soda, and tea are not good fluids to replace water loss.

- Maintain good physical fitness. Work cautiously until your body has adjusted (acclimated) to the heat.

- Recognize the signs and symptoms of heat stress.

- Monitor pulse, temperature, and weight.

- Check with your doctor if you have a chronic disease or are taking medication.

If you experience signs or symptoms of heat stress while working, stop work immediately and notify a supervisor or appropriately trained emergency personnel. If a co-worker shows or complains of heat stress symptoms, notify the appropriate person.

Note: Taking salt tablets to replace the salt lost through sweating is **not** recommended. A normal diet contains more than enough salt.

Cold Stress

Exposure to cold temperatures can lead to cold stress. When air temperatures decrease, your body maintains its temperature by reducing blood flow to the skin. This causes a marked decrease in skin temperature. The most extreme effect is on your fingers, toes, ear lobes, and nose. In addition, cold hands and fingers become numb and insensitive, which leads to an increased possibility of accidents.

If the restriction of blood flow to the skin does not maintain body temperature, then shivering occurs. (Shivering generates heat in the muscles.) If shivering does not warm your body, then your body temperature may drop.

There are several harmful effects of cold stress:

- Frostbite – The fluid surrounding the tissue cells freezes, causing freezing of other body parts. Fingers, toes, ear lobes, and the nose are especially susceptible to frostbite. The first warning is a sharp, pricking sensation. However, numbness caused by the cold increases the chance of frostbite occurring without warning. Injuries range from redness of the skin to numbness to loss of skin and body parts.

- Immersion foot (trench foot) – The skin is injured from long exposure to cold combined with dampness or contact with water. There is no freezing. Injuries range from swelling, tingling, itching, and pain to loss of skin and skin ulcers.

- Hypothermia – The body temperature drops below 96°F (35.6° C). Hypothermia can lead to hallucinations, sleepiness, irregular heart beat, unconsciousness, and death.

Individuals at Risk

You are at risk of developing cold stress when you are:

- Exposed to cold temperatures.

- Wet from sweating or contact with water.

- Doing heavy labor and you become fatigued.

- Taking sedatives or drinking alcohol before or during work.
- Living with chronic diseases that affect your heart or the blood vessels of your hands or feet.
- Physically unfit or you have not worked in a cold environment recently.
- Using pavement breakers or other vibrating equipment.
- Performing tasks in high humidity and/or high winds.
- Inadequately dressed.
- In contact with metal and/or wet surfaces.

Preventing Cold Stress

You should take the following actions to prevent cold stress:

- Wear several layers of loose-fitting, dry clothes that can be adjusted to match changing temperatures. A top layer of wind-proof clothing protects against wind.
- Do not become overheated and sweaty.
- Keep extremities warm and check for numbness.
- Go to a warm shelter if you experience any of the following:
  - Chills
  - Sleepiness
  - Pain and cold in your extremities
- Avoid working in cold weather if you have a chronic heart or blood vessel disease.
- Do not use sedatives or drink alcohol excessively. See a doctor if you have questions about medications.
- Cover your head. Your body can lose up to 40 percent of its heat when your head is uncovered.

SECTION 3 - ASSIGNMENT SHEET

1. List and describe four types of health effects from toxic chemicals.

2. List and define the three routes of entry for chemicals to enter the body.

3. Describe the two types of asphyxiants and give examples of each.

4. Identify the six physical warning signs of exposure to toxic chemicals.

5. List the four stages of heat stress and identify the symptoms of each.

6. Describe at least two actions that can be taken to prevent heat stress.

PERMIT-REQUIRED CONFINED SPACE ENTRY

Section

4

Title

ATMOSPHERIC MONITORING

TRAINEE OBJECTIVES

After completing Section 4, you will be able to:

1. Define atmospheric monitoring and list three monitoring methods.
2. List and describe the three required pre-entry atmospheric tests in their proper order.
3. Explain when and where continuous monitoring is necessary.
4. Define direct reading instruments (DRIs). List at least five DRIs and explain their functions.
5. Identify at least five factors that may limit the ability of a DRI to accurately detect hazards.
6. Perform a calibration check on a DRI.
7. List the steps to take if a DRI fails.
8. List at least two personal air sampling devices; give at least one reason for using personal air sampling devices.

INTRODUCTION

Hazardous atmospheres within a permit-required confined space are a threat to worker health and safety. Employers are required to evaluate the atmosphere in confined spaces and monitor for potential hazards before anyone may enter.

Atmospheric monitoring is the process of collecting, detecting, and/or measuring the air for chemical, physical, and biological hazards. The means used for identifying and/or measuring these hazards are:

1. Direct reading instruments (*DRI*)
2. Laboratory analysis
3. Air sampling

The information gathered from these methods is used to develop a program to effectively deal with confined space hazards. The main objectives of monitoring are to ensure that confined space atmospheres are safe for entry and toxic exposures stay below regulatory limits. Because monitoring in confined spaces relies primarily on DRIs, this section will focus only on them.

TESTING FOR HAZARDOUS ATMOSPHERES

Before workers can enter a permit-required confined space, *pre-entry atmospheric tests* must be completed and documented on the entry permit. During entry, the atmosphere may need either periodic testing or continuous monitoring to ensure that the confined space remains safe.

The Occupational Safety and Health Administration (*OSHA*) standard 29 CFR 1910.146 states that authorized entrants or their representatives shall be given an opportunity to observe any testing or monitoring conducted before entry into confined spaces.

Pre-Entry Testing

Pre-entry atmospheric testing is performed from the outside of the confined space using remote probes and sampling lines. Three tests are used to identify hazardous atmospheres in a confined space. They must be performed in the following order:

1. Oxygen content
2. Flammability/explosivity
3. Toxicity

It is very important to test all areas of a confined space (top, middle, and bottom). Some vapors and gases have different vapor densities than normal air. Normal air has a vapor density of 1. Gases and vapors that have a vapor density greater than 1 will initially settle to the bottom of a confined space. Gases and vapors that have a vapor density of less than 1 will collect around the top of a confined space. The area closest to the opening where testing is being performed should be sampled first.

If testing reveals an unsafe atmosphere, the space must be ventilated and retested before workers enter. If ventilation is not possible and entry is necessary (i.e., for emergency rescue), workers must be provided with the appropriate respiratory protection.

Never rely on your sense of sight or smell to determine if the air in a confined space is safe. Many toxic gases and vapors have poor warning properties. Hydrogen sulfide and carbon monoxide are two examples. Also, it is impossible to determine oxygen content by sight or smell.

Oxygen Content

The first pre-entry test is for oxygen concentration. The atmosphere in a confined space is hazardous if its oxygen level is less than 19.5 percent. Air with more than 23.5 percent oxygen is an extreme fire hazard.

Flammability/Explosivity

Measuring for flammability in a confined space is performed after the oxygen level is determined. Many combustible gas indicators (*CGI*) will not work properly in an oxygen-deficient atmosphere.

The atmosphere in a confined space is hazardous when the concentration of the flammable gas, vapor, or mist exceeds 10 percent of the lower explosive limit (*LEL*). Air is also explosive when the concentration of airborne combustible dust meets or exceeds its LEL. After entry, if tests indicate that the atmosphere has exceeded 10 percent of the LEL, the confined space must be evacuated immediately and all equipment must be shut off until it is safe to reenter.

Toxicity

The third test measures the level of known or potential toxic air contaminants within the space. If the concentration of any toxic substance exceeds OSHA's permissible exposure limit (*PEL*), the atmosphere in the space is considered hazardous. The entry permit must list which toxic materials to test for and the PEL for each substance.

Periodic Testing and Continuous Monitoring

Immediately after entering a confined space, workers should retest the oxygen level, flammability, and toxicity in the following areas:

- All three levels of the space (top, middle, and bottom).
- Areas that could not be tested from outside the space.
- Any area where hazardous chemicals might leak or collect in the space.

The air inside a confined space must be monitored continuously, or retested regularly, for as long as anyone is inside the confined space. The entry permit will note whether continuous monitoring is needed or how often the air should be retested.

Continuous monitoring is important if the work being performed inside the space can cause the atmosphere to become unsafe. Potentially hazardous work activities include:

- Hot work, such as welding, cutting, and burning
- Painting
- Scraping/scaling
- Using solvents

Continuous monitoring is also necessary if the source of a hazardous atmosphere cannot be completely eliminated, For example, vapor build-up could occur from residue left from material previously stored in a tank.

Air monitors must be placed in appropriate locations so that their sensors perform accurate, continuous monitoring. The best spots are:

- Areas where contaminants can leak into the confined space
- Areas near the source of contaminants
- Worker breathing zones

When an air monitoring alarm sounds, workers must leave the confined space immediately. The alarm indicates that a change has taken place in the air and is approaching a hazardous condition. The hazard must be brought under control and the air retested before workers may reenter the space.

DIRECT READING INSTRUMENTS

Direct reading instruments (*DRIs*) are used to detect concentrations of oxygen and combustible and toxic gases. They are usually lightweight, compact, and portable instruments. And they have several major advantages:

- Provides information at the time of sampling
- Allows for rapid decision-making
- Responds to a broad category of chemical and physical hazards

Initially, DRIs were developed for use in industrial settings. They functioned as early warning devices in areas where a leak or accident could release a high concentration of a known chemical into the surrounding atmosphere. With advancements in technology, many DRIs are now sensitive enough to detect contaminants in concentrations below one part per million (*ppm*).

Types of Direct Reading Instruments

Many types of DRIs are used to monitor workplace conditions. Most monitoring activities are done by trained technicians. However, workers in confined spaces may be required to wear, observe, or use DRIs. So it is important for you to understand how DRIs work, their limitations, and their uses.

The type of DRI used depends upon the following:

- Hazards being monitored
- Physical states of the material being monitored
- Purpose of monitoring

Different DRIs may be used for hazard identification or exposure assessment or to provide an early warning.

The three major categories of DRIs are:

1. Portable DRIs
2. Personal monitoring devices
3. Fixed (stationary) monitoring devices

Limitations

DRIs have basic limitations in their ability to detect hazards. Before wearing or using a DRI, workers need to understand how the following factors affect the accuracy and reliability of its readings:

- Proper operation
- Calibration and checks
- Detection range
- Response time
- Intrinsic safety
- Interference
- Environmental conditions

Proper Operation

For a DRI to respond accurately, it must operate correctly and function properly. Some preliminary checks and measures can be performed to ensure that an instrument is functioning properly:

- Battery check – Most instruments have a battery monitoring function that notifies an operator when the battery needs recharging or replacement.

- Instrument warm-up – All instruments need time to warm up before an accurate reading can be taken. Warm-up times vary from one second to as long as 30 minutes, depending on the instrument being used.

- Instrument condition – To ensure the proper operation, the DRI should be cleaned and maintained on a regular basis.

Calibration and Checks

When sampling and analyzing an unknown atmosphere, the DRI internally compares it to a known reference gas. This reference gas is called a *calibration gas*. To ensure DRIs are providing accurate results, a calibration check should be performed before and after each use. The check should follow the manufacturer's instructions and use the appropriate calibration gas.

A calibration check is performed by observing the meter response after connecting a calibration gas to the DRI. If the DRI's response is within the specifications for the calibration gas, the instrument is properly calibrated. If a DRI's response is outside the specifications of the calibration gas, it must not be used until it has been calibrated or readjusted.

Depending on the DRI, an air monitoring device may be calibrated in percent LEL, ppm, or percent gas. The manufacturer's instructions in the operating manual of a DRI must be followed for calibration, maintenance, and use. Only qualified individuals should do calibrations.

Often the employer will rent or lease DRIs. In these cases, a DRI should not be used unless it has been calibrated by the manufacturer or distributor. Normally, calibration documentation will come with the DRI.

Detection Range

DRIs are designed to detect specific substances within a certain range or concentration. For example, a DRI that is sensitive to 1 ppm cannot be used to measure an atmosphere containing a chemical below that level. The DRI simply will not detect that chemical. Also, an area with high energy or chemical concentrations can cause the DRI's readout to go off the scale.

Response Time

Response times may vary among DRIs, and any single DRI's response time may be affected by the following factors:

- Length of the sample hose – The longer the hose, the slower the response.
- Flow rate of pump – A slower flow rate means a longer response time.

- Response of DRI – Most DRIs have a response time between 5 and 60 seconds. The DRI must be kept in the test area for the length of the response time specified in the operator's manual.

- Contaminants – Other contaminants may affect a DRI's response.

Intrinsic Safety

Since most DRIs use electronic circuitry, they can be a source of ignition in an explosive environment. When instruments are going to be used in areas containing potentially flammable atmospheres, they must have the Underwriters Laboratories (*UL*) or Factory Mutual (*FM*) stamp of approval. This stamp indicates that the instrument is *intrinsically safe* for use in flammable atmospheres.

Interference

Manufacturers provide information about chemicals and/or conditions that may interfere with their instruments' ability to respond accurately. Some vapors and gases can interfere with the ability of a DRI to provide accurate readings, or they can cause false readings. Examples of gases and vapors that cause interference are listed below:

- Lead in leaded gasoline permanently damages the filament in a combustible gas detector.

- Carbon dioxide poisons the cell in an oxygen meter.

- Certain vapors and gases can react with detector tubes to produce false responses.

Consult the operations manual to identify interference problems and change to a different type of DRI if the problem continues.

Note: Calibration checks with a known gas do **not** solve interference problems.

Environmental Conditions

Environmental conditions, such as temperature, humidity, and barometric pressure, can affect an instrument's operation. For example, high humidity prevents the detection of some gases and vapors when using a photoionization detector. Humidity can also interfere with the chemical reactions that take place inside a detector tube.

PORTABLE DIRECT READING INSTRUMENTS

Portable DRIs are commonly used to perform surveys and gather information required for decisions. Some of the more common types of portable instruments include:

- Combustible gas/oxygen indicator
- Flame ionization detector
- Photoionization detector
- Detector tube
- Multi-gas monitor

Combustible Gas and Oxygen Indicator

The combustible gas and oxygen indicator (*CG/OI*) is a dual purpose instrument that detects and measures areas for combustible gases and oxygen deficiency. Many CG/OIs are now equipped with sensors to detect other commonly encountered toxic gases, such as carbon monoxide and hydrogen sulfide.

The CG/OI has factory preset alarms for both oxygen and combustible gases. Most CG/OIs are equipped with both visual and audible alarms. This allows the instrument to be used as a continuous air monitor in most work areas.

CG/OIs are intended for use in atmospheres with normal oxygen concentrations. They are not to be used in atmospheres that are oxygen-enriched. Oxygen concentrations significantly lower or higher than those of normal air can cause incorrect readings.

A CG/OI is easy to operate. However for monitoring to be effective, the user must be able to record monitoring results and make decisions based on these readings. Additionally, the user must be knowledgeable in the operation, limitations, and calibration procedures of the instrument.

Some of the applications for using a CG/OI **within a confined space** include:

- Monitoring for explosive vapor concentrations
- Monitoring for oxygen content
- Verifying the effectiveness of ventilation and inerting operations
- Acting as a continuous air monitoring station

Table 4-1 lists the features and limitations of the CG/OI.

Table 4-1. Combustible gas/oxygen indicator.

Instrument	Features	Limitations
Combustible Gas/Oxygen Indicator (CG/OI)  (Image courtesy of MSA, Co.)	• Measures oxygen concentration and combustible gas concentration as a percentage of the lower explosive limit (LEL). • Lightweight, portable, and easy to use. • Visible and audible alarms. • Probes and sample lines provide remote sensing capabilities. • 8 to 12 hours of battery life. • Accuracies of ± 2 to 3% are attainable.	• Potential interferences from leaded gasoline and silicates. • Most models do not measure specific gases. • May not function properly in atmospheres with less than 10% oxygen. • High humidity may interfere with the oxygen cell. • A strong oxidizer may cause an artificially high oxygen readout.

Flame Ionization Detector

The flame ionization detector (*FID*) is a portable DRI used to detect *organic compounds*. It is a type of organic vapor analyzer (*OVA*).

An FID can operate in two modes—survey mode and gas chromatograph (*GC*) mode. In survey mode, the FID detects the total concentration of contaminants in the tested atmosphere. In GC mode, it detects and measures individual contaminants with detection limits as low as a few ppm. To obtain accurate readings, instrument operators must be thoroughly trained in FID operation and data interpretation.

FIDs may be used for the following:

- Monitor for trace contaminants during the evaluation of the confined space.
- Verify the effectiveness of ventilation.
- Assist in choosing the appropriate level of respiratory protection.

Table 4-2 lists the features and limitations of the FID.

Table 4-2. Flame ionization detector.

Instrument	Features	Limitations
Flame Ionization Detector (FID) 	• Measures the total concentration of organic materials in the air. In GC mode, it can identify specific compounds. • Lightweight and portable. • 8-hour battery life, 3-hour if using a strip recorder. • Reads from 0 to 1,000 ppm.	• Should not be used in temperatures below 40°F. • System modification required in oxygen deficient and high concentration atmospheres. • Does not detect inorganic gases and vapors. • Requires training and experience to operate and interpret data.

Photoionization Detector

Another type of OVA is the photoionization detector (*PID*), a portable instrument used to detect many organic and a few *inorganic* gases and vapors. This instrument is factory calibrated to benzene and will respond to benzene concentrations as low as .2 ppm. The primary use of a photoionization detector is identical to that of the FID. However, the PID is easier to use, costs less, and has a faster response time.

A PID is designed for trace gas analysis in normal air. PIDs may be used for the following:

- Aid in choosing the appropriate level of respiratory protection
- Verify the effectiveness of ventilation
- Monitor for trace contaminants

Table 4-3 lists the features and limitations of the PID.

Table 4-3. Photoionization detector.

Instrument	Features	Limitations
Photoionization Detector (PID)  (Image courtesy of RAE Systems, Inc.)	• Measures the total concentration of organic and inorganic materials in air. • Lightweight, portable, and fairly easy to operate and interpret data. • 10-hour battery life, 5-hour if using a strip recorder. • Reads from 0 to 2,000 ppm.	• Does not detect methane. • Must have the correct probe to detect certain compounds. • Does not identify individual components.

Detector Tube

A detector tube is a glass vial containing a chemical that reacts with the contaminant being monitored. It is capable of measuring the concentrations of a wide variety of compounds. A pump is used to draw a known volume of air through the detector tube. The chemical concentration is determined from the color change in the tube. This color change is the result of a chemical reaction between the detector tube's chemical and the contaminant.

Detector tubes may be used for screening for specific organic and inorganic gases and vapors. Table 4-4 lists the features and limitations of detector tubes.

Table 4-4. Detector tube.

Instrument	Features	Limitations
Detector Tube  (Image courtesy of MSA)	• Provides a measure of both volatile organic and inorganic materials in air. • Simple to use and inexpensive.	• Low accuracy of (±) 25% • Requires previous knowledge of gases and vapors to select the appropriate detector tube. • Some chemicals will react with the tube and cause a false positive. • Temperature and humidity may affect readings.

Multi-Gas Monitor

The multi-gas monitor is a portable DRI used to measure oxygen content, combustible gases, and other specific chemicals. Depending on the manufacturer and array of sensors installed, multi-gas monitors can detect three or more additional chemicals.

A multi-gas monitor simultaneously samples and provides readings for all gases being tested. Oxygen is measured in percent by volume. Combustible gases are measured as a percentage of the LEL, and specific chemicals are measured in ppm. Alarms are factory set but can be modified by the user.

Multi-gas monitors can be an effective part of a confined space entry program by:

- Evaluating confined spaces for specific substances
- Assisting in choosing the appropriate level of respiratory protection
- Verifying the effectiveness of ventilation

Table 4-5 lists the features and limitations of multi-gas monitors.

Table 4-5. Multi-gas monitor.

Instrument	Features	Limitations
Multi-Gas Monitor  (Image courtesy of MSA)	• Measures multiple gases simultaneously. • Lightweight and portable. • 8-hour battery life. • Sensors for specific substances can detect in ppm. • Can measure specific substances by TWA and *STEL*.	• May not function properly in atmospheres with less than 10% oxygen. • Potential interferences from leaded gasoline and silicates. • Different sensors measure different ranges. • Requires experience to operate and interpret data. • Can only detect specific substances based on sensors installed.

PERSONAL MONITORING DEVICES

Personal monitoring devices are small compact DRIs used to measure worker exposure to certain types of physical or chemical agents. These devices work on the same principles as portable DRIs, but are much smaller and are carried on a worker's body. The devices are battery operated and detect various forms of chemical hazards, such as toxic and flammable vapors, and energy, such as sound and temperature. The energy or chemical being detected is converted electronically into an audible or visible signal and then recorded.

Some of the more common types of personal monitoring devices include:

- Personal combustible gas/oxygen indicators
- Carbon monoxide monitors
- Chlorine and hydrogen sulfide monitors
- Colormetric dosimeters
- Self-reading dosimeters

Proper Use

Workers who wear a personal monitoring device should:

- Wear the device as instructed
- Not tamper with or remove the device during the monitoring period

Responding to Equipment Failure

When personal monitoring devices fail, they may warn you by various means, such as:

- A low-battery alarm may sound
- An instrument may behave erratically
- Readings may go off the scale for no apparent reason

Follow these general steps when dealing with a failed personal monitoring device:

1. Secure the area
2. Notify co-workers of the situation
3. Exit the confined space immediately
4. Notify the supervisor

LABORATORY ANALYSIS

OSHA requires that employers evaluate the workplace to determine if there are any permit-required confined spaces. Because DRIs cannot detect all atmospheric hazards, a more detailed laboratory analysis may be necessary for a thorough evaluation of the air in a confined space.

Laboratory analysis consists of collecting samples of air from the confined space and analyzing them for chemical contaminants under controlled conditions. This process is also used on hazardous waste sites where samples of soil or water may be collected.

Laboratory analysis is useful in the following situations:

- Extremely low concentrations of chemicals are present, and they cannot be adequately assessed using DRIs.
- A chemical contaminant is in the form of a solid or mist that cannot be assessed using DRIs.
- Worker exposure to chemical or physical hazards needs to be measured over an extended period of time (such as during a work shift or when special maintenance work is required).

SECTION 4 - ASSIGNMENT SHEET

1. Define atmospheric monitoring and list three monitoring methods.

2. List and describe the three required pre-entry atmospheric tests in their proper order.

3. Explain when and where continuous monitoring is necessary.

4. Define direct reading instruments (DRIs) List at least five DRIs and explain their functions.

5. Identify at least five factors that may limit the ability of a DRI to accurately detect hazards.

6. Perform a calibration check on a DRI.

7. List the steps to take if a DRI fails.

____

____

____

____

____

8. List at least two personal air sampling devices and give at least one reason for using personal air sampling devices.

____

____

____

____

____

SECTION 4 - STANDARD OPERATING PROCEDURE 1

Air Sampling with Draeger Pump

Take an air sample with detector tubes and pump using the following steps:

1. Check the pump for leaks by inserting an unopened tube in the pump and completely compressing the bellows. The pump is in working order if the bellows have not expanded after 60 seconds.

2. Select the proper tube for testing and break off both tips of the tube in the break-off eyelet. (Be careful, the ends are extremely sharp.)

3. Tightly insert the tube in the pump head. The arrow must be pointed towards the pump.

4. Hold the pump with your thumb and palm on the top of the pump and your fingers on the bottom plate.

5. Fully compress the bellows evenly and completely.

6. Straighten your fingers and allow the bellows to fill. The limit chain will become tight. Do not restrict the bellows.

7. Repeat Steps 5 and 6 the required number of times. This number will be marked on the tube and tube package.

8. After completing this procedure, remove the tube and flush the pump by making five to six strokes. This prevents corrosion and contamination of the inside of the pump.

9. Decontaminate the pump if necessary and store in the proper location.

10. Dispose of the tube in the proper manner. The best method is to place it in a bucket of water with a small amount of baking soda for 10 to 30 minutes. Then discard according to area regulations. Never break open a tube.

SECTION 4 - STANDARD OPERATING PROCEDURE 2

Multi-Gas Monitor

This procedure is for operation of the MSA Passport Five Star Multi-Gas Monitor

1. Inspect the instrument for any physical damage or contamination (dirt, oil, or other foreign matter).

2. Check the rear of the unit to ensure the battery pack is installed.

3. Turn on the power to the unit by pressing the ON/OFF button. This button is on the lower center of the instrument display panel.

4. The unit will automatically perform a series of self-tests. If ERROR appears, the unit is malfunctioning. Report the malfunction to your supervisor immediately. Do **not** use it for confined space entry.

5. Once the tests are complete, the unit will ask if the user wants a fresh air setup (FAS). If you are certain there are no hazardous gases present, answer "Yes." If FAS CANCELLED appears, move to another location. If the unit still responds with FAS CANCELLED, repeat steps 3 and 4. If FAS CANCELLED still appears, report the condition to your supervisor immediately.

   Note: Use the PAGE button to answer "No" and the RESET button to answer "Yes."

6. The instrument samples air and automatically adjusts the combustible and toxic sensors to zero. Then the instrument enters the EXPOSURE display page and is ready to operate. In this display, the instrument shows readings for oxygen, combustible gases, and any specific toxic sensors installed, such as carbon monoxide and hydrogen sulfide.

PERMIT-REQUIRED CONFINED SPACE ENTRY

Section

5

Title

ENTRY PROGRAM

TRAINEE OBJECTIVES

After completing Section 5, you will be able to:

1. List the components of a permit-required confined space entry program.
2. Explain the purposes of an entry permit.
3. List at least 5 of the 15 required elements of an entry permit.
4. List the required elements of pre-entry atmospheric testing.
5. Identify the members of a confined space entry team and describe the duties of each.
6. Describe at least two instances when training is required for confined space entry.

INTRODUCTION

The Occupational Safety and Health Administration (*OSHA*) requires employers to have a written entry program if their employees will be entering permit-required confined spaces. The entry program must establish procedures for controlling the hazards associated with entry into permit spaces. Workers are encouraged to participate in the development of the program.

The entry program must include the following:

- Identification of all permit-required confined spaces in the workplace.
- Permit-required entry procedures.
- Posted warning signs and appropriate barriers.
- Documented compliance through a *confined space entry permit*.
- *Entry supervisors* and *attendants* to control and monitor entry operations.
- Confined space entry training for authorized *entrants*, attendants, and entry supervisors.
- Evaluation and control of permit-required confined space hazards.
- Personal protective equipment (*PPE*) and rescue equipment for authorized entrants.
- Trained and available *rescue team*.

ENTRY PERMIT

OSHA requires employers to establish a confined space entry permit system as part of their entry program. A *confined space entry permit* is an authorization form that must be completed prior to permit-required confined space entry. It explains the hazards in the confined space and how to control them. Also, the permit explains the duties of entrants, attendants, and entry supervisors during the entry procedure.

The permit must be posted at the entrance to the confined space for the length of the entry procedure. In addition, it must be available to authorized entrants so they can confirm that all pre-entry preparations have been made, appropriate PPE is being worn, and tasks are proceeding in compliance with the permit.

All entry permits must be retained for at least one year after their expiration date so that review of the confined space entry program can be done. The review will ensure that workers participating in entry operations are protected from permit space hazards.

Permits are the primary source of information for the potential hazards found in permit-required confined spaces. The permit's success in protecting workers comes from guiding the entry supervisor, attendant, and entrant through a systematic evaluation of the confined space to be entered.

Although entry permits have many different formats, all must contain the following basic information:

- Location of space to be entered
- Purpose of entry
- Date and authorized duration of the permit
- Authorized entrants
- Authorized attendants
- Name of entry supervisor
- Hazards in the space
- Measures used to isolate the space or control hazards
- Acceptable entry conditions
- Results of initial and periodic atmospheric monitoring
- Rescue and emergency services
- Communication procedures
- Equipment needed, such as:
  - PPE
  - Alarm systems
  - Testing, communications, and rescue equipment
- Any other necessary information
- Any additional permits issued

Entry permits vary in size, length, and number of conditions covered. Therefore, it is important that complete information be provided, especially if the person authorizing the entry will not be at the entry site. Employers must design permits to address the specific hazards in the confined spaces where their employees will be working.

A checklist of safety measures may also be included on the entry permit. The list should include all the equipment needed and the steps to be taken before entering a confined space. The entry supervisor, attendant, and the entrant must review the checklist to ensure that all necessary precautions have been taken.

Some permits contain additional information that is not required but can be valuable to the specific work site. Remember, each work site must develop an entry permit that best fits its safety needs.

Permit Explanation

An example of a confined space entry permit is provided in Figure 5-1. The following is an explanation for each section of the entry permit.

Location, Purpose, and Date of Entry

This section identifies the name and location of the permit space to be entered, purpose of the entry, date, and authorized duration of the entry.

Authorized Entrants

This section identifies the current personnel who are authorized to enter the permit space. The identity of the entrants can be by name or by a tracking system number (e.g., social security or employee number). Recording the names of entrants and their times of entry and exit allows the attendant to keep track of who is in the confined space at any given time.

Authorized Attendants

This section identifies the attendants on duty by name. If there is a change in work shifts and one attendant replaces another, then the permit must reflect the change of duty. The new attendant's name as well as the date and time of the duty change must be listed.

Location/Description of permit space: ____
Purpose of entry: ____
Entry authorized: From: ________________ To: __________________ Date: ________________

Current authorized entrants:

Name	Time In/Out	Time In/Out	Time In/Out
______________________	_____/_____	_____/_____	_____/_____
______________________	_____/_____	_____/_____	_____/_____

Current attendant(s): (Print: name/time when duties assumed and relinquished)
____

Authorizing entry supervisor: (Print: name/time/date)
____

Current entry supervisor: (Print: name/time when duties assumed and relinquished)
____

Known hazards: ____

Pre-entry atmospheric testing:	Reading	Time	Initials
Oxygen content:	______________	________	________
Flammability level (% LEL):	______________	________	________
Toxicity (ppm):	______________	________	________

Initial tests within limits? Yes: _____ No: _____
If no, test and record in remarks section every: ________ minutes.
Is there a known presence or potential for the presence of any other toxic hazards or flammables?
Yes: _____ No: _____

Initial All Items		Yes	Not Necessary
1.	Tank cleaned, washed, and purged:	__________	__________
2.	Wash water tested for neutrality:	__________	__________
3.	All fuses or safety jacks pulled:	__________	__________
4.	All lines broken and/or blanked:	__________	__________
5.	Observer assigned and properly instructed:	__________	__________
6.	Employees in the immediate area alerted to help if needed:	__________	__________
7.	Ventilation provided:	__________	__________
8.	Electrical equipment bonded and grounded:	__________	__________
9.	Intrinsically safe equipment required:	__________	__________

Continuous atmospheric monitoring: Yes: _______ No: _______
Periodic atmospheric testing: _______ Intervals

Oxygen level: __________ % ________ Time: ______________________________
Signature

Combustible
Gas level: __________ % ________ Time: ______________________________
(LEL) Signature

Specific air
Contaminant: __________ % ________ Time: ______________________________
(ppm) Signature

Chemical: ____
____

Figure 5-1. Confined space entry permit.

Required personal protective equipment:
Gloves: __________ Splash suit: __________ Boots: __________
SCBA: __________ SAR: __________ APR: __________
Goggles: __________ Glasses: __________ Face shield: __________
Body harness: __________
Individual Responsible for PPE Selection: ____
Signature

Communications equipment/procedures to be used:
2-way radio: __________ Hand signals: ____________ Alarm: __________
Radio channel to use: __________ Mobile phone: ____________ Batteries in good condition: __________

Special tools and equipment, including lighting equipment: ____

All tools and equipment are safe for the environment being used in, i.e. water-tight and spark-proof:
____

All power cords visually inspected: Yes: __________ No: __________
Batteries in good condition: Yes: __________ No: __________

Emergency Rescue Procedures:
Location of written emergency response plan: ____
Type of emergencies/rescue team required: On-site: __________ Off-site: __________

Emergency rescue equipment available on-site:
Full body harness w/ D-rings: __________
Lifelines: __________ Fire extinguishers: __________
Retrieval system: __________ Evacuation alarm: __________
PPE: __________
SCBAs: __________
Explosion proof emergency lighting: __________
Powered communication equipment available/tested: __________

Off-Site rescue service procedures: __________
Name of rescue service: __________
Phone number: __________

Rescue team notified of location, potential hazards, and route to site:
Yes: __________ No: __________
Does the rescue service have the necessary rescue equipment to meet the sites needs:
Yes: __________ No: __________

Authorization: All actions/conditions necessary for safe entry into, working in, and exiting from the confined space have been performed. Entry is permitted on the date and time, and for the duration, specified above.

____
(Signature of authorizing entry supervisor)

Cancellation: All entrants have exited the confined space and this permit is canceled.

____
(Time) (Signature of authorizing entry supervisor)

Describe problems encountered during entry: ____

Hot work [may] / [shall not] be conducted in this permit-required confined space.
Hot work permit issued: __________ Additional controls: __________
Other permits issued: __________ Specify: __________

Additional precautionary remarks: ____
____

Figure 5-1 (cont'd). Confined space entry permit.

Entry Supervisor	This section identifies the entry supervisor who is responsible for overseeing the confined space entry. The entry supervisor's name, as well as the date and time of duty must be recorded. If there is a change in work shifts and one entry supervisor replaces another, the permit must reflect the change of duty. The new entry supervisor's name as well as the date and the time of duty change must be listed. The entry supervisor must also sign the permit. This signature is usually located in another part of the permit.
Known Hazards and Pre-entry Testing	This section identifies the initial hazards present in the confined space. It is not always easy to identify the hazards in and around a confined space. Therefore, pre-entry atmospheric testing is required. Testing is conducted by the designated competent person or entry supervisor. The initial atmospheric test results must be compared to the required limits. If the testing data is found to be above the allowable exposure limits, or if there is the presence or potential for other hazards, control measures should be used to eliminate or control them.
Hazard Control Measures	This section contains the procedures that must be used to isolate and/or eliminate hazards. These measures must be satisfactorily completed before the permit can be signed.
Acceptable Entry Conditions	This section identifies any remaining hazards in the confined space after all possible hazard control measures have been conducted. Continuous or periodic atmospheric monitoring may be necessary to ensure that conditions do not change or worsen while the entrant is in the confined space.
Personal Protective Equipment	This section identifies the PPE that must be worn in the permit space to comply with acceptable entry requirements. A *competent person* must be in charge of selecting the proper PPE.
Communication System	This section identifies the communication system and types of communication devices used by authorized entrants and attendants to maintain contact during entry. The type of communication device used depends on

the circumstances. Voice and hand signals are used if the attendant and entrant remain within sight and hearing range of one another. However, as soon as they lose that contact, they will not be able to hear or see the commands.

Two-way radios, mobile phones, and other mechanical devices have several advantages over verbal and visual communications. For example:

- Entrant does not have to be in visual or vocal contact with the attendant.

- In an emergency, the attendant can summon help using either the radio or phone.

There is one disadvantage to using radios or mobile phones. They are electrical devices and can create a spark when used. Therefore, when working in an atmosphere that has the potential to become flammable, radios and mobile phones must be spark-proof or equipped with flame arrestors (which are *intrinsically safe*).

Special Tools and Equipment

This section identifies additional equipment to be used for safety and compliance with the acceptable entry condition requirements.

Emergency Response

This section identifies the emergency response procedures to be followed when an incident or accident occurs. It is the employer's responsibility to develop and implement procedures for emergency rescue services, including choosing between an on-site rescue team or off-site rescue service.

If the rescue is to be made by on-site personnel, then the rescue team must be adequately trained. Rescue equipment must be immediately available and constantly maintained in good condition. When an off-site emergency rescue service is used, such as the local fire department, it must be contacted and informed about the entry and its hazards prior to an entry permit being issued.

Authorization and Cancellation Signatures

This section includes the entry supervisor's signature on the authorization line of the permit. By signing here, the entry supervisor verifies that acceptable entry conditions have been met and entry can begin.

Sometimes conditions in or around a permit space change or worsen and no longer meet the acceptable entry conditions. When this happens, all entrants must stop work and immediately exit the confined space. The entry supervisor must then cancel the permit by signing on the cancellation line and authorizing all work to be suspended.

Additionally, each time that procedures detailed on the permit are completed, the entry supervisor must cancel the permit.

Additional Permits

This section identifies any additional permits, such as hot work permits, that have been issued to authorize work in the permit space.

Additional Precautions

This section identifies any other areas that need to be included to ensure worker safety in or around the permit space, e.g., limiting equipment, vehicle, or pedestrian traffic.

ENTRY TEAM

The use of an entry team is required when working in permit-required confined spaces. This is one of the major protections provided by 29 CFR 1910.146 As a minimum, a confined space *entry team* is made up of the following:

- Entrant
- Attendant
- Entry supervisor
- Rescue team

A confined space entry team must always have at least two people—the attendant and entrant. However, either person can have more than one role. For example, the attendant may also be the entry supervisor. Often the confined space entry team has three or more workers. The work performed inside the space may require more than one entrant, or two attendants may be needed.

Confined space entry teams are most effective when team members are:

- Confident of each others' abilities
- Cross-trained in all functions
- Knowledgeable of each others' responsibilities

Training

Your employer is required to provide and certify training for all members of the entry team. Training is required:

- Before workers are assigned their duties.
- Before there is a change in assigned duties.
- Whenever there is a change in permit space operations that presents a hazard for which a worker has not been trained.
- Whenever there are deviations from permit space entry procedures.
- When workers demonstrate a lack of knowledge of permit space entry procedures.

Additionally, entrants must receive self-rescue training and attendants must receive nonentry rescue training when specified in the entry program.

Entrant

The entrant is the worker who enters the confined space to work. The primary responsibility of the entrant is to complete the job assignment safely and properly. Additional responsibilities include the following:

- Know the hazards associated with each specific confined space entry.
- Know how to use the necessary equipment for completing the entry safely.
- Review the entry permit before entering confined space.
- Wear and use appropriate PPE.

- Attend to personal physical reactions that could signal an unsafe condition caused by the work environment.
- Signal the attendant for help when sensing any reaction to chemicals.
- Maintain communication with the attendant.
- Exit from the permit space whenever:
  - An order is given by the attendant or entry supervisor
  - Warning signs or symptoms of exposure to danger are present
  - A prohibited condition is present
  - An evacuation alarm is activated

Attendant

The attendant is the worker who remains outside the confined space while the work is being done inside the space. The primary responsibility of the attendant is to make sure the entrant remains safe. Additional responsibilities include the following:

- Is familiar with the possible health and behavioral effects of hazard exposure to the entrant.
- Knows the hazards that may be faced during entry.
- Reviews the entry permit before allowing entrants to enter the confined space.
- Keeps track of who is in the space at all times.
- Keeps unauthorized individuals out of the area.
- Maintains continuous communication, visual or vocal, with the entrant during the entry.
- Ensures ventilation equipment is working properly.
- Attends to atmospheric monitoring equipment.
- Attends to entrant's lifeline and air line.
- Remains alert for early danger signs in the space.

- Maintains clear access to and from the space.
- Notifies and orders evacuation of the space under the following conditions:
  – A prohibited condition occurs.

  – An entrant shows effects of hazard exposure.

  – Hazards outside the confined space that could endanger the entrants are detected.

  – The attendant cannot effectively and safely perform his or her required duties.
- Is prepared to call for emergency assistance.
- Performs non-entry rescues as specified by the rescue procedure.
- Performs no duties that might interfere with his or her primary duty to monitor and protect the authorized entrant.
- Remains at the entry point except for the following situations:
  - Relieved by another trained attendant
  - Communicating an emergency
  - Self-preservation

Sometimes the confined space permit program allows the attendant to enter for a rescue. Attendants may enter a permit space to attempt a rescue only under the following conditions:

- Attendant is trained, authorized, and equipped for rescue operations.
- Attendant is replaced by another trained and authorized attendant.
- It is part of the emergency response procedure for that specific entry.

Entry Supervisor

The entry supervisor is responsible for determining if acceptable entry conditions are present in a permit-required confined space. The entry supervisor authorizes entry, oversees entry operations, and terminates entry as required by the regulations. This person may also be responsible for identifying and evaluating confined spaces at the job site. Additional responsibilities include the following:

- Plans each entry:
  - Describes the work to be done
  - Evaluates the hazards of the space
  - Identifies the workers involved
  - Performs or arranges for testing and monitoring of the atmosphere
- Ensures the entry permit is completed, dated, and signed.
- Determines the need for appropriate equipment.
- Ensures atmospheric monitoring is performed.
- Makes sure all necessary procedures, practices, and equipment for safe entry, exit, and rescue are used and maintained.
- Determines, at appropriate intervals, that working conditions remain acceptable.
- Removes unauthorized persons from the permit space during entry operations.
- Ensures all procedures are in compliance with the permit.
- Cancels the permit and terminates work when conditions are not acceptable.
- Cancels the permit and secures the space when work is done.
- Verifies that emergency help is available and that the method of summoning assistance is operable.
- Ensures compliance with OSHA, state, and local regulations.

Rescue Team

The rescue team retrieves endangered or injured entrants from the confined space. The team may be on-site and made up of workers from the workplace. Or the team may be an off-site rescue service, such as a fire department or a hazardous materials (*HAZMAT*) response team. Unauthorized workers, including attendants, are prohibited from attempting a rescue.

Important: Unauthorized workers, including attendants, must not attempt to rescue entrants. The majority of confined space fatalities are untrained rescuers.

The rescue team must have access to all the permit spaces where rescue may be needed so that rescue plans and operations can be practiced before they are needed.

Responsibilities of the rescue team include the following:

- Capable of reaching an endangered entrant within a time frame that is appropriate for the hazard(s) identified.
- Equipped for and proficient in performing the needed rescue.
- Knows the hazards that will be encountered when performing a rescue.
- Knows the duties and responsibilities of the entrant.
- Is trained in the use of PPE needed to conduct permit space rescues safely.
- Is trained in basic first-aid and cardiopulmonary resuscitation (*CPR*). At least one team member holding a current certification in first aid and CPR must be available.

When the rescue team is made up of on-site workers, the employer must:

- Train team members to perform assigned rescue duties.
- Train team members in basic first aid and CPR.
- Ensure team members practice simulated rescues at least once every 12 months.

RETRIEVAL SYSTEMS

To facilitate nonentry rescue, retrieval systems must be used whenever an authorized entrant enters a permit space. The only time a retrieval system should not be used is when the retrieval equipment would increase the overall risk of entry or would not contribute to the rescue of the entrant.

Equipment

There are different types of retrieval equipment:

- Full body harnesses
- Wristlets
- Heavy duty lifelines
- Mechanical winches
- Tripods
- Fall arrest devices
- Multiple pulley systems

Selection of the proper retrieval equipment for a confined space entry depends upon several factors, including:

- The type and configuration of the space
- Size of the opening
- Obstacles in the space
- Identification of potential hazards in the space

Use

Normally, a worker is attached to a tripod to aid in a nonentry rescue, when needed. A tripod should not be used to lower or raise a worker into or out of a confined space, unless there is no other way to enter or exit. Ladders, stairs, or other means of entrance or exit should be used first. The purpose of the tripod is to help retrieve a worker during a rescue attempt where the victim needs to be evacuated from the space as quickly as possible. A tripod should have at least two mechanisms, one for rescue and one for fall arrest. With new advances in equipment, most tripods have one mechanism that can be used for rescue and fall protection. Fall protection devices must be self-braking to prevent a worker from free falling.

The ideal situation is to have an entrant in a full-body harness, with a main, lifesaving lanyard hooked to a D-ring on the back of the body, and a fall arrest lanyard hooked to the same D-ring. Using both lanyards aids the egress procedure by keeping the entrant stable as he/she is raised or lowered into the confined space. If this configuration is not practical then the life line should be attached in a way which establishes a profile small enough for the successful removal of the equipment. When using newer equipment with one mechanism for fall arrest and rescue, the lanyard is hooked to the back of the body.

If the use of a full-body or chest harness creates a problem for the worker, wristlets can be used. For example, wristlets are used when entering a grain silo because a silo's opening for entering and exiting is limited.

There will be different hazards associated with every confined space a worker encounters. For this reason, the employer must evaluate each confined space separately, before choosing the proper retrieval equipment.

SECTION 5 - ASSIGNMENT SHEET

1. List the components of a permit-required confined space entry program.

2. Explain the purposes of an entry permit.

3. List at least 5 of the 15 required elements of an entry permit.

4. List the required elements of pre-entry atmospheric testing.

5. Identify the members of a confined space entry team and describe the duties of each.

6. Describe at least two instances when training is required for confined space entry.

PERMIT-REQUIRED CONFINED SPACE ENTRY

Section

6

Title

CONTROLLING ATMOSPHERIC HAZARDS

TRAINING OBJECTIVES

After completing Section 6, you will be able to:

1. Define ventilation.
2. List and describe at least three problems associated with ventilating a confined space.
3. List at least four controllable atmospheric hazards and the methods to control them.
4. Explain supply and exhaust ventilation; explain the advantages and disadvantages of each.
5. List at least five planning considerations to be given when ventilating confined spaces; explain why each is important.
6. Given a mock confined space, ventilation blower and manufacturers purge chart, calculate the amount of time to ventilate the confined space.
7. Evaluate a mock confined space for atmospheric hazards; plan and set up ventilation to remove hazards from the space in time specified on purge chart.

INTRODUCTION

Most of the atmospheric hazards found in a permit-required confined space can be controlled through the use of proper ventilation. *Ventilation* is the continuous movement of fresh, uncontaminated air throughout a confined space to eliminate or reduce atmospheric hazards. Fans, blowers, or natural movement are used to move the fresh air.

There are a number of problems associated with ventilating a confined space. Confined spaces come in a variety of sizes, shapes, and environments, and are used for many different purposes. Some confined spaces are storage tanks, either aboveground vertical tanks or underground horizontal tanks. Most of these tanks have an open interior with no internal obstructions to block air movement. However, some confined spaces, such as tankers, have internal baffles that hinder air movement. Also, some confined spaces have unusual shapes, with angles and corners that must be taken into account during ventilation.

A confined space without internal obstructions can usually be ventilated with a single blower or fan, depending on the size of the space and the capacity of the blower. Confined spaces with internal baffles, such as tanks, may require multiple blowers, sometimes arranged in an elaborate manner to ensure complete ventilation.

The entry supervisor determines how a confined space will be ventilated. These ventilation procedures then become part of the confined space entry permit.

CONTROLLABLE HAZARDS

The atmospheric hazards in a permit-required confined space that can be controlled by ventilation include the following:

- Oxygen-deficient atmospheres
- Flammable and explosive atmospheres
- Toxic atmospheres
- Temperature extremes

Oxygen-Deficient Atmospheres

An oxygen-deficient atmosphere occurs when the oxygen concentration falls below 19.5 percent. This can happen in a confined space when the oxygen is displaced by another gas, such as hydrogen sulfide or methane.

The two options for controlling an oxygen-deficient atmosphere are:

1. Set up the ventilation so that the source displacing the oxygen is removed from the confined space. This allows fresh air to naturally flow in through the openings of the confined space.

2. Position the ventilation to push fresh air through the opening. This allows the source of displacement to flow out through the openings.

In both cases, the proper positioning of duct work allows for circulation of air. Oxygen content should gradually rise.

Flammable and Explosive Atmospheres

Flammable and explosive atmospheres are prevented or controlled by either purging or inerting the confined space. Each method deals with a different element of the fire triangle (Figure 6-1).

Purging

Purging replaces or dilutes flammable vapors in a confined space using air, steam, or water. In a flammable atmosphere, purging eliminates the fuel component of the fire triangle.

Inerting

The term *inerting*, as it applies to confined spaces, means the purposeful removal of oxygen within the confined space so that ignition or combustion is not possible. The procedure uses an *inerting gas* such as nitrogen to displace the oxygen. This affects the fuel and oxygen mixture. Combustion is not possible if the oxygen level falls below 10–12 percent. Ideally, the oxygen level should be lowered to 6 percent as a safety factor.

Important: Inerting creates an immediately dangerous to life and health (*IDLH*) atmosphere because it is oxygen deficient. Entry can only be done if supplied air respirators are used.

Inerting removes the oxygen component of the fire triangle. Consequently, a confined space must be ventilated with breathable air before entry can take place. This situation is sometimes referred to as a *double purge*.

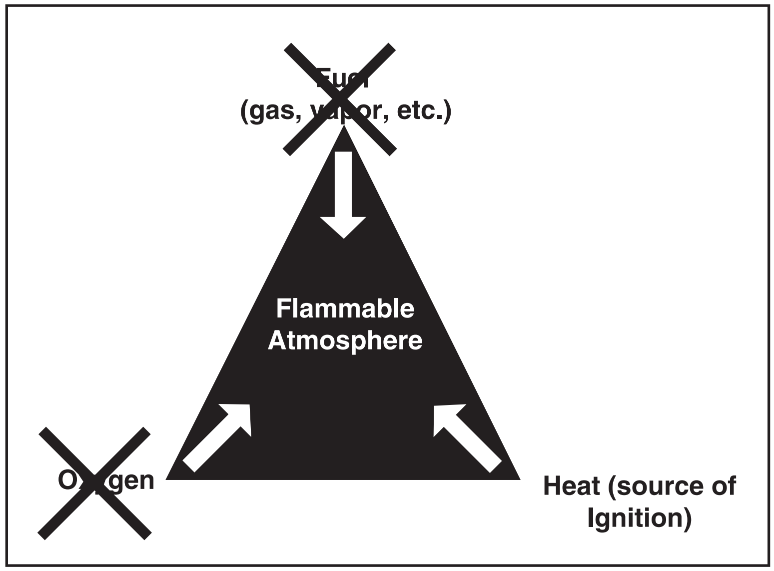


Figure 6-1. Purging and inerting eliminate the fuel and oxygen components of the fire triangle.

A hazard to be aware of when using purging and inerting is the possibility of a spark being produced. The reason is that the movement of fluids or gases can create static electricity. Static electricity can result in sparks and become an ignition source. Therefore, it is important to understand and control static electricity when using these methods.

Static Electricity

Static electricity is generated by moving liquids, gases, or solids. It builds up on objects until another object comes close enough for the charge to arc or jump across. For example, when you walk across a nylon carpet, static electricity accumulates on your body. When your hand comes close to a door knob, the static electricity jumps to the door knob and causes a spark. This spark can serve as an ignition source.

For example, when liquid is transferred from a confined space into a truck, an electrical charge is formed on the surface of the liquid. A charge also builds up on the outside of the truck because the truck's tires insulate the truck from the earth. Static electricity can jump from the vacuum nozzle to the edge of the fill opening. The spark that is created during the arcing is an ignition source. If the liquid is flammable, the spark could cause a fire or explosion.

In a confined space, static electricity can occur as gases flow through hoses during purging or inerting. Air flowing through duct work during ventilation also could create static electricity.

Controlling Static Electricity

The simplest way to control static electricity is to provide a path for the electricity to follow so it does not build up and arc. There are two methods for controlling static electricity:

1. Bonding
2. Grounding

Bonding and grounding are used to eliminate the ignition source, such as static electricity (Figure 6-2). However, eliminating the ignition source of the fire triangle is more difficult and less certain than eliminating the other two elements of the triangle.

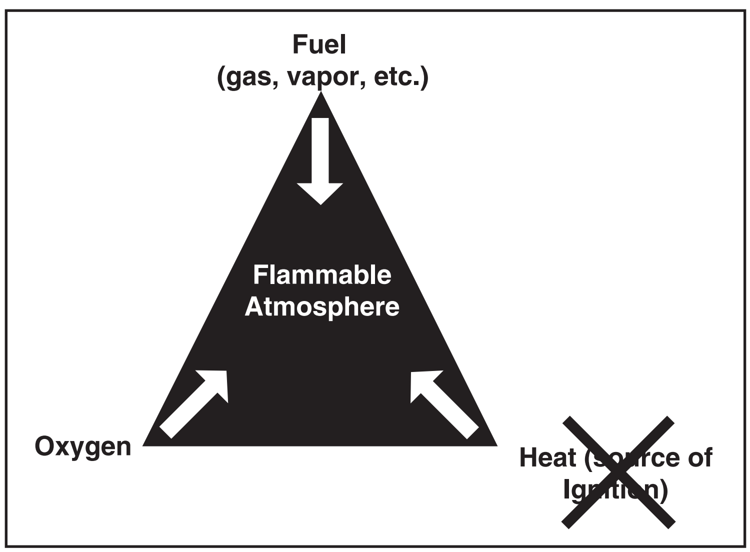


Figure 6-2. Bonding and grounding eliminate the ignition source.

Bonding

Bonding connects two or more conductive objects together with a conductor, such as a copper or steel cable (Figure 6-3). The cable allows the electricity to flow freely between the two objects instead of arcing and creating a spark.

Grounding

Grounding is a form of bonding where one or more conductive objects are connected directly to the earth or to a metal object in contact with the earth, such as a grounding rod or water main. The electrical charge flows harmlessly into the ground (Figure 6-3).

Follow these steps when bonding and grounding objects:

- Make connections directly to bare metal surfaces. Dirt, rust, and paint must be removed before bonding or grounding cables are attached.
- Make bonding connections from the source outward.
- Ensure that all pieces of equipment, connections, and hose couplings are electrically continuous. This can be tested by using an ohm meter.
- Bond and ground while transferring liquids or gases.

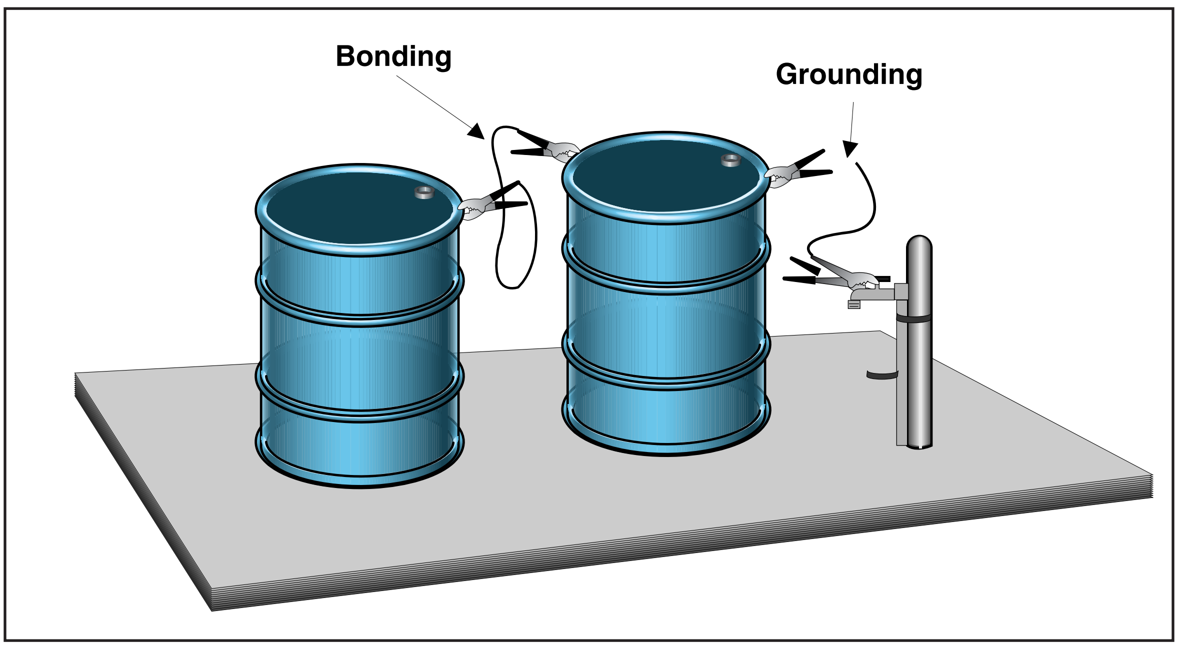


Figure 6-3. Bonding connects two objects together. Grounding connects an object to the earth or to a metal object in the earth.

Toxic Atmospheres

Ventilation is the most preferred method for controlling a toxic atmosphere in a confined space. Fresh air is brought into the confined space to lower the concentration of contaminants to a safe level for entrants. If work activities within the confined space are causing a toxic atmosphere, ventilation can exhaust these contaminants.

Temperature Extremes

High temperatures can occur within a confined space either from the work processes being performed or the lack of air movement. Ventilating the space can keep temperatures within a reasonable range so that tasks can be completed safely.

VENTILATION CATEGORIES

There are two basic categories of ventilation. They are referred to as *general ventilation* and *local exhaust*. General ventilation is the process of ventilating the entire space. Usually, fresh, uncontaminated air is used to dilute the concentration of contaminants within the confined space. Also, general ventilation can be used to cool workers inside a confined space.

Local exhaust is a process that removes contaminants at the source from where they are generated. For example, this process is commonly used during welding operations inside a confined space. Fume hoods or ducts are located just above the area where the welding is taking place. The fumes are gathered quickly before they spread throughout the confined space.

METHODS OF VENTILATION

By definition, ventilation means to “move air.” The two methods used to move air are supply and exhaust.

A *supply system* supplies fresh air by pushing air into a space using blowers or natural air movement. An *exhaust system* pulls air from a confined space.

The main difference between a supply system and an exhaust system is efficiency. Air can be pushed much farther than it can be pulled. More precisely, air can be pushed 30 feet but pulled only 1 foot with the same energy. In other words, these systems have a 30:1 exhaust to capture ratio.

However, pushing air into a space may not always be the best option. For example, when ventilating hydrogen sulfide, it is better to exhaust it because of its vapor density. (Hydrogen sulfide has a vapor density greater than 1.) Rather than trying to push the heavier gas out, it is easier to pull it directly from the bottom of the space.

Mechanical Ventilation

Ventilation in confined spaces involves bringing fresh, uncontaminated air into the space. The most common way to accomplish this is by the use of *mechanical ventilation* using a ventilation blower.

Depending upon the specific conditions, air is either pushed into the space (supply system) or pulled out of the space (exhaust system).

If air is pulled from the space, it exits through the blower duct. If fresh air is pushed in through the blower and duct, then the air inside the space will exhaust through an opening. For example, if fresh air were pushed into a manhole with only one opening, air within the space would exhaust out of that opening. If there were two openings, the air would exhaust out of both.

Ventilation can be used as an initial purge before entry or run continuously during entry operations. The choice will depend on the conditions inside the space. In general, if the source of the atmospheric hazard can be eliminated, then the space will only need to be purged.

Initial Purge

There are three steps for determining appropriate ventilation for an initial purge:

1. Calculate the volume of the space
2. Identify the rated capacity of the blower
3. Calculate the time for one air change

Calculate the Volume of the Space

Before ventilation can begin, the volume of the space must be determined to select the appropriate blower. Volume is calculated using the formula below, and it is written in cubic feet (cu ft).

Volume = length x width x height

Identify the Rated Capacity

Ventilation blowers come in many different sizes and have different capacities. Capacity is a rating given by the manufacturer that identifies the amount of air the blower is able to move in one minute. This is referred to as rated capacity and is written as cubic feet per minute (cfm). A machine that has a rated capacity of 1,500 cfm is capable of moving 1,500 cu ft of air in one minute.

Often rated capacity only refers to the ability of the blower to move "free air." In other words, the blower can move 1,500 cfm when there are no ducts, 90° elbows, or saddle vents, which create resistance. However, the addition of these components can reduce the effective capacity of the blower to 1,000 cfm.

In nearly all ventilation situations, at least one 90° bend and one 25-foot length of duct will be needed. Therefore, components such as duct work or bends must be considered when calculating the ventilation capacity needed.

Calculate the Air Change

An air change is the process of completely replacing the air in a confined space. Using the volume of the confined space and the capacity of the blower, you can determine the time for 1 air change.

The following example illustrates how to determine an air change time for initial purge of a confined space. (These figures are used only for the example. They may not accurately reflect actual conditions.)

Example:

1. Calculate volume:

   Confined space dimensions are 8 ft x 10 ft x 40 ft.

   8 ft x 10 ft x 40 ft = 3,200 cu ft

   The confined space has a total volume of 3,200 cu ft.

2. Identify the rated capacity:

   The blower has a rated capacity of 1,570 cfm. But the space will require one 25-foot length of duct and one 90° bend. This reduces the rated capacity to 1,000 cfm.
3. Calculate the time for 1 air change:

   Divide the volume of the space by the capacity of the blower.

   3,200 cu ft ÷ 1,000 cfm = 3.2 minutes

It will take 3.2 minutes to completely change the air in the space.

Purge Chart

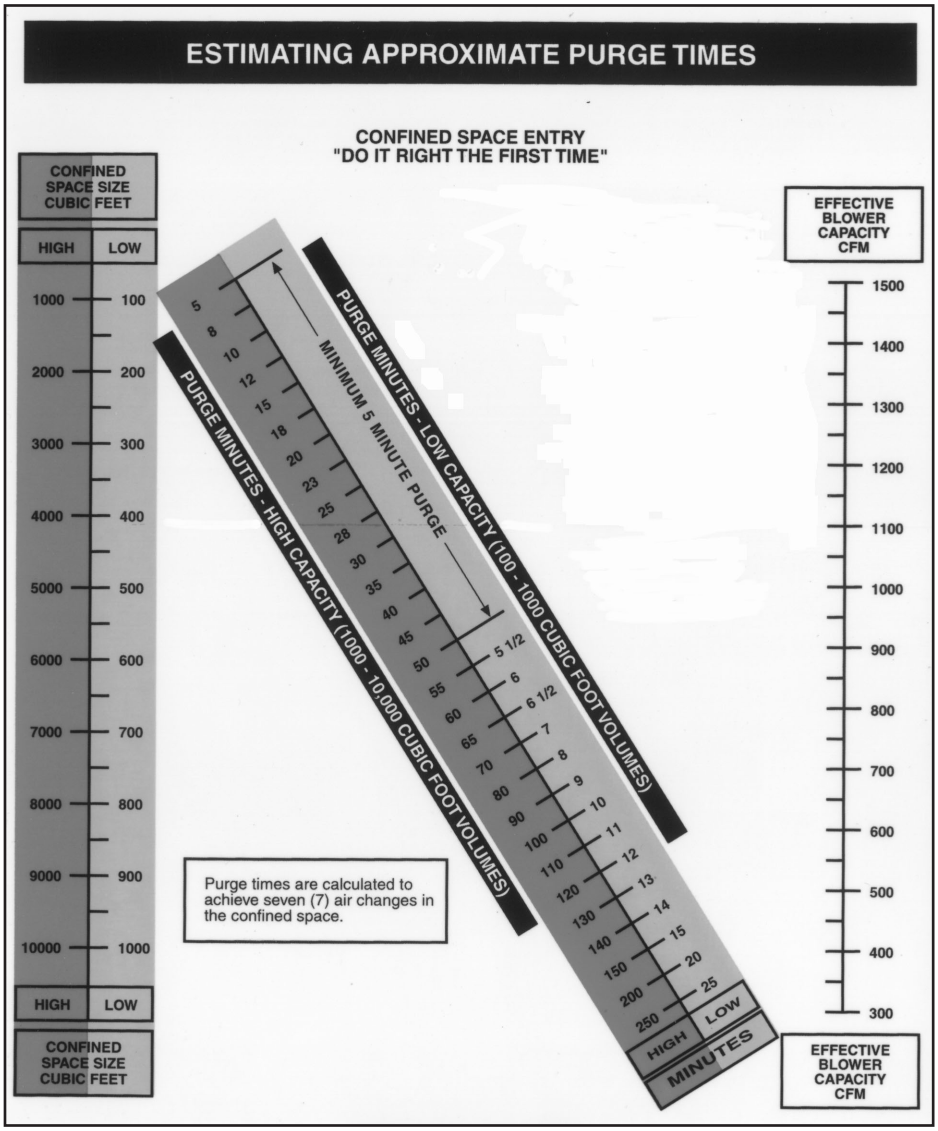
Another way to determine how long it will take to ventilate a confined space is to use a purge chart. Air Systems International, a manufacturer of ventilation equipment, posts a purge chart on each of their blowers. An example is shown in Figure 6-4.

The chart calculates purge times based on seven air changes.

Exercise:

Follow the instructions on the chart using the same figures as in the previous example. You should get a number of about 23. That is, it will take 23 minutes to change the air seven times in the space. This calculation is good to know.

Before an entry, calculate the volume of the space, determine the capacity of the blower, and use the chart to determine how long you will have to run ventilation before it is safe to enter the space.



How to Use This Chart

1. Select the proper size scale at left, high or low, depending on size of confined space.
2. Place one end of a straight edge on the proper size scale at left.
3. Place other end of straight edge on blower capacity scale at right.
4. Read required purge time from the diagonal scale, orange (left side) or green (right side), that corresponds to the high or low volume scale selected.

Selected Notes

1. Air quality of the confined space should be tested prior to ventilation.
2. Ventilate confined space for the minimum times as determined in the above chart and then retest air quality.
3. If toxic (combustible) gases or low oxygen is encountered, increase purge times by 50 percent.
4. If 2 blowers are used, add the two capacities, then proceed with the “How to use chart” above.
5. Effective blower capacity is measured with one or two 90° bends in 8" diameter 25-foot blower hose.

Reference: Bell Systems Standard ISS 10, Section 620-140-501

Figure 6-4. This chart shows how to estimate purge times. (Courtesy Air Systems International, Inc.)

Continuous Ventilation

The same steps can be used to calculate air changes for continuous ventilation.

Example:

Confined space dimensions are 10 ft x 40 ft x 40 ft

1. Calculate the volume:

   10 ft x 40 ft x 40 ft = 16,000 cu ft

2. Identify rated capacity:

   The blower has a capacity 2,000 cfm.

3. Calculate the time for one air change:

   Divide volume by rated capacity.

   16,000 cu ft ÷ 2,000 cfm = 8 minutes

The air in the space will be changed every 8 minutes.

How many air changes will there be in 1 hour? Divide 60 minutes (1 hour) by 8 minutes:

   60 ÷ 8 = 7.5

In this example, the air will be changed 7.5 times per hour.

Advantages and Disadvantages

There are distinct advantages to using mechanical ventilation:

- It is very reliable when properly maintained
- It can be adjusted to remove contaminants from most confined spaces
- Most systems can either supply or exhaust fresh air

There also are disadvantages to using this method:

- Possible ignition source
- Possible introduction of carbon monoxide
- Electrical and mechanical hazards

Important: When the possibility of a flammable or explosive atmosphere exists, precautions must be taken to prevent mechanical ventilation from becoming an ignition source. Because there is a potential for static electricity during mechanical ventilation, ventilation units should always be grounded or bonded. Additionally, any flammable vapors that are exhausted from the confined space must be contained. If this is not practical, then precautions must be taken to ensure that no heat, sparks, or open flames are introduced to the area.

Even with these disadvantages, mechanical ventilation is still the preferred way to ventilate a confined space.

Natural Ventilation

In some work environments and with favorable weather conditions, the forces of nature can be used to ventilate a confined space. In this situation, the wind velocity and direction would have to be easily forecast. However, natural ventilation is typically used to improve worker comfort and not to remove contaminants. There are several advantages to natural ventilation:

- Low noise levels
- No start up costs
- No sources of ignition
- No electrical parts
- No mechanical parts

The main disadvantage to this method is that wind velocity and direction are unpredictable, making natural ventilation an unreliable and sometimes dangerous method to use.

PLANNING CONSIDERATIONS

No matter which ventilation method is used, careful thought has to be given to all aspects of the confined space entry. Planning considerations must include the following:

- Size and shape of the confined space
- Previous contents and operations
- Internal obstructions
- External factors
- Existing openings
- Natural drafts

- Vapor density
- Operations in the space
- Contaminant reentrainment
- Short circuiting

Size and Shape of the Confined Space

The size and shape of a confined space will influence the selection of ventilation equipment as well as the method of ventilation. For example, the larger the confined space, the more air there is to be moved. Therefore, the ventilation equipment chosen would need to be able to exchange a large volume of air or a series of blowers may have to be used. The size would also influence whether an exhaust system or a supply system is used.

Smaller confined spaces have different issues, such as less room for equipment. Also, heat and fumes build up quicker in a smaller space.

The shape impacts selection as well. For example a confined space with bends and angles would require a more complicated setup of ducts and may also require additional blowers.

Previous Contents and Operations

The contents that were previously stored in a confined space as well as the operations that took place will influence the ventilation needs.

- Contents previously stored in the confined space – If hazardous materials were stored in the confined space, every effort must be made to clean or flush the space from the outside.

- Operations that previously took place inside the confined space can affect – Some work operations produce toxic by-products, such as fumes. These fumes may linger in a confined space and create a hazardous atmosphere.

Internal Obstructions

Some confined spaces have internal obstructions, such as baffles, which are used to increase the strength of the structure. Baffles make ventilation more complicated. They prevent air from flowing freely. Additionally, they make it more difficult to install duct work. In both cases, ventilation blowers with higher capacities will be needed to ensure all parts of the space are ventilated

External Factors

Conditions outside a permit space can present external hazards. For example, exhaust fumes from a vehicle or an air compressor can be pulled into the space. Care must be taken so that these hazards are not introduced into the space. Hazards should be removed or eliminated from the area if possible. If not, then ventilation must be located so that these hazards are not reintroduced.

Existing Openings

Confined spaces usually have fixed openings. When ventilation is being used, these openings can aid the process by allowing air to enter or exit the space. Special consideration must be given for using these openings to the best advantage. Often the same opening is used both to ventilate the duct work and to allow workers to enter and exit the confined space. A piece of equipment called a *saddle vent* makes this process easier. A saddle vent connects to the duct work at the opening and makes the duct narrower. This gives workers more room to enter and exit the confined space.

During entry operations, every effort must be made to keep these openings free of any obstructions, so that air flow will not be affected.

Natural Drafts

Air movement outside a confined space can be very helpful in enhancing the ventilation system. For example, strong air currents outside the space can supply fresh air through the ducts and into the confined space. Natural air movement should also be taken into consideration when placing the ventilation blower or fan. For example, the blower may need to be located downwind of the confined space to prevent exhausted material from reentering the space.

Vapor Density

Gases and vapors have different weights or vapor densities. Normal air has a *vapor density* of 1. The vapor densities of the gases and vapors in the confined space will affect the following:

- Choice of ventilation method, i.e., supply or exhaust
- Placement of the ventilating equipment

For example:

- Vapor density is greater than 1 – The chemical is heavier than air and will initially settle to the bottom of the space. Therefore, the exhaust fans or ducts should be located at the bottom of the space where the vapors will accumulate.

- A vapor density less than 1 – The chemical is lighter than air and will initially rise to the top area of the space. In this case, ducts should be located in the top of the space.

In either example, the decision of whether a supply or exhaust method is used and the location of the duct work depends upon the size, shape, and location of the confined space openings.

Operations in the Space

Work that is taking place inside a confined space can create hazards. Work operations and their hazards must be considered when setting up ventilation.

For example:

- Air monitoring results show the atmosphere to be relatively clean at the time of entry. The first layer of sludge is removed. Toxic vapors can be released by the next layer of sludge or by the solvent used to remove the sludge. These vapors must be ventilated because the atmosphere is no longer safe.

- Welding operations are conducted in the confined space. The welding process releases fumes into the space, creating a hazardous atmosphere.

In both of these examples, continuous ventilation is often required.

Reentrainment

Reentrainment is the term given to the situation in which external contaminants are drawn into a confined space. The following are two examples:

1. Exhaust gases are drawn into the confined space – A gas-powered blower is used to ventilate the space. Care must be taken to prevent the blower's exhaust gases from entering the space. Locate fresh air intakes to avoid reentrainment (Figure 6-5).

2. Exhausted air is reintroduced into the space – A ventilation blower is set up to supply air into the space (Figure 6-6). If it is located downwind from the exhaust vent, it will pull contaminated air back into the space.

Short Circuiting

Short circuiting occurs when the fresh air entering the confined space is exhausted before it can travel throughout the entire space. To prevent this, always position duct work so the fresh air can travel completely through the confined space before it is exhausted.

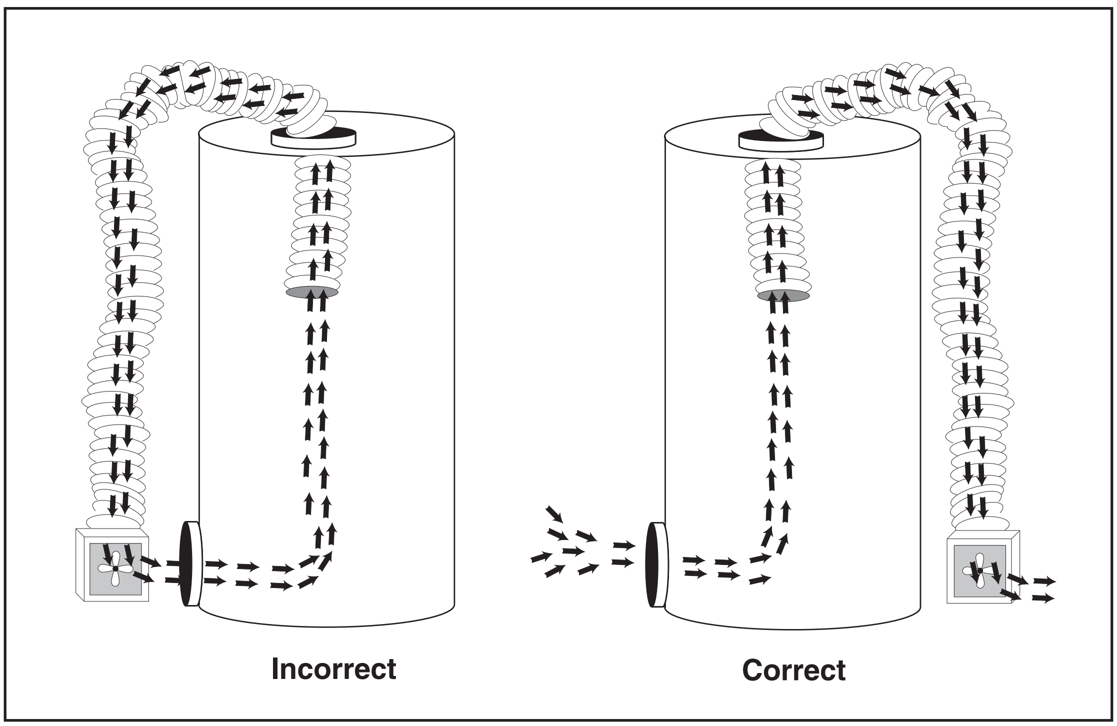


Figure 6-5. The correct and incorrect ways to prevent external contaminants from entering a confined space (contaminant reentrainment).

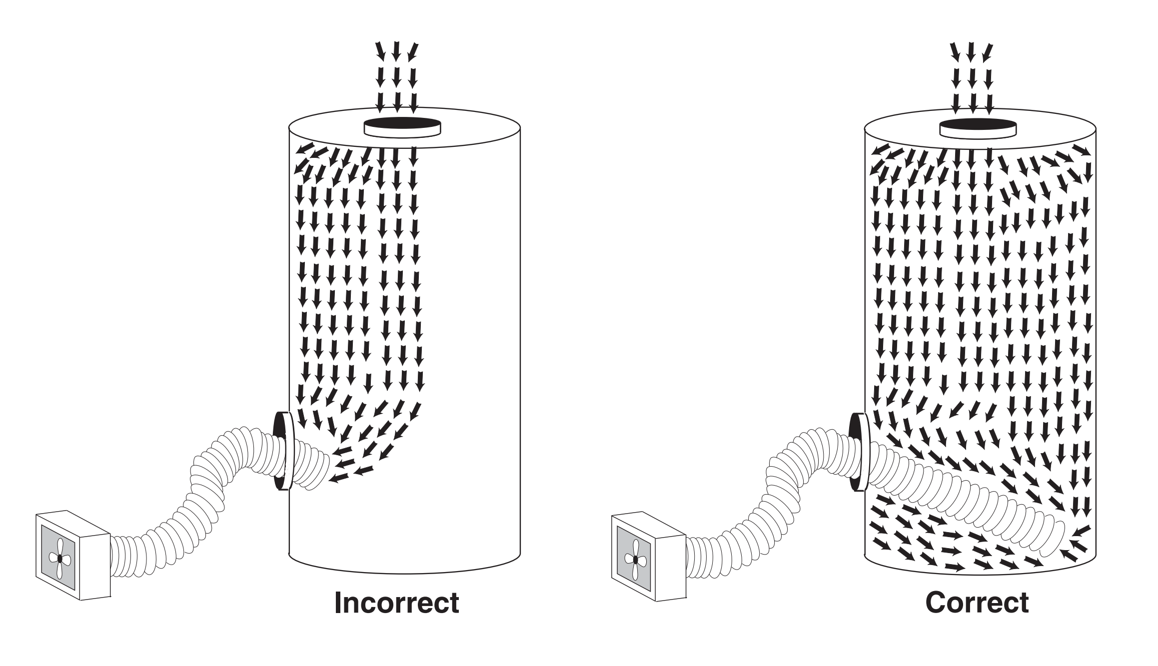


Figure 6-6. The correct and incorrect ways to prevent supply and exhaust from occurring too close together (short circuiting).

SECTION 6 - ASSIGNMENT SHEET

1. Define ventilation.

2. List and describe at least three problems associated with ventilating a confined space.

3. List at least four controllable atmospheric hazards and the methods to control them.

4. Explain supply and exhaust ventilation; explain the advantages and disadvantages of each.

5. List at least five planning considerations to be given when ventilating confined spaces; explain why each is important.

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6. Given a mock confined space, ventilation blower and manufacturers purge chart, calculate the amount of time to ventilate the confined space..

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7. Evaluate a mock confined space for atmospheric hazards; plan and set up ventilation to remove hazards from space in time specified on purge chart.

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PERMIT-REQUIRED CONFINED SPACE ENTRY

Section
7

Title
CONTROL OF HAZARDOUS ENERGY

TRAINEE OBJECTIVES

After completing Section 7, you will be able to:

1. Define the following terms:

   Affected employee
   Authorized employee
   Energy isolating device
   Energy source
   Lockout
   Lockout device
   Tagout
   Tagout device

2. Identify the four categories of hazardous energy and the means for controlling each.

3. Define the roles of affected and authorized employees when working under an energy control program.

4. Given a scenario, identify potential sources of hazardous energy and a method for controlling each.

INTRODUCTION

During the course of your job, you may need to enter a permit-required confined space that contains pipe lines, water mains, hydraulic lines, or some other working system or equipment. These systems could contain water, hydraulic fluid, electricity, or steam, to name a few examples. Should any of these materials be released into the permit space while you are in it, you could be injured or killed. Therefore it is important that you understand the concept of hazardous energy and how it can be controlled.

Energy is defined as the ability or capacity for doing work. There are two kinds of energy—kinetic energy and potential energy:

1. Kinetic energy is the energy of motion. For example, a crane lifting a load or water running through pressurized pipes has kinetic energy.

2. Potential energy is stored energy. When the hoist is at rest, it has potential energy. When the water pressure is shut off, the water has potential energy.

Examples of different forms of energy include:

- Electric
- Heat (thermal)
- Light
- Mechanical

All of these forms can be broken into either kinetic or potential energy. Some forms of energy can be released into a permit-required confined space to become hazardous energy.

Examples of hazardous energy include:

- Mechanical energy – Energy that comes from the moving parts of equipment. Examples: rock crushers or sewage digesters.
- Potential energy – Stored energy in hydraulic and pneumatic systems. Also energy stored in mechanical parts such as springs.
- Electrical energy – Energy from electrical power, static sources, or electrical storage devices, such as batteries or capacitors.
- Thermal energy (high or low temperature) – Energy resulting from mechanical operations, radiation, chemical reaction, or electrical resistance.

ENERGY CONTROL PROGRAM

The control of hazardous energy is regulated by the Occupational Safety and Health Administration (*OSHA*) through 29 *CFR* 1910.147. The standard requires employers to set up an energy control program to protect workers. This energy control program must include the following:

- Energy control procedures
- Employee training
- Periodic inspections

Energy Control Procedures

The procedures must clearly outline the scope, purpose, authorization, techniques used, and the means to ensure compliance (the procedures are being followed). These procedures should include the following:

- Statement on the intended use of the procedures.
- Steps to shut down, isolate, block, and secure equipment.
- Steps for the placement, removal, and transfer of lockout and tagout devices.
- Requirements for testing equipment to prove the effectiveness of lockout and tagout devices.

Additionally OSHA requires all energy control procedures to be documented. However, the employer does not need to document procedures for a particular machine or equipment when all of the following conditions are met:

- The equipment has no potential for stored or residual energy, or the reaccumulation of stored energy that could endanger workers after it is isolated.
- The equipment has a single energy source that can be readily identified and isolated.
- The isolation and locking out of the energy source will completely deenergize and deactivate the equipment.
- The equipment is isolated from the energy source and locked out during servicing or maintenance.
- A single lockout device achieves lockout.
- The lockout device is under the exclusive control of the authorized employee performing the servicing or maintenance.
- The servicing or maintenance does not create hazards for other workers.
- The employer, in using this exception, has had no accidents involving the unexpected activation or reenergization of the equipment during servicing or maintenance.

Under the standard, workers are either affected employees or authorized employees:

- *Affected employee* – Person who operates or uses a machine or equipment on which servicing or maintenance is being performed under lockout/tagout or who works in that area.
- *Authorized employee* – Person who locks out or tags out machines or equipment to perform servicing or maintenance on that machine or equipment.

An affected employee becomes an authorized employee when he or she performs the servicing or maintenance.

LOCKOUT AND TAGOUT DEVICES

Lockout or tagout devices are attached to energy isolating devices to ensure that machines or equipment are shut down. Only those lockout or tagout devices identified by the energy control procedures can be used for controlling hazardous energy. An energy-isolating device is a mechanical device that physically prevents the release of energy. Energy-isolating devices include the following:

- Manually operated electrical circuit breaker
- Disconnect switch
- Line valve
- Block
- Manually operated switch that disconnects circuit conductors from all ungrounded supply conductors and prevents a pole from being operated independently.

Note: Push buttons, selector switches, and other control circuit type devices are not energy-isolating devices.

Lockout Devices

A lockout device holds an energy-isolating device in a safe position and prevents the energizing of a machine or equipment. Lockout devices include the following:

- Locks using keys or combinations
- Blank flanges
- Bolted slip blinds

Figure 7-1 shows examples of lockout devices.

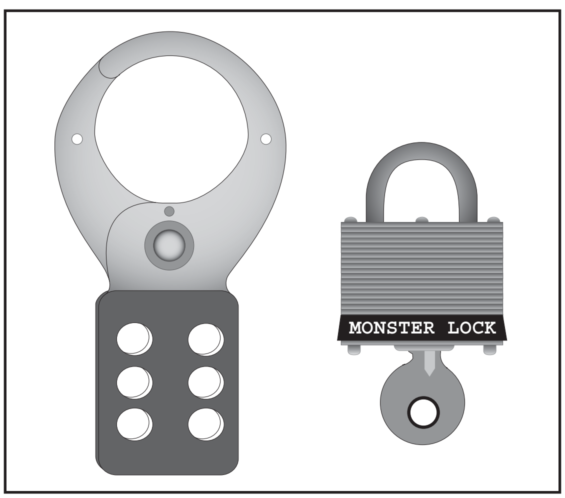


Figure 7-1. Examples of lockout devices.

Tagout Devices

A tagout device is a warning device that is attached to the energy-isolating device (Figure 7-2). It is easy to see and consists of a tag and a way to attach the tag. The tagout device warns that the energy-isolating device and the equipment being controlled may not be operated until the tagout device is removed. The tagout device is securely fastened to the energy-isolating device according to an established procedure.

Important: Tags are warning devices and do not provide the same protection as locks or other lockout devices.

Figure 7-2. A tagout device.

Device Requirements

All of the lockout and tagout devices used in an energy control program must be:

- Durable
- Standardized
- Substantial
- Identifiable

Durable

Lockout and tagout devices must be able to withstand all of the conditions in the environment where they are used. Tagout devices must be constructed and imprinted so that they do not deteriorate or become illegible.

Standardized

Lockout and tagout devices must be standardized within the facility they are being used in at least one of the following ways:

- Color
- Shape
- Size

Additionally, the print and format of tagout devices must be standardized. This helps workers to recognize tags more effectively.

Substantial

Lockout devices must be strong enough to prevent removal except by excessive force, such as using bolt cutters or other metal cutting tools. Tagout devices and their attachments must be strong enough to prevent accidental removal.

Attachments for tagout devices must have the following characteristics:

- Non-reusable
- Attachable by hand
- Self-locking
- Non-releasable, with a minimum unlocking strength of no less than 50 pounds

Identifiable

Lockout and tagout devices must clearly identify the worker who applies them.

Use and Limitations of Tagout Devices

Tagout devices are used when an energy-isolating device cannot be locked out, or when the employer can show that the tagout system will provide full protection to workers. They must warn against hazardous conditions that would occur if the equipment becomes energized.

A tag must include legends that can be used alone or in combination with each other. Some examples are:

- Do Not Start
- Do Not Open
- Do Not Close
- Do Not Energize
- Do Not Operate

When a tagout device is used on an energy-isolating device that is lockable, the tagout device must be attached where the lockout device would have been attached.

For an employer to be able to use a tagout system, he or she must prove that it provides the same level of protection as a lockout system.

There must be full compliance with all the tagout provisions and any additional safety measures, if required. Additional safety measures include:

- Removal of an isolating circuit element
- Blocking of a controlling switch
- Opening of an extra disconnecting device
- Removal of a valve handle to reduce the likelihood of inadvertent energization

Tagout devices are essentially warning devices attached to energy isolating devices. As such they may give a false sense of security. So it is important to remember that tagout devices do **not** provide the physical restraint of a lock.

Other rules to keep in mind about tags are:

- Tags must **not** be removed without approval from the authorized person.

- Tags must **never** be bypassed, ignored, or otherwise defeated.

- Tags must be legible and understandable by all workers.

- Tags are only one part of an energy control program.

Additional Personnel Requirements

When groups, outside workers, and workers involved in shift or personnel changes are protected by energy control procedures, additional measures are required.

Groups

Sometimes maintenance is performed by a group or a crew rather than an individual worker. When this occurs, the energy control procedure must offer the same level of protection as a personal lockout or tagout device. A group lockout or tagout device must be applied in the same way that a personal lockout or tagout device is applied.

Group lockout or tagout procedures must include the following:

- One authorized employee is responsible for a set number of workers protected by the group lockout or tagout device.
- The authorized employee determines the risk of exposure to hazardous energy for each group member.
- When more than one group is involved, one authorized employee is chosen to be responsible for the protection of all the groups.
- The authorized employee **shall** also apply a personal lockout or tagout device to the group lockout device.

A group lockout/tagout device is shown in Figure 7-3.

Figure 7-3. This hasp is one example of a group lockout/tagout device. (Courtesy of Brady Worldwide, Inc.)

Outside Workers

Whenever outside employees or contractors work in confined spaces protected by an energy control program, the on-site and outside employers must inform each other of their respective lockout or tagout procedures.

On-site workers must comply with the outside employer's energy control program. (This is a common situation on job sites where laborers work.)

Shift or Personnel Changes

Employers must ensure the continuity of worker protection when shifts or personnel change, including an orderly transfer of lockout or tagout device protection between outgoing and incoming workers. This will help to minimize exposure to hazards from the unexpected energization or start-up of the machine or equipment, or the release of stored energy.

Periodic Inspection of Procedures

Periodic inspections of procedures are required to ensure that energy control procedures and devices are in place and being used correctly. An inspection of procedures shall be done:

- At least annually
- Whenever procedures are not followed
- Whenever problems related to equipment or devices are discovered

The inspection must be performed by an authorized employee. However, one employee cannot be both the authorized employee of the inspection and the authorized employee of the energy control procedure being inspected. These two roles must be filled by two different people.

The inspection includes the following:

- For lockout procedures – The inspector reviews the responsibilities of each authorized employee under the procedure being inspected.

- For tagout procedures – The inspector reviews the responsibilities of both the authorized and affected employees under the procedure being inspected. Also review is conducted on the limitations of tags.

The employer is required to certify periodic inspections by identifying the following:

- Equipment involved in the energy control procedure
- Date of the inspection
- Workers involved in the inspection
- Inspector

TRAINING

Training is an important part of an energy control program. Everyone who works in a confined space where hazardous energy is a potential threat needs to understand the purpose of the program and be instructed in its procedures. Training must be given to individual workers, groups of workers, and outside workers who do the following:

- Apply energy control devices (authorized employees).

- Operate equipment when servicing or maintenance is performed under lockout or tagout (affected employees).

- Work in a confined space where servicing or maintenance is being performed (affected employees).

Authorized employees must receive training in the following areas:

- How to recognize the source, type, and magnitude of hazardous energy in the confined space.

- Purpose and use of energy control procedures.

- Procedures to ensure the continuity of lockout or tagout protection when shifts change.

Affected employees must have training in the following:

- Energy control procedures used to protect them.

- The importance of not restarting or reenergizing the equipment that has been locked or tagged out.

When a tagout system is used, employees must receive training in the limitations of tags.

Employers are required to certify that workers have been trained and must document worker names and their dates of training.

Retraining

Retraining must be provided for all authorized and affected employees when the following conditions exist:

- A change in job assignments, machines, equipment, or processes presents a new hazard.
- A change in the energy control procedures.
- A periodic inspection reveals that an employee did not follow or did not know the energy control procedures.

GENERAL LOCKOUT PROCEDURES

The following text explains the general sequences and steps for:

- Locking out equipment
- Restoring equipment to service
- Testing or positioning machines

Remember that when energy isolating devices cannot be locked out, tagout will be used as the only means of energy control. When tagout alone is used, additional training and more rigorous periodic inspections will be needed.

Locking Out Equipment

These are the general steps to be followed in the lockout of energy isolating devices. An employer may develop further steps for your workplace, as required by the type of equipment, hazardous energy, and the specific conditions of your workplace.

The lockout steps are:

1. All affected workers must be notified that servicing or maintenance of equipment is required, and that the equipment must be shut down and locked out first.

2. The equipment is shut down or turned off using the normal stopping procedure (e.g., depress the stop button, open switch, or close valve).

3. The energy isolating device(s) is deactivated so that the equipment is isolated from the energy source(s).

4. The energy isolating device(s) is locked out with assigned personal lock(s).

5. Any stored or residual energy is relieved, disconnected, drained, or restrained by methods such as grounding, repositioning, blocking, or bleeding. Examples of stored energy include energy in springs, pressurized air or water lines, or batteries.

6. The equipment is disconnected from the energy source(s) after first checking that no workers are exposed.

7. Then the isolation of the equipment is verified by:

   - Operating the push button or other normal operating control(s).

     or

   - Testing to make certain the equipment will not operate.

8. The operating control(s) are returned to the neutral or off position after verifying the equipment is isolated.

7. The equipment is now locked out.

Restoring Equipment to Service

When servicing or maintenance is completed, the equipment is returned to normal operating condition by these steps:

1. The equipment and its immediate area are checked to ensure that nonessential items have been removed and that the equipment parts are intact for operation.

2. The work area is checked to ensure that all workers are safe or removed from the area.

3. It is verified that the controls are in neutral.

4. The lockout devices are removed and the equipment is reenergized.

   Note: Some blocking energy isolating devices may require reenergization before the lockout devices are removed.

5. Workers are notified that the the lockout or tagout devices have been removed. The servicing or maintenance is completed, and the equipment is ready for use.

Testing or Positioning of Equipment

Sometimes lockout or tagout devices must be temporarily removed from the energy isolating device. This can happen when equipment must be energized to test it or position it. For these situations, follow these steps:

1. Remove tools and materials from the equipment.

2. Remove workers from the machine or equipment area.

3. Remove the lockout or tagout devices.

4. Energize the equipment and proceed with testing or positioning.

5. Deenergize all systems and reapply energy control measures to continue with the servicing and maintenance.

SPECIFIC LOCKOUT PROCEDURES

The confined space entry permit must list the procedures and devices that will be used to control hazardous energy. Procedures often used in confined spaces include:

- Locking out all electrical devices at their power source
- Disconnecting or blanking pipes and process lines

Some confined spaces have many systems that need to be locked out. One space may have electrical lines, a pump, and sewage pipes that all must be locked out. The following are specific procedures to control hazardous energy in commonly encountered confined spaces.

Locking Out Electrical Devices at Their Power Source

Many workers have died when switches were shut off, but not locked out. Before servicing or maintaining electrical equipment and systems, make sure to lockout and tagout their power sources such as:

- Electrical breaker panels
- Start-stop buttons
- Other disconnect switches

Some people may see lockout as an inconvenience instead of a way to protect themselves or their co-workers. They may think it takes too much time and effort to implement it. Tragically, this attitude has lead to injuries and deaths.

"One worker, one lock, one key" is a method that is safer than any OSHA standard. This means there should only be one key for each lock assigned to the authorized employee responsible for the lockout and tagout of electrical devices. Ask your employer to use the safer standard.

Isolating Pipe Systems

Liquids and gases can leak into a confined space through pipe connections. Injuries and deaths can be avoided by thorough training in the procedures to isolate a pipe system after draining or depressurizing a line. The methods to isolate a pipe system include the following:

- Disconnecting lines
- Blanking or blinding flanges
- Double-blocking and bleeding valves

Disconnecting Lines

Before a line is disconnected, the authorized employee reviews the relevant *material safety data sheets* (*MSDSs*). It is important to identify:

- Any hazardous substances in the line and surrounding area.

- Whether or not the substances in the line are under pressure or at a high temperature.

Then all possible methods to drain the pipeline should be considered, and the safest method chosen.

Pipelines are disconnected by removing the bolts from the flanges or by loosening some of the threaded pipe sections. *First-break* is the term used for the initial disconnection or breaking of the pipeline.

Line-breaking is the term used for the intentional opening of a pipe, line, or duct that has been carrying any of the following materials:

- Inert gases
- Flammable, corrosive, or toxic materials
- Fluids at a volume, pressure, or temperature capable of causing injury

Once a pipeline is disconnected, it can be misaligned to stop the flow of any hazardous substance into the space.

Blanking or Blinding Flanges

Blanking or *blinding* is the absolute closure of a pipe, line, or duct. A solid plate is fastened over the bore to completely cover it. The plate must be able to withstand the maximum pressure of the pipe, line, or duct with no leaks beyond the plate. Leaks can cause the plate to corrode or react with the material in the pipeline, causing additional hazards such as a leak or toxic fumes. The plate must fit perfectly between the flanges so the bolts can be tightened enough to prevent leakage and movement.

A spectacle blind or skillet blind are two examples of a blinding system. A spectacle blind looks like a pair of glasses (Figure 7-4). One side of the blind is open and allows the contents to flow through the line. The other side of the blind is a solid plate that closes off the line.

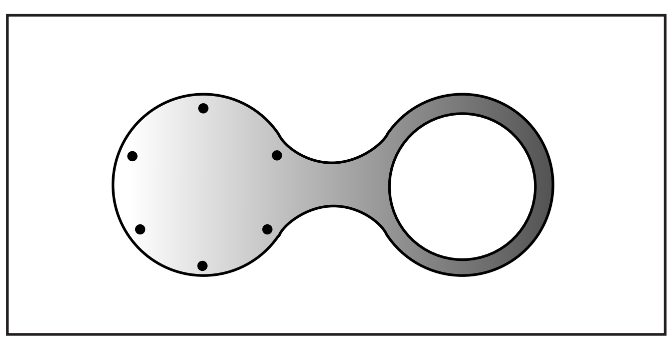


Figure 7-4. A spectacle blind.

You place one blind inside the pipe, and the other side sticks out of the pipe. In this way you can tell immediately whether the line is open or closed. Plates and blinds are designed and manufactured specifically for the pipes on which they will be used.

Double-Blocking and Bleeding Valves

Double-block and bleed is a three-valve system for closing off a pipe. This system works in a "T" configuration (Figure 7-5). Two valves close off each end of a section of pipe. A third valve is located at the bottom of the pipe. The two end valves are drained out by opening the bottom valve.

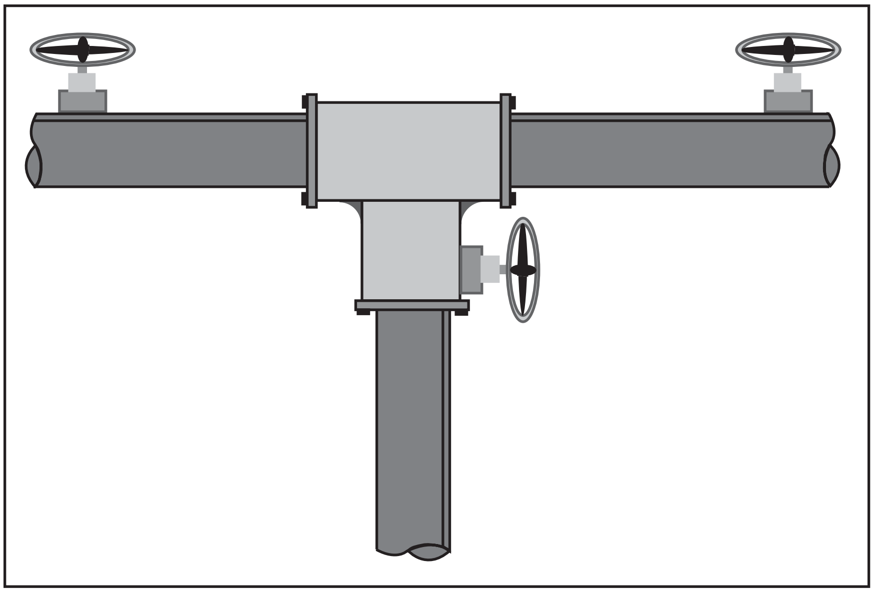


Figure 7-5. A double-block and bleed three-valve system.

SECTION 7 - ASSIGNMENT SHEET

1. Define the following terms:

   Affected employee ____

   ____

   Authorized employee ____

   ____

   Energy isolating device ____

   ____

   Energy source ____

   ____

   Lockout ____

   ____

   Lockout device ____

   ____

   Tagout ____

   ____

   Tagout device ____

   ____

2. Identify the four categories of hazardous energy and the means for controlling each.

   ____

   ____

   ____

   ____

   ____

   ____

   ____

   ____

3. Define the roles of affected and authorized employees when working under an energy control program.

____

____

____

____

____

____

4. Given a scenario, identify potential sources of hazardous energy and a method for controlling each.

PERMIT-REQUIRED CONFINED SPACE ENTRY

Section 8

Title: RESPIRATORY PROTECTION

TRAINEE OBJECTIVES

After completing Section 8, you will be able to:

1. Define the following terms:

   Protection factor
   Maximum use concentration
   Qualitative fit test
   Quantitative fit test

2. Write out the following abbreviations or acronyms.

APR	PAPR
PPE	SCBA
MUC	ESLI
HEPA	IDLH

3. Describe the two basic types of filtering devices, giving examples of each.

4. List five types of respirators and their protection factors.

5. Describe the two types of atmosphere supplying respirators and the type of regulator used for work in confined space.

6. List the limitations of the full-face air line respirator.

7. List the limitations of SCBAs.

8. Describe the personal use factors that affect protection provided by respirators.

Standard Operating Procedures

1. Inspect a full-face APR.
   Don a full-face APR.
   Perform a negative pressure check with a full-face APR.
   Perform a positive pressure check with a full-face APR.
   Clean, sanitize, and maintain a full-face APR.

2. Inspect a full-face atmosphere supplying respirator.
   Don a full-face atmosphere supplying respirator.
   Clean, maintain, and store a full-face atmosphere supplying respirator.

INTRODUCTION

Personal protective equipment (*PPE*) is any protective clothing or device worn to prevent contact with, and exposure to, hazards in confined space. Examples of PPE worn in confined spaces include:

- Respirators
- Gloves
- Protective suits
- Boots
- Hard hats
- Safety glasses

PPE is critical for the safe performance of workers in confined space. Therefore, workers need to know the types of PPE, their limitations, and how they are selected for work in confined space. Because no one type protects against all hazardous exposures, there are many types of protective gear. Choosing the correct type may also require the industrial hygienist to know the chemical exposure(s) in the confined space.

Respirators and protective clothing are the PPE commonly required for work in confined space. However, this section will discuss respirators only.

RESPIRATORS

A respirator is a piece of equipment that reduces exposure to toxic substances and oxygen-deficient atmospheres. There are many different types of respirators, all useful in specific situations. (See Appendix 8-1, Respirator Profiles.)

Respirators are composed of a facepiece that seals out contaminants, and a device that provides clean air. Two types of respirators are used for obtaining clean air:

1. Air purifying – Filters are used to purify the air.

2. Atmosphere supplying – A supply of clean air is provided from a tank or hose.

Respirators differ in how much protection they afford. A paper mask is less protective than a firefighter's respirator with an air tank. But how much difference is there? Industrial hygienists have developed a scoring system to rank different types of respirators. Each respirator is given a score based on the amount of protection it can provide. This score is known as a *protection factor* (*PF*).

Protection Factors

The key to understanding respirator protection is to realize that all respirators leak to a certain degree. The amount of leakage depends on how well the facepiece seals to the face. A leak in the facepiece means that contaminated air can enter the facepiece. The act of inhaling creates negative air pressure inside the facepiece that results in a slight suction effect. The suction can draw in contaminated air. These leaks compromise the protection given by the respirator. Breathing contaminated air can lead to adverse health effects depending on the type and amount of contaminant.

Respirators are tested for leakage by measuring the contaminant levels both outside and inside the respirator. Using the ratio of these two measurements, a PF is assigned. A PF is based on the assumption that the respirator is working properly, is worn correctly, and fits the wearer. Respirator PFs range from 5 to 10,000.

The lower the PF, the lower the protection. The higher the PF, the higher the protection. Figure 8-1 shows the calculation for determining the PF.

The PF is calculated by dividing:

$$PF = \frac{\text{Concentration of airborne contaminant outside respirator}}{\text{Concentration inside the respirator}}$$

$$= \frac{500 \text{ ppm (concentration outside the respirator)}}{50 \text{ ppm (concentration inside the respirator)}}$$

$$= 10$$

Figure 8-1. Calculating the protection factor.

The goal of a respirator is to reduce the amount of hazardous chemical inside the mask to below the OSHA *permissible exposure limit* (*PEL*). Respirators must be chosen to ensure that workers are never overexposed while wearing the respirator. The practical application of PF can be summed up as: How much of the outside contaminant level is reduced by the respirator? Examples follow:

- A respirator with a PF of 10 reduces a worker's exposure by 10 times, or to 1/10 of the outside level. Therefore, if the contaminant level outside the respirator is 500 ppm, the contamination inside the respirator is 50 ppm. Should the PEL for the contaminant be below 50 ppm, the worker is overexposed. A PF of 10 means that the respirator can only be used in exposures up to 10 times over the PEL.

- A respirator with a PF of 10,000 reduces the worker's exposure by 10,000 times. Concentration inside the respirator may be 1/10,000 of the outside level.

Remember: The lower the PF, the lower the protection. The higher the PF, the higher the protection.

Maximum Use Concentration

Maximum use concentration (*MUC*) is that level of contaminants which, if exceeded, will cause a worker to be exposed above the PEL because of leakage into the respirator. The MUC is the highest concentration of contaminants in which a respirator can be used safely. At no time should a respirator be used in an environment that exceeds the MUC.

The MUC is calculated by multiplying PF times PEL. Figure 8-2 gives an example of calculating the MUC for nitric acid. (Appendix 8-2 summarizes information on PF and MUC.)

Calculate the MUC of nitric acid:

MUC = PF x PEL
PEL for nitric acid = 2 ppm
PF of half-face respirator = 10

MUC = 2 ppm x 10
= 20 ppm

A half-face respirator cannot be used in atmospheres with a nitric acid concentration greater than 20 ppm.

Figure 8-2. Calculating the MUC for nitric acid.

AIR PURIFYING RESPIRATORS

Air purifying respirators (*APRs*) clean the air a worker breathes by removing or filtering a contaminant from the air before it enters the lungs. APRs have two components—the facepiece and the filter or cartridge. When a worker inhales, contaminated air is pulled into the respirator through a filter or cartridge attached to the facepiece. The filter or cartridge removes the contaminant from the air before it enters the inside of the respirator through the inhalation valve. When the wearer exhales, air from the lungs reverses the airflow through the facepiece and out a separate valve called the exhalation valve.

Negative Pressure Respirators

APRs are commonly called negative pressure respirators. They depend on lung power to pull the air through the filters. The suction created when a worker inhales draws air into the respirator. This suction creates a momentary negative pressure. During inhalation, the negative pressure brings contaminants into the facepiece through leaks and improper seals. During exhalation air is blown out and a positive pressure is created in the facepiece. It is important to remember that negative pressure respirators must only be used if the oxygen level in the work place is above 19.5 percent oxygen.

Disposable Paper Masks

Many workers are familiar with the disposable paper masks. They are the throwaway type, and do not seal to the face well enough to provide a good fit. Laboratory tests done with mannequins show PFs of 5 to 10. However, studies done under actual work conditions show even lower PFs. The leakage for this type of mask is too severe. Furthermore, the paper of a disposable mask is only effective for large-particle dusts. Gases, vapors, fumes, and fine dusts, such as asbestos, may pass right through the paper. These masks must not be used when there is a potential for any hazardous atmosphere.

Half-Face APRs

The half-face APR is made of rubber or plastic. It fits from the top of the nose to under the chin. Figure 8-3 shows a typical half-face APR.

Figure 8-3. The half-face APR fits from the top of the nose to under the chin. (Image courtesy of MSA)

A half-face APR uses one or two filter cartridges attached to the facepiece to filter the air. The fit given by the respirator rates a fairly low PF of 10 by the National Institute of Occupational Safety and Health (*NIOSH*).

Limitations of the half-face APR are:

- No eye protection – The respirator does not cover the eyes. Eye protection must be used.

- Cartridge life problems – The filter has a limited ability to remove chemical contaminants. When the saturation point is reached, chemicals begin to pass through the filter. This condition is called *breakthrough*. Some chemicals have poor warning properties so a worker will not notice any chemical smell when breakthrough occurs. This situation can lead to serious exposure problems. As a result, the half-face APR cannot be used for chemicals with poor warning properties. Some filters have end of service life indicators (*ESLI*) that change color when a filter is used up. However, few indicators have been successfully developed and most are for specific chemicals only.

- Cartridge efficiency problems – There are many types of organic solvents, but only one type of organic solvent filter. Studies show that while this filter is very efficient for some solvents, it allows other solvents to pass through quickly. For example, the organic vapor filter lasts 143 minutes in an atmosphere with a concentration of 1,000 ppm of 1-nitropropane. But at 1,000 ppm of ethyl chloride, the filter only lasts 5.6 minutes. Therefore, the half-face APR and filter are not used for solvents that have rapid breakthrough. However, not all solvents have been tested.

- Oxygen limitations – The half-face APR can only be used when sufficient oxygen is present in the work atmosphere. Normal breathing air contains about 21 percent oxygen, which can be less in confined areas with other chemicals present.

- Not suitable for areas of unknown chemicals or levels – The protection offered by this respirator is limited, therefore, it cannot be used for unknown situations. The levels might exceed ten times the PEL or different chemicals might go right through the filter to cause health effects. Specific cartridges are manufactured to protect against specific chemicals and may not be used in some mixed chemical atmospheres.

- Not suitable for concentrations that are *immediately dangerous to life or health* (*IDLH*) – Under no circumstances should an APR be used in an IDLH atmosphere. For most chemicals this is not an issue, because the MUC is lower than the IDLH level. But there are exceptions. For some chemicals, the IDLH is lower than the MUC and the respirator cannot be used if the level approaches the IDLH level.

- Humidity problems – Some studies have shown that breakthrough occurs more quickly under conditions of high humidity.

- Usage – The useful life of a filter is limited once the filter is opened. Usually filters are discarded after each use, not to exceed one shift. If breakthrough occurs and is noticed, then filters are changed at that time even if it is less than one shift.

Half-face respirators can protect you against exposure to only some toxic substances, and then only when their concentrations are low. The reason is half-face respirators have a low PF and many cartridge-related problems. One way to find out if there is a cartridge problem for a specific chemical is to refer to the *NIOSH Pocket Guide to Hazardous Chemicals*. The Pocket Guide includes respirator recommendations. If there is a cartridge problem, NIOSH will not recommend that APRs be used.

Table 8-1 is a list of some chemicals that cannot be safely protected against by APRs. Table 8-2 lists general MUCs for chemical cartridges that have hazardous breakthrough problems.

Table 8-1. APRs cannot safely protect against these chemicals.

Acrolein	Nickel carbonyl
Aniline	Nitro compounds
Arsine	Nitrobenzene
Bromide	Nitrogen oxides
Carbon monoxide	Nitroglycerin
Dimethylaniline	Nitromethane
Dimethyl sulfate	Ozone
Hydrogen cyanide	Phosgene
Hydrogen fluoride	Phosphine
Hydrogen selenide	Phosphorous trichloride
Hydrogen sulfide	Stibine
Methanol	Sulfur chloride
Methyl bromide	Toluene diisocyanate
Methyl chloride	
Methylene bisphenyl isocyanate	

Table 8-2. The MUCs for chemical cartridges that have hazardous breakthrough problems.

Type of Cartridge	Maximum Use Concentrations
Organic vapors	1,000 ppm
Acid gases	1,000 ppm
Sulfur dioxide	50 ppm
Chlorine	10 ppm
Hydrochloric acid	50 ppm
Ammonia	300 ppm
Methylamine	100 ppm

Full-Face APR

A full-face APR is made of rubber or plastic. It covers the whole face, starting at the forehead, down over the temples and the eyes, and under the chin (Figure 8-4). The full-face APR has a NIOSH assigned PF of 50 because it is easier to get a good seal across the forehead than across the nose. Also, the respirator is held more securely in place because it has a harness instead of straps. The full-face APR uses the same types of filters as the half-face APR, so it also carries the same limitations. It does protect the eyes, although it has a tendency to fog up.

Figure 8-4. The full-face APR covers the whole face. (Image courtesy of MSA)

Some full-face APRs can use larger chin, chest, or back-mounted canister-type filters. These filters are larger, and have fewer limitations. There are several filters available in larger sizes for full-face APRs that are not available for half-face APRs. Since canisters are larger than cartridges, they have higher capacities. Even though full-face APRs protect more than half-face APRs, they still do not offer enough protection to be used in IDLH conditions.

Powered Air Purifying Respirators

The powered air purifying respirator (*PAPR*) is an APR that uses a small, lightweight battery-operated blower to draw air through the filters and into the facepiece. It uses the same type of facepiece and filters as the full-face APR (Figure 8-5).

Figure 8-5. The powered air purifying respirator has a battery-operated blower. (Image courtesy of MSA)

The blower keeps a slight positive pressure inside the facepiece. This positive pressure reduces the likelihood of contaminants leaking into the respirator during inhalation. Any leaks from an imperfect seal tend to be outward.

Additionally, the blower offers the advantage of increased comfort for the user. Because the blower draws air into the facepiece, less work is required for inhalation. In addition, air is blown across the user's face and provides some degree of cooling.

Despite the fact that a PAPR seals the face in the same manner as the full-face negative pressure APR, the PFs assigned by government agencies vary. For example, OSHA assigns a PAPR a PF of 100 in the asbestos standard, while NIOSH assigns a PF of 50. The PF for a PAPR can vary even within the same agency. For example, OSHA assigns a PAPR a PF of 100 in the asbestos standard, but a PF of 50 in the lead standard.

PAPR Limitations

The PAPR has two limitations:

1. Weak batteries cause the fan motor to slow down, thus delivering less air to the facepiece. The batteries are designed to last a full shift, and then require a full charge. PAPR units come with a small flow meter that enables you to test the air flow, and thus, the battery charge.

2. Under heavy work conditions, you can use more air then the PAPR provides, creating a negative pressure in the facepiece. This condition is called *overbreathing* a PAPR. When overbreathing occurs, the PAPR functions like a negative pressure full-face respirator.

FILTERING DEVICES

Air purifying respirators are manufactured with two basic types of filtering devices:

1. Particulate filters
2. Vapor and gas removing canisters and cartridges

Particulate Filters

Particulate filter respirators use a filter made of a fibrous material to capture contaminant particles before the air reaches the lungs. The particles are pulled through the filter as the worker inhales, and become trapped by the fibers of the filter. Particulate filter respirators are used for protection against particles of dusts, fumes, and/or mists.

42 CFR 84 for Particulate Filters

Respirator certification regulations 30 CFR 11 were first promulgated in 1972 and were commonly referred to as Part 11. Since that date, new research, tests, and technologies have required that certification regulations be revised. In July 1995, the Part 11 standard was retitled 42 CFR 84 or Part 84.

NIOSH plans to revise the certification requirements for all respirator classes, although the process is expected to take many years. The revisions will take place in modules. The first module completed was the certification requirements for nonpowered, air-purifying, particulate-filtering respirators. These respirators now fall under Part 84. Therefore, all new nonpowered, air-purifying, particulate-filter respirators must be based on Part 84 performance testing procedures to receive NIOSH approval. All other respirators (PAPRs, SCBAs, etc.) are still under the Part 11 standard.

Filter Labels

Part 84 filter labels have two changes from Part 11 filter labels, which will help to tell them apart. These changes are shown below:

1. Sequence of approval numbers:

   Part 84 – TC-84A-XXXX
   Part 11 – TC-21C-XXX

2. Approving agencies:

   Part 84 – NIOSH and the Department of Health and Human Services (DHHS)

   Part 11 – NIOSH and Mine Safety and Health Administration (*MSHA*)

Labels are normally found on the respirator box, cartridge box, or backpack. Figure 8-6 shows the Part 84 label for nonpowered, air-purifying particulate filters. Figure 8-7 shows the Part 11 label for all other respirators.

PERMISSIBLE

Department of Health and Human Services
DHHS

Respirator for Dusts, Fumes, Mists, Asbestos, and Radionuclides

U.S. Department of Health and Human Services
Centers for Disease Control
NIOSH
National Institute for Occupational Safety and Health

DEPARTMENT OF HEALTH AND HUMAN SERVICES
NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH

APPROVAL NO. TC-84A-1234

ISSUED TO
WILSON SAFETY PRODUCTS
READING, PENNSYLVANIA, U.S.A.

LIMITATIONS

Approved for respiratory protection against dust, fumes, and mists having a Time Weighted Average (TWA) less than 0.05 milligrams per cubic meter, asbestos containing dusts and mists, and radionuclides. Not for use in atmospheres immediately dangerous to life or health. This respirator shall be selected, fitted, used, and maintained in accordance with Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

CAUTION

In making renewals or repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained. Follow the manufacturers instructions for changing filters.

Figure 8-6. Part 84 label showing NIOSH and DHHS as the approving agencies.

PERMISSIBLE

United States Department of Labor
MSHA
Mine Safety and Health Administration

Respirator for Dusts, Fumes, Mists, Asbestos, and Radionuclides

U.S. Department of Health and Human Services
Centers for Disease Control
NIOSH
National Institute for Occupational Safety and Health

DEPARTMENT OF HEALTH AND HUMAN SERVICES
NATIONAL INSTITUTE FOR OCCUPATIONAL
SAFETY AND HEALTH

APPROVAL NO. TC-21C-377

ISSUED TO
WILSON SAFETY PRODUCTS
READING, PENNSYLVANIA, U.S.A.

LIMITATIONS

Approved for respiratory protection against dust, fumes, and mists having a Time Weighted Average (TWA) less than 0.05 milligrams per cubic meter, asbestos containing dusts and mists, and radionuclides. Not for use in atmospheres immediately dangerous to life or health. This respirator shall be selected, fitted, used, and maintained in accordance with Mine Safety and Health Administration, Occupational Safety and Health Administration, and other applicable regulations.

CAUTION

In making renewals or repairs, parts identical with those furnished by the manufacturer under the pertinent approval shall be maintained. Follow the manufacturers instructions for changing filters.

Figure 8-7. Part 11 label showing NIOSH and MSHA as the approving agencies.

Particulate Filter Efficiency

Particulate filters are not designed to be 100 percent efficient in removing particulates from the air. It would be too hard for a worker to pull air through the filters when inhaling. Filters are manufactured to create maximum filter efficiency while keeping the resistance to breathing low. As contaminated air is drawn through the filter, the particles are captured by the filter, plugging up the holes between the fibers of the filter. This increases breathing resistance for the wearer.

Particulate filter efficiencies are classified into two groups—high efficiency and lower efficiency. High efficiency filters are capable of capturing 99.97 percent of the particles pulled through the filter. Filters of this type are commonly called *high efficiency particulate air* (*HEPA*) *filters*. HEPA filters are used for dusts, fumes, and mists having an exposure limit less than 0.05 milligrams per cubic meter of air (0.05 mg/m^3). Particulates with exposure limits this low are the most hazardous to workers' health, which explains why high efficiency filters are to be used. For example, HEPA filters must be used for exposures to asbestos or lead.

Lower efficiency filters are less efficient than HEPA filters and capable of capturing approximately 99 percent of dust, fume, and mist particulates. Lower efficiency filters are used for particulates that have exposure limits greater than 0.05 mg/m^3. These substances are not as hazardous to the health of exposed workers.

Particulate Filter Classification

NIOSH regulation Part 84 created nine classes of particulate filters, made up of:

- Three filter series for resistance to filter efficiency degradation.
- Three filter efficiency levels.

Filter Series

The three filter series define different degrees of resistance to filter efficiency degradation. They are labeled as N, R, and P.

N series filters have the following characteristics:

- Used for solid or water-based particulates.
- **Not** resistant to oil. Cannot be used in atmospheres containing oil or for oil-based particulates.
- Can be used for more than one work shift if there are no problems with hygiene, damage, or breathing.

R series filters have the following characteristics:

- Used for solid or liquid particles.
- Resistant to oil but not oil proof.
- Can be used for an extended time in an oil-free atmosphere.
- Has limited use time in an environment containing oil (one eight-hour shift or a combined total of eight hours).

P series filters have the following characteristics:

- Used for solid or liquid particles, both oil-based and non-oil based.
- Considered oil proof. Can be used as long as a worker has no breathing problems.

An easy way to remember the filter series is:

- N is **N**ot resistant to oil
- R is **R**esistant to oil
- P is oil **P**roof

NIOSH update to selection guide: Originally, it was assumed P-series filters would not degrade from oil exposure and would only need to be changed when breathing resistance, hygiene concerns, or filter damaged occurred. However, a recent NIOSH study indicates the P-series particulate filter may lose efficiency with long-term exposure to oil. Therefore, NIOSH recommends replacing any P-filter that has been exposed to oil after the work shift. No changes were made to the selection logic for the N and R series filters.

Filter Efficiency Levels

Each of the three filter series has three filter efficiency levels. The minimum efficiency levels are 95 percent, 99 percent, and 99.97 percent. They have the following designations:

- Filters with N95, R95, and P95 designations are certified as having a minimum efficiency of 95 percent. The series of 95 percent efficiency filters replaces the dust/fume and dust/fume/mist filters.
- Filters with N99, R99, and P99 designations are certified as having a minimum efficiency of 99 percent.
- Filters with N100, R100, and P100 designations are certified as having a minimum efficiency of 99.97 percent. These filters replace the HEPA filters under the old certification standard. Unlike the old HEPAs, the N100 and R100 have the following limitations:
  - N100: No oil exposure
  - R100: Oil exposure for one shift only

  The P100 filter is the only filter that will keep the familiar magenta color.

Table 8-3 lists the nine classes of particulate filters. Appendix 8-3 shows the Part 84 flow chart for choosing the correct filter.

Table 8-3. The nine classes of particulate filters.

Filter Series	Filter Efficiency Levels	Filter Classes	Service Time
N-Series	99.97%	N100	Non-specific
	99%	N99	Non-specific
	95%	N95	Non-specific
R-Series	99.97%	R100	One Shift
	99%	R99	One Shift
	95%	R95	One Shift
P-Series	99.97%	P100	Non-specific
	99%	P99	Non-specific
	95%	P95	Non-specific

Vapor and Gas Removing Cartridges and Canisters

Vapor and gas removing cartridges and canisters are used with APRs to protect workers from exposures to air that is contaminated with toxic vapors and gases.

While particulate filters are effective for nearly all types of particles, gas and vapor removing cartridges and canisters are designed to protect against specific individual contaminants. Examples include carbon monoxide, ammonia gas, or combinations of gases and vapors, such as acid gases or organic vapors.

Contaminants are removed as inhaled air enters the cartridge or canister and passes through a granular material called a *sorbent*. The sorbent absorbs contaminants from the air, and provides protection from the toxic effects of the gas or vapor.

Materials used as sorbents include activated charcoal, silica gel, and various mixtures of specific chemicals that capture the contaminant. Initially a gas and vapor sorbent is 100 percent efficient in capturing a contaminant. As the sorbent is used up, the efficiency decreases. When the sorbent is exhausted, the contaminant passes completely through the sorbent and into the facepiece where it is inhaled. This loss of capturing efficiency is opposite to particulate filters, which become more efficient as particles collect on the filter.

Sorbents for gases and vapors are packaged into either cartridges or canisters. The only difference between a cartridge and a canister is the amount of sorbent they contain. Cartridges are designed to be used singly or in pairs on quarter-, half-, and full-facepieces. The amount of sorbent contained in a cartridge is small, making their useful lifetime short in duration. This limitation restricts the use of cartridges to low concentrations of gases and vapors.

Canisters contain larger amounts of sorbent material than cartridges. Therefore, they can be used in situations where the workplace air concentration of gases or vapors is high. Canisters are designed as chin, front, or back-mounted devices. When a canister is used with a facepiece, the respirator is called a gas mask.

Cartridges or canisters are designed for either one specific type of gas or vapor, or a combination of gases and vapors together. In addition, some cartridges and canisters are manufactured to protect against both gases and vapors, as well as particulates by combining particulate filters with sorbent materials. When filters are combined with gas and vapor sorbents, the filter is located in the inlet side of the cartridge. It is either built into the cartridge itself or held to the outside of the cartridge by a snap-on cover.

Both canisters (gas masks) and chemical cartridges are available for the following specific gases and vapors:

- Ammonia
- Organic vapors
- Pesticides
- Vinyl chloride
- Hydrogen fluoride
- Hydrogen sulfide
- Formaldehyde
- Acid gases (chlorine, hydrogen chloride, sulfur dioxide)

Only chemical cartridges are available for these additional substances:

- Paints, lacquers, and enamels
- Mercury
- Chlorine dioxide

Likewise, only canisters (gas masks) are available for:

- Chlorine
- Sulfur dioxide
- Carbon monoxide
- Ethylene oxide
- Hydrogen cyanide
- Hydrogen chloride

A color coding scheme has been established to identify the contaminants that a gas and vapor canister or cartridge protects against. The color coding is assigned to either individual contaminants or combinations of contaminants as shown in Table 8-4.

Table 8-4. Contaminant color coding.

Atmospheric Contaminant	Assigned Color
Acid gases	White
Organic vapors	Black
Ammonia gas	Green
Carbon monoxide gas	Blue
Acid gases and organic vapors	Yellow
Acid gases, ammonia, and organic vapors	Brown
Acid gases, ammonia, carbon monoxide, and organic vapor	Red
Other vapors and gases not listed above	Olive
Radioactive materials (except tritium and noble gases)	Purple (magenta)
Dusts, fumes, and mists (other than radioactive materials)	Orange

When the sorbent becomes exhausted or used up, breakthrough will occur. Warning signs include odor, taste, or throat irritation. If the wearer notices any warning signs, follow these steps:

1. Leave the work area immediately
2. Go to a location with fresh air
3. Notify the safety and health officer
4. Replace the cartridge or canister

Gas and vapor cartridges have short useful service times. Therefore, it is recommended workers discard their cartridges or canisters at least daily, even if no odor, taste, or irritation is detected. Some canisters are designed for use against substances with poor warning properties (no odor or taste). These canisters have end of service life indicators (*ESLI*s) that show the canister is exhausted and needs to be replaced. For example, cartridges used for mercury have ESLIs because mercury has poor warning properties that are not readily noticed by a worker being exposed.

ATMOSPHERE SUPPLYING RESPIRATORS

There are two types of atmosphere supplying respirators—supplied air respirator (*SAR*) and self-contained breathing apparatus (*SCBA*).

Both types of respirators supply clean breathable air to the wearer and do not depend on filters. With an air line respirator, air is delivered by a hose connected to a compressor. The compressor is equipped with a filtering system that purifies the air. The air for an SCBA is contained either in a compressed air tank or cylinder. The air in the tank or cylinder is under pressure. Regulators are used to reduce the pressure and control the flow of air into the facepiece.

There are two types of regulators:

- Demand flow
- Pressure demand

Demand Flow vs. Pressure Demand Regulators

A demand flow regulator uses the suction force of inhalation to open the regulator valve and let air flow into the facepiece. In other words, when the worker "demands" the air, he or she gets it. When the wearer exhales, the flow of air into the facepiece stops. The advantage of the demand flow regulator is that the air supply is not wasted, so the time allowed by the tank is maximized. The disadvantage is that the regulator depends on negative air conditions during inhalation.

Because of this disadvantage, the PF for demand type atmosphere supplying respirators is only 50. A respirator with a demand flow regulator is **not** recommended for permit-required confined space work.

Pressure demand regulators are similar to demand flow regulators in that airflow into the facepiece occurs mainly during inhalation (Figure 8-8). However, there is also a constant flow of air into the facepiece that keeps it pressurized. A negative pressure condition never exists even during inhalation. Positive pressure conditions exist at all times, and leakage is minimized. This regulator is used most often in permit-required confined space work.

Figure 8-8. A pressure demand regulator. (Image courtesy of MSA)

Supplied Air Respirators

SARs supply air to a facepiece through a length of hose (Figure 8-9). The hose is connected to either a compressed air cylinder or a compressor that is equipped with equipment to purify the air. The air supply can be used to pressurize the respirator to achieve a high PF. With a pressure demand regulator and a full facepiece, NIOSH assigns an SAR a PF of 2,000. The SAR is being used more and more for personnel and equipment decontamination.

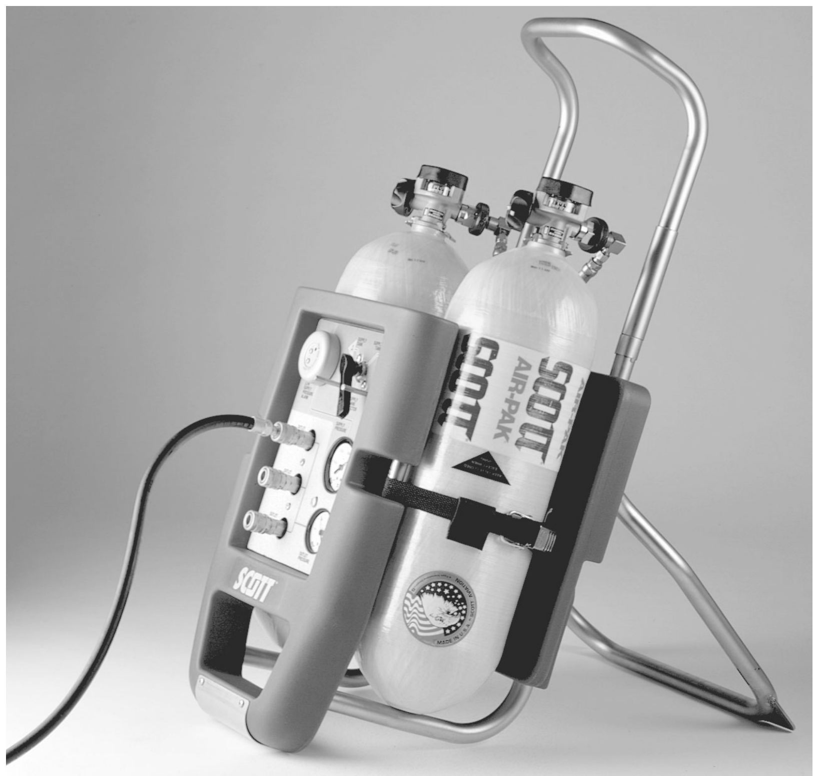


Figure 8-9. SARs receive air from compressed air cylinders. (Image courtesy of Scott Health and Safety)

SARs have the following limitations:

- The air line impairs worker movement and cannot exceed 300 feet in length according to regulations. Workers must carefully retrace their steps coming off the job.

- The air line can be damaged. Rough or sharp surfaces can puncture the line. Chemicals can deteriorate the rubber hose. Falling drums, vehicles, and heavy equipment can damage the air line.

- The location of the system air compressor. The compressor must be located away from potential chemical or contamination hazards and from any ventilation systems. All filters and alarms must be working properly, and the system must be maintained according to the manufacturer's recommendations.

Due to the limitations of SARs, they are often used with an escape SCBA that contains a five to ten minute air supply. When an escape SCBA is provided, NIOSH assigns the unit a PF of 10,000. Escape SCBAs are required for SARs being used in IDLH atmospheres.

Self-Contained Breathing Apparatus

An SCBA consists of a facepiece and regulator mechanism connected to a cylinder of compressed air that is worn by a worker (Figure 8-10). SCBAs are used during the most hazardous aspects of confined space entry because they have a NIOSH assigned PF of 10,000. With an SCBA, a worker does not have air line problems. Worker training is essential to the safe use of SCBAs.

Figure 8-10. SCBAs consist of a regulator and an air cylinder. (Image courtesy of Scott Health and Safety)

There are different types of SCBAs with their own set of limitations. They include:

- Closed circuit or rebreathers
- Open circuit SCBAs
    - Entry
    - Escape

Open Circuit vs. Closed Circuit SCBAs

With an open circuit SCBA, exhaled air goes through valves directly into the outside air. The system comprises a tank of breathing quality air containing between 19.5 and 23.5 percent oxygen, a regulator, and the respirator. Open circuit tanks usually are rated at 30 to 60 minutes.

Closed circuit SCBAs are called rebreathers because the exhaled air goes back into the system to be recycled. A closed-circuit system consists of a scrubber device to remove exhaled carbon dioxide, a tank of pure oxygen, and a breathing bag to blend the mixture. The closed circuit unit supplies enough breathing air for up to four hours.

Rebreathers work in the following manner. The air for breathing is mixed in a flexible breathing bag. As the wearer inhales and deflates the bag, oxygen flows into the bag from the oxygen tank. The oxygen tank can contain either compressed or liquid oxygen. The exhaled air goes through a filter known as an alkaline scrubber, which removes the carbon dioxide from the exhaled breath. The scrubbed air then mixes with the oxygen in the bag, so that a breathing quality mixture is available for the next inhalation.

One problem for rebreathers is that they typically use demand regulators, which means that they have a lower PF. This demand type rebreather is not recommended for permit-required confined space work. There are a few companies that make rebreathers with pressure demand regulators, which can be used. NIOSH has given them a PF of 10,000.

Escape vs. Entry SCBAs

The typical pressure demand SCBA is an open circuit unit with a large cylinder. It provides enough air for 30 to 60 minutes and weighs about 25 or 30 pounds. This SCBA is called an entry SCBA and is good for any type of work.

Escape SCBAs are small cylinders capable of providing 5 to 15 minutes worth of breathable air (Figure 8-11). They do not provide enough air for entry to do work, but are only used for emergency evacuation. Some air line respirators have attached escape SCBAs, which provide additional protection (PF is 10,000). Other escape SCBAs use hoods and workers wearing non-SCBA respirators use them for emergencies.

Figure 8-11. Escape SCBAs are small cylinders that provide 5 to 15 minutes of air. (Image courtesy of Scott Health and Safety)

Pressure-demand, open-circuit, entry SCBAs are the workhorse respirators used on waste sites when hazards are severe or unknown. They provide excellent protection to the worker. The chief drawbacks to these respirators are their weight and a limited air supply. These limitations greatly affect the work schedule because the work day is broken up into many smaller segments. Also, some workers feel uncomfortable and confined in the respirator. It is important that workers be able to familiarize themselves with SCBA equipment, as well as practice using it before going into a permit-required confined space.

Appendix 8-4 contains inspection guidelines for the SCBA.

RESPIRATOR PROGRAM REQUIREMENTS

The safe use of a respirator is more than just knowing how to put it on. OSHA Standard 1910.134 governs general requirements for respirator usage. The respiratory protection program must cover certain required work site-specific procedures for respirator use. Also it must be updated when there are changes in workplace conditions that affect respirator use. The respiratory protection program includes the following requirements:

1. Procedures for selecting respirators for use in the workplace.

2. Medical evaluations of employees who are required to use respirators.

3. Fit testing procedures for tight-fitting respirators.

4. Procedures for proper use of respirators in routine situations and reasonably foreseeable emergencies.

5. Procedures and schedules for cleaning, storing, inspecting, repairing, discarding, and otherwise maintaining respirators.

6. Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere supplying respirators.

7. Worker training in the respiratory hazards to which they are potentially exposed during routine and emergency situations.

8. Worker training in the proper use of respirators, including:

    - Donning and doffing
    - Limitations
    - Maintenance

9. Procedures for regularly evaluating the effectiveness of the program.

Respirator Program Administration

The employer must designate a respirator program administrator (*RPA*) to oversee the respiratory protection program and to conduct the required evaluations of program effectiveness. To fulfill these duties, the RPA must have the training or experience that matches the complexity of the program.

As part of the administration of the program, the RPA is responsible for ensuring the following:

- Appropriate care is taken to properly select, use, and maintain the respirators.
- The nature of the air contaminant and its exposure concentration is considered in properly selecting a respirator.
- Workers are trained in the proper use and care of the respirators that are provided.
- Workers are medically fit to wear the respirator.

Note: An employer does not have to comply with the requirements of OSHA Standard 1910.134 if his or her workers will wear respirators for 30 days or less per year.

RESPIRATOR SELECTION

Employers are responsible for selecting the appropriate respirators for their employees. To do this the employer must:

1. Gather information
2. Apply information to respirator selection process
3. Choose the respirator based on the selection process

Gather Information

It is impossible to choose a respirator without knowing the hazards within a confined space and the workers' potential exposure levels. The employer can use two methods for identifying the hazards and their airborne levels:

1. Personal air monitoring devices
2. Past exposure levels encountered on similar jobs

It is very important that some actual or educated estimate of exposure levels is known before selecting a respirator. In the absence of such information, OSHA requires that the job's exposure level be considered IDLH.

In addition to airborne contaminants and their exposure levels, the employer must gather other types of information:

- General use conditions and determination of contaminants
- Properties of the contaminants
- Odor threshold data
- Exposure limits
- IDLH concentrations
- Eye irritation potential
- Service life information

Once the criteria information is gathered and evaluated, the employer applies it to a respirator selection process. The selection process uses a sequence of questions to identify the recommended class of respirators for the airborne contaminants. One example of this process is the NIOSH Respirator Decision Logic.

General Use Conditions and Determination of Contaminants

General use conditions include the following:

- Descriptions of the job tasks to be performed
- Duration and frequency of the tasks to be performed
- Work location
- Physical demands of the work to be performed
- Respirator comfort

Determination of contaminants includes the following:

- Identity of the substances present in the air.

- Actual measured exposure level of the contaminant on the job.

- If possible, an estimate of the highest level of exposure that workers are likely to encounter.

Properties of the Contaminants

Information is needed on the physical, chemical, and toxic properties of the contaminant. This information includes:

- Form in which the substance is found on the job site, such as dust, mist, fume, gas, or vapor.
- Chemical properties, such as organic vapor, pesticide, metal, or acid gas.
- Toxicological properties of the substance as they pertain to adverse health effects (e.g., *carcinogen*) and warning properties.

Odor Threshold Data

Information on odor threshold is essential to determine whether a contaminant has warning properties at or below the exposure limit that would allow an APR to be selected. If the odor threshold exceeds the exposure limits, the contaminant is considered to have poor warning properties. Therefore, an APR would not be recommended for use unless it had an ESLI. Odor threshold data would be obtained from industrial hygienists or other experts such as NIOSH or OSHA.

Exposure Limits

Several organizations require, recommend, or publish exposure limits. They are listed below:

- OSHA – Permissible exposure limit (*PEL*)
- NIOSH – Recommended exposure limit (*REL*)
- ACGIH – Threshold limit value (*TLV*)

Exposure limit information is necessary to calculate MUCs for the types or classes of respirators using their assigned PFs. The *NIOSH Pocket Guide to Chemical Hazards* is an excellent source of information for many chemicals and their exposure limits.

IDLH Concentrations

Contaminant concentrations that are IDLH are life threatening and call for the most protective respirators for the wearer. The *NIOSH Pocket Guide to Chemical Hazards* provides IDLH concentrations for many chemicals found in the workplace. The IDLH concentration for a substance must be compared to the actual concentration measurement of the substance on the job.

Eye Irritation

Some contaminants have the potential to cause eye irritation. In these situations, a full facepiece, hood, or helmet should be selected instead of a half mask to provide eye protection.

Service Life Information

Service life refers to the length of time a filter cartridge or canister will provide protection to the wearer. This information is necessary to determine a filter change schedule for the chosen respirator.

NIOSH Respirator Decision Logic

Appendix 8-5 contains the NIOSH Respirator Decision Logic. This process is used by industrial hygienists to identify the respirators recommended by NIOSH for airborne contaminants.

MEDICAL EVALUATION

Wearing a respirator may place a physiological burden on the wearer. Therefore, OSHA requires that an employer provide a medical evaluation to determine if a worker can wear a respirator. The evaluation must be done before a worker is fit tested or required to use a respirator.

FIT TESTING

A *qualitative fit test* (*QLFT*) or *quantitative fit test* (*QNFT*) must be performed on all negative or positive pressure tight-fitting respirators before a worker is required to wear one. The worker must be fit tested on the same make, model, size, and style of respirator that will be used in the workplace.

A fit test must be conducted at least annually and whenever changes in the worker's physical condition could affect the respirator fit. Such conditions include, but are not limited to:

- Cosmetic surgery
- Dental changes
- Facial scarring
- Obvious changes in body weight

Fit testing atmosphere supplying respirators and PAPRs shall be accomplished by performing the fit tests in negative pressure mode.

Fit Testing Protocols

OSHA has provided specific procedures for performing QLFTs and QNFTs. By following these procedures for each fit test, the test results will be consistent from one test to another. For a QLFT, the worker is tested using a testing agent to ensure that the respirator is fitting properly. For a QNFT, a machine is used to make sure that the respirator fits correctly.

Qualitative Fit Test

A QLFT is a pass/fail fit test used to check respirator fit that relies on the user's response to a test agent. It involves introducing a harmless odorous or irritating test agent into the breathing zone of the user. If he or she does not detect the test agent, the respirator fits properly.

Four test agents are approved by OSHA for conducting a QLFT:

1. Banana oil (isoamyl acetate or isopentyl acetate)
2. Irritant smoke (stannic oxychloride or titanium tetrachloride)
3. Saccharin (sodium saccharin) solution
4. Bitrex™ (denatonium benzoate) solution

Before a test agent is used, OSHA requires an odor and taste threshold screening be conducted. The screening determines if the user can smell or taste the test agent at low concentrations. If the user can smell or taste the testing agent, he or she can be fit tested with it.

Qualitative fit testing addresses the following issues:

- Choosing the respirator needed.

- Determining comfort level. Comfort is important when respirators are used for long periods of time.

- Establishing a facepiece-to-face seal with a particular respirator.

- Identifying facial complications that affect the fit, such as dentures, facial surgery, or dental/oral surgery.

A QLFT is simple and inexpensive, which makes it the most common type of fit testing done for respirators. However, a QLFT relies upon a user's subjective response to the testing agent. In other words, the user must inform the tester if he/she can smell or taste the substance. Because of the subjectivity of the QLFT, a respirator should never be assigned a PF higher than 10 when using this type of test.

Note: Before performing any test, make sure the correct respirator cartridge for the testing agent has been installed.

Isoamyl Acetate Protocols

Isoamyl acetate (*IAA*) is also known as banana oil. This test requires the respirator be fitted with organic vapor cartridges or offer protection against organic vapors. The user stands inside a fit test chamber while taking this test (Figure 8-12).

In some individuals, exposure to IAA can cause the following health effects:

- *Olfactory fatigue* – the sense of smell is dulled
- Feelings of lightheadedness and drunkenness

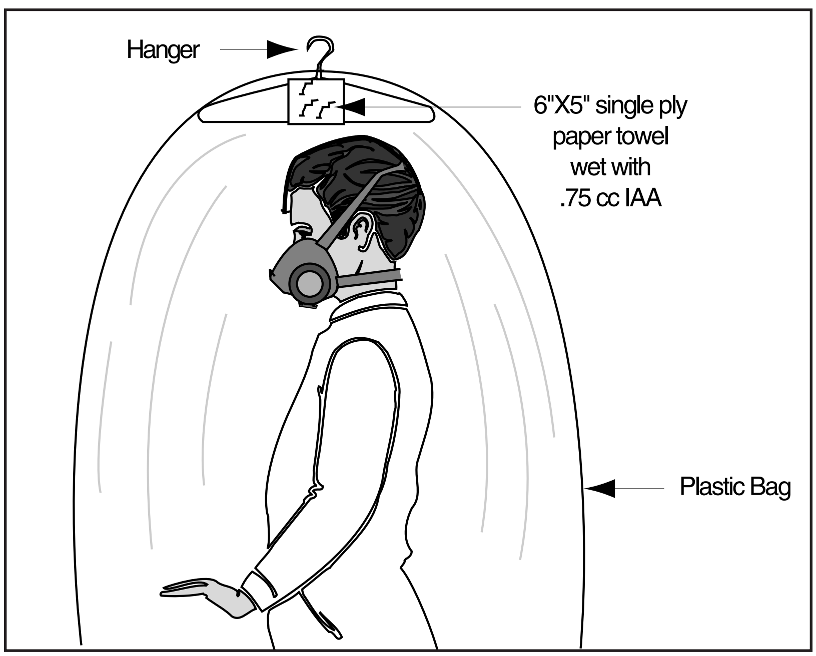


Figure 8-12. The fit test chamber is only used with isoamyl acetate (IAA), also called banana oil.

Irritant Smoke Test

Irritant smoke is very irritating to the eyes, nose, and throat and usually causes coughing. The worker being tested must keep his or her eyes closed during the fit test when wearing a half facepiece. This test requires the respirator be fitted with a HEPA filter or P100 particulate filter.

Saccharin Test

The saccharin test uses a saccharin aerosol. If saccharin leaks into the facepiece, the worker will have a sweet taste on the lips and tongue. Workers must take a taste test before using this testing agent because some people cannot taste saccharin. A small nebulizer is used to create a saccharin aerosol inside the test chamber. This test uses a particulate filter.

Bitrex Test

The Bitrex™ test is a Bitrex aerosol that has a citrus or orange flavor. The fit testing protocol for Bitrex is identical to the saccharin protocol.

Quantitative Fit Test

A *quantitative fit test* (*QNFT*) is a more sophisticated fit test. It measures the actual amount of leakage into the respirator. Figure 8-13 shows how a QNFT is set up.

A variety of methods are available for performing a QNFT, and each one uses a different technology. The quantitative fit test protocols are:

- Generated aerosol – An aerosol is generated and dispersed in a room. Air monitoring instruments are used to measure both the concentration in the room and the concentration inside the actual facepiece.

- Ambient aerosol condensation nuclei counter – The amount of natural dusts in the air is measured and compared to the amount of dust inside the facepiece.

- Controlled negative pressure – Air pressure inside the facepiece is kept constant. As air leaks into the facepiece, air is exhausted to maintain the constant inside air pressure. Therefore, the exhausted air is equivalent to the amount of leakage and can be measured to determine leakage.

Figure 8-13. A QNFT uses sophisticated equipment to measure the leakage into the respirator. (Image courtesy of Scott Health and Safety)

RESPIRATOR USE

The employer is required to establish and implement procedures for the proper use of respirators. These procedures are listed below:

- Prohibiting conditions that may result in facepiece seal leakage.
- Preventing workers from removing respirators in hazardous environments.
- Taking actions to ensure continued effective respirator operation throughout the work shift.
- Establishing procedures for the use of respirators in IDLH atmospheres.

Facepiece Seal Conditions

OSHA does not permit respirators to be worn when conditions prevent a good seal. These conditions include the following:

- Facial hair that crosses the sealing surface (stubble beard growth, beard, mustache, or sideburns)
- Skull cap that projects under the facepiece
- Temple pieces on glasses
- Absence of one or both dentures
- Facial scars or deformities that hinder a good seal

The need for a good seal is the reason facial hair is prohibited for workers who must wear respirators. Facial hair prevents the facepiece from sealing against the face and results in a high rate of leakage.

Eyeglasses pose another facepiece seal problem. The temple bars on eyeglasses prevent a respirator from sealing against the side of the head. However to go without eyeglasses creates vision-related problems, such as tripping hazards. Respirator manufacturers make fittings that hold lenses in place in the facepiece without temple bars. OSHA requires that this type of fitting be made available at the employer's expense to workers who wear glasses.

User Seal Checks

A respirator must be adjusted each time you put it on to ensure the best possible seal. To do this, conduct a user seal check. You can use either of the two methods listed:

1. Positive pressure seal check and negative pressure seal check
2. Manufacturer's recommended user seal check

User seal checks are **not** substitutes for qualitative or quantitative fit tests.

Positive Pressure User Seal Check

To perform a positive pressure user seal check, follow these steps:

1. Cover the exhalation valve of the respirator.

2. Exhale gently for about ten seconds. Do **not** exhale too hard or push the mask into the face because the check will be inaccurate.

If the respirator fits, a slight pressure should build up inside the facepiece. If air leaks out, the respirator does not fit properly, and the seal is inadequate. Figure 8-14 illustrates a positive pressure seal check.

This test is done on an atmosphere supplying respirator by covering the inlet and exhalation valve with your hands and exhaling.

Figure 8-14. Cover the exhalation valve with the palm of your hand for a positive pressure user seal check. (Image courtesy of MSA)

Negative Pressure User Seal Check

To perform a negative pressure user seal check, follow these steps:

1. Cover the filter openings with the palms of your hands.

2. Inhale gently and hold your breath for about ten seconds. Do **not** push the respirator into the face too hard, or the check will be inaccurate.

If the respirator fits correctly, the facepiece should collapse slightly inward. If the respirator does not fit correctly, the facepiece will not collapse, and you will feel an air leak (Figure 8-15).

This test is done on an atmosphere supplying respirator by covering the inlet with the hand and inhaling.

Figure 8-15. Cover the filter openings with the palms of your hands for a negative pressure user seal check. (Image courtesy of MSA)

Continued Respirator Effectiveness

OSHA requires the employer to monitor the workplace for changes that may affect the effectiveness of the respirators. Examples include changes in work area conditions or in worker exposure or stress. When such changes occur, the employer shall reevaluate the continued effectiveness of the respirator.

If you experience any trouble with your respirator, leave the area and fix the problem. Specifically, leave the work area for any of the following conditions:

- To wash your face and respirator to prevent eye or skin irritation
- If you detect vapor or gas breakthrough
- If you experience increased breathing resistance
- If you detect a leak in the facepiece seal
- To replace the respirator or the filter, cartridge, or canister

IDLH Conditions

OSHA Standard 29 CFR 1910.134 requires that additional standby worker(s) be located outside an IDLH atmosphere when a worker(s) has entered that area. The purpose of the standby worker is to assist co-workers in case of an emergency. The standby person must:

- Be trained and equipped to provide effective emergency response.

- Maintain visual, voice, or signal line of communication with worker(s) in the IDLH atmosphere.

MAINTENANCE AND CARE

The employer must provide for the following regarding the respirators used by workers:

- Cleaning and disinfecting
- Storage
- Inspection
- Repair

Cleaning and Disinfecting

It is the employer's responsibility to provide clean and disinfected respirators. A respirator issued for the exclusive use of one worker must be cleaned and disinfected by that worker to maintain the respirator in a sanitary condition (Figure 8-16). If a respirator is issued to more than one worker, for emergency use, or for fit testing, it must be cleaned and disinfected after each use.

Storage

For a respirator to remain in good condition and proper working order, it must be stored correctly to protect it from the following:

- Chemicals
- Contamination
- Damage
- Dust
- Excessive moisture
- Extreme temperatures
- Sunlight

In addition, a respirator shall be packed and stored to prevent the facepiece and exhalation valve from being deformed.

Figure 8-16. Your respirator must be kept cleaned and disinfected. (Image courtesy of MSA)

Inspection

All respirators must be inspected before each use and during cleaning. Atmosphere suppling respirators and respirators used for emergency purposes must be inspected monthly or according to manufacturer specifications. All written inspection records for emergency use respirators must be kept.

Air cylinders must be maintained in a fully charged state. They must be recharged when the pressure falls below 90 percent of manufacturer's recommended pressure.

Check the following items when conducting a respirator inspection:

- Function
- Connections, including tightness
- Condition of parts, especially rubber parts, for flexibility and deterioration (Figure 8-17)

Figure 8-17. The facepiece seal is one part to check when inspecting your respirator. (Image courtesy of MSA)

Repair

The following list outlines OSHA's requirements regarding respirator repairs:

- Repairs must be performed by a trained individual.
- Only the manufacturer's NIOSH-approved parts designed for the specific respirator shall be used.
- Repairs performed on the regulator, alarms, or admission valves of an atmosphere supplying respirator shall be performed by the manufacturer or a technician trained by the manufacturer.

BREATHING AIR QUALITY

Breathing air used in atmosphere supplying respirators must meet at least the requirements for Grade D breathing air as described in the American National Standards Institute (*ANSI)*/Compressed Gas Association Commodity specifications for Air, G-7.1-1989. Grade D air has the following limits:

- Oxygen content – 19.5 percent to 23.5 percent (similar to normal breathing air)
- Hydrocarbons – No greater than 5 mg/m^3 of air
- Carbon monoxide – No greater than 10 *ppm*
- Carbon dioxide – No greater than 1,000 ppm

OSHA addresses the following issues in 29 CFR 1910.134 (i):

- Air cylinders must be tested and meet minimum standards to ensure they can be safely pressurized.
- Air line couplings must be incompatible with outlets for other gases. This incompatibility prevents injury caused by the accidental use of other gases.
- Compressors used for air line systems must have built-in safety devices. These include:
  - Air purifying filters
  - Alarms for compressor failure
  - Alarms for overheating and high carbon monoxide levels
  - Reserve air systems to provide back-up air in the case of compressor failure
- Compressed oxygen shall **not** be used in open circuit atmosphere supplying respirators.

Note: Compressors used for pneumatic tools must not be used for air line systems. The air contains carbon monoxide, making it unbreathable and dangerous.

TRAINING

The respiratory protection standard requires that the employer provide effective training to workers who are required to use respirators. Training must be:

- Given to workers before they begin using respirators
- Understandable to the worker
- Comprehensive enough that it covers all required items
- Provided annually or more often if necessary

Workers who voluntarily wear a respirator shall be given the information located in OSHA Standard 29 CFR 1910.134 Appendix D. This information can be given written or verbally.

An employer must ensure that workers demonstrate knowledge in the following topics:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator.

- Limitations and capabilities of the respirator.

- How to use the respirator in an emergency situation.

- How to inspect, don, doff, use, and seal check the respirator.

- Procedures for maintaining and storing the respirator.

- How to recognize medical signs and symptoms that may limit or prevent the effective use of the respirator.

Retraining shall be done every year, or sooner, for the following reasons:

- Changes in the workplace or type of respirator render the old training ineffective.
- A worker does not retain information from the initial course.
- Any other situation occurs in which retraining appears necessary to ensure safe respirator use.

PROGRAM EVALUATION

The employer is required to evaluate the written respiratory protection program as necessary to ensure it is being properly implemented and is effective. The evaluation shall include consulting workers who use respirators for their views on program effectiveness as well as problems.

RECORDKEEPING

The employer must establish and retain written information regarding the following:

- Exposure assessments
- Medical evaluations
- Respirator inspections
- Written respirator program

Fit Testing Records

Qualitative and quantitative fit testing records also must be kept. They must be retained until the worker's next fit test. These records shall contain the following:

- Name of the worker tested
- Type of fit test performed
- Make, model style, and size of the respirator tested
- Test date
- Test results:
  - Pass/fail results of qualitative fit tests
  - Fit factor and strip chart recording
  - Other recordings of test results for QNFTs

Training Records

Written documentation of worker respirator training and respirator program evaluation results shall also be maintained.

PERSONAL USE FACTORS

Several items can affect the protection provided by respirators. It is important that workers are aware of these items. They include the following:

- Facial hair
- Long hair
- Eyeglasses
- Contact lenses
- Gum and tobacco chewing

Facial Hair

A beard or long sideburns prevent a good seal between the face and the respirator. Studies have shown that any facial hair reduces the protection received from a respirator. This includes a full beard, as well as a few days growth. A mustache is acceptable if it fits under the mask without affecting the seal.

Long Hair

Long hair may interfere with a good seal in some situations. The hair must be contained under the protective suit.

Eyeglasses

The temple bars that extend from the ear to the lens prevent the respirator from fitting up against the side of the head. Spectacle kits take care of this situation quite easily (Figure 8-18). They are inexpensive and must be provided by the employer. Under no condition should workers hesitate to request a spectacle kit. To work without eyeglasses creates a serious potential for accident and injury.

Figure 8-18. A spectacle kit lets you see yet does not interfere with the facepiece seal. (Image courtesy of MSA)

Contact Lenses

Contact lenses cannot be used with a respirator in a contaminated atmosphere for the following reasons:

- A contact lens is porous. It can absorb chemicals causing the chemicals to contact the eye. This can lead to eye injury.
- Sometimes the humidity inside the mask can be very low or very high. The degree of humidity affects the ability to wear contact lens comfortably.
- If the lenses were to pop out of the eye in a hazardous area, the worker might be put into a dangerous situation. There would be no way to put the lens back in without taking off the respirator.

Gum and Tobacco Chewing

Gum and tobacco chewing are prohibited when wearing a respirator. The chewing action puts a strain on the respirator seal. It could also lead to ingestion of contaminants.

INSPECTIONS

Inspection are an important part of a good PPE program. Checklists and written records are needed to verify and maintain the effectiveness and safety of the PPE. There are different types of inspections:

1. Inspection and testing of new equipment
2. Inspection of equipment at the time it is issued to workers
3. Inspection after use
4. Periodic inspection of stored equipment
5. Inspection when problems are reported

The responsibility to inspect PPE must be assigned to a specific qualified person. However, it is a good practice for workers to know how to do a basic equipment inspection.

SECTION 8 - ASSIGNMENT SHEET

1. Define the following terms:

   Protection factor ____

   ____

   Maximum use concentration ____

   ____

   ____

   Qualitative fit test ____

   ____

   Quantitative fit test ____

   ____

   ____

2. Write out the following abbreviations:

   APR ____

   PPE ____

   MUC ____

   HEPA ____

   PAPR ____

   SCBA ____

   ESLI ____

   IDLH ____

3. Describe the two basic types of filtering devices, giving examples of each.

   ____

   ____

   ____

   ____

4. List five types of respirators and their protection factors.

5. Describe the two types of atmosphere supplying respirators and the type of regulator used for work in confined space.

6. List the limitations of the full-face supplied air respirator.

7. List the limitations of SCBAs.

8. Describe the personal use factors that affect protection provided by respirators.

SECTION 8 - STANDARD OPERATING PROCEDURE 1

A. Inspect a full-face APR using the following steps. Check for signs of wear, dirt, and integrity. Check to ensure that all parts work properly.

1. Overall general appearance (no deformities).
2. Harness assembly and connections.
3. Lens and lens gasket.
4. Facepiece seal area.
5. Inner nose cup.
6. Inhalation valves and their seating surfaces.
7. Exhalation valves and its seating surface.
8. Filter or cartridge holder and gaskets.
9. Filter(s) or cartridge(s).
10. Install proper filter(s) or cartridge(s).

B. Don a full-face APR using the following steps.

1. Inspect the respirator.
2. Loosen the harness assembly completely.
3. Hang the facepiece around the neck using neck strap (if available).
4. Raise the facepiece upward and open to expose the chin and nose cup.
5. Place chin in the chin cup and pull the harness over the top of the head. Make sure no hair or other obstructions are between the face and facepiece.
6. Tighten the bottom harness straps (not too tight).
7. Tighten the middle two harness straps.
8. Tighten the top strap slightly.
9. Adjust the facepiece if needed. It should be centered on the face.

C. Perform a negative pressure check with a full-face APR.

1. Inspect the respirator.
2. Don the respirator.
3. Cover the filter or cartridge inlet openings. The palms of the hands, duct tape, plastic wrap, or surgeon's gloves may be used.
4. Inhale so the facepiece collapses inward and hold for ten seconds.
5. If the facepiece stays collapsed, go to step 7.
6. If there is leakage, readjust the facepiece and try again. If there is still leakage, reinspect the respirator and try again. If it is still not possible to get a seal, try a different size or make of respirator.
7. Remove the coverings from the filter or cartridge inlets.

D. Perform a positive pressure check with a full-face APR.

1. Inspect the respirator.
2. Don the respirator.
3. Cover the exhalation outlet. The palm of the hand, duct tape, plastic wrap, or surgeon's gloves may be used.
4. Exhale so that the facepiece is enlarged slightly and hold for ten seconds.
5. If the facepiece stays enlarged, go to step 7.
6. If there is leakage, readjust the facepiece and try again. If there is still leakage, reinspect the respirator and try again. If it is still not possible to get a seal, try a different size or make of respirator.
7. Remove the coverings from the exhalation outlet.

E. Clean, sanitize, and maintain a full-face APR.

1. Remove and properly discard filters and/or cartridges.
2. Immerse the respirator in a warm (about 110°F/43.3°C) solution of germicidal or disinfecting detergent.
3. Scrub respirator body and parts gently with a cloth or soft brush.
4. Rinse in clean, warm (about 110°F/43.3°C) water.
5. Shake gently to remove excess water. It may be necessary to tip the respirator in several directions.
6. Wipe the lens and respirator with a soft, clean cloth (if available) or allow to air dry away from direct heat or sunlight.
7. Inspect the respirator.
8. Replace all damaged or missing parts according to the manufacturer's instructions.
9. Loosen harness straps.
10. Place respirator in a clean bag, box, or appropriate storage area. The storage area should be in a cool, dry place. Do not place any weight on the respirator.

SECTION 8 - STANDARD OPERATING PROCEDURE 2

A. Inspect a full-face atmosphere supplying respirator using the following steps:

1. Check all hoses and lines for signs of excessive wear or abuse. Do not use if there is a doubt.
2. Inspect the manifold assembly for integrity.
3. Inspect the breathing valve for integrity.
4. Check the air supply from the manifold to the respirator. It should be between 60–125 psi.
5. Inspect the facepiece.

B. Don a full-face atmosphere supplying respirator using the following steps:

1. Inspect the air line respirator.
2. Adjust the waist straps and buckle. Be sure the straps are not twisted.
3. Make sure the positive pressure is off if there is a donning valve.
4. Hang the head strap over the neck.
5. Make the proper connections to the air supply and manifold.
6. Don the facepiece.
7. Do a positive pressure (two-finger) check.
8. Do a negative pressure check (optional).
9. Check the bypass valve to make sure it is working properly.

C. Clean, maintain, and store a full-face atmosphere supplying respirator using the following steps:

1. Turn off the positive pressure.

2. If needed, clean the apparatus with a brush and mild detergent.

3. Rinse well and towel or air dry.

4. Unscrew the breathing hose at the manifold end.

5. Remove the cover on the facepiece by unscrewing the two screws and pulling off the cover.

6. Remove the breathing valve by twisting the valve clockwise, disconnecting the bayonet coupling.

7. Cover the inhalation side of the valve with your thumb and immerse the breathing valve in a warm (about 110°F/43.3°C) solution of germicidal or disinfecting detergent. Do not allow water into the inhalation side of the valve!

8. Immerse the breathing valve (again covering the inhalation side) in clean, warm water and rinse.

9. Gently shake the valve to remove excess water. Wipe with a clean soft cloth and allow to air dry.
10. Immerse the facepiece in the warm germicidal or disinfecting solution.
11. Gently scrub with a cloth or soft brush.
12. Rinse in clean warm water.
13. Shake gently to remove excess water.
14. Wipe the lens and facepiece with a soft cloth or allow to air dry away from direct heat or sunlight.
15. Inspect the air line respirator and facepiece.
16. Connect the breathing valve to the facepiece by pushing and turning counterclockwise to engage the bayonet coupling.
17. Lock the breathing valve in position with the cover, speech diaphragm, or radio attachment by tightening the locking screws.
18. Connect the breathing hose to the manifold.
19. Store the apparatus in its case or in a clean, dry, dust-free area.

APPENDIX 8-1
RESPIRATOR PROFILES

Type of Respirator	Other Common Names	Protection Factor (NIOSH)	Limitations
Disposable paper masks	Single use masks	5	Limitations are severe. **Not** used for confined space operations.
Quarter masks	Type B mask	5	Limitations are severe. **Not** used for confined space operations.
Half facepiece	Cartridge mask, type A mask, negative pressure mask	10	Can only be used at low levels, where contaminants are known and adequate filters are available. Cannot be worn in an oxygen-deficient atmosphere.
Full facepiece	Cartridge mask, canister mask, negative pressure mask.	50	Limited. protection. Can only be used when levels are fairly low and contaminants are known. Limited selection of filters. Cannot be worn in an oxygen-deficient atmosphere.
Powered air purifying	PAPR	50	Protection depends on charged battery. Use is restricted by the same limitations as other full-face masks. Cannot be worn in an oxygen-deficient atmosphere.
Air line respirator	Hose masks, atmosphere supplying respirator facepieces, type C respirators	2,000 for full face pppd 10,000 for full face pppd w/ back-up air tank	Problems with hose limits and its usefulness.
Self-contained breathing apparatus	SCBA	50 for demand units 10,000 for pppd units	Very heavy. Limited air supply of 30, 45, or 60 minutes in 2,220 or 4,500 psi cylinders. Longer times with rebreathers—1, 2, and 4 hours.

APPENDIX 8-2
RESPIRATOR INFORMATION

Protection Factors

Protection factor (PF) is a value assigned to a respirator based on its efficiency. If a respirator allows contaminants to leak around the face seal into the mask, it is less efficient.

The technical definition of PF is the concentration outside the respirator divided by the concentration that can get inside the respirator.

$$PF = \frac{\text{Concentration of contaminant outside the respirator}}{\text{Concentration inside the respirator}}$$

The practical definition of PF is how much of the outside contaminant level is reduced by the respirator.

- A respirator with a PF of 10 reduces exposure 10 times. The wearer is exposed to a concentration 1/10 of the outside concentration level.
- A respirator with a PF of 10,000 reduces exposure 10,000 times. The wearer is exposed to a concentration 1/10,000 of the outside concentration level.

A rule of thumb for protection factors is: Low PFs give the **lowest protection** and high PFs give the **highest protection**.

Maximum Use Concentrations

Using the PF and the OSHA Permissible Exposure Limit (PEL), you can determine the highest level at which a respirator can be safely used. This level is called the maximum use concentration (MUC). The MUC is the PF multiplied by the PEL.

MUC = PF x PEL

Example for nitric acid and half-face air purifying respirator (APR):

OSHA PEL for nitric acid	=	**2**	**ppm**
PF of half-face APR	=	**10**	
MUC	=	**10 x 2**	
	=	**20**	**ppm**

A half-face mask cannot be used in nitric acid levels exceeding 20 ppm. At no time should a respirator be used in an environment that exceeds the MUC.

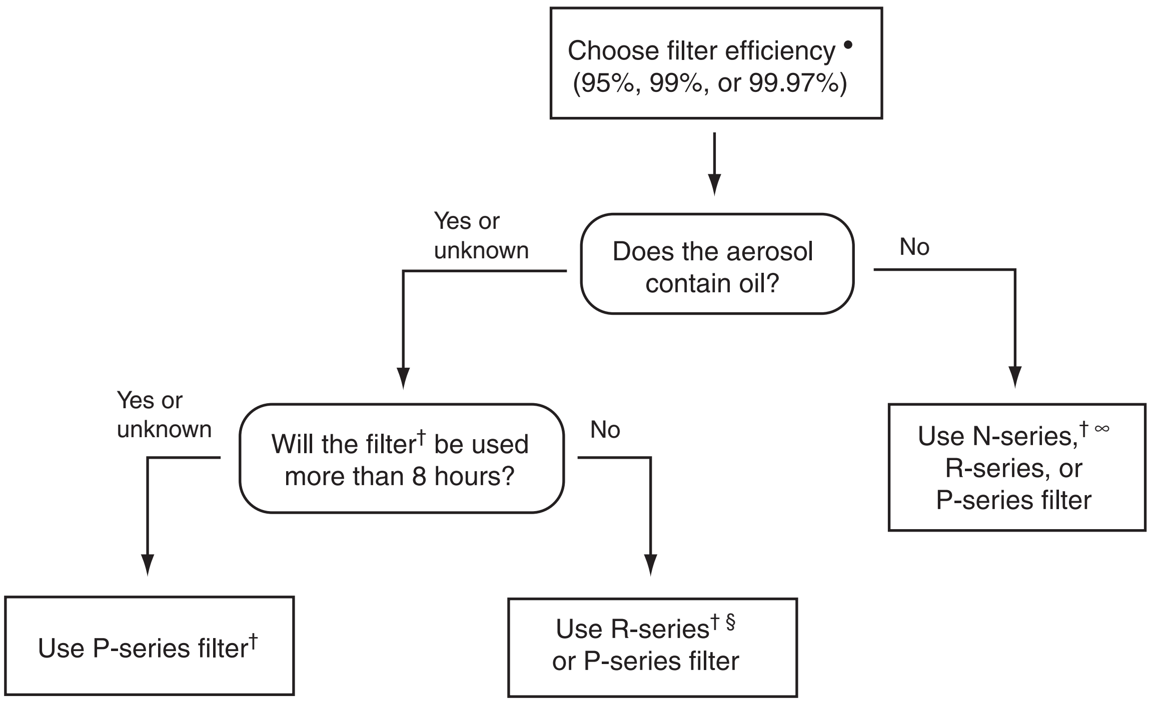
Respirator Selection

The industrial hygienist selects the correct respirator with the protection factor in mind. If airborne chemical levels are high, there is a chance that the respirator will not reduce exposure enough. If this happens, the worker may be overexposed even wearing a respirator.

Example

Workers are using half-masks in an area where nitric acid levels are 50 ppm. Is this acceptable? No. The MUC for nitric acid and a half-face APR is 20 ppm.

APPENDIX 8-3
PART 84 - RESPIRATOR DECISION PROCESS



• The higher the filter efficiency, the lower the filter leakage.

† Limited by considerations of hygiene, damage, and breathing resistance.

∞ High (200 mg) filter loading in the cerrification test is intended to address the potential for filter efficiency degradation by solid or water-based (i.e., non-oil) aerosols in the workplace. Accordingly there is no recommended service time in most workplace settings. however, in dirty workplaces (high aerosol concentrations), service time should only be extended beyond 8 hours of use (continuous or intermittent) by performing an evaluation in specific workplace settings that demonstrates (a) that extended use will not degrade the filter efficiency below the certified efficiency level, or (b) that the total mass loading of the filter is less than 200 mg (100 mg per filter for dual-filter respirators).

§ No specific service time limit when oil aerosols are not present. In the presence of oil aerosols, service time may be extended beyond 8 hours of use (continuous or intermittent) by demonstring (a) that extended use will not degrade the filter efficiency below the certified efficiency level, or (b) that the total mass loading of the filter is less than 200 mg (100 mg per filter for dual-filter respirators).

APPENDIX 8-4
SCBA INSPECTION GUIDELINES

Before an SCBA can be used, it must be properly inspected to help prevent malfunction during use. The specific manufacturer's instructions for the devices you use should always be followed. However the following checklist is a general guideline for proper inspection of a positive-pressure, pressure-demand SCBA.

Prior to starting on checklist, make sure that the:

1. High pressure hose connector is tight on cylinder fitting
2. By-pass valve is closed
3. Mainline valve is closed
4. Regulator outlet is not covered or obstructed
5. Cylinder valve is closed

Checklist for a positive pressure, pressure-demand SCBA:

Backpack and harness assembly:

1. Visually inspect straps for complete set
2. Visually inspect straps for frayed or damaged straps
3. Visually inspect buckles for mating ends
4. Physically check buckle locking function
5. Visually inspect back plate for cracks and missing rivets or screws
6. Visually inspect cylinder hold-down strap, physically check strap tightener and lock to assure that it is fully engaged

Cylinder and cylinder valve assembly:

1. Physically check cylinder pressure (should be 2,200 or 4,500 psi)
2. Physically check hydrostatic test date monthly to assure it is current
3. Visually inspect for large dents or gouges in the metal. Do this monthly.
4. Physically check to ensure that it is tightly fastened to back plate
5. If a fiberglass hoop wrapped cylinder (4,500 psi) is used, make sure it has a retrofitted steel cylinder neck ring (Luxfur cylinders)

Head and valve assembly:

1. Visually determine if the cylinder valve lock is present. Do this monthly.

2. Visually inspect the cylinder gauge for condition of face, needle, and lens. Do this monthly.

3. Open cylinder valve and listen or feel for leakage around packing. (If leakage is noted, do not use until repaired.) Note the functioning of the valve lock.

Regulator and high-pressure hose:

1. Listen or feel for leakage in hose or at hose-to-cylinder connector. (Bubble in outer hose covering may be caused by seepage of air through hose when stored under pressure. This does not necessarily indicate a faulty hose.)

2. Check to ensure that the regulator outlet is not covered or obstructed. Open and close bypass valve momentarily to assure flow of air through the by-pass system.

3. Cover regulator outlet with palm of hand or cap provided. Open mainline valve and read regulator gauge. (The gauge must read at least 1,800 or 4,000 psi and not more than rated cylinder pressure.) The alarm or bell should ring when the mainline valve is opened and the respirator is pressurized.

4. Close the cylinder valve and slowly bleed the emergency by-pass valve to allow air to flow slowly. Gauge should begin to show immediate loss of pressure as air flows. Low-pressure alarm should sound between 520 and 480 psi or 25 percent of remaining air (1125 psi in a 4500 psi cylinder). This alarm is the second alarm or bell.

5. Cover regulator outlet with palm of hand or cap provided. Open mainline valve and read regulator gauge. (The gauge must read at least 1,800 or 4,000 psi and not more than rated cylinder pressure.) The alarm or bell should ring when the mainline valve is opened and the respirator is pressurized. This is the third alarm or bell in a three-bell check.

Facepiece and corrugated breathing tube:

1. Visually inspect facepiece head harness for damaged serrations and deteriorated rubber. Visually inspect rubber facepiece body for signs of deterioration or extreme distortion.

2. Visually inspect the lens for proper seal in rubber facepiece, retaining clamp properly in place, and absence of cracks or large scratches.

3. Visually inspect exhalation valve for visible deterioration or build-up of foreign materials.

4. Carry out a negative pressure check for overall seal and check exhalation valve. During the monthly inspection, place mask against face and use following procedure: in preparing for use, don backpack, then facepiece. With facepiece held tightly to face (or facepiece properly donned), stretch breathing tube to open corrugations and place thumb or hand over end of

connector. Inhale. Negative pressure should be created inside mask, causing it to pull tightly to face for 5–10 seconds. If negative pressure drops, this indicates a leak in the facepiece.

Breathing tube and connector:

1. Stretch the breathing tube and visually inspect for deterioration and holes.

2. Visually inspect connector to assure good condition of threads and for presence and proper condition of rubber gasket seals.

If the above mentioned inspection criteria is not met, then the SCBA unit should be set aside for repair by a certified technician.

Storage of the Positive Pressure, Pressure-Demand SCBA Units

To properly store an SCBA, follow these steps:

1. Refill cylinder as necessary. Clean and inspect unit.

2. Close cylinder valve.

c. Tighten high-pressure-hose connector on cylinder.

d. Bleed off the pressure in the high-pressure hose and regulator.

e. Close bypass valve.

f. Close mainline valve.

g. Loosen all straps completely and lay straight.

h. Store the facepiece properly to protect against dust, direct sunlight, extreme temperatures, excessive moisture, and damaging chemicals. Or store in a carrying case available from the manufacturer.

APPENDIX 8-5
NIOSH RESPIRATOR DECISION LOGIC

After criteria information is gathered and evaluated, the industrial hygienist follows a sequence of questions to identify the NIOSH recommended class of respirators for the airborne contaminants. The questions listed below are summarized from the Respirator Decision Logic document. They should be followed in sequence, while using the criteria information that has been gathered to select the proper respirator.

1. *Is the respirator to be used for firefighting?*

   a. If yes, use a full facepiece SCBA operated in a pressure demand mode.

   b. If no, go to step 2.

2. *Will the respirator be used in an oxygen deficient atmosphere?*

   a. If yes, any type SCBA or atmosphere supplying respirator with auxiliary SCBA can be used.

   b. If no, go to step 3.

3. *Will the respirator be used in emergency situations?*

   a. If yes, use a full facepiece SCBA operated in a pressure demand mode or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

   b. If no, go to step 4.

4. *Is the contaminant a carcinogen?*

   a. If yes, use a full facepiece SCBA operated in pressure demand mode, or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

   b. If no, go to step 5.

5. *Is the contaminant exposure level less than the OSHA PEL or NIOSH REL?*

   a. If yes, a respirator is not required except for escape. Go to step 7.

   b. If no, go to step 6.

6. *Is contaminant exposure level less than IDLH concentration*?

   a. If yes, go to step 7.

b. If no, conditions are IDLH. Use a full facepiece SCBA operated in pressure demand mode or a full facepiece atmosphere supplying respirator operated in pressure demand mode in combination with an auxiliary SCBA operated in pressure demand mode.

7. *Is the contaminant an eye irritant?*

a. If yes, respirators with full facepieces, helmet, or hood are recommended. Go to step 8.

b. If no, half mask respirators may be used, depending on exposure concentration. Go to step 8.

8. *Determine the minimum PF that is required.*

Divide the measured exposure concentration of the contaminant by its OSHA or NIOSH exposure limit. For escape respirators, determine the potential for a hazardous condition to occur caused by an accident or equipment failure. Go to step 9.

9. *If the contaminant is a particulate, go to step 10.*
If the contaminant is a gas or vapor, go to step 11.
If the contaminant is a combination, go to step 12.

10. *Particulate Respirators*

10.1 Is the particulate respirator to be used only for escape purposes?

a. If yes, use the table of NIOSH recommendations for escape respirators.

b. If no, the respirator will be used for normal work activities. Go to step 10.2.

10.2 Determine the type of filter that should be used for the particulate contaminant. Go to step 10.3

10.3 Select a particulate respirator with a PF equal to or greater than the minimum PF calculated in step 8.

11. *Gas / Vapor Respirators*

11.1 Is the gas/vapor respirator to be used only for escape purposes?

a. If yes, use the table of NIOSH recommendations for escape respirators.

b. If no, the respirator will be used for normal work activities. Go to step 11.2.

11.2 Are the warning properties for the gas/vapor contaminant adequate at or below the exposure limit (PEL or REL)?

a. If yes, go to step 11.3.

b. If no, an APR equipped with an ESLI, a atmosphere supplying respirator, or a SCBA is recommended. Go to step 11.4.

11.3 An APR chemical cartridge/canister respirator is recommended. Go to step 11.4.

11.4 Select a gas/vapor respirator with a PF equal to or greater than the minimum PF calculated in step 8.

12. Combination Particulate and Gas / Vapor Respirators

12.1 Is the combination respirator to be used only for escape purposes?

a. If yes, use the table of NIOSH recommendations for escape respirators.

b. If no, the respirator will be used for normal work activities. Go to step 12.2.

12.2 Does the gas/vapor contaminant have adequate warning properties at or below the exposure limit (PEL or REL)?

a. If yes, go to step 12.3
b. If no, an APR equipped with an ESLI, an atmosphere supplying respirator, or a SCBA is recommended. Go to step 12.4.

12.3 Use an APR with chemical cartridge/canister that has a particulate pre-filter. Go to step 12.4.

12.4 Select a combination gas/vapor and particulate respirator with a PF equal to or greater than the minimum PF calculated in step 8.

Figure 8-19 shows the respirator decision flow chart. The chart helps to organize the information and keep track of the flow of questions in the sequence.

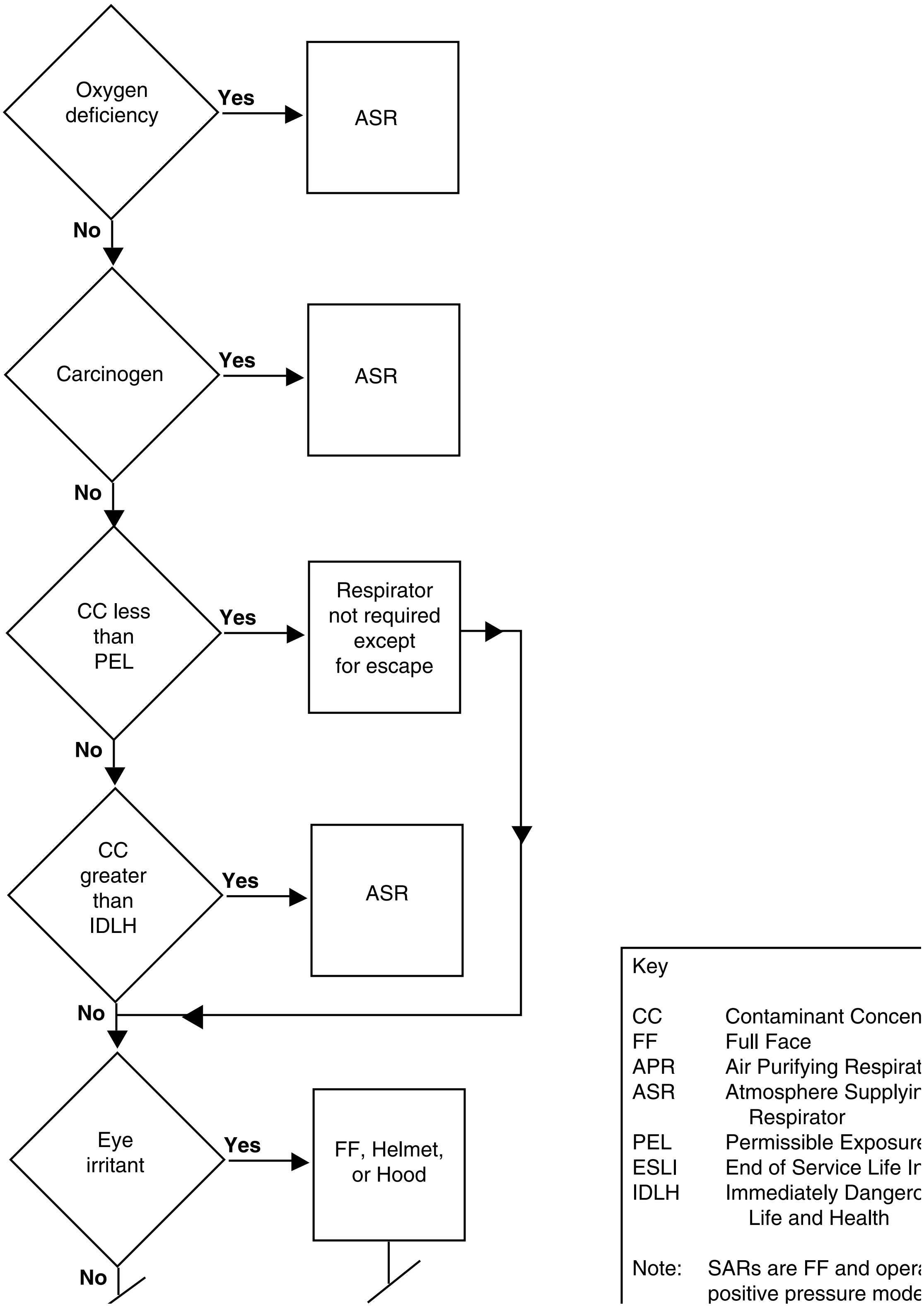


Figure 8-19. The respirator decision flow chart helps to organize the information gathered from the NIOSH Respirator Decision Logic.

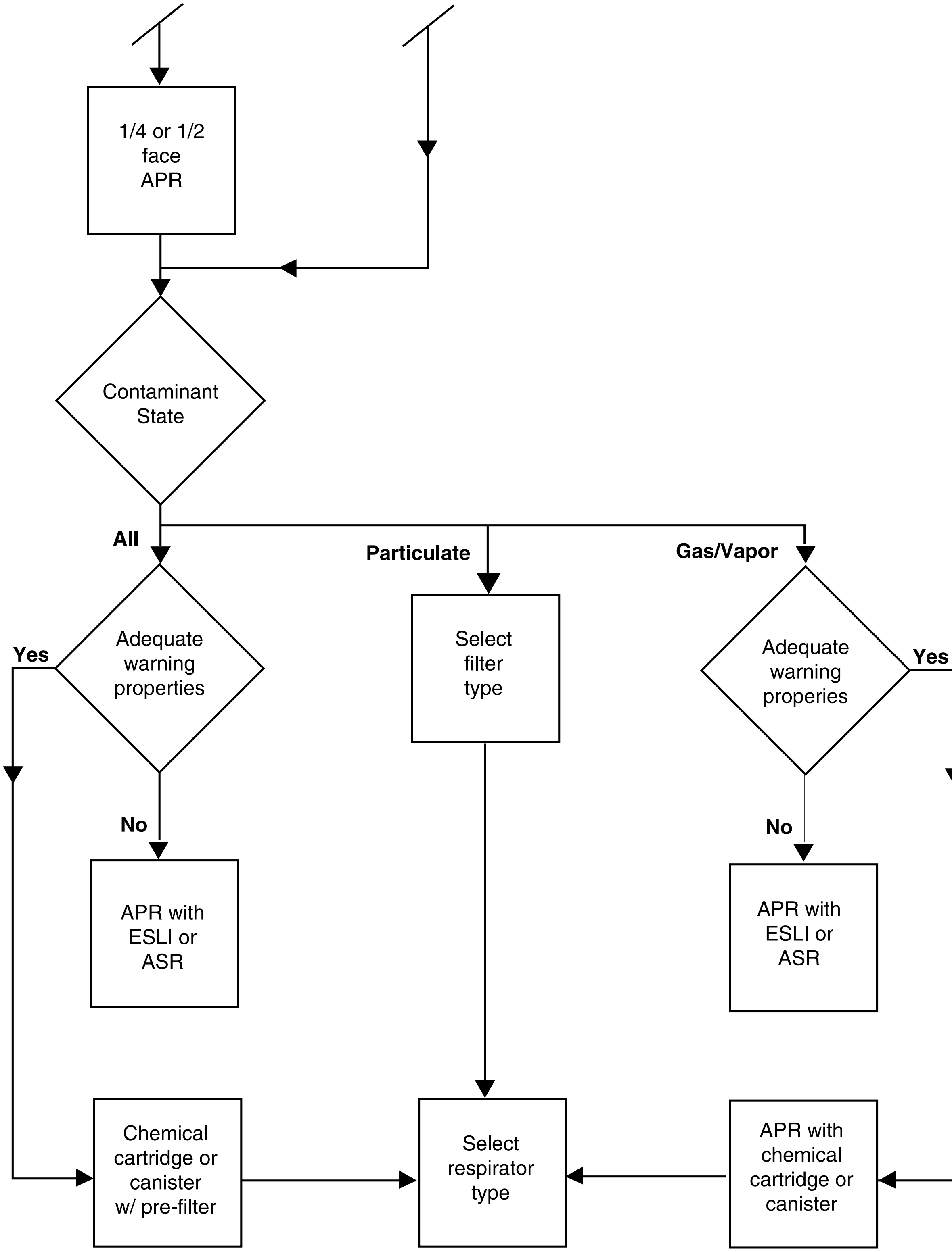


Figure 8-19. (continued) The respirator decision flow chart helps to organize the information gathered from the NIOSH Respirator Decision Logic.

Section

Regulations

PERMIT-REQUIRED CONFINED SPACE ENTRY

Title

OSHA REGULATIONS

SUBPART J GENERAL ENVIRONMENTAL CONTROLS

1910.146 Permit-required confined spaces

(a) Scope and application.

This section contains requirements for practices and procedures to protect employees in general industry from the hazards of entry into permit-required confined spaces. This section does not apply to agriculture, to construction, or to shipyard employment (Parts 1928, 1926, and 1915 of this chapter, respectively).

(b) Definitions.

Acceptable entry conditions means the conditions that must exist in a permit space to allow entry and to ensure that employees involved with a permit-required confined space entry can safely enter into and work within the space.

Attendant means an individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all attendant's duties assigned in the employer's permit space program.

Authorized entrant means an employee who is authorized by the employer to enter a permit space.

Blanking or blinding means the absolute closure of a pipe, line, or duct by the fastening of a solid plate (such as a spectacle blind or a skillet blind) that completely covers the bore and that is capable of withstanding the maximum pressure of the pipe, line, or duct with no leakage beyond the plate.

Confined space means a space that:

(1) Is large enough and so configured that an employee can bodily enter and perform assigned work; and

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

(3) Is not designed for continuous employee occupancy.

Double block and bleed means the closure of a line, duct, or pipe by closing and locking or tagging two in-line valves and by opening and locking or tagging a drain or vent valve in the line between the two closed valves.

Emergency means any occurrence (including any failure of hazard control or monitoring equipment) or event internal or external to the permit space that could endanger entrants.

Engulfment means the surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing.

Entry means the action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space.

Entry permit (permit) means the written or printed document that is provided by the employer to allow and control entry into a permit space and that contains the information specified in paragraph (f) of this section.

Entry supervisor means the person (such as the employer, foreman, or crew chief) responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations, and for terminating entry as required by this section.

Note: An entry supervisor also may serve as an attendant or as an authorized entrant, as long as that person is trained and equipped as required by this section for each role he or she fills. Also, the duties of entry supervisor may be passed from one individual to another during the course of an entry operation.

Hazardous atmosphere means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

(1) Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);

(2) Airborne combustible dust at a concentration that meets or exceeds its LFL;

Note: This concentration may be approximated as a condition in which the dust obscures vision at a distance of 5 feet (1.52 m) or less.

(3) Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;

(4) Atmospheric concentration of any substance for which a dose or a permissible

exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of this part and which could result in employee exposure in excess of its dose or permissible exposure limit;

Note: An atmospheric concentration of any substance that is not capable of causing death, incapacitation, impairment of ability to self-rescue, injury, or acute illness due to its health effects is not covered by this provision.

(5) Any other atmospheric condition that is immediately dangerous to life or health.

Note: For air contaminants for which OSHA has not determined a dose or permissible exposure limit, other sources of information, such as Material Safety Data Sheets that comply with the Hazard Communication Standard, Sec. 1910.1200 of this part, published information, and internal documents can provide guidance in establishing acceptable atmospheric conditions.

Hot work permit means the employer's written authorization to perform operations (for example, riveting, welding, cutting, burning, and heating) capable of providing a source of ignition.

Immediately dangerous to life or health (IDLH) means any condition that poses an immediate or delayed threat to life or that would cause irreversible adverse health effects or that would interfere with an individual's ability to escape unaided from a permit space.

Note: Some materials--hydrogen fluoride gas and cadmium vapor, for example--may produce immediate transient effects that, even if severe, may pass without medical attention, but are followed by sudden, possibly fatal collapse 12-72 hours after exposure. The victim ``feels normal'' from recovery from transient effects until collapse. Such materials in hazardous quantities are considered to be ``immediately'' dangerous to

Inerting means the displacement of the atmosphere in a permit space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.

Note: This procedure produces an IDLH oxygen-deficient atmosphere.

Isolation means the process by which a permit space is removed from service and completely protected against the release of energy and material into the space by such means as: blanking or blinding; misaligning or removing sections of lines, pipes, or ducts; a double block and bleed system; lockout or tagout of all sources of energy; or blocking or disconnecting all mechanical linkages.

Line breaking means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

Non-permit confined space means a confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

Oxygen deficient atmosphere means an atmosphere containing less than 19.5 percent oxygen by volume.

Oxygen enriched atmosphere means an atmosphere containing more than 23.5 percent oxygen by volume.

Permit-required confined space (permit space) means a confined space that has one or more of the following characteristics:

(1) Contains or has a potential to contain a hazardous atmosphere;

(2) Contains a material that has the potential for engulfing an entrant;

(3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or

(4) Contains any other recognized serious safety or health hazard.

Permit-required confined space program (permit space program) means the employer's overall program for controlling, and, where appropriate, for protecting employees from, permit space hazards and for regulating employee entry into permit spaces.

Permit system means the employer's written procedure for preparing and issuing permits for entry and for returning the permit space to service following termination of entry.

Prohibited condition means any condition in a permit space that is not allowed by the permit during the period when entry is authorized.

Rescue service means the personnel designated to rescue employees from permit spaces.

Retrieval system means the equipment (including a retrieval line, chest or full-body harness, wristlets, if appropriate, and a lifting device or anchor) used for non-entry rescue of persons from permit spaces.

Testing means the process by which the hazards that may confront entrants of a permit space are identified and evaluated. Testing includes specifying the tests that are to be performed in the permit space.

Note: Testing enables employers both to devise and implement adequate control measures for the protection of authorized entrants and to determine if acceptable entry conditions are present immediately prior to, and during, entry.

(c) General requirements.

(1) The employer shall evaluate the workplace to determine if any spaces are permit-required confined spaces.

Note: Proper application of the decision flow chart in appendix A to Sec. 1910.146 would facilitate compliance with this requirement.

(2) If the workplace contains permit spaces, the employer shall inform exposed employees, by posting danger signs or by any other equally effective means, of the existence and location of and the danger posed by the permit spaces.

Note: A sign reading ``DANGER--PERMIT-REQUIRED CONFINED SPACE, DO NOT ENTER'' or using other similar language would satisfy the requirement for a sign.

(3) If the employer decides that its employees will not enter permit spaces, the employer shall take effective measures to prevent its employees from entering the permit spaces and shall comply with paragraphs (c)(1), (c)(2), (c)(6), and (c)(8) of this section.

(4) If the employer decides that its employees will enter permit spaces, the employer shall develop and implement a written permit space program that complies with this section. The written program shall be available for inspection by employees and their authorized representatives.

(5) An employer may use the alternate procedures specified in paragraph (c)(5)(ii) of this section for entering a permit space under the conditions set forth in paragraph (c)(5)(i) of this section.

(i) An employer whose employees enter a permit space need not comply with paragraphs (d) through (f) and (h) through (k) of this section, provided that:

(A) The employer can demonstrate that the only hazard posed by the permit space is an actual or potential hazardous atmosphere;

(B) The employer can demonstrate that continuous forced air ventilation alone is sufficient to maintain that permit space safe for entry;

(C) The employer develops monitoring and inspection data that supports the demonstrations required by paragraphs (c)(5)(i)(A) and (c)(5)(i)(B) of this section;

(D) If an initial entry of the permit space is necessary to obtain the data required by paragraph (c)(5)(i)(C) of this section, the entry is performed in compliance with paragraphs (d) through (k) of this section;

(E) The determinations and supporting data required by paragraphs (c)(5)(i)(A), (c)(5)(i)(B), and (c)(5)(i)(C) of this section are documented by the employer and are made available to each employee who enters the permit space under the terms of paragraph (c)(5) of this section or to that employee's authorized representative; and

(F) Entry into the permit space under the terms of paragraph (c)(5)(i) of this section is performed in accordance with the requirements of paragraph (c)(5)(ii) of this section.

Note: See paragraph (c)(7) of this section for reclassification of a permit space after all hazards within the space have been eliminated.

(ii) The following requirements apply to entry into permit spaces that meet the conditions set forth in paragraph (c)(5)(i) of this section.

(A) Any conditions making it unsafe to remove an entrance cover shall be eliminated before the cover is removed.

(B) When entrance covers are removed, the opening shall be promptly guarded by a railing, temporary cover, or other temporary barrier that will prevent an accidental fall through the opening and that will protect each employee working in the space from foreign objects entering the space.

(C) Before an employee enters the space, the internal atmosphere shall be tested, with a calibrated direct-reading instrument, for oxygen content, for flammable gases and vapors, and for potential toxic air contaminants, in that order. Any employee who enters the space, or that employee's authorized representative, shall be provided an opportunity to observe the pre-entry testing required by this paragraph.

(D) There may be no hazardous atmosphere within the space whenever any employee is inside the space.

(E) Continuous forced air ventilation shall be used, as follows:

(1) An employee may not enter the space until the forced air ventilation has eliminated any hazardous atmosphere;

(2) The forced air ventilation shall be so directed as to ventilate the immediate areas where an employee is or will be present within the space and shall continue until all employees have left the space;

(3) The air supply for the forced air ventilation shall be from a clean source and may not increase the hazards in the space.

(F) The atmosphere within the space shall be periodically tested as necessary to ensure that the continuous forced air ventilation is preventing the accumulation of a hazardous atmosphere. Any employee who enters the space, or that employee's authorized representative, shall be provided with an opportunity to observe the periodic testing required by this paragraph.

(G) If a hazardous atmosphere is detected during entry:

(1) Each employee shall leave the space immediately;

(2) The space shall be evaluated to determine how the hazardous atmosphere developed; and

(3) Measures shall be implemented to protect employees from the hazardous atmosphere before any subsequent entry takes place.

(H) The employer shall verify that the space is safe for entry and that the pre-entry measures required by paragraph (c)(5)(ii) of this section have been taken, through a written certification that contains the date, the location of the space, and the signature of the person providing the certification. The certification shall be made before entry and shall be made available to each employee entering the space or to that employee's authorized representative .

(6) When there are changes in the use or configuration of a non-permit confined space that might increase the hazards to entrants, the employer shall reevaluate that space and, if necessary, reclassify it as a permit-required confined space.

(7) A space classified by the employer as a permit-required confined space may be reclassified as a non-permit confined space under the following procedures:

(i) If the permit space poses no actual or potential atmospheric hazards and if all hazards within the space are eliminated without entry into the space, the permit space may be reclassified as a non-permit confined space for as long as the non-atmospheric hazards remain eliminated.

(ii) If it is necessary to enter the permit space to eliminate hazards, such entry shall be performed under paragraphs (d) through (k) of this section. If testing and inspection during that entry demonstrate that the hazards within the permit space have been eliminated, the permit space may be reclassified as a non-permit confined space for as long as the hazards remain eliminated.

Note: Control of atmospheric hazards through forced air ventilation does not constitute elimination of the hazards. Paragraph (c)(5) covers permit space entry where the employer can demonstrate that forced air ventilation alone will control all hazards in the space.

(iii) The employer shall document the basis for determining that all hazards in a permit space have been eliminated, through a certification that contains the date, the location of the space, and the signature of the person making the determination. The certification shall be made available to each employee entering the space or to that employee's authorized representative.

(iv) If hazards arise within a permit space that has been declassified to a non-permit space under paragraph (c)(7) of this section, each employee in the space shall exit the space. The employer shall then reevaluate the space and determine whether it must be reclassified as a permit space, in accordance with other applicable provisions of this section.

(8) When an employer (host employer) arranges to have employees of another employer (contractor) perform work that involves permit space entry, the host employer shall:

(i) Inform the contractor that the workplace contains permit spaces and that permit space entry is allowed only through compliance with a permit space program meeting the requirements of this section;

(ii) Apprise the contractor of the elements, including the hazards identified and the host employer's experience with the space, that make the space in question a permit space;

(iii) Apprise the contractor of any precautions or procedures that the host employer has implemented for the protection of employees in or near permit spaces where contractor personnel will be working;

(iv) Coordinate entry operations with the contractor, when both host employer personnel and contractor personnel will be working in or near permit spaces, as required by paragraph (d)(11) of this section; and

(v) Debrief the contractor at the conclusion of the entry operations regarding the permit space program followed and regarding any hazards confronted or created in permit spaces during entry operations.

(9) In addition to complying with the permit space requirements that apply to all employers, each contractor who is retained to perform permit space entry operations shall:

(i) Obtain any available information regarding permit space hazards and entry operations from the host employer;

(ii) Coordinate entry operations with the host employer, when both host employer personnel and contractor personnel will be working in or near permit spaces, as required by paragraph (d)(11) of this section;
and

(iii) Inform the host employer of the permit space program that the contractor will follow and of any hazards confronted or created in permit spaces, either through a debriefing or during the entry operation.

(d) Permit-required confined space program (permit space program).

Under the permit space program required by paragraph (c)(4) of this section, the employer shall:

(1) Implement the measures necessary to prevent unauthorized entry;

(2) Identify and evaluate the hazards of permit spaces before employees enter them;

(3) Develop and implement the means, procedures, and practices necessary for safe permit space entry operations, including, but not limited to, the following:

(i) Specifying acceptable entry conditions;

(ii) Providing each authorized entrant or that employee's authorized representative with the opportunity to observe any monitoring or testing of permit spaces;

(iii) Isolating the permit space;

(iv) Purging, inerting, flushing, or ventilating the permit space as necessary to eliminate or control atmospheric hazards;

B Providing pedestrian, vehicle, or other barriers as necessary to protect entrants from external hazards; and

(vi) Verifying that conditions in the permit space are acceptable for entry throughout the duration of an authorized entry.

(4) Provide the following equipment (specified in paragraphs (d)(4)(i) through (d)(4)(ix) of this section) at no cost to employees, maintain that equipment properly, and ensure that employees use that equipment properly:

(i) Testing and monitoring equipment needed to comply with paragraph (d)(5) of this section;

(ii) Ventilating equipment needed to obtain acceptable entry conditions;

(iii) Communications equipment necessary for compliance with paragraphs (h)(3) and (i)(5) of this section;

(iv) Personal protective equipment insofar as feasible engineering and work practice controls do not adequately protect employees;

(v) Lighting equipment needed to enable employees to see well enough to work safely and to exit the space quickly in an emergency;

(vi) Barriers and shields as required by paragraph (d)(3)(iv) of this section;

(vii) Equipment, such as ladders, needed for safe ingress and egress by authorized entrants;

(viii) Rescue and emergency equipment needed to comply with paragraph (d)(9) of this section, except to the extent that the equipment is provided by rescue services; and

(ix) Any other equipment necessary for safe entry into and rescue from permit spaces.

(5) Evaluate permit space conditions as follows when entry operations are conducted:

(i) Test conditions in the permit space to determine if acceptable entry conditions exist before entry is authorized to begin, except that, if isolation of the space is infeasible because the space is large or is part of a continuous system (such as a sewer), pre-entry testing shall be performed to the extent feasible before entry is authorized and, if entry is authorized, entry conditions shall be continuously monitored in the areas where authorized entrants are working;

(ii) Test or monitor the permit space as necessary to determine if acceptable entry conditions are being maintained during the course of entry operations; and

(iii) When testing for atmospheric hazards, test first for oxygen, then for combustible gases and vapors, and then for toxic gases and vapors.

(iv) Provide each authorized entrant or that employee's authorized representative an opportunity to observe the pre-entry and any subsequent testing or monitoring of permit spaces;

(v) Reevaluate the permit space in the presence of any authorized entrant or that employee's authorized representative who requests that the employer conduct such reevaluation because the entrant or representative has reason to believe that the evaluation of that space may not have been adequate;

(vi) Immediately provide each authorized entrant or that employee's authorized representative with the results of any testing conducted in accord with paragraph (d) of this section.

Note: Atmospheric testing conducted in accordance with appendix B to Sec. 1910.146 would be considered as satisfying the requirements of this paragraph. For permit space operations in sewers, atmospheric testing conducted in accordance with appendix B, as supplemented by appendix E to Sec. 1910.146, would be considered as satisfying the requirements of this paragraph.

(6) Provide at least one attendant outside the permit space into which entry is authorized for the duration of entry operations;

Note: Attendants may be assigned to monitor more than one permit space provided the duties described in paragraph (i) of this section can be effectively performed for each permit space that is monitored. Likewise, attendants may be stationed at any location outside the permit space to be monitored as long as the duties described in paragraph (i) of this section can be effectively performed for each permit space that is monitored.

(7) If multiple spaces are to be monitored by a single attendant, include in the permit program the means and procedures to enable the attendant to respond to an emergency affecting one or more of the permit spaces being monitored without distraction from the attendant's responsibilities under paragraph (i) of this section;

(8) Designate the persons who are to have active roles (as, for example, authorized entrants, attendants, entry supervisors, or persons who test or monitor the atmosphere in a permit space) in entry operations, identify the duties of each such employee, and provide each such employee with the training required by paragraph (g) of this section;

(9) Develop and implement procedures for summoning rescue and emergency services, for rescuing entrants from permit spaces, for providing necessary emergency services to rescued employees, and for preventing unauthorized personnel from attempting a rescue;

(10) Develop and implement a system for the preparation, issuance, use, and cancellation of entry permits as required by this section;

(11) Develop and implement procedures to coordinate entry operations when employees of more than one employer are working simultaneously as authorized entrants in a permit space, so that employees of one employer do not endanger the employees of any other employer;

(12) Develop and implement procedures (such as closing off a permit space and canceling the permit) necessary for concluding the entry after entry operations have been completed;

(13) Review entry operations when the employer has reason to believe that the measures taken under the permit space program may not protect employees and revise the program to correct deficiencies found to exist before subsequent entries are authorized; and

Note: Examples of circumstances requiring the review of the permit space program are: any unauthorized entry of a permit space, the detection of a permit space hazard not covered by the permit, the detection of a condition prohibited by the permit, the occurrence of an injury or near-miss during entry, a change in the use or configuration of a permit space, and employee complaints about the effectiveness of the program.

(14) Review the permit space program, using the canceled permits retained under paragraph (e)(6) of this section within 1 year after each entry and revise the program as necessary, to ensure that employees participating in entry operations are protected from permit space hazards.

Note: Employers may perform a single annual review covering all entries performed during a 12-month period. If no entry is performed during a 12-month period, no review is necessary.

Appendix C to Sec. 1910.146 presents examples of permit space programs that are considered to comply with the requirements of paragraph (d) of this section.

(e) Permit system.

(1) Before entry is authorized, the employer shall document the completion of measures required by paragraph (d)(3) of this section by preparing an entry permit.

Note: Appendix D to Sec. 1910.146 presents examples of permits whose elements are considered to comply with the requirements of this section.

(2) Before entry begins, the entry supervisor identified on the permit shall sign the entry permit to authorize entry.

(3) The completed permit shall be made available at the time of entry to all authorized entrants or their authorized representatives, by posting it at the entry portal or by any other equally effective means, so that the entrants can confirm that pre-entry preparations have been completed.

(4) The duration of the permit may not exceed the time required to complete the assigned task or job identified on the permit in accordance with paragraph (f)(2) of this section.

(5) The entry supervisor shall terminate entry and cancel the entry permit when:

(i) The entry operations covered by the entry permit have been completed; or

(ii) A condition that is not allowed under the entry permit arises in or near the permit space.

(6) The employer shall retain each canceled entry permit for at least 1 year to facilitate the review of the permit-required confined space program required by paragraph (d)(14) of this section. Any problems encountered during an entry operation shall be noted on the pertinent permit so that appropriate revisions to the permit space program can be made.

(f) Entry permit.

The entry permit that documents compliance with this section and authorizes entry to a permit space shall identify:

(1) The permit space to be entered;

(2) The purpose of the entry;

(3) The date and the authorized duration of the entry permit;

(4) The authorized entrants within the permit space, by name or by such other means (for example, through the use of rosters or tracking systems) as will enable the attendant to determine quickly and accurately, for the duration of the permit, which authorized entrants are inside the permit space;

Note: This requirement may be met by inserting a reference on the entry permit as to the means used, such as a roster or tracking system, to keep track of the authorized entrants within the permit space.

(5) The personnel, by name, currently serving as attendants;

(6) The individual, by name, currently serving as entry supervisor, with a space for the signature or initials of the entry supervisor who originally authorized entry;

(7) The hazards of the permit space to be entered;

(8) The measures used to isolate the permit space and to eliminate or control permit space hazards before entry;

Note: Those measures can include the lockout or tagging of equipment and procedures for purging, inerting, ventilating, and flushing permit spaces.

(9) The acceptable entry conditions;

(10) The results of initial and periodic tests performed under paragraph (d)(5) of this section, accompanied by the names or initials of the testers and by an indication of when the tests were performed;

(11) The rescue and emergency services that can be summoned and the means (such as the equipment to use and the numbers to call) for summoning those services;

(12) The communication procedures used by authorized entrants and attendants to maintain contact during the entry;

(13) Equipment, such as personal protective equipment, testing equipment, communications equipment, alarm systems, and rescue equipment, to be provided for compliance with this section;

(14) Any other information whose inclusion is necessary, given the circumstances of the particular confined space, in order to ensure employee safety; and

(15) Any additional permits, such as for hot work, that have been issued to authorize work in the permit space.

(g) Training.

(1) The employer shall provide training so that all employees whose work is regulated by this section acquire the understanding, knowledge, and skills necessary for the safe performance of the duties assigned under this section.

(2) Training shall be provided to each affected employee:

(i) Before the employee is first assigned duties under this section;

(ii) Before there is a change in assigned duties;

(iii) Whenever there is a change in permit space operations that presents a hazard about which an employee has not previously been trained;

(iv) Whenever the employer has reason to believe either that there are deviations from the permit space entry procedures required by paragraph (d)(3) of this section or that there are inadequacies in the employee's knowledge or use of these procedures.

(3) The training shall establish employee proficiency in the duties required by this section and shall introduce new or revised procedures, as necessary, for compliance with this section.

(4) The employer shall certify that the training required by paragraphs (g)(1) through (g)(3) of this section has been accomplished. The certification shall contain each employee's name, the signatures or initials of the trainers, and the dates of training. The certification shall be available for inspection by employees and their authorized representatives.

(h) Duties of authorized entrants.

The employer shall ensure that all authorized entrants:

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

(2) Properly use equipment as required by paragraph (d)(4) of this section;

(3) Communicate with the attendant as necessary to enable the attendant to monitor entrant status and to enable the attendant to alert entrants of the need to evacuate the space as required by paragraph (i)(6) of this section;

(4) Alert the attendant whenever:

(i) The entrant recognizes any warning sign or symptom of exposure to a dangerous situation, or

(ii) The entrant detects a prohibited condition; and

(5) Exit from the permit space as quickly as possible whenever:

(i) An order to evacuate is given by the attendant or the entry supervisor,

(ii) The entrant recognizes any warning sign or symptom of exposure to a dangerous situation,

(iii) The entrant detects a prohibited condition, or

(iv) An evacuation alarm is activated.

(i) Duties of attendants.

The employer shall ensure that each attendant:

(1) Knows the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;

(2) Is aware of possible behavioral effects of hazard exposure in authorized entrants;

(3) Continuously maintains an accurate count of authorized entrants in the permit space and ensures that the means used to identify authorized entrants under paragraph (f)(4) of this section accurately identifies who is in the permit space;

(4) Remains outside the permit space during entry operations until relieved by another attendant;

Note: When the employer's permit entry program allows attendant entry for rescue, attendants may enter a permit space to attempt a rescue if they have been trained and equipped for rescue operations as required by paragraph (k)(1) of this section and if they have been relieved as required by paragraph (i)(4) of this section.

(5) Communicates with authorized entrants as necessary to monitor entrant status and to alert entrants of the need to evacuate the space under paragraph (i)(6) of this section;

(6) Monitors activities inside and outside the space to determine if it is safe for entrants to remain in the space and orders the authorized entrants to evacuate the permit space immediately under any of the following conditions;

(i) If the attendant detects a prohibited condition;

(ii) If the attendant detects the behavioral effects of hazard exposure in an authorized entrant;

(iii) If the attendant detects a situation outside the space that could endanger the authorized entrants; or

(iv) If the attendant cannot effectively and safely perform all the duties required under paragraph (i) of this section;

(7) Summon rescue and other emergency services as soon as the attendant determines that authorized entrants may need assistance to escape from permit space hazards;

(8) Takes the following actions when unauthorized persons approach or enter a permit space while entry is underway:

(i) Warn the unauthorized persons that they must stay away from the permit space;

(ii) Advise the unauthorized persons that they must exit immediately if they have entered the permit space; and

(iii) Inform the authorized entrants and the entry supervisor if unauthorized persons have entered the permit space;

(9) Performs non-entry rescues as specified by the employer's rescue procedure; and

(10) Performs no duties that might interfere with the attendant's primary duty to monitor and protect the authorized entrants.

(j) Duties of entry supervisors.

The employer shall ensure that each entry supervisor:

(1) Knows the hazards that may be faced during entry, including information on the mode, signs or symptoms, and consequences of the exposure;

(2) Verifies, by checking that the appropriate entries have been made on the permit, that all tests specified by the permit have been conducted and that all procedures and equipment specified by the permit are in place before endorsing the permit and allowing entry to begin;

(3) Terminates the entry and cancels the permit as required by paragraph (e)(5) of this section;

(4) Verifies that rescue services are available and that the means for summoning them are operable;

(5) Removes unauthorized individuals who enter or who attempt to enter the permit space during entry operations; and

(6) Determines, whenever responsibility for a permit space entry operation is transferred and at intervals dictated by the hazards and operations performed within the space, that entry operations remain consistent with terms of the entry permit and that acceptable entry conditions are maintained.

(k) Rescue and emergency services.

(1) An employer who designates rescue and emergency services, pursuant to paragraph (d)(9) of this section, shall:

(i) Evaluate a prospective rescuer's ability to respond to a rescue summons in a timely manner, considering the hazard(s) identified;

Note to paragraph (k)(1)(i): What will be considered timely will vary according to the specific hazards involved in each entry. For example, Sec. 1910.134, Respiratory Protection, requires that employers provide a standby person or persons capable of immediate action to rescue employee(s) wearing respiratory protection while in work areas defined as IDLH atmospheres.

(ii) Evaluate a prospective rescue service's ability, in terms of proficiency with rescue-related tasks and equipment, to function appropriately while rescuing entrants from the particular permit space or types of permit spaces identified;

(iii) Select a rescue team or service from those evaluated that:

(A) Has the capability to reach the victim(s) within a time frame that is appropriate for the permit space hazard(s) identified;

(B) Is equipped for and proficient in performing the needed rescue services;

(iv) Inform each rescue team or service of the hazards they may confront when called on to perform rescue at the site; and

(v) Provide the rescue team or service selected with access to all permit spaces from which rescue may be necessary so that the rescue service can develop appropriate rescue plans and practice rescue operations.

Note to paragraph (k)(1): Non-mandatory appendix F contains examples of criteria which employers can use in evaluating prospective rescuers as required by paragraph (k)(1) of this section.

(2) An employer whose employees have been designated to provide permit space rescue and emergency services shall take the following measures:

(i) Provide affected employees with the personal protective equipment (PPE) needed to conduct permit space rescues safely and train affected employees so they are proficient in the use of that PPE, at no cost to those employees;

(ii) Train affected employees to perform assigned rescue duties. The employer must ensure that such employees successfully complete the training required to establish proficiency as an authorized entrant, as provided by paragraphs (g) and (h) of this section;

(iii) Train affected employees in basic first-aid and cardiopulmonary resuscitation (CPR). The employer shall ensure that at least one member of the rescue team or service holding a current certification in first aid and CPR is available; and

(iv) Ensure that affected employees practice making permit space rescues at least once every 12 months, by means of simulated rescue operations in which they remove dummies, manikins, or actual persons from the actual permit spaces or from representative permit spaces. Representative permit spaces shall, with respect to opening size, configuration, and accessibility, simulate the types of permit spaces from which rescue is to be performed.

(3) To facilitate non-entry rescue, retrieval systems or methods shall be used whenever an authorized entrant enters a permit space, unless the retrieval equipment would increase the overall risk of entry or would not contribute to the rescue of the entrant. Retrieval systems shall meet the following requirements.

(i) Each authorized entrant shall use a chest or full body harness, with a retrieval line attached at the center of the entrant's back near shoulder level, above the entrant's head, or at another point which the employer can establish presents a profile small enough for the successful removal of the entrant.

Wristlets may be used in lieu of the chest or full body harness if the employer can demonstrate that the use of a chest or full body harness is infeasible or creates a greater hazard and that the use of wristlets is the safest and most effective alternative.

(ii) The other end of the retrieval line shall be attached to a mechanical device or fixed point outside the permit space in such a manner that rescue can begin as soon as the rescuer becomes aware that rescue is necessary. A mechanical device shall be available to retrieve personnel from vertical type permit spaces more than 5 feet (1.52 m) deep.

(4) If an injured entrant is exposed to a substance for which a Material Safety Data Sheet (MSDS) or other similar written information is required to be kept at the work site, that MSDS or written information shall be made available to the medical facility treating the exposed entrant.

(l) Employee participation. (1) Employers shall consult with affected employees and their authorized representatives on the development and implementation of all aspects of the permit space program required by paragraph (c) of this section.

(2) Employers shall make available to affected employees and their authorized representatives all information required to be developed by this section.

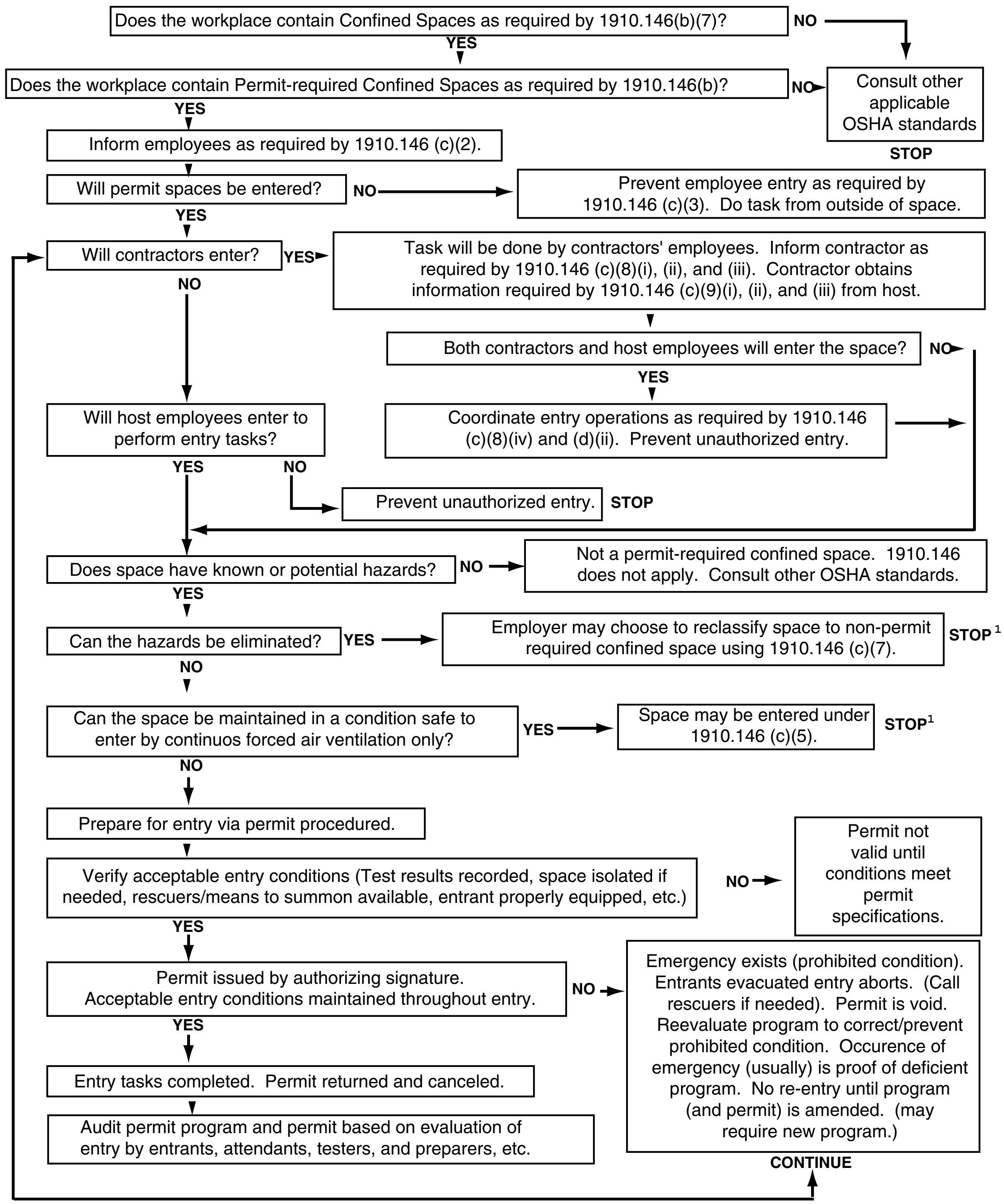
APPENDICES TO Sec. 1910.146--PERMIT-REQUIRED CONFINED SPACES

Note: Appendices A through F serve to provide information and non-mandatory guidelines to assist employers and employees in complying with the appropriate requirements of this section.

Appendix A to Sec. 1910.146--Permit-Required Confined Space Decision Flow Chart

See next page.

Appendix A to 1910.146 - Permit-Required Confined Space Decision Flow Chart



[1] Spaces may have to be evacuated and re-evaluated if hazards arise during entry.

Appendix B to Sec. 1910.146--Procedures for Atmospheric Testing

Atmospheric testing is required for two distinct purposes: evaluation of the hazards of the permit space and verification that acceptable entry conditions for entry into that space exist.

(1) Evaluation testing.
The atmosphere of a confined space should be analyzed using equipment of sufficient sensitivity and specificity to identify and evaluate any hazardous atmospheres that may exist or arise, so that appropriate permit entry procedures can be developed and acceptable entry conditions stipulated for that space. Evaluation and interpretation of these data, and development of the entry procedure, should be done by, or reviewed by, a technically qualified professional (e.g., OSHA consultation service, or certified industrial hygienist, registered safety engineer, certified safety professional, certified marine chemist, etc.) based on evaluation of all serious hazards.

(2) Verification testing.
The atmosphere of a permit space which may contain a hazardous atmosphere should be tested for residues of all contaminants identified by evaluation testing using permit specified equipment to determine that residual concentrations at the time of testing and entry are within the range of acceptable entry conditions. Results of testing (i.e., actual concentration, etc.) should be recorded on the permit in the space provided adjacent to the stipulated acceptable entry condition.

(3) Duration of testing.
Measurement of values for each atmospheric parameter should be made for at least the minimum response time of the test instrument specified by the manufacturer.

(4) Testing stratified atmospheres.
When monitoring for entries involving a descent into atmospheres that may be stratified, the atmospheric envelope should be tested a distance of approximately 4 feet
(1.22 m) in the direction of travel and to each side. If a sampling probe is used, the entrant's rate of progress should be slowed to accommodate the sampling speed and detector response.

(5) Order of testing.
A test for oxygen is performed first because most combustible gas meters are oxygen dependent and will not provide reliable readings in an oxygen deficient atmosphere. Combustible gasses are tested for next because the threat of fire or explosion is both more immediate and more life threatening, in most cases, than exposure to toxic gasses and vapors. If tests for toxic gasses and vapors are necessary, they are performed last.

Appendix C to Sec. 1910.146--Examples of Permit-Required Confined Space Programs

Example 1.

Workplace. Sewer entry.

Potential hazards. The employees could be exposed to the following:

Engulfment. Presence of toxic gases. Equal to or more than 10 ppm hydrogen sulfide measured as an 8-hour time-weighted average. If the presence of other toxic contaminants is suspected, specific monitoring programs will be developed.
Presence of explosive/flammable gases. Equal to or greater than 10% of the lower flammable limit (LFL).
Oxygen Deficiency. A concentration of oxygen in the atmosphere equal to or less than 19.5% by volume.

A. ENTRY WITHOUT PERMIT/ATTENDANT

Certification. Confined spaces may be entered without the need for a written permit or attendant provided that the space can be maintained in a safe condition for entry by mechanical ventilation alone, as provided in Sec. 1910.146(c)(5). All spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. Any employee required or permitted to pre-check or enter an enclosed/confined space shall have successfully completed, -as a minimum, the training as required by the following sections of these procedures. A written copy of operating and rescue procedures as required by these procedures shall be at the work site for the duration of the job. The Confined Space Pre-

Entry Check List must be completed by the LEAD WORKER before entry into a confined space. This list verifies completion of items listed below. This check list shall be kept at the job site for duration of the job. If circumstances dictate an interruption in the work, the permit space must be re-evaluated and a new check list must be completed.

Control of atmospheric and engulfment hazards.

Pumps and Lines. All pumps and lines which may reasonably cause contaminants to flow into the space shall be disconnected, blinded and locked out, or effectively isolated by other means to prevent development of dangerous air contamination or engulfment. Not all laterals to sewers or storm drains require blocking. However, where experience or knowledge of industrial use indicates there is a reasonable potential for contamination of air or engulfment into an occupied sewer, then all affected laterals shall be blocked. If blocking and/or isolation requires entry into the space the provisions for entry into a permit- required confined space must be implemented.

Surveillance. The surrounding area shall be surveyed to avoid hazards such as drifting vapors from the tanks, piping, or sewers.

Testing. The atmosphere within the space will be tested to determine whether dangerous air contamination and/or oxygen deficiency exists. Detector tubes, alarm only gas monitors and explosion meters are examples of monitoring equipment that may be used to test permit space atmospheres. Testing shall be performed by the LEAD WORKER who has successfully completed the Gas Detector training for the monitor he will use. The minimum parameters to be monitored are oxygen deficiency, LFL, and hydrogen sulfide concentration. A written record of the pre-entry test results shall be made and kept at the work site for the duration of the job. The supervisor will certify in writing, based upon the results of the pre-entry testing, that all hazards have been eliminated. Affected employees shall be able to review the testing results. The most hazardous conditions shall govern when work is being performed in two adjoining, connecting spaces.

Entry Procedures. If there are no non-atmospheric hazards present and if the pre-entry tests show there is no dangerous air contamination and/or oxygen deficiency within the space and there is no reason to believe that any is likely to develop, entry into and work within may proceed. Continuous testing of the atmosphere in the immediate vicinity of the workers within the space shall be accomplished. The workers will immediately leave the permit space when any of the gas monitor alarm set points are reached as defined. Workers will not return to the area until a SUPERVISOR who has completed the gas detector training has used a direct reading gas detector to evaluate the situation and has determined that it is safe to enter.

Rescue. Arrangements for rescue services are not required where there is no attendant. See the rescue portion of section B., below, for instructions regarding rescue planning where an entry permit is required.

B. ENTRY PERMIT REQUIRED

Permits. Confined Space Entry Permit. All spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. Any employee required or permitted to pre-check or enter a permit-required confined space shall have successfully completed, as a minimum, the training as required by the following sections of these procedures. A written copy of operating and rescue procedures as required by these procedures shall be at the work site for the duration of the job. The Confined Space Entry Permit must be completed before approval can be given to enter a permit-required confined space. This permit verifies completion of items listed below. This permit shall be kept at the job site for the duration of the job. If circumstances cause an interruption in the work or a change in the alarm conditions for which entry was approved, a new Confined Space Entry Permit must be completed.

Control of atmospheric and engulfment hazards.

Surveillance. The surrounding area shall be surveyed to avoid hazards such as drifting vapors from tanks, piping or sewers.

Testing. The confined space atmosphere shall be tested to determine whether dangerous air contamination and/or oxygen deficiency exists. A direct reading gas monitor shall be used.

Testing shall be performed by the SUPERVISOR who has successfully completed the gas detector training for the monitor he will use. The minimum parameters to be monitored are oxygen deficiency, LFL and hydrogen sulfide concentration. A written record of the pre- entry test results shall be made and kept at the work site for the duration of the job. Affected employees shall be able to review the testing results. The most hazardous conditions shall govern when work is being performed in two adjoining, connected spaces.

Space Ventilation. Mechanical ventilation systems, where applicable, shall be set at 100% outside air. Where possible, open additional manholes to increase air circulation. Use portable blowers to augment natural circulation if needed. After a suitable ventilating period, repeat the testing. Entry may not begin until testing has demonstrated that the hazardous atmosphere has been eliminated.

Entry Procedures. The following procedure shall be observed under any of the following conditions: 1.) Testing demonstrates the existence of dangerous or deficient conditions and additional ventilation cannot reduce concentrations to safe levels; 2.) The atmosphere tests as safe but unsafe conditions can reasonably be expected to develop; 3.) It is not feasible to provide for ready exit from spaces equipped with automatic fire suppression systems and it is not practical or safe to deactivate such systems; or 4.) An emergency exists and it is not feasible to wait for pre-entry procedures to take effect.

All personnel must be trained. A self contained breathing apparatus shall be worn by any person entering the space. At least one worker shall stand by the outside of the space ready to give assistance in case of emergency. The standby worker shall have a self contained breathing apparatus available for immediate use. There shall be at least one additional worker within sight or call of the standby worker. Continuous powered communications shall be maintained between the worker within the confined space and standby personnel.

If at any time there is any questionable action or non- movement by the worker inside, a verbal check will be made. If there is no response, the worker will be moved immediately. Exception: If the worker is disabled due to falling or impact, he/she shall not be removed from the confined space unless there is immediate danger to his/her life. Local fire department rescue personnel shall be notified immediately. The standby worker may only enter the confined space in case of an emergency (wearing the self contained breathing apparatus) and only after being relieved by another worker. Safety belt or harness with attached lifeline shall be used by all workers entering the space with the free end of the line secured outside the entry opening. The standby worker shall attempt to remove a disabled worker via his lifeline before entering the space.

When practical, these spaces shall be entered through side openings--those within 3 1/2 feet (1.07 m) of the bottom. When entry must be through a top opening, the safety belt shall be of the harness type that suspends a person upright and a hoisting device or similar apparatus shall be available for lifting workers out of the space.

In any situation where their use may endanger the worker, use of a hoisting device or safety belt and attached lifeline may be discontinued.

When dangerous air contamination is attributable to flammable and/or explosive substances, lighting and electrical equipment shall be Class 1, Division 1 rated per National Electrical Code and no ignition sources shall be introduced into the area.

Continuous gas monitoring shall be performed during all confined space operations. If alarm conditions change adversely, entry personnel shall exit the confined space and a new confined space permit issued.

Rescue. Call the fire department services for rescue. Where immediate hazards to injured personnel are present, workers at the site shall implement emergency procedures to fit the situation.

Example 2.

Workplace. Meat and poultry rendering plants.

Cookers and dryers are either batch or continuous in their operation. Multiple batch cookers are operated in parallel. When one unit of a multiple set is shut down for repairs, means are available to isolate that unit from the others which remain in operation.

Cookers and dryers are horizontal, cylindrical vessels equipped with a center, rotating shaft and agitator paddles or discs. If the inner shell is jacketed, it is usually heated with steam at

pressures up to 150 psig (1034.25 kPa). The rotating shaft assembly of the continuous cooker or dryer is also steam heated.
Potential Hazards. The recognized hazards associated with cookers and dryers are the risk that employees could be:

1. Struck or caught by rotating agitator;
2. Engulfed in raw material or hot, recycled fat;
3. Burned by steam from leaks into the cooker/dryer steam jacket or the condenser duct system if steam valves are not properly closed and locked out;
4. Burned by contact with hot metal surfaces, such as the agitator shaft assembly, or inner shell of the cooker/dryer;
5. Heat stress caused by warm atmosphere inside cooker/dryer;
6. Slipping and falling on grease in the cooker/dryer;
7. Electrically shocked by faulty equipment taken into the cooker/dryer;
8. Burned or overcome by fire or products of combustion; or
9. Overcome by fumes generated by welding or cutting done on grease covered surfaces.

Permits. The supervisor in this case is always present at the cooker/dryer or other permit entry confined space when entry is made. The supervisor must follow the pre-entry isolation procedures described in the entry permit in preparing for entry, and ensure that the protective clothing, ventilating equipment and any other equipment required by the permit are at the entry site.

Control of hazards. Mechanical. Lock out main power switch to agitator motor at main power panel. Affix tag to the lock to inform others that a permit entry confined space entry is in progress.

Engulfment. Close all valves in the raw material blow line. Secure each valve in its closed position using chain and lock. Attach a tag to the valve and chain warning that a permit entry confined space entry is in progress. The same procedure shall be used for securing the fat recycle valve.

Burns and heat stress. Close steam supply valves to jacket and secure with chains and tags. Insert solid blank at flange in cooker vent line to condenser manifold duct system. Vent cooker/dryer by opening access door at discharge end and top center door to allow natural ventilation throughout the entry. If faster cooling is needed, use an portable ventilation fan to increase ventilation. Cooling water may be circulated through the jacket to reduce both outer and inner surface temperatures of cooker/dryers faster. Check air and inner surface temperatures in cooker/dryer to assure they are within acceptable limits before entering, or use proper protective clothing.

Fire and fume hazards. Careful site preparation, such as cleaning the area within 4 inches (10.16 cm) of all welding or torch cutting operations, and proper ventilation are the preferred controls. All welding and cutting operations shall be done in accordance with the requirements of 29 CFR Part 1910, Subpart Q, OSHA's welding standard. Proper ventilation may be achieved by local exhaust ventilation, or the use of portable ventilation fans, or a combination of the two practices.

Electrical shock. Electrical equipment used in cooker/dryers shall be in serviceable condition.

Slips and falls. Remove residual grease before entering cooker/dryer.

Attendant. The supervisor shall be the attendant for employees entering cooker/dryers.

Permit. The permit shall specify how isolation shall be done and any other preparations needed before making entry. This is especially important in parallel arrangements of cooker/dryers so that the entire operation need not be shut down to allow safe entry into one unit.

Rescue. When necessary, the attendant shall call the fire department as previously arranged.

Example 3.

Workplace. Workplaces where tank cars, trucks, and trailers, dry bulk tanks and trailers, railroad tank cars, and similar portable tanks are fabricated or serviced.

A. During fabrication. These tanks and dry-bulk carriers are entered repeatedly throughout the fabrication process. These products are not configured identically, but the manufacturing processes by which they are made are very similar.

Sources of hazards. In addition to the mechanical hazards arising from the risks that an entrant would be injured due to contact with components of the tank or the tools being used, there is also the risk that a worker could be injured by breathing fumes from welding materials or mists or vapors from materials used to coat the tank interior. In addition, many of these vapors and mists are flammable, so the failure to properly ventilate a tank could lead to a fire or explosion.

Control of hazards.

Welding. Local exhaust ventilation shall be used to remove welding fumes once the tank or carrier is completed to the point that workers may enter and exit only through a manhole. (Follow the requirements of 29 CFR 1910, Subpart Q, OSHA's welding standard, at all times.) Welding gas tanks may never be brought into a tank or carrier that is a permit entry confined space.

Application of interior coatings and linings. Atmospheric hazards shall be controlled by forced air ventilation sufficient to keep the atmospheric concentration of flammable materials below 10% of the lower flammable limit (LFL) (or lower explosive limit (LEL), whichever term is used locally). The appropriate respirators are provided and shall be used in addition to providing forced ventilation if the forced ventilation does not maintain acceptable respiratory conditions.

Permits. Because of the repetitive nature of the entries in these operations, an ``Area Entry Permit'' will be issued for a 1 month period to cover those production areas where tanks are fabricated to the point that entry and exit are made using manholes.

Authorization. Only the area supervisor may authorize an employee to enter a tank within the permit area. The area supervisor must determine that conditions in the tank trailer, dry bulk trailer or truck, etc. meet permit requirements before authorizing entry.

Attendant. The area supervisor shall designate an employee to maintain communication by employer specified means with employees working in tanks to ensure their safety. The attendant may not enter any permit entry confined space to rescue an entrant or for any other reason, unless authorized by the rescue procedure and, and even then, only after calling the rescue team and being relieved by as attendant by another worker.

Communications and observation. Communications between attendant and entrant(s) shall be maintained throughout entry. Methods of communication that may be specified by the permit include voice, voice powered radio, tapping or rapping codes on tank walls, signalling tugs on a rope, and the attendant's observation that work activities such as chipping, grinding, welding, spraying, etc., which require deliberate operator control continue normally. These activities often generate so much noise that the necessary hearing protection makes communication by voice difficult.

Rescue procedures. Acceptable rescue procedures include entry by a team of employee-rescuers, use of public emergency services, and procedures for breaching the tank. The area permit specifies which procedures are available, but the area supervisor makes the final decision based on circumstances. (Certain injuries may make it necessary to breach the tank to remove a person rather than risk additional injury by removal through an existing manhole. However, the supervisor must ensure that no breaching procedure used for rescue would violate terms of the entry permit. For instance, if the tank must be breached by cutting with a torch, the tank surfaces to be cut must be free of volatile or combustible coatings within 4 inches (10.16 cm) of the cutting line and the atmosphere within the tank must be below the LFL.

Retrieval line and harnesses. The retrieval lines and harnesses generally required under this standard are usually impractical for use in tanks because the internal configuration of the tanks and their interior baffles and other structures would prevent rescuers from hauling out injured entrants. However, unless the rescue procedure calls for breaching the tank for rescue, the rescue team shall be trained in the use of retrieval lines and harnesses for removing injured employees through manholes.

B. Repair or service of ``used'' tanks and bulk trailers.

Sources of hazards. In addition to facing the potential hazards encountered in fabrication or manufacturing, tanks or trailers which have been in service may contain residues of dangerous materials, whether left over from the transportation of hazardous cargoes or generated by chemical or bacterial action on residues of non-hazardous cargoes.

Control of atmospheric hazards. A ``used'' tank shall be brought into areas where tank entry is authorized only after the tank has been emptied, cleansed (without employee entry) of any residues, and purged of any potential atmospheric hazards.

Welding. In addition to tank cleaning for control of atmospheric hazards, coating and surface materials shall be removed 4 inches (10.16 cm) or more from any surface area where welding or other torch work will be done and care taken that the atmosphere within the tank remains well below the LFL. (Follow the requirements of 29 CFR 1910, Subpart Q, OSHA's welding standard, at all times.)

Permits. An entry permit valid for up to 1 year shall be issued prior to authorization of entry into used tank trailers, dry bulk trailers or trucks. In addition to the pre-entry cleaning requirement, this permit shall require the employee safeguards specified for new tank fabrication or construction permit areas.

Authorization. Only the area supervisor may authorize an employee to enter a tank trailer, dry bulk trailer or truck within the permit area. The area supervisor must determine that the entry permit requirements have been met before authorizing entry.

APPENDIX D TO SEC. 1910.146--Sample Permits

Appendix D to §1910.146
Confined Space Pre-Entry Check List
Appendix D - 1

Confined Space Entry Permit

Date and Time Issued: ____________________________ Date and Time Expires:____________________________
Job site/Space I.D:____________________________ Job Supervisor: ____________________________
Equipment to be worked on:________________________ Work to be performed: ____________________________
Stand-by personnel: _____________________ _____________________ _____________________

1. Atmospheric Checks: Time _____________________
Oxygen _____________________ %
Explosive _____________________ % L.F.L.
Toxic _____________________ PPM

2. Tester's signature:

3. Source isolation (No Entry):	N/A	Yes	No
Pumps or lines blinded,	( )	( )	( )
disconnected, or blocked	( )	( )	( )

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

5. Atmospheric check after isolation and Ventilation:

Oxygen	_______________	%	>	19.5	%
Explosive	_______________	% L.F.L	<	10	%
Toxic	_______________	PPM	<	10	PPM H(2)S
Time:	_______________				

Testers signature: ____

6. Communication procedures: ____
____

7. Rescue procedures: ____
____
____

8. Entry, standby, and back up persons:	Yes	No
Successfully completed required training?		
Is it current?	( )	( )

9. Equipment:	N/A	Yes	No
Direct reading gas monitor - tested	( )	( )	( )
Safety harnesses and lifelines for entry and standby persons	( )	( )	( )
Hoisting equipment	( )	( )	( )
Powered communications	( )	( )	( )
SCBA's for entry and standby persons	( )	( )	( )
Protective Clothing	( )	( )	( )
All electric equipment listed Class I, Division I, Group D and Non-sparking tools	( )	( )	( )

10. Periodic atmospheric tests:

Oxygen	________	%	Time	________	Oxygen	________	%	Time	________
Oxygen	________	%	Time	________	Oxygen	________	%	Time	________
Explosive	________	%	Time	________	Explosive	________	%	Time	________
Explosive	________	%	Time	________	Explosive	________	%	Time	________
Toxic	________	%	Time	________	Toxic	________	%	Time	________

We have reviewed the work authorized by this permit and the information contained here-in. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit Prepared By: (Supervisor) ____________________
Approved By: (Unit Supervisor) ____________________
Reviewed By (Cs Operations Personnel) :
____________________ ____________________
(printed name) (signature)

This permit to be kept at job site. Return job site copy to Safety Office following job completion.

Copies: White Original (Safety Office)
Yellow (Unit Supervisor)
Hard(Job site)

Appendix D - 2

ENTRY PERMIT

PERMIT VALID FOR 8 HOURS ONLY. ALL COPIES OF PERMIT WILL REMAIN AT JOB SITE UNTIL JOB IS COMPLETED

DATE: ________SITE LOCATION and DESCRIPTION ____________________
PURPOSE OF ENTRY ____________________

SUPERVISOR(S) in charge of crews Type of Crew Phone#
____
____
COMMUNICATION PROCEDURES ____________________
RESCUE PROCEDURES (PHONE NUMBERS AT BOTTOM)
____
____

* BOLD DENOTES MINIMUM REQUIREMENTS TO BE COMPLETED AND REVIEWED PRIOR TO ENTRY*

REQUIREMENTS COMPLETED	DATE	TIME
Lock Out/De-energize/Try-out	________	________
Line(s) Broken-Capped-Blanked	________	________
Purge-Flush and Vent	________	________
Ventilation	________	________
Secure Area (Post and Flag)	________	________
Breathing Apparatus	________	________
Resuscitator - Inhalator	________	________
Standby Safety Personnel	________	________
Full Body Harness w/"D" ring	________	________
Emergency Escape Retrieval Equip	________	________
Lifelines	________	________
Fire Extinguishers	________	________
Lighting (Explosive Proof)	________	________
Protective Clothing	________	________
Respirator(s) (Air Purifying)	________	________
Burning and Welding Permit	________	________

Note: Items that do not apply enter N/A in the blank.

**RECORD CONTINUOUS MONITORING RESULTS EVERY 2 HOURS

CONTINUOUS MONITORING**	Permissible		________	________	________	________	________
TEST(S) TO BE TAKEN	Entry Level		________	________	________	________	________
PERCENT OF OXYGEN	19.5% to 23.5%		________	________	________	________	________
LOWER FLAMMABLE LIMIT	Under 10%		________	________	________	________	________
CARBON MONOXIDE	+35 PPM		________	________	________	________	________
Aromatic Hydrocarbon	+ 1 PPM	* 5 PPM	________	________	________	________	________
Hydrogen Cyanide	(Skin)	* 4 PPM	________	________	________	________	________
Hydrogen Sulfide	+10 PPM	*15 PPM	________	________	________	________	________
Sulfur Dioxide	+ 2 PPM	* 5 PPM	________	________	________	________	________
Ammonia	*35 PPM		________	________	________	________	________

* Short-term exposure limit: Employee can work in the area up to 15 minutes.
+ 8 hr. Time Weighted Avg.: Employee can work in area 8 hrs (longer with appropriate respiratory protection).
REMARKS: ____

GAS TESTER NAME & CHECK #	INSTRUMENT(S) USED	MODEL &/ OR TYPE	SERIAL &/OR UNIT #
____________	____________	____________	____________
____________	____________	____________	____________

SAFETY STANDBY PERSON IS REQUIRED FOR ALL CONFINED SPACE WORK

SAFETY STANDBY PERSON(S)	CHECK #	CONFINED SPACE ENTRANT(S)	CHECK #	CONFINED SPACE ENTRANT(S)	CHECK #
____________	______	________	______	________	______
____________	______	________	______	________	______

SUPERVISOR AUTHORIZING - ALL CONDITIONS SATISFIED ____________________
DEPARTMENT/PHONE ____________________

AMBULANCE 2800 FIRE 2900 SAFETY 4901 GAS COORDINATOR 4529/5387

58 FR 4549, Jan. 14, 1993; 58 FR 34846, June 29, 1993

APPENDIX E TO SEC. 1910.146—Sewer System Entry

Sewer entry differs in three vital respects from other permit entries; first, there rarely exists any way to completely isolate the space (a section of a continuous system) to be entered; second, because isolation is not complete, the atmosphere may suddenly and unpredictably become lethally hazardous (toxic, flammable or explosive) from causes beyond the control of the entrant or employer, and third, experienced sewer workers are especially knowledgeable in entry and work in their permit spaces because of their frequent entries. Unlike other employments where permit space entry is a rare and exceptional event, sewer workers' usual work environment is a permit space.

(1) Adherence to procedure.

The employer should designate as entrants only employees who are thoroughly trained in the employer's sewer entry procedures and who demonstrate that they follow these entry procedures exactly as prescribed when performing sewer entries.

(2) Atmospheric monitoring.

Entrants should be trained in the use of, and be equipped with, atmospheric monitoring equipment which sounds an audible alarm, in addition to its visual readout, whenever one of the following conditions are encountered: Oxygen concentration less than 19.5 percent; flammable gas or vapor at 10 percent or more of the lower flammable limit (LFL); or hydrogen sulfide or carbon monoxide at or above 10 ppm or 35 ppm, respectively, measured as an 8-hour time-weighted average. Atmospheric monitoring equipment needs to be calibrated according to the manufacturer's instructions. The oxygen sensor/broad range sensor is best suited for initial use in situations where the actual or potential contaminants have not been identified, because broad range sensors, unlike substance-specific sensors, enable employers to obtain an overall reading of the hydrocarbons (flammables) present in the space. However, such sensors only indicate that a hazardous threshold of a class of chemicals has been exceeded. They do not measure the levels of contamination of specific substances. Therefore, substance-specific devices, which measure the actual levels of specific substances, are best suited for use where actual and potential contaminants have been identified. The measurements obtained with substance-specific devices are of vital importance to the employer when decisions are made concerning the measures necessary to protect entrants (such as ventilation or personal protective equipment) and the setting and attainment of appropriate entry conditions. However, the sewer environment may suddenly and unpredictably change, and the substance-specific devices may not detect the potentially lethal atmospheric hazards which may enter the sewer environment.

Although OSHA considers the information and guidance provided above to be appropriate and useful in most sewer entry situations, the Agency emphasizes that each employer must consider the unique circumstances, including the predictability of the atmosphere, of the sewer permit spaces in the employer's workplace in preparing for entry. Only the employer can decide, based upon his or her knowledge of, and experience with permit spaces in sewer systems, what the best type of testing instrument may be for any specific entry operation.

The selected testing instrument should be carried and used by the entrant in sewer line work to monitor the atmosphere in the entrant's environment, and in advance of the entrant's direction of movement, to warn the entrant of any deterioration in atmospheric conditions. Where several entrants are working together in the same immediate location, one instrument, used by the lead entrant, is acceptable.

(3) Surge flow and flooding.

Sewer crews should develop and maintain liaison, to the extent possible, with the local weather bureau and fire and emergency services in their area so that sewer work may be delayed or interrupted and entrants withdrawn whenever sewer lines might be suddenly flooded by rain or fire suppression activities, or whenever flammable or other hazardous materials are released into sewers during emergencies by industrial or transportation accidents.

(4) Special Equipment.

Entry into large bore sewers may require the use of special equipment. Such equipment might include such items as atmosphere monitoring devices with automatic audible alarms, escape self-contained breathing apparatus (ESCBA) with at least 10 minute air supply (or other NIOSH approved self-rescuer), and waterproof flashlights, and may also include boats and rafts, radios and rope stand-offs for pulling around bends and corners as needed.

APPENDIX F TO SEC. 1910.146--Rescue Team or Rescue Service Evaluation Criteria (Non-Mandatory)

(1) This appendix provides guidance to employers in choosing an appropriate rescue service. It contains criteria that may be used to evaluate the capabilities both of prospective and current rescue teams. Before a rescue team can be trained or chosen, however, a satisfactory permit program, including an analysis of all permit-required confined spaces to identify all potential hazards in those spaces, must be completed. OSHA believes that compliance with all the provisions of Sec. 1910.146 will enable employers to conduct permit space operations without recourse to rescue services in nearly all cases. However, experience indicates that circumstances will arise where entrants will need to be rescued from permit spaces. It is therefore important for employers to select rescue services or teams, either on-site or off-site, that are equipped and capable of minimizing harm to both entrants and rescuers if the need arises.

(2) For all rescue teams or services, the employer's evaluation should consist of two components: an initial evaluation, in which employers decide whether a potential rescue service or team is adequately trained and equipped to perform permit space rescues of the kind needed at the facility and whether such rescuers can respond in a timely manner, and a performance evaluation, in which employers measure the performance of the team or service during an actual or practice rescue. For example, based on the initial evaluation, an employer may determine that maintaining an on-site rescue team will be more expensive than obtaining the services of an off-site team, without being significantly more effective, and decide to hire a rescue service. During a performance evaluation, the employer could decide, after observing the rescue service perform a practice rescue, that the service's training or preparedness was not adequate to effect a timely or effective rescue at his or her facility and decide to select another rescue service, or to form an internal rescue team.

A. Initial Evaluation

I. The employer should meet with the prospective rescue service to facilitate the evaluations required by Sec. 1910.146(k)(1)(i) and Sec. 1910.146(k)(1)(ii). At a minimum, if an off-site rescue service is being considered, the employer must contact the service to plan and coordinate the evaluations required by the standard. Merely posting the service's number or planning to rely on the 911 emergency phone number to obtain these services at the time of a permit space emergency would not comply with paragraph (k)(1) of the standard.

II. The capabilities required of a rescue service vary with the type of permit spaces from which rescue may be necessary and the hazards likely to be encountered in those spaces. Answering the questions below will assist employers in determining whether the rescue service is capable of performing rescues in the permit spaces present at the employer's workplace.

1. What are the needs of the employer with regard to response time (time for the rescue service to receive notification, arrive at the scene, and set up and be ready for entry)? For example, if entry is to be made into an IDLH atmosphere, or into a space that can quickly develop an IDLH atmosphere (if ventilation fails or for other reasons), the rescue team or service would need to be standing by at the permit space. On the other hand, if the danger to entrants is restricted to mechanical hazards that would cause injuries (e.g., broken bones, abrasions) a response time of 10 or 15 minutes might be adequate.

2. How quickly can the rescue team or service get from its location to the permit spaces from which rescue may be necessary? Relevant factors to consider would include: the location of the rescue team or service relative to the employer's workplace, the quality of roads and highways to be traveled, potential bottlenecks or traffic congestion that might be encountered in transit, the reliability of the rescuer's vehicles, and the training and skill of its drivers.

3. What is the availability of the rescue service? Is it unavailable at certain times of the day or in certain situations? What is the likelihood that key personnel of the rescue service might be unavailable at times? If the rescue service becomes unavailable while an entry is underway, does it have the capability of

notifying the employer so that the employer can instruct the attendant to abort the entry immediately?

4. Does the rescue service meet all the requirements of paragraph (k)(2) of the standard? If not, has it developed a plan that will enable it meet those requirements in the future? If so, how soon can the plan be implemented?

5. For off-site services, is the service willing to perform rescues at the employer's workplace? (An employer may not rely on a rescuer who declines, for whatever reason, to provide rescue services.)

6. Is an adequate method for communications between the attendant, employer and prospective rescuer available so that a rescue request can be transmitted to the rescuer without delay? How soon after notification can a prospective rescuer dispatch a rescue team to the entry site?

7. For rescues into spaces that may pose significant atmospheric hazards and from which rescue entry, patient packaging and retrieval cannot be safely accomplished in a relatively short time (15-20 minutes), employers should consider using airline respirators (with escape bottles) for the rescuers and to supply rescue air to the patient. If the employer decides to use SCBA, does the prospective rescue service have an ample supply of replacement cylinders and procedures for rescuers to enter and exit (or be retrieved) well within the SCBA's air supply limits?

8. If the space has a vertical entry over 5 feet in depth, can the prospective rescue service properly perform entry rescues? Does the service have the technical knowledge and equipment to perform rope work or elevated rescue, if needed?

9. Does the rescue service have the necessary skills in medical evaluation, patient packaging and emergency response?

10. Does the rescue service have the necessary equipment to perform rescues, or must the equipment be provided by the employer or another source?

B. Performance Evaluation

Rescue services are required by paragraph (k)(2)(iv) of the standard to practice rescues at least once every 12 months, provided that the team or service has not successfully performed a permit space rescue within that time. As part of each practice session, the service should perform a critique of the practice rescue, or have another qualified party perform the critique, so that deficiencies in procedures, equipment, training, or number of personnel can be identified and corrected. The results of the critique, and the corrections made to respond to the deficiencies identified, should be given to the employer to enable it to determine whether the rescue service can quickly be upgraded to meet the employer's rescue needs or whether another service must be selected. The following questions will assist employers and rescue teams and services evaluate their performance.

1. Have all members of the service been trained as permit space entrants, at a minimum, including training in the potential hazards of all permit spaces, or of representative permit spaces, from which rescue may be needed? Can team members recognize the signs, symptoms, and consequences of exposure to any hazardous atmospheres that may be present in those permit spaces?

2. Is every team member provided with, and properly trained in, the use and need for PPE, such as SCBA or fall arrest equipment, which may be required to perform permit space rescues in the facility? Is every team member properly trained to perform his or her functions and make rescues, and to use any rescue equipment, such as ropes and backboards, that may be needed in a rescue attempt?

3. Are team members trained in the first aid and medical skills needed to treat victims overcome or injured by the types of hazards that may be encountered in the permit spaces at the facility?

4. Do all team members perform their functions safely and efficiently? Do rescue service personnel focus on their own safety before considering the safety of the victim?

5. If necessary, can the rescue service properly test the atmosphere to determine if it is IDLH?

6. Can the rescue personnel identify information pertinent to the rescue from entry permits, hot work permits, and MSDSs?

7. Has the rescue service been informed of any hazards to personnel that may arise from outside the space, such as those that may be caused by future work near the space?

8. If necessary, can the rescue service properly package and retrieve victims from a permit space that has a limited size opening (less

than 24 inches (60.9 cm) in diameter), limited internal space, or internal obstacles or hazards?

9. If necessary, can the rescue service safely perform an elevated (high angle) rescue?

10. Does the rescue service have a plan for each of the kinds of permit space rescue operations at the facility? Is the plan adequate for all types of rescue operations that may be needed at the facility? Teams may practice in representative spaces, or in spaces that are ``worst-case'' or most restrictive with respect to internal configuration, elevation, and portal size.

The following characteristics of a practice space should be considered when deciding whether a space is truly representative of an actual permit space:

1) Internal configuration.

(a) Open--there are no obstacles, barriers, or obstructions within the space. One example is a water tank.

(b) Obstructed--the permit space contains some type of obstruction that a rescuer would need to maneuver around. An example would be a baffle or mixing blade. Large equipment, such as a ladder or scaffold, brought into a space for work purposes would be considered an obstruction if the positioning or size of the equipment would make rescue more difficult.

(2) Elevation.

(a) Elevated--a permit space where the entrance portal or opening is above grade by 4 feet or more. This type of space usually requires knowledge of high angle rescue procedures because of the difficulty in packaging and transporting a patient to the ground from the portal.

(b) Non-elevated--a permit space with the entrance portal located less than 4 feet above grade. This type of space will allow the rescue team to transport an injured employee normally.

(3) Portal size.

(a) Restricted--A portal of 24 inches or less in the least dimension. Portals of this size are too small to allow a rescuer to simply enter the space while using SCBA. The portal size is also too small to allow normal spinal immobilization of an injured employee.

(b) Unrestricted--A portal of greater than 24 inches in the least dimension. These portals allow relatively free movement into and out of the permit space.

(4) Space access.

(a) Horizontal--The portal is located on the side of the permit space. Use of retrieval lines could be difficult.

(b) Vertical--The portal is located on the top of the permit space, so that rescuers must climb down, or the bottom of the permit space, so that rescuers must climb up to enter the space. Vertical portals may require knowledge of rope techniques, or special patient packaging to safely retrieve a downed entrant.

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SUBPART J GENERAL ENVIRONMENTAL CONTROLS

1910.147 The control of hazardous energy (lockout/tagout).

(a) Scope, application and purpose

(1) Scope

(i) This standard covers the servicing and maintenance of machines and equipment in which the unexpected energization or start up of the machines or equipment, or release of stored energy could cause injury to employees. This standard establishes minimum performance requirements for the control of such hazardous energy.

(ii) This standard does not cover the following:

(A) Construction, agriculture and maritime employment;

(B) Installations under the exclusive control of electric utilities for the purpose of power generation, transmission and distribution, including related equipment for communication or metering; and

(C) Exposure to electrical hazards from work on, near, or with conductors or equipment in electric utilization installations, which is covered by Subpart S of this part; and

(D) Oil and gas well drilling and servicing.

(2) Application.

(i) This standard applies to the control of energy during servicing and/or maintenance of machines and equipment.

(ii) Normal production operations are not covered by this standard (See Subpart O of this Part). Servicing and/or maintenance which takes place during normal production operations is covered by this standard only if:

(A) An employee is required to remove or bypass a guard or other safety device; or

(B) An employee is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being processed (point of operation) or where an associated danger zone exists during a machine operating cycle.

Note: Exception to paragraph (a)(2)(ii): Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by this standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection (See Subpart O of this Part).

(iii) This standard does not apply to the following:

(A) Work on cord and plug connected electric equipment for which exposure to the hazards of unexpected energization or start up of the equipment is controlled by the unplugging of the equipment from the energy source and by the plug being under the exclusive control of the employee performing the servicing or maintenance.

(B) Hot tap operations involving transmission and distribution systems for substances such as gas, steam, water or petroleum products when they are performed on pressurized pipelines, provided that the employer demonstrates that-

(1) continuity of service is essential;

(2) shutdown of the system is impractical; and

(3) documented procedures are followed, and special equipment is used which will provide proven effective protection for employees.

(3) Purpose.

(i) This section requires employers to establish a program and utilize procedures for affixing appropriate lockout devices or tagout devices to energy isolating devices, and to otherwise disable machines or equipment to prevent unexpected energization, start up or release of stored energy in order to prevent injury to employees.

(ii) When other standards in this part require the use of lockout or tagout, they shall be used and supplemented by the procedural and training requirements of this section.

(b) Definitions applicable to this section.

Affected employee. An employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under lockout or tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed.

Authorized employee. A person who locks out or tags out machines or equipment in order to perform servicing or maintenance on that machine or equipment. An affected employee becomes an authorized employee when that employee's duties include performing servicing or maintenance covered under this section.

Capable of being locked out. An energy isolating device is capable of being locked out if it has a hasp or other means of attachment to which, or through which, a lock can be affixed, or it has a locking mechanism built into it. Other energy isolating devices are capable of being locked out, if lockout can be achieved without the need to dismantle, rebuild, or replace the energy isolating device or permanently alter its energy control capability.

Energized. Connected to an energy source or containing residual or stored energy.

Energy isolating device. A mechanical device that physically prevents the transmission or release of energy, including but not limited to the following: A manually operated electrical circuit breaker; a disconnect switch; a manually operated switch by which the conductors of a circuit can be disconnected from all ungrounded supply conductors, and, in addition, no pole can be operated independently; a line valve; a block; and any similar device used to block or isolate energy. Push buttons, selector switches and other control circuit type devices are not energy isolating devices.

Energy source. Any source of electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other energy.

Hot tap. A procedure used in the repair, maintenance and services activities which involves welding on a piece of equipment (pipelines, vessels or tanks) under pressure, in order to install connections or appurtenances. it is commonly used to replace or add sections of pipeline without the interruption of service for air, gas, water, steam, and petrochemical distribution systems.

Lockout. The placement of a lockout device on an energy isolating device, in accordance with an established procedure, ensuring that the energy isolating device and the equipment being controlled cannot be operated until the lockout device is removed.

Lockout device. A device that utilizes a positive means such as a lock, either key or combination type, to hold an energy isolating device in the safe position and prevent the energizing of a machine or equipment. Included are blank flanges and bolted slip blinds.

Normal production operations. The utilization of a machine or equipment to perform its intended production function.

Servicing and/or maintenance. Workplace activities such as constructing, installing, setting up, adjusting, inspecting, modifying, and maintaining and/or servicing machines or equipment. These activities include lubrication, cleaning or unjamming of machines or equipment and making adjustments or tool changes, where the employee may be exposed to the unexpected energization or startup of the equipment or release of hazardous energy.

Setting up. Any work performed to prepare a machine or equipment to perform its normal production operation.

Tagout. The placement of a tagout device on an energy isolating device, in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

Tagout device. A prominent warning device, such as a tag and a means of attachment, which can be securely fastened to an energy isolating device in accordance with an established procedure, to indicate that the energy isolating device and the equipment being controlled may not be operated until the tagout device is removed.

(c) General

(1) Energy control program.

The employer shall establish a program consisting of energy control procedures, employee training and periodic inspections to ensure that before any employee performs any servicing or maintenance on a machine or equipment where the unexpected energizing, startup or release of stored energy could occur and cause injury, the machine or equipment shall be isolated from the energy source and rendered inoperative.

(2) Lockout/tagout.

(i) If an energy isolating device is not capable of being locked out, the employer's energy control program under paragraph (c)(1) of this section shall utilize a tagout system.

(ii) If an energy isolating device is capable of being locked out, the employer's energy control program under paragraph (c)(1) of this section shall utilize lockout, unless the employer can demonstrate that the utilization of a tagout system will provide full employee protection as set forth in paragraph (c)(3) of this section.

(iii) After January 2, 1990, whenever replacement or major repair, renovation or modification of a machine or equipment is performed, and whenever new machines or equipment are installed, energy isolating devices for such machine or equipment shall be designed to accept a lockout device.

(3) Full employee protection.

(i) When a tagout device is used on an energy isolating device which is capable of being locked out, the tagout device shall be attached at the same location that the lockout device would have been attached, and the employer shall demonstrate that the tagout program will provide a level of safety equivalent to that obtained by using a lockout program.

(ii) In demonstrating that a level of safety is achieved in the tagout program which is equivalent to the level of safety obtained by using a lockout program, the employer shall demonstrate full compliance with all tagout-related provisions of this standard together with such additional elements as are necessary to provide the equivalent safety available from the use of a lockout device. Additional means to be considered as part of the demonstration of full employee protection shall include the implementation of additional safety measures such as the removal of an isolating circuit element, blocking of a controlling switch, opening of an extra disconnecting device, or the removal of a valve handle to reduce the likelihood of inadvertent energization.

(4) Energy control procedure.

(i) Procedures shall be developed, documented and utilized for the control of potentially hazardous energy when employees are engaged in the activities covered by this section.

Note: Exception: The employer need not document the required procedure for a particular machine or equipment, when all of the following elements exist: (1) The machine or equipment has no potential for stored or residual energy or reaccumulation of stored energy after shut down which could endanger employees; (2) the machine or equipment has a single energy source which can be readily identified and isolated; (3) the isolation and locking out of that energy source will completely deenergize and deactivate the machine or equipment; (4) the machine or equipment is isolated from that energy source and locked out during servicing or maintenance; (5) a single lockout device will achieve a locker-out condition; (6) the lockout device is under the exclusive control of the authorized employee performing the servicing or maintenance; (7) the servicing or maintenance does not create hazards for other employees; and (8) the employer, in utilizing this exception, has had no accidents involving the unexpected activation or reenergization of the machine or equipment during servicing or maintenance.

(ii) The procedures shall clearly and specifically outline the scope, purpose, authorization, rules, and techniques to be utilized for the control of hazardous energy, and the means to enforce compliance including, but not limited to, the following:

(A) A specific statement of the intended use of the procedure;

(B) Specific procedural steps for shutting down, isolating, blocking and securing machines or equipment to control hazardous energy;

(C) Specific procedural steps for the placement, removal and transfer of lockout devices or tagout devices and the responsibility for them; and

(D) Specific requirements for testing a machine or equipment to determine and verify the effectiveness of lockout devices, tagout devices, and other energy control measures.

(5) Protective materials and hardware.

(i) Locks, tags, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware shall be provided by the employer for isolating, securing or blocking of machines or equipment from energy sources.

(ii) Lockout devices and tagout devices shall be singularly identified; shall be the only devices(s) used for controlling energy; shall not be used for other purposes; and shall meet the following requirements:

(A) Durable.

(1) Lockout and tagout devices shall be capable of withstanding the environment to which they are exposed for the maximum period of time that exposure is expected.

(2) Tagout devices shall be constructed and printed so that exposure to weather conditions or wet and damp locations will not cause the tag to deteriorate or the message on the tag to become illegible.

(3) Tags shall not deteriorate when used in corrosive environments such as areas where acid and alkali chemicals are handled and stored.

(B) Standardized. Lockout and tagout devices shall be standardized within the facility in at least one of the following criteria: Color; shape; or size; and additionally, in the case of tagout devices, print and format shall be standardized.

(C) Substantial -

(1) Lockout devices. Lockout devices shall be substantial enough to prevent removal without the use of excessive force or unusual techniques, such as with the use of bolt cutters or other metal cutting tools.

(2) Tagout devices. Tagout devices, including their means of attachment, shall be substantial enough to prevent inadvertent or accidental removal. Tagout device attachment means shall be of a non-reusable type, attachable by hand, self-locking, and non-releasable with a minimum unlocking strength of no less than 50 pounds and having the general design and basic characteristics of being at least equivalent to a one-piece, all environment-tolerant nylon cable tie.

(D) Identifiable. Lockout devices and tagout devices shall indicate the identity of the employee applying the device(s).

(iii) Tagout devices shall warn against hazardous conditions if the machine or equipment is energized and shall include a legend such as the following: Do Not Start. Do Not Open. Do Not Close. Do Not Energize. Do Not Operate.

(6) Periodic inspection.

(i) The employer shall conduct a periodic inspection of the energy control procedure at least annually to ensure that the procedure and the requirements of this standard are being followed.

(A) The periodic inspection shall be performed by an authorized employee other than the ones(s) utilizing the energy control procedure being inspected.

(B) The periodic inspection shall be conducted to correct any deviations or inadequacies identified.

(C) Where lockout is used for energy control, the periodic inspection shall include a review, between the inspector and each authorized employee, of that employee's responsibilities under the energy control procedure being inspected.

(D) Where tagout is used for energy control, the periodic inspection shall include a review, between the inspector and each authorized and affected employee, of that employee's responsibilities under the energy control procedure being inspected, and the elements set forth in paragraph (c)(7)(ii) of this section.

(ii) The employer shall certify that the periodic inspections have been performed. The certification shall identify the machine or equipment on which the energy control procedure was being utilized, the date of the inspection, the employees included in the inspection, and the person performing the inspection.

(7) Training and communication.

(i) The employer shall provide training to ensure that the purpose and function of the energy control program are understood by employees and that the knowledge and skills required for the safe application, usage, and removal of the energy controls are acquired by employees. The training shall include the following:

(A) Each authorized employee shall receive training in the recognition of applicable hazardous energy sources, the type and magnitude of the energy available in the workplace, and the methods and means necessary for energy isolation and control.

(B) Each affected employee shall be instructed in the purpose and use of the energy control procedure.

(C) All other employees whose work operations are or may be in an area where energy control procedures may be utilized, shall be instructed about the procedure, and about the prohibition relating to attempts to restart or reenergize machines or equipment which are locked out or tagged out.

(ii) When tagout systems are used, employees shall also be trained in the following limitations of tags:

(A) Tags are essentially warning devices affixed to energy isolating devices, and do not provide the physical restraint on those devices that is provided by a lock.

(B) When a tag is attached to an energy isolating means, it is not to be removed without authorization of the authorized person responsible for it, and it is never to be bypassed, ignored, or otherwise defeated.

(C) Tags must be legible and understandable by all authorized employees, affected employees, and all other employees whose work operations are or may be in the area, in order to be effective.

(D) Tags and their means of attachment must be made of materials which will withstand the environmental conditions encountered in the workplace.

(E) Tags may evoke a false sense of security, and their meaning needs to be understood as part of the overall energy control program.

(F) Tags must be securely attached to energy isolating devices so that they cannot be inadvertently or accidentally detached during use.

(iii) Employee retraining.

(A) Retraining shall be provided for all authorized and affected employees whenever there is a change in their job assignments, a change in machines, equipment or processes that present a new hazard, or when there is a change in the energy control procedures.

(B) Additional retraining shall also be conducted whenever a periodic inspection under paragraph (c)(6) of this section reveals, or whenever the employer has reason to believe that there are deviations from or inadequacies in the employee's knowledge or use of the energy control procedures.

(C) The retraining shall reestablish employee proficiency and introduce new or revised control methods and procedures, as necessary.

(iv) The employer shall certify that employee training has been accomplished and is being kept up to date. The certification shall contain each employee's name and dates of training.

(8) Energy isolation.

Lockout or tagout shall be performed only by the authorized employees who are performing the servicing or maintenance.

(9) Notification of employees.

Affected employees shall be notified by the employer or authorized employee of the application and removal of lockout devices or tagout devices. Notification shall be given before the controls are applied, and after they are removed from the machine or equipment.

(d) Application of control.

The established procedures for the application of energy control (the lockout or tagout procedures) shall cover the following elements and actions and shall be done in the following sequence:

(1) Preparation for shutdown.

Before an authorized or affected employee turns off a machine or equipment, the authorized employee shall have knowledge of the type and magnitude of the energy, the hazards of the energy to be controlled, and the method or means to control the energy.

(2) Machine or equipment shutdown.

The machine or equipment shall be turned off or shut down using the procedures established for the machine or equipment. An orderly shutdown must be utilized to avoid any additional or increased hazard(s) to employees as a result of the equipment stoppage.

(3) Machine or equipment isolation.

All energy isolating devices that are needed to control the energy to the machine or equipment shall be physically located and operated in such a manner as to isolate the machine or equipment from the energy source(s).

(4) Lockout or tagout device application.

(i) Lockout or tagout devices shall be affixed to each energy isolating device by authorized employees.

(ii) Lockout devices, where used, shall be affixed in a manner to that will hold the energy isolating devices in a "safe" or "off" position.

(iii) Tagout devices, where used, shall be affixed in such a manner as will clearly indicate that the operation or movement of energy isolating devices from the "safe" or "off" position is prohibited.

(A) Where tagout devices are used with energy isolating devices designed with the capability of being locked, the tag attachment shall be fastened at the same point at which the lock would have been attached.

(B) Where a tag cannot be affixed directly to the energy isolating device, the tag shall be located as close as safely possible to the device, in a position that will be immediately obvious to anyone attempting to operate the device.

(5) Stored energy.

(i) Following the application of lockout or tagout devices to energy isolating devices, all potentially hazardous stored or residual energy shall be relieved, disconnected, restrained, and otherwise rendered safe.

(ii) If there is a possibility of reaccumulation of stored energy to a hazardous level, verification of isolation shall be continued until the servicing or maintenance is completed, or until the possibility of such accumulation no longer exists.

(6) Verification of isolation.

Prior to starting work on machines or equipment that have been locked out or tagged out, the authorized employee shall verify that isolation and deenergization of the machine or equipment have been accomplished.

(e) Release from lockout or tagout.

Before lockout or tagout devices are removed and energy is restored to the machine or equipment, procedures shall be followed and actions taken by the authorized employee(s) to ensure the following:

(1) The machine or equipment.

The work area shall be inspected to ensure that nonessential items have been removed and to ensure that machine or equipment components are operationally intact.

(2) Employees.

(i) The work area shall be checked to ensure that all employees have been safely positioned or removed.

(ii) After lockout or tagout devices have been removed and before a machine or equipment is started, affected employees shall be notified that the lockout or tagout device(s) have been removed.

(3) Lockout or tagout devices removal.

Each lockout or tagout device shall be removed from each energy isolating device by the employee who applied the device. Exception to paragraph (e)(3): When the authorized employee who applied the lockout or tagout device is not available to remove it, that device may be removed under the direction of the employer, provided that specific procedures and training for such removal have been developed, documented and incorporated into the employer's energy control program. The employer shall demonstrate that the specific procedure provides equivalent safety to the removal of the device by the authorized employee who applied it. The specific procedure shall include at least the following elements:

(i) Verification by the employer that the authorized employee who applied the device is not at the facility:

(ii) Making all reasonable efforts to contact the authorized employee to inform him/her that his/her lockout or tagout device has been removed; and

(iii) Ensuring that the authorized employee has this knowledge before he/she resumes work at that facility.

(f) Additional requirements.

(1) Testing or positioning of machines, equipment or components thereof.

In situations in which lockout or tagout devices must be temporarily removed from the energy isolating device and the machine or equipment energized to test or position the machine, equipment or component thereof, the following sequence of actions shall be followed:

(i) Clear the machine or equipment of tools and materials in accordance with paragraph (e)(1) of this section;

(ii) Remove employees from the machine or equipment area in accordance with paragraph (e)(2) of this section;

(iii) Remove the lockout or tagout devices as specified in paragraph (e)(3) of this section;

(iv) Energize and proceed with testing or positioning;

(v) Deenergize all systems and reapply energy control measures in accordance with paragraph (d) of this section to continue the servicing and/or maintenance.

(2) Outside personnel (contractors, etc.).

(i) Whenever outside servicing personnel are to be engaged in activities covered by the scope and application of this standard, the on-site employer and the outside employer shall inform each other of their respective lockout or tagout procedures.

(ii) The on-site employer shall ensure that his/her employees understand and comply with the restrictions and prohibitions of the outside employer's energy control program.

(3) Group lockout or tagout.

(i) When servicing and/or maintenance is performed by a crew, craft, department or other group, they shall utilize a procedure which affords the employees a level of protection equivalent to that provided by the implementation of a personal lockout or tagout device.

(ii) Group lockout or tagout devices shall be used in accordance with the procedures required by paragraph (c)(4) of this section including, but not necessarily limited to, the following specific requirements:

(A) Primary responsibility is vested in an authorized employee for a set number of employees working under the protection of a group lockout or tagout device (such as an operations lock);

(B) Provision for the authorized employee to ascertain the exposure status of individual group members with regard to the lockout or tagout of the machine or equipment and

(C) When more than one crew, craft, department, etc. is involved, assignment of overall job-associated lockout or tagout control responsibility to an authorized employee designated to coordinate affected work forces and ensure continuity of protection; and

(D) Each authorized employee shall affix a personal lockout or tagout device to the group lockout device, group lockbox, or comparable mechanism when he or she begins work, and shall remove those devices when he or she stops working on the machine or equipment being serviced or maintained.

(4) Shift or personnel changes.

Specific procedures shall be utilized during shift or personnel changes to ensure the continuity of lockout or tagout protection, including provision for the orderly transfer of lockout or tagout device protection between off-going and oncoming employees, to minimize exposure to hazards from the unexpected energization or start-up of the machine or equipment, or the release of stored energy.

Note: The following appendix to §1910.147 services as a non-mandatory guideline to assist employers and employees in complying with the requirements of this section, as well as to provide other helpful information. Nothing in the appendix adds to or detracts from any of the requirements of this section.

[54 FR 36687, Sept. 1, 1989, as amended at 54 FR 42498, Oct. 17, 1989; 55 FR 38685, 38686, Sept. 20, 1990; 61 FR 5507, Feb. 13, 1996]

APPENDIX A TO SEC. 1910.147--Typical minimal lockout procedures

General

The following simple lockout procedure is provided to assist employers in developing their procedures so they meet the requirements of this standard. When the energy isolating devices are not lockable, tagout may be used, provided the employer complies with the provisions of the standard which require additional training and more rigorous periodic inspections. When tagout is used and the energy isolating devices are lockable, the employer must provide full employee protection (see paragraph (c)(3)) and additional training and more rigorous periodic inspections are required. For more complex systems, more comprehensive procedures may need to be developed, documented, and utilized.

Lockout Procedure

Lockout Procedure for

(Name of Company for single procedure or identification of equipment if multiple procedures are used).

Purpose

This procedure establishes the minimum requirements for the lockout of energy isolating devices whenever maintenance or servicing is done on machines or equipment. It shall be used to ensure that the machine or equipment is stopped, isolated from all potentially hazardous energy sources and locked out before employees perform any servicing or maintenance where the unexpected energization or start-up of the machine or equipment or release of stored energy could cause injury.

Compliance With This Program

All employees are required to comply with the restrictions and limitations imposed upon them during the use of lockout. The authorized employees are required to perform the lockout in accordance with this procedure. All employees, upon observing a machine or piece of equipment which is locked out to perform servicing or maintenance shall not attempt to start, energize, or use that machine or equipment.

Type of compliance enforcement to be taken for violation of the above.

Sequence of Lockout

(1) Notify all affected employees that servicing or maintenance is required on a machine or equipment and that the machine or equipment must be shut down and locked out to perform the servicing or maintenance.

Name(s)/Job Title(s) of affected employees and how to notify.

(2) The authorized employee shall refer to the company procedure to identify the type and magnitude of the energy that the machine or equipment utilizes, shall understand the hazards of the energy, and shall know the methods to control the energy.

Type(s) and magnitude(s) of energy, its hazards and the methods to control the energy.

(3) If the machine or equipment is operating, shut it down by the normal stopping procedure (depress the stop button, open switch, close valve, etc.).

Type(s) and location(s) of machine or equipment operating controls.

(4) De-activate the energy isolating device(s) so that the machine or equipment is isolated from the energy source(s).

Type(s) and location(s) of energy isolating devices.

(5) Lock out the energy isolating device(s) with assigned individual lock(s).

(6) Stored or residual energy (such as that in capacitors, springs, elevated machine members, rotating flywheels, hydraulic systems, and air, gas, steam, or water pressure, etc.) must be dissipated or restrained by methods such as grounding, repositioning, blocking, bleeding down, etc.

Type(s) of stored energy - methods to dissipate or restrain.

(7) Ensure that the equipment is disconnected from the energy source(s) by first checking that no personnel are exposed, then verify the isolation of the equipment by operating the push button or other normal operating control(s) or by testing to make certain the equipment will not operate.

Caution: Return operating control(s) to neutral or "off" position after verifying the isolation of the equipment.

Method of verifying the isolation of the equipment.

(8) The machine or equipment is now locked out.

"Restoring Equipment to Service." When the servicing or maintenance is completed and the machine or equipment is ready to return to normal operating condition, the following steps shall be taken.

(1) Check the machine or equipment and the immediate area around the machine to ensure that nonessential items have been removed and that the machine or equipment components are operationally intact.

(2) Check the work area to ensure that all employees have been safely positioned or removed from the area.

(3) Verify that the controls are in neutral.

(4) Remove the lockout devices and reenergize the machine or equipment. Note: The removal of some forms of blocking may require reenergization of of the machine before safe removal.

(5) Notify affected employees that the servicing or maintenance is completed and the machine or equipment is ready for used.

[54 FR 36687, Sept. 1, 1989 as amended at 54 FR 42498, Oct. 17, 1989; 55 FR 38685, Sept. 20, 1990; 61 FR 5507, Feb. 13, 1996]

SUBPART C GENERAL SAFETY AND HEALTH PROVISIONS

1926.21 Safety training and education

(a) General requirements.

The Secretary shall, pursuant to section 107(f) of the Act, establish and supervise programs for the education and training of employers and employees in the recognition, avoidance and prevention of unsafe conditions in employments covered by the act.

(b) Employer responsibility.

(1) The employer should avail himself of the safety and health training programs the Secretary provides.

(2) The employer shall instruct each employee in the recognition and avoidance of unsafe conditions and the regulations applicable to his work environment to control or eliminate any hazards or other exposure to illness or injury.

(3) Employees required to handle or use poisons, caustics, and other harmful substances shall be instructed regarding the safe handling and use, and be made aware of the potential hazards, personal hygiene, and personal protective measures required.

(4)

In job site areas where harmful plants or animals are present, employees who may be exposed shall be instructed regarding the potential hazards, and how to avoid injury, and the first aid procedures to be used in the event of injury.

(5) Employees required to handle or use flammable liquids, gases, or toxic materials shall be instructed in the safe handling and use of these materials and made aware of the specific requirements contained in Subparts D, F, and other applicable subparts of this part.

(6)

(i) All employees required to enter into confined or enclosed spaces shall be instructed as to the nature of the hazards involved, the necessary precautions to be taken, and in the use of protective and emergency equipment required. The employer shall comply with any specific regulations that apply to work in dangerous or potentially dangerous areas.

(ii) For purposes of paragraph (b)(6)(i) of this section, "confined or enclosed space" means any space having a limited means of egress, which is subject to the accumulation of toxic or flammable contaminants or has an oxygen deficient atmosphere. Confined or enclosed spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than 4 feet in depth such as pits, tubs, vaults, and vessel.

SUBPART J WELDING AND CUTTING

1926.352 Fire Prevention

(a) When practical, objects to be welded, cut, or heated shall be moved to a designated safe location or, if the objects to be welded, cut, or heated cannot be readily moved, all movable fire hazards in the vicinity shall be taken to a safe place, or otherwise protected.

(b) If the object to be welded, cut, or heated cannot be moved and if all the fire hazards cannot be removed, positive means shall be taken to confine the heat, sparks, and slag, and to protect the immovable fire hazards from them.

(c) No welding, cutting, or heating shall be done where the application of flammable paints, or the presence of other flammable compounds, or heavy dust concentrations creates a hazard.

(d) Suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained in a state of readiness for instant use.

(e) When the welding, cutting, or heating operation is such that normal fire prevention precautions are not sufficient, additional personnel shall be assigned to guard against fire while the actual welding, cutting, or heating operation is being performed, and for a sufficient period of time after completion of the work to ensure that no possibility of fire exists. Such personnel shall be instructed as to the specific anticipated fire hazards and how the firefighting equipment provided is to be used.

(f) When welding, cutting, or heating is performed on walls, floors, and ceilings, since direct penetration of sparks or heat transfer may introduce a fire hazard to an adjacent area, the same precautions shall be taken on the opposite side as are taken on the side on which the welding is being performed.

(g) For the elimination of possible fire in enclosed spaces as a result of gas escaping through leaking or improperly closed torch valves, the gas supply to the torch shall be positively shut off at some point outside the enclosed space whenever the torch is not to be used or whenever the torch is left unattended for a substantial period of time, such as during the lunch period. Overnight and at the change of shifts, the torch and hose shall be removed from the confined space. Open end fuel gas and oxygen hoses shall be immediately removed from enclosed spaces when they are disconnected from the torch or other gas-consuming device.

(h) Except when the contents are being removed or transferred, drums, pails, and other containers which contain or have contained flammable liquids shall be kept closed. Empty containers shall be removed to a safe area apart from hot work operations or open flames.

(i) Drums containers, or hollow structures which have contained toxic or flammable substances shall, before welding, cutting, or heating is undertaken on them, either be filled with water or thoroughly cleaned of such substances and ventilated and tested. For welding, cutting and heating on steel pipelines containing natural gas, the pertinent portions of regulations issued by the Department of Transportation, Office of Pipeline Safety, 49 CFR Part 192, Minimum Federal Safety Standards for Gas Pipelines, shall apply.

(j) Before heat is applied to a drum, container, or hollow structure, a vent or opening shall be provided for the release of any built-up pressure during the application of heat.

SUBPART J WELDING AND CUTTING

1926.353 Ventilation and protection in welding, cutting, and heating

(a) Mechanical ventilation.

For purposes of this section, mechanical ventilation shall meet the following requirements:

(1) Mechanical ventilation shall consist of either general mechanical ventilation systems or local exhaust systems.

(2) General mechanical ventilation shall be of sufficient capacity and so arranged as to produce the number of air changes necessary to maintain welding fumes and smoke within safe limits, as defined in Subpart D of this part.

(3) Local exhaust ventilation shall consist of freely movable hoods intended to be placed by the welder or burner as close as practicable to the work. This system shall be of sufficient capacity and so arranged as to remove fumes and smoke at the source and keep the concentration of them in the breathing zone within safe limits as defined in Subpart D of this part.

(4) Contaminated air exhausted from a working space shall be discharged into the open air or otherwise clear of the source of intake air.

(5) All air replacing that withdrawn shall be clean and respirable.

(6) Oxygen shall not be used for ventilation purposes, comfort cooling, blowing dust from clothing, or for cleaning the work area.

(b) Welding, cutting, and heating in confined spaces.

(1) Except as provided in paragraph (b)(2) of this section, and paragraph (c)(2) of this section, either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section shall be provided whenever welding, cutting, or heating is performed in a confined space.

(2) When sufficient ventilation cannot be obtained without blocking the means of access, employees in the confined space shall be protected by air line respirators in accordance with the requirements of Subpart E of this part, and an employee on the outside of such a confined space shall be assigned to maintain communication with those working within it and to aid them in an emergency.

(3) "Lifelines." Where a welder must enter a confined space through a manhole or other small opening, means shall be provided for quickly removing him in case of emergency. When safety belts and lifelines are used for this purpose they shall be so attached to the welder's body that his body cannot be jammed in a small exit opening. An attendant with a pre-planned rescue procedure shall be stationed outside to observe the welder at all times and be capable of putting rescue operations into effect.

(c) Welding, cutting, or heating of metals of toxic significance.

(1) Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section:

(i) Zinc-bearing base or filler metals or metals coated with zinc-bearing materials;

(ii) Lead base metals;

(iii) Cadmium-bearing filler materials;

(iv) Chromium-bearing metals or metals coated with chromium-bearing materials.

(2) Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with local exhaust ventilation in accordance with the requirements of paragraph (a) of this section, or employees shall be protected by air line respirators in accordance with the requirements of Subpart E of this part:

(i) Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;

(ii) Cadmium-bearing or cadmium-coated base metals;

(iii) Metals coated with mercury-bearing metals;

(iv) Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.

(3) Employees performing such operations in the open air shall be protected by filter-type respirators in accordance with the requirements of Subpart E of this part, except that employees performing such operations on beryllium-

containing base or filler metals shall be protected by air line respirators in accordance with the requirements of Subpart E of this part.

(4) Other employees exposed to the same atmosphere as the welders or burners shall be protected in the same manner as the welder or burner.

(d) Inert-gas metal-arc welding.

(1) Since the inert-gas metal-arc welding process involves the production of ultra-violet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in, or be exposed to the process until the following special precautions have been taken:

(i) The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.

(ii) Employees in the area not protected from the arc by screening shall be protected by filter lenses meeting the requirements of Subpart E of this part. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type, meeting the requirements of Subpart E of this part, shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.

(iii) Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and free of highly reflective surfaces.

(iv) When inert-gas metal-arc welding is being performed on stainless steel, the requirements of paragraph (c)(2) of this section shall be met to protect against dangerous concentrations of nitrogen dioxide.

(e) General welding, cutting, and heating.

(1) Welding, cutting, and heating, not involving conditions or materials described in paragraph (b), (c), or (d) of this section, may normally be done without mechanical ventilation or respiratory protective equipment, but where, because of unusual physical or atmospheric conditions, an unsafe accumulation of contaminants exists, suitable mechanical ventilation or respiratory protective equipment shall be provided.

(2) Employees performing any type of welding, cutting, or heating shall be protected by suitable eye protective equipment in accordance with the requirements of Subpart E of this part.

[44 FR 8577, Feb. 9, 1979; 44 FR 20940, Apr. 6, 1979, as amended at 55 FR 42328, Oct. 18, 1990; 58 FR 35179, June 30, 1993]

PERMIT-REQUIRED CONFINED SPACE ENTRY

A

Absorption - Absorption is the route of entry into the body through the skin (either broken or unbroken) and sometimes through the eye. Chemicals that are absorbed through the skin can enter the bloodstream. These chemicals then travel to other organs and cause damage.

Accident - An undesirable, unplanned event resulting in personal physical harm, damage to property, or interruption of business.

Acclimatization - The process of adapting to a new temperature, altitude, climate, environment, or situation

ACGIH - American Conference of Governmental Industrial Hygienists

Affected employee - Person who operates or uses a machine or equipment on which servicing or maintenance is being performed under lockout/tagout or who works in that area.

ANSI - American National Standards Institute

APR - Air purifying respirator

Asphyxiant - Agent or condition that causes a lack of oxygen in the blood. It can lead to loss of consciousness, serious injury, or death. See simple asphyxiant and chemical asphyxiant.

Atmospheric monitoring - The process of collecting, detecting, and measuring the air in confined spaces for chemical, physical, and biological hazards.

Attendant - A worker who remains outside the confined space while work is being done inside.

Authorized employee - Person who locks out or tags out machines or equipment to perform servicing or maintenance on that machine or equipment.

B

Blanking (or blinding) - The absolute closure of a pipe, line, or duct by the fastening of a solid plate that completely covers the bore and is capable of withstanding the maximum pressure of the pipe, line, or duct.

Blinding - (see Blanking)

BLS - Bureau of Labor Statistics

Breakthrough - The point at which chemicals begin to pass through a respirator filter because the filter's saturation point has been reached.

Bridging - A condition that occurs when grain, or a similar loose material, clings to the sides of a container or vessel that is being emptied from below. A hollow space is created with an unstable covering of grain over it.

C

C - Centigrade

Calibration gas - A reference gas used to adjust the settings on an air monitoring instrument to known measurements.

Carcinogen - A substance that causes cancer.

CCL - Construction craft laborer

CFR - Code of Federal Regulations

CGI - Combustible gas indicator

CG/OI - Combustible gas and oxygen indicator

Chemical asphyxiant - Substance that reduces or blocks the ability of the blood to carry oxygen.

Competent person - Per OSHA, a competent person is an individual who, by way of training and/or experience, is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, is designated by the employer, and has authority to take appropriate actions (1926.32). Some standards add specific requirements which must be met by the competent person.

Confined space - Any area with the following characteristics: adequate size and shape to allow a person to enter; limited opening for workers to enter and exit; and not designed for continuous human occupancy.

Confined space entry permit - An authorization form that is the primary source of information for hazards found in a permit-required confined space and their controls.

CPR - Cardiopulmonary resuscitation

cu ft - cubic foot or feet

D

Decontamination - Process of removing or neutralizing chemicals that have accumulated on PPE, tools, or equipment used on the job.

Delayed effect - A health effect that takes a long time to develop, usually the result of repeated exposures to low doses of a substance over a long period of time.

Dermatitis - Skin irritation with symptoms such as red, itchy skin, swelling, ulcers, and blisters.

DHHS - Department of Health and Human Services

Doffing - The act of removing PPE.

Donning - The act of putting on PPE.

Dose - The amount or concentration of a substance a person receives over a specific period of time.

Double block and bleed - A system of closing off a pipe using a T-configuration. Two valves block off materials and one valve bleeds the pipe. It's used to isolate a confined space.

Double purge - The process of ventilating a confined space with breathable air after it has been inerted.

DRI - Direct reading instruments

Dusts - Solid particles suspended in air. They are produced by crushing, grinding, sanding, sawing, or the impact of materials against each other.

E

e.g. - For example

Ensemble - The term used for a whole outfit of protective equipment, usually a specific pairing of a respirator with a type of protective clothing.

Entrant - A worker who enters the confined space to work.

Entry supervisor - The person (such as the employer, foreman, or crew chief) responsible for determining if acceptable entry conditions are present at a permit space where entry is planned, for authorizing entry and overseeing entry operations, and for terminating entry as required by the regulations.

Entry team - Entrant, attendant, entry supervisor, and the rescue team. Required for entry into a permit-required confined space.

EPA - Environmental Protection Agency

ESLI - End of service life indicator

Exhaust system - A method of ventilation that pulls air out of a confined space using fans or fume hoods.

F

F - Fahrenheit

FID - Flame ionization detector

First-break - The initial disconnection or breaking of the pipeline.

Flammable or explosive atmosphere - An atmosphere resulting from vaporization of flammable liquids, by-products of chemical reaction, or concentrations of combustible dusts.

Flammable range - Concentrations between the lower flammability limit and the upper flammability limit.

FM - Factory Mutual

Fumes - Solid particles in the air. Fumes are usually formed when metals are heated to their melting points, e.g., when welding or soldering.

G

Gases - Gases have no definite shape or volume. They expand to fill their containers and mix with air at normal temperatures.

General ventilation - The process of ventilating the entire confined space.

H

Hazard - Any condition, situation, or agent that has the potential to produce an undesirable effect.

Hazardous atmosphere - An atmosphere that contains one or more of the following hazards: oxygen deficiency/oxygen enrichment, flammable/explosive atmosphere, or toxic air contaminants.

HazMat - Hazardous Materials

HEPA - High efficiency particulate air (filter)

High efficiency particulate air filter - A filter capable of capturing 99.97% of the particles pulled through it.

I

IAA - Isoamyl acetate

IDLH - Immediately dangerous to life and health

Immediately dangerous to life or health - An exposure level in an environment likely to cause death or serious health effects with very short exposures.

Inerting - The process of removing oxygen from a confined space by introducing a nonreactive gas to reduce the flammable mixture of fuel and oxygen so that ignition or combustion is not possible.

Inerting gas - A nontoxic gas used during the inerting process to displace air (oxygen) from a confined space.

Ingestion - 1.The act of taking food and other substances into the body by the mouth. 2. A route of entry into the body along with food or water, or through inhalation and then swallowing.

Inhalation - 1. The act of breathing in a substance in the form of a gas, vapor, fume, mist, or dust. 2. A route of entry into the body for microorganisms, chemicals, or physical agents during breathing.

Inorganic - A substance that is made up of something other than plant or animal, such as a mineral.

Intrinsically safe - Something that is safe because of the nature of its design or basic characteristics. Ex: intrinsic safety is a protection concept used in potentially explosive atmospheres. Intrinsic safety relies on the electrical apparatus being designed so that it is unable to release sufficient energy, either through heat or electricity, to cause ignition of a flammable gas.

Isolation - The process by which a space is removed from service and completely protected against the release of energy and material into the space.

L

Latency period - The time period between the first exposure and the appearance of disease caused by the exposure.

LEL - Lower explosion limit

LFL - Lower flammability limit

Line-breaking - The term used for the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic materials; inert gases; or any fluids at a volume, pressure, or temperature that is capable of causing injury.

LIUNA - Laborers' International Union of North America

Local effect - The health effect that occurs at the location where a chemical comes in contact with the body.

Local exhaust - The process of removing contaminants at their source.

M

Material safety data sheet - The primary source of information for hazardous chemicals used on a hazardous waste work site.

Maximum use concentration - The highest concentration of a specific contaminant for which a cartridge or canister provides approved protection.

Mechanical ventilation - The use of blowers or fans and ducts to ventilate a confined space.

mg/m^3 - milligrams per cubic meter

Mists - Mists and fogs are fine droplets of liquid suspended in the air. Fogs may be created by vapors condensing to the liquid state. Mists are droplets being splashed or sprayed.

MSDS - Material safety data sheet

MSHA - Mine Safety and Health Administration

MUC - Maximum use concentration

N

NIOSH - National Institute of Occupational Safety and Health

O

Olfactory fatigue - Condition that occurs when the sense of smell is dulled from a chemical exposure.

Organic compound - A chemical compound containing carbon, such as gasoline, benzene, and toluene.

OSHA - Occupational Safety and Health Administration

OVA - Organic vapor analyzer.

Over breathing - A condition that occurs when a worker uses more air than a PAPR can provide, creating negative pressure in the mask.

Oxygen consumption - Condition that occurs when a substance reacts with and uses up oxygen in the atmosphere.

Oxygen-deficient atmosphere - As defined by OSHA, an atmosphere that contains less than 19.5% oxygen by volume. This atmosphere cannot support life.

Oxygen displacement - Condition that occurs when a gas is introduced into a confined space pushes the oxygen out to make room for itself.

Oxygen-enriched atmosphere - As defined by OSHA, an atmosphere that contains more than 23.5% oxygen by volume. This atmosphere is a serious fire hazard.

P

PAPR - Powered air purifying respirator

PEL - Permissible exposure limit

Permissible exposure limit - Exposure guidelines for airborne concentrations of regulated substances that set limits upon a worker's inhalation exposure (the amount of substance a worker can safely breath).

Permit-required confined space - A confined space that contains or has the potential to contain a hazardous atmosphere, contains a material that has the potential for engulfing the entrant, has an internal configuration that could trap or asphyxiate an entrant by inwardly converging walls or by a floor that slopes downward to a smaller cross-section, or contains any other recognized serious hazard.

Personal protective equipment - Any protective clothing or device used to prevent contact with and exposure to chemical and nonchemical hazards in the work place.

PF - Protection factor

PID - Photoionization detector

PPE - Personal protective equipment

ppm - parts per million

Poor warning properties - Absence of odor, taste, or other trait which warns about a chemical's presence.

Pre-entry atmospheric testing - Testing performed from the outside of a confined space to identify hazardous conditions inside.

Prompt effect - A health effect that is seen quickly, usually after an exposure to a high concentration of a hazardous material.

Protection factor - The rating assigned to a respirator or class of respirators that represents the level of protection it provides.

Purging - The process of replacing or diluting flammable vapors in a confined space by introducing air, steam, or water.

Q

QLFT - Qualitative fit testing

QNFT - Quantitative fit testing

Qualitative fit test - A test that determines respirator fit and involves introducing a harmless, odorous, or irritating substance into the breathing zone of the wearer.

Quantitative fit test - A sophisticated type of fit test that measures the actual amount of leakage into the respirator.

R

REL - Recommended exposure limit (NIOSH).

Rescue team - That part of the confined space entry team responsible for and trained in retrieving endangered or injured entrants from a confined space.

RPA - Respirator program administrator

S

Saddle vent - A piece of equipment connected to the duct work at the opening of a confined space that makes the duct narrower. It provides more room for workers to enter and exit the confined space.

Safety - The state of being secure from hurt, injury, or loss.

SAR - Supplied air respirator

SCBA - Self-contained breathing apparatus

Short term exposure limit - Maximum concentration level of a substance to which workers can be exposed for a short period of time (usually 10 to 15 minutes) without suffering from adverse health effects.

Simple asphyxiant - Chemical gas or vapors at such a concentration in a confined space that the oxygen content is below a level that will sustain life.

SOP - Standard operating procedure

Sorbent - Granular material in a respirator cartridge or canister that absorbs specific contaminants from the air as the air is inhaled.

Standard operating procedure - Required procedures for performing the variety of work associated with activities at a hazardous waste site.

STEL - Short-term exposure limit

Supply system - A method of ventilation that supplies fresh air by pushing air into a confined space using blowers.

Systemic effect - A health effect that occurs in the body at some place other than the point of contact.

T

Target organs - An organ or system affected by a chemical.

Time weighted average - Average concentration of a substance in an area over an 8-hour work shift of a 40-hour work week.

TLV - Threshold limit values (ACGIH)

Toxic chemical - A substance that has poisonous or deadly effects on the body when it's inhaled, ingested, absorbed, or comes in contact with the skin.

TWA - Time weighted average

U

UEL - Upper explosion limit

UFL - Upper flammability limit

UL - Underwriters Laboratories

V

Vapors - Gaseous forms of certain materials that are usually solid or liquid at room temperatures. Vapors may be formed when liquids or solids are heated. Some materials, such as solvents and gasoline, release vapors without being heated.

Vapor density - The weight of a vapor or gas compared to the weight of an equal volume of air.

Ventilation - The continuous movement of fresh, uncontaminated air throughout a confined space to eliminate or reduce atmospheric hazards.

W, X, Y, Z

No entries