IUOE National Training Fund

National HAZMAT Program

Student Manual

Confined Space Awareness

M-070-20104ST

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This publication was supported by the National Institute Of Environmental Health Sciences of the National Institutes of Health under Award Numbers U45ES006182 and U45ES009763. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

- It is not the intent of the content developers to provide compliance-based training in this presentation, the intent is to address hazard awareness in the hazardous waste operations and emergency response (HAZWOPER) industry, and to recognize the overlapping hazards present in many construction workplaces.
- It should NOT be assumed that the suggestions, comments, or recommendations contained herein constitute a thorough review of the applicable standards, nor should discussion of "issues" or "concerns" be construed as a prioritization of hazards or possible controls. Where opinions ("best practices") have been expressed, it is important to remember that safety issues general and HAZWOPER jobsites specifically will require a great deal of site- or hazard-specificity – a "one size fits all" approach is not recommended, nor will it likely be very effective.

To: Users of IUOE National Training Fund Programs

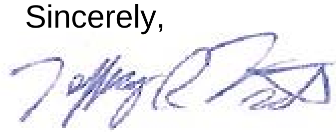
The IUOE National Training Fund -- National HAZMAT Program offers a broad spectrum of safety and health training, as well as training support to other users of the National HAZMAT Program's resources. The National HAZMAT Program has available, at ***no cost***, the following:

- Direct training for IUOE Local Union members and other appropriate groups conducted at the Local Union, at an employer's site, or other appropriate locations
- Training materials, including personal protective equipment, and other types of equipment for National HAZMAT Program Master Instructors' HAZWOPER and other safety and health related classes
- New instructor mentoring for HAZWOPER and other safety and health related classes
- Safety and health regulations and standards interpretation assistance
- Technical safety and health, emergency/disaster response, and energy security and restoration assistance
- Training data information from the National training database for Local Union members and others who have completed training through the National HAZMAT Program
- Expertise to provide best practices and information sharing, develop scenarios, and conduct exercises to prepare all stakeholders to protect and restore critical infrastructure should an event, manmade or natural, occur
- Training information on HAZWOPER, OSHA, emergency/disaster response, and other safety and health classes held at other IUOE Local Unions nationwide

Inquiries regarding the services the IUOE National Training Fund -- National HAZMAT Program have to offer can be directed to Barbara McCabe at 1293 Airport Road, Beaver, WV 25813, called in at (304) 253-8674, faxed to (304) 253-7758, or emailed to hazmat@iuoehazmat.org. Forms requesting classes and materials can also be submitted via the Internet at www.iuoehazmat.org.

The IUOE National Training Fund encourages all workers to take advantage of the National HAZMAT Program's services to assist you to be employable, competitive, and safe in the workplace.

Sincerely,



Jeffrey R. Vincent
Executive Director,
IUOE National Training Fund

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Module 1: Introduction

Objectives

After completing this section you will be able to:

- ✓ Explain the broad goals of this course.
- ✓ Contrast this course with the OSHA Training Institute Course #2264.
- ✓ Describe what this course will enable you to do.
- ✓ Clearly list what this course does not prepare you to do.

Overview of this course

This is a two-day awareness training course specifically designed for IUOE members.

It is **not**:

1. A skills training to enter confined spaces.
2. A skills training to perform confined space retrieval.
3. OSHA OTI Course # 2264, Permit-Required Confined Space Entry.

There are 3 broad themes to this course.

They are:

1. Confined spaces are particularly lethal, often leading to multiple fatalities.
2. Following the OSHA standard, 29 CFR 1910.146 will prevent injuries and deaths, even though it doesn't apply to construction.
3. Workers must keep their guard up all the time, any lapse can be fatal.

Worker deaths in confined spaces

The following information is from a study called "Worker deaths in confined spaces" from *Professional Safety*, (Pettit, Nov. 1996). It is an old study but very comprehensive.

Worker fatalities related to confined spaces were examined. A total of 585 fatal incidents and 670 worker fatalities occurred in confined spaces between 1983 and 1993. The riskiest industries included manufacturing, agriculture, **construction,** transportation and public utilities. The common atmospheric causes of fatalities were hydrogen sulfide, methane, inert gases, and carbon monoxide, as well as oxygen deficiency. Numerous fatalities were attributed to mechanical asphyxiation, entrapment in grain and other agricultural products, and engulfment in sand, sawdust, and other building materials.

From 1980 to 1989, a total of 572 trench cave-ins claimed 606 lives, most of which occurred in the construction industry. Nearly one-quarter of the 1,018 poisoning deaths and 1,218 asphyxiation deaths occurred in confined spaces.

NIOSH Fatality Assessment and Control Evaluation (FACE) Investigations

NIOSH investigators examined 70 fatal incidences in this same period that resulted in 109 deaths related to confined spaces. They found that:

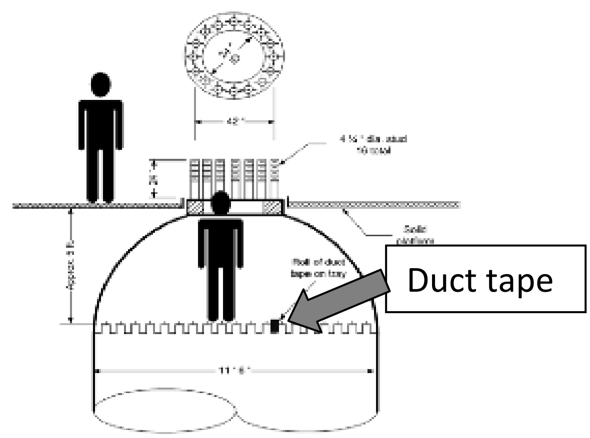
- The construction, public administration and manufacturing industries accounted for most of the fatalities;
- About 80 percent of the incidences involved hazardous atmospheres, of which 43 percent were oxygen deficient;
- Written safety procedures were **not** established in 60 percent of the incidences;
- Of the victims examined, 40 percent were repairing or maintaining the confined space and 36 percent were attempting to rescue a victim;
- Confined spaces such as tanks, vats/pits, digesters and sewer manholes were frequently involved in fatal incidences; and
- Only 6 percent of the victims received safety training specifically aimed at confined space entry.

Case Study
Confined Space Entry

How much does this cost?

The workers died in this space, which was just 5 feet deep.

This case study was created by the U.S. Chemical Safety and Hazard Investigation Board. It describes the Valero Delaware City refinery asphyxiation death of two contractor employees who were preparing to reassemble a pipe on a pressure vessel while it was being purged with nitrogen. The first worker, in an attempt to retrieve a roll of duct tape that fell inside the vessel, was overcome by nitrogen, collapsed in the vessel, and died. His co-worker, the crew foreman, was asphyxiated while attempting to rescue him.



Let's draw some lessons based on what you already know.

Think about these questions and write your answers below.

1. What are the health hazards associated with nitrogen?
2. Is the reactor a confined space?
3. What are the options for removing the tape?

1. By dangling his legs into the reactor, has the worker entered the confined space without a permit?
2. Prior to entering a confined space, what must be done and how does this protect those that enter?

1. What types of instrument are used to test the atmosphere of confined spaces and what would they have shown in this case?
2. How long can one remain conscious in an atmosphere without oxygen?
3. What should the foreman do now?

1. What is the job of the attendant and what must he or she never do?
2. How might the foreman have rescued the worker if proper confined space entry procedures had been followed?

1. What must be worn to enter this space safely and attempt a rescue or recovery?
2. What should the first worker have been wearing to facilitate his rescue?

Module 2:
What is a confined space?

Objectives

After completing this section you will be able to:

- ✓ Describe the meaning of a confined space
- ✓ Explain the difference between a 'permit-required' confined space and a 'non-permit' confined space.
- ✓ List common tasks that operating engineers perform in permit-required confined spaces.

Defining a confined space

The first question that must be answered is whether an area is a confined space. A *confined space* is an area that meets these 3 conditions:

1. It is large enough for a worker to enter and work in.
2. It has limited means for a worker to enter or exit.
3. It is not meant to be continuously occupied.

Does the presence of a door mean it isn't a confined space?

☐ Yes ☐ No

This is a large Air Handling Unit (AHU) in a commercial building.

According to OSHA, “A space has limited or restricted means of entry or exit if an entrant's ability to escape in an emergency would be hindered. The dimensions of a door and its location are factors in determining whether an entrant can easily escape; however, the presence of a door does not in and of itself mean that the space is not a confined space.”
http://www.osha.gov/html/faq-confinedspaces.html

A *‘permit-required confined space’* is a confined space that has at least one of these conditions:

1. Contains or has the potential to contain a hazardous atmosphere;
2. Contains a material that could engulf an entrant;
3. Is shaped in such a way that a worker could be trapped by inwardly sloping walls or walls which slope down to a smaller section; or
4. Contains any other known serious safety or health hazard.

A.

Is this a confined space? ☐Yes ☐No
Could it be a permit-required confined space? ☐Yes ☐No

Boiler,
photo courtesy John Crooks

B.

Is this a confined space? ☐Yes ☐No
Could it be a permit-required confined space? ☐Yes ☐No

Sawdust separator,
photo courtesy John Crooks

C.

Is this a confined space? ☐Yes ☐No
Could it be a permit-required confined space? ☐Yes ☐No

Cooling tower,
photo courtesy John Crooks

D.

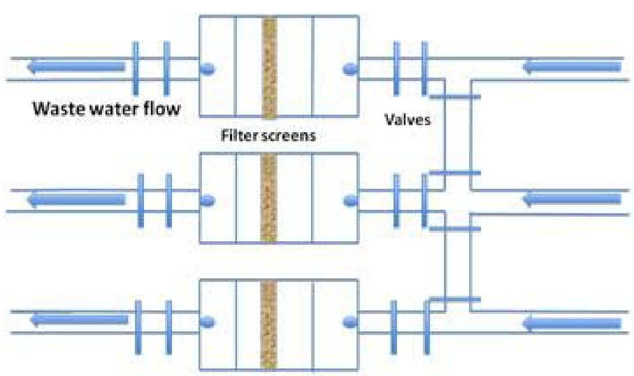
Is this a confined space? ☐Yes ☐No
Could it be a permit-required confined space? ☐Yes ☐No

Waste water operation

Wastewater treatment plants have different types of confined spaces

Here is an exercise using a wastewater treatment plant.

Diagram of first stage filter

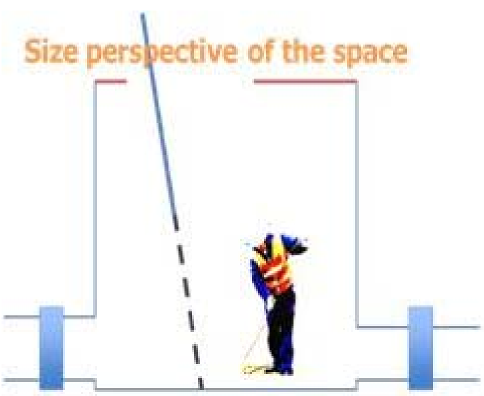


Background on the process

As the material enters the plant the material flows through these screens. The screens collect larger solids like paper and plastics, and smaller materials, as small as a 2" diameter uninflated balloon. An automatic cleaning process is used to remove the debris from the screen by scraping the solids from the intake side of the screen with what appears to be a very large rake.

This rake runs automatically when sensors detect enough pressure difference across the screen to tell it that enough material is covering the screen to cause a loss of flow. When the process initiates, the large rake descends into the water to the bottom of the trough, settles against the screen, ascends applying pressure against the screen bringing the material up the face of the screen and dumps the material onto a travelling belt to be removed to a solid waste repository.

The solid waste is then removed from the plant by truck after it has been disinfected.
The system uses double valves on the discharge side of the screen and double valves, blanking plates, and bypass valves on the supply side. The dimensions in the pit are 40' long 30' wide and 20' deep. The screen section is full width and 15' tall leading to a solid sheet of steel another 15' tall with a rolled lip to allow the retrieved material to fall onto the conveyor drive.



This is a not-to-scale description of the work space. You can see that a person can move under the slab into a position where the attendant would not be able to see the entrant. The screen has very sharp edges from the rake sliding across the screen. Heavier materials build up on the bottom and sides of the vault and need to be removed on an as needed basis. The work usually done in this vault is cleaning the heavier materials that have fallen out of solution and repairing the screen when it gets damaged. Repairing the screen requires oxyfuel cutting and welding (electric arc) in a new screen section.

Image of the rake moving up the front of the screen.

Manholes are located on each side of the pit. What could they be used for during entry?

Class Exercise

Is this waste water filter operation a permit-required confined space?
Can it be reclassified to just a confined space?

In your group, discuss your answers and write them below.

Is it a permit-required confined space?

Yes. Not only is it a configuration hazard but the amount of added possible hazards are too numerous to count even if we tested and monitored the area today, the next time a team had to work in this space the contaminants could be different.

Can it be reclassified to just a confined space?

No. Even if you could clean the pit area of contaminants self rescue would be very difficult. The configuration hazard stays very real. Oxygen levels may always be a challenge. Sharps will always be present. H2S will permeate the concrete.

Actual sign from wastewater filter operation

What hazards would you expect in this area?

In your group, discuss your answers and write them below. Don't look on the next page!

What PPE would you recommend the entrant wear to repair a section of the screen? Why?

In your group, discuss your answers and write them below.

Possible hazards include:

- Blood-borne pathogens
- Sharps
- Toxic Chemicals (H2S, petroleum distillates, chromates, pesticides, organic phosphates, biological remains of dead pets)
- Inhalation hazards (organic vapors, steam)
- Possible explosive environment (methane)
- Heat exposure
- Ergonomics

PPE considerations:

Most likely an organic gas, acid vapor cartridge would be the absolute minimum respirator cartridge allowed but supplied air would be more appropriate.
Because of the possible pesticides non-absorbing apparel should be required. Gloves would be needed to protect against sharps.
Then we need to add welding on top of this which requires eye protection and full arc flash and welding apparel.

Permit-required confined spaces must be clearly marked.

Notice the excellent placement of the warning sign.

How could units that only move air become hazardous?

This is another large air handling unit.

Large Air Handling Units (AHUs) could become hazardous by:

1. Maintenance workers becoming physically stuck in the space or hitting their heads;
2. Significant amounts of mold and dust being present if poorly maintained;
3. Chemicals being used to disinfect units which may pose health risks; and
4. Fans and other moving parts possibly becoming energized while workers are inside, unless they are properly de-energized.

Heavy equipment operators work at cement plants. What confined spaces might be present?

This is a small plant, but at most plants the operators should be concerned about operations and particularly maintenance procedures in:

1. The preheater tower
2. The Kiln
3. The ball mill
4. The clinker cooler and finish grinding

There is a terrific animation of a cement plant operation available at:
http://www.cement.org/basics/images/flashtour.html

Equipment operators also work at asphalt plants.

What confined spaces might exist in these operations?

Confined spaces could exist in:

1. Heated insulated stainless steel silos used for storing product
2. The mixing drum, which may need to be cleaned out occasionally
3. Storage hoppers for raw materials

Background on types of plants (source: Wikipedia)

Batch heater

A batch heater plant weighs the raw aggregates into a heater drum, where the batch is then heated up to temperature. The hot aggregate is discharged into a mixing drum where (dry) filler and binder are added. The blend is mixed and discharged either directly into the delivery vehicles or into a small weighing and collecting hopper.

Continuous

In the continuous plant, raw aggregate is brought up from ground hoppers at a precisely controlled rate and fed into a heater drum similar to that used in the asphalt plant. Once heated it is immediately coated in the same drum (with the binder spraybars situated behind the burner) or in a smaller drum situated immediately behind it. Finished product is almost invariably discharged into a hot store rather than directly into delivery vehicles.

Hot storage

Finished product must be kept heated to avoid setting. It is commonly stored in large electrically heated insulated stainless steel silos, from which it is weighed into delivery vehicles.

Sewer work is so dangerous OSHA created a separate appendix for it in 1910.146.

Sewers have been a major source of fatalities in confined spaces so OSHA created Appendix E to specifically address entry.

What are three ways that OSHA considers sewers different?

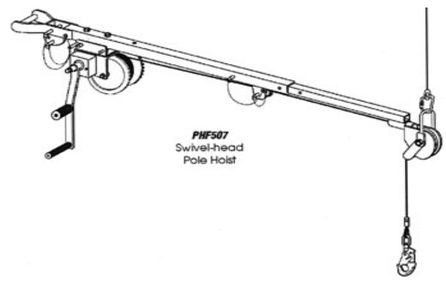
In your group, discuss your answers and write them below. Don't turn the page, please.

The following is directly from OSHA:

"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."

Some entries are horizontal. What additional difficulties does this pose?

This is a Pelsue rescue/retrieval system that works just like a fishing rod. The pole hoist can be attached to a tower tie off ring. The swivel head models allow for both vertical and horizontal retrieval in areas of limited space.



Horizontal or vertical retrieval system, courtesy of Pelsue Corporation

Additional difficulties:

1. Tripods for vertical entry and retrieval are not useful for horizontal retrieval. Planning is usually for vertical entry
2. Manually attempting a horizontal retrieval requires more than one person, although it appears easier than vertical retrieval.
3. The worker will have to be dragged across the surface and, if unconscious, may become injured, particularly if face down.

There are many common confined spaces.

How many of these have you entered? Who has the highest score in class?

☐ Tanks	☐ Vaults
☐ Manholes	☐ Pipe
☐ Boilers	☐ Trenches
☐ Furnaces	☐ Tunnels
☐ Sewers	☐ Ducts
☐ Silos	☐ Bins
☐ Hoppers	☐ Pits

Class Exercise

What other types of permit-required confined spaces are in your workplace?

In your group, identify the confined spaces members of the group have in their workplaces. It is important to note whether they are hoisting and portable or stationary workplaces.
Write your answers below.

Module 3: What are the hazards in confined spaces?

Objectives

After completing this section you will be able to:

- ✓ Explain how hazards enter the body.
- ✓ Describe the dangers of too much or too little oxygen in confined spaces.
- ✓ Name potential flammable and explosive hazards.
- ✓ Describe potential toxic vapors and gases in confined spaces.
- ✓ Identify physical and safety hazards that might be present.
- ✓ List infectious diseases that can be present in confined spaces.
- ✓ List potential animal dangers in confined spaces.

There are different types of hazards that might be in a confined space.

The potential hazards fall into these general categories:

- chemical,
- physical hazards such as electricity, heat and cold, radiation and noise,
- safety hazards such as slips, trips, and falls,
- biological, and
- ergonomic.

There are four main ways hazards enter the body. Which is most common in confined spaces?

- breathing through the nose and mouth (inhalation),
- swallowing (ingestion),
- passing through intact skin (absorption), or
- passing through cuts or punctures of the skin (injection).

Exposure does not always mean that a hazard must enter the body to cause damage. A person can hurt their back from lifting something too heavy. Someone can get frostbite from working outside in the winter.

The type of harm depends on the part of the body that is exposed and other factors including:

- length of exposure,
- amount of the agent you are exposed to, and
- potency, or ability of an agent or process to cause serious problems.

More than most worksites, confined spaces can have conditions that are immediately dangerous to life or health (IDLH).

Some conditions in confined space are *immediately dangerous to life or health*, which are called IDLH hazards. An example of an IDLH condition is a buildup of methane that could explode if there is an ignition source. Concentrations of nitrogen or hydrogen sulfide at the bottom of a pit are also IDLH situations.

Can you think of IDLH situations you have come across in your job? Write them below.

There are 3 types of atmospheric hazards in confined spaces.

There are:

- too little or too much oxygen,
- fire and explosions, and
- toxic gases and vapors.

Oxygen Content

The amount of oxygen should be between 19.5% and 23.5%

A concentration of less than 19.5% oxygen is considered to be oxygen deficient. As the amount of oxygen in a space decreases, the risk of injury and death increases. The effects of oxygen deficiency are shown as the amount of oxygen in the air decreases, with death in a matter of minutes when the oxygen level is down to six percent.

Case study of an asphyxiation at a water system plant in Montana from NIOSH (FACE 9117)

Gas	Concentration found (%)	Safe level?
Oxygen	1.8 - 8.8 (3.5 avg.)	
Nitrogen	74.1 - 78.5 (76.3 avg.)	
Carbon Dioxide	11.62	
Hydrogen Sulfide	0.0 - 1.9 ppm (0.5 ppm avg.)	
Methane	0.1 - 3.8 (1.7% avg.)	

A 35-year old male water system operator (victim) was asphyxiated after entering a valve vault at a municipal water system plant. The victim was assigned to turn on a water line valve serving a nearby tree farm. The valve was located at the water treatment plant inside an underground valve vault that "always had normal air." The victim entered the valve vault through a ground-level manhole without testing or ventilating the vault atmosphere. A co-worker, who had last seen the victim 1 hour earlier, checked the manhole and saw the victim lying on his back at the bottom. The victim did not respond to any calls. Other workers summoned from the plant building and local fire department personnel ventilated the valve vault and removed the victim. Note there were no other fatalities.

There was no full-time safety manager. Employees rotated the responsibility of "safety manager" among themselves on a monthly basis.

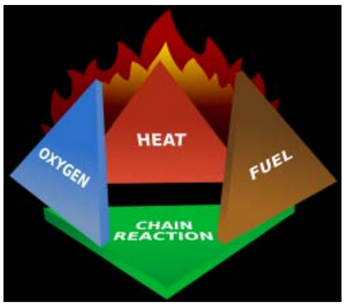
Based on these facts and the results above, what do you think happened? Write your answers below. Don't turn the page, please.

The vault atmosphere was subsequently found to be oxygen deficient. There were no witnesses to the incident, but evidence suggests that the victim lost consciousness and fell from the ladder railings to the bottom of the vault.

NIOSH investigators determined that to prevent future similar occurrences, employers should recognize that confined space atmospheres are dynamic environments subject to unexpected changes, and address those dynamics in all written and practiced safe work procedures and subsequent worker training

In addition, municipalities should ensure that police, as well as fire and rescue personnel, are trained in confined space entry and rescue procedures.

A fire needs fuel, heat, oxygen and a *chain reaction* to burn.



The NFPA no longer teaches the "fire triangle" choosing to illustrate the process with this tetrahedron, which includes a chain reaction.

NFPA Fire Tetrahedron
Courtesy Wikimedia Free

Toxic gases and vapors may rise or sink in a confined space. Which way do most go?

Vapor density is the weight of a gas compared to normal air. Gases that are lighter than normal air, those with a vapor density of less than 1, will rise to the top of a confined space. Heavier vapors, those greater than 1, will sink. Two common hazards in confined spaces are methane and hydrogen sulfide. Methane, which is an explosive hazard, rises to the top of the space. Hydrogen sulfide, a toxic gas, is found in the lower depths of the space.

This chlorine rail car leak illustrates how most industrial gases behave.

This photo illustrates a gas that is denser than air courtesy of KTVI TV in St. Louis. The greenish-white fog you see is chlorine gas leaking from the tank car dome, running down the side of the car, and then pooling in the rail yard.

Photo courtesy KTVI TV in St. Louis

There are many potential physical hazards in confined spaces that must be controlled.

Uncontrolled Energy Sources

Electrical or mechanical equipment can be improperly activated. If equipment is only turned off with a switch, but still energized, it could be turned on and activated by someone outside the space. Hydraulic, pneumatic, mechanical, heat or chemical energy are other types of energy that are used to run equipment.

Engulfment

Workers can be engulfed by materials in a confined space. Gravel, sand, paving and other solid materials can bury a worker in a confined space. Liquids could cause a worker to drown.

Workers can be buried in a matter of seconds when the sides of a trench collapse. A worker can die even if the soil does not cover the person's head. Soil is so heavy that a person will not be able to breathe if the dirt surrounds their stomach and chest.

An unprotected wall collapsed in this trench killing a 17 year-old worker. The day before an excavator had removed the trench shield to allow access to broken sewer pipes.

Conditions that increase the chance of cave-ins include:

- digging in unstable soil or in soil that has been dug before,
- vibration from construction equipment or traffic near the dig,
- too much weight on the sides of the trench,
- water that has collected in the hole, and
- changes in the weather such as freezing, melting snow or ice, or heavy rain.

Other serious dangers of trenching and excavation operations include:

- contact with underground utility lines,
- being crushed or struck by equipment, and
- air containing toxic gases and vapors or not have enough oxygen.

NIOSH case study of an engulfment fatality at a concrete pipe plant

This is from NIOSH's FACE Investigation # 98NJ047, which was done in New Jersey.

On June 6, 1998, a 56 year-old worker died when he was engulfed by sand in a hopper at a concrete pipe manufacturing company. His job as a "material man" was to direct the flow of sand and gravel from storage bins to hoppers housed in a shed on top of the plant. Since there was only one conveyor that moved sand and gravel from storage bins to the shed, the material man had to enter the shed and manually operate a lever that controlled the flow of sand or gravel into the correct hopper. He entered the 17 foot deep hopper filled with sand, perhaps by falling, was engulfed, and suffocated.

FACE investigators concluded that in order to prevent similar incidents, the following safety guidelines should be followed:

- The employer should develop, implement, and enforce a permit-required confined space entry program.
- The employer should conduct a job hazard analysis; policies and training should be implemented based upon the findings of the evaluation.
- The employer should consider establishing a joint labor/management safety and health committee.

Temperature Extremes

The temperature in a confined space can range from very cold to very hot.

Cold environments can cause injuries.

Cold environments can cause a number of injuries.

- *Frostbite* occurs as the body tries to prevent heat loss by having less blood going to the body's surface. Hands and feet become numb and the skin freezes. Severe frostbite may require amputating the affected parts. Do not rub frost-bitten areas. Warm the area by soaking or running under cool or lukewarm water.
- *Hypothermia* is a condition that results from being in cold weather or submerged in cold water. The body can no longer create heat, causing dizziness, fatigue, and can lead to unconsciousness and death.
- *Trench foot* results from long periods of exposure to wet and cold conditions, which can cause severe nerve and muscle damage in the feet.

Our physiological responses to cold stress are less effective than our responses to heat stress. What is the main response?

We primarily depend on behaviors, such as increasing insulation with clothing, increasing activity levels and moving to warmer locations, to limit cold stress.

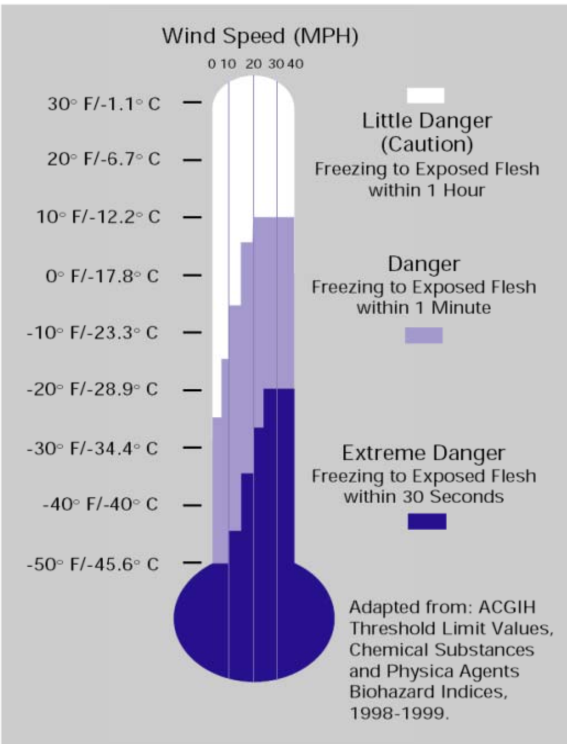
Photo courtesy U.S Department of Defense (Air Force)

Manual dexterity decreases with temperature below 60°F.

How could this affect work in a confined space?

Write your answers below.

Wind-chill index is the accepted measure of cold stress.

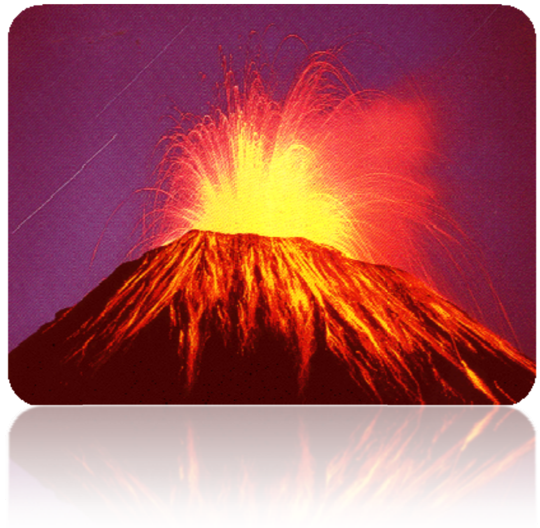


Wind-chill, also known as equivalent chill temperature (ECT), is often used to determine an approximate time before frostbite is a concern. The index considers both air temperature and wind speed and provides a measure of heat exchange between a person and the environment.

Wind
Wetness
+ Low temperature
INJURY AND ILLNESS

Heat Stress can be like a volcano - explosive and deadly.

Heat stroke can come on suddenly and explosively.



- Fifty percent of individuals stricken by heat stroke will either die or have permanent brain damage.
- There are many more cases of heat illnesses than heat stroke. They represent a larger portion of the volcano. Any incident should be given serious consideration: it could erupt in heat stroke.
- An even greater portion of the volcano is filled with the jobs that involve excess heat. There are many jobs, including the testing of new technologies that expose workers to excess heat. We need to recognize that all of them could lead to illness and stroke if preventive measures are not consistently taken.

Exposure to excessive heat also causes problems.

Humidity adds to the problem. The heat index shown here calculates how the environment feels based on temperature and humidity. As the combination of heat and humidity rises, so do the health risks.

Heat Index (Apparent Temperature)

Relative Humidity (%) / Air Temperature (°F)

°F	40	45	50	55	60	65	70	75	80	85	90	95	100
110	136												
108	130	137											
106	124	130	137										
104	119	124	131	137									
102	114	119	124	130	137								
100	109	114	118	124	129	136							
98	105	109	113	117	123	128	134						
96	101	104	108	112	116	121	126	132					
94	97	100	102	106	110	114	119	124	129	136			
92	94	96	99	101	105	108	112	116	121	126	131		
90	91	93	95	97	100	103	106	109	113	117	122	127	132
88	88	89	91	93	95	98	100	103	106	110	113	117	121
86	85	87	88	89	91	93	95	97	100	102	105	108	112
84	83	84	85	86	88	89	90	92	94	96	98	100	103
82	81	82	83	84	84	85	86	88	89	90	91	93	95
80	80	80	81	81	82	82	83	84	84	85	86	86	87

With Prolonged Exposure and/or Physical Activity

Extreme Danger	Heat stroke or sunstroke highly likely
Danger	Sunstroke, muscle cramps, and/or heat exhaustion likely
Extreme Caution	Sunstroke, muscle cramps, and/or heat exhaustion possible
Caution	Fatigue possible

Problems caused by excessive heat include:

- *Heat rash* is also known as prickly heat.
- *Heat cramps* are painful muscle spasms. The cramps usually are felt in the arms, legs and stomach area. They usually occur after sweating heavily and not drinking enough liquids.
- *Heat exhaustion* symptoms include tiredness, dizziness, clammy skin, heavy sweating, loss of appetite, nausea and pain in the stomach area. These symptoms are brought on when the body loses too much fluid (dehydration) during hard physical labor.
- *Heat stroke* means the body can no longer cool itself. The person's skin becomes hot and red or blotchy, and their body temperature is as high as 105 degrees or more. Heat stroke can cause a person to lose consciousness and go into a coma. **Heat stroke can kill**; it is a condition that needs immediate medical attention.

DOE asked the IUOE to survey workers about heat exposures.

This is an important study that the IUOE conducted on behalf of the Department of Energy's environmental cleanup organization (EM) in 2001.

- January 2001, surveyed 197 workers selected randomly from IUOE training database
- 97% reported receiving heat stress training
- 58% indicated they would benefit from additional training
- 63% said there had been times when their ability to perform their job could have been improved by technologies that reduce heat stress exposure

Heat stress is a production and safety issue, too.

- Workers aren't as alert or productive in the heat.
- A 1993 study of Israeli helicopter pilot errors (n=500) found dose-response relationship with ambient temperature. (Froom)
- Work/rest scheduling can greatly increase the amount of productive work time.

Putting workers in impermeable suits greatly increases the risk of heat stress illnesses.

Two workers operate a floor scabbler to remove contamination.

Confined spaces can increase noise levels.

Too much noise can damage hearing. Continuous or periodic noise can be harmful. A temporary hearing loss may last for minutes, hours or days, but normal hearing does return. Permanent hearing loss usually develops gradually from being exposed to high levels of noise over a long period of time.

Other effects of excessive noise include fatigue, nervousness and increased blood pressure, which can lead to problems such as heart disease.

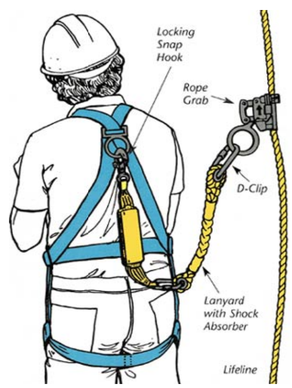
The level of sound is measured in units called decibels. The abbreviation for decibels is dB. On the decibel scale, each time the number of decibels goes up by three, the level of the noise is doubled. In other words, 93 decibels is a noise that is twice as loud as a sound that is 90 decibels. A whisper at 5 feet is 25 decibels, a quiet office is 40, a conversation is 60, a printing press is 80, heavy city street traffic is 90, a jackhammer is 110 and a gunshot is 140 decibels.

Confined spaces may contain safety hazards such as slips, trips and falls.

Many confined spaces have surfaces that are wet or covered with other slippery material. The shape of the floor or walls may be sloped, curved or otherwise make it easy to lose your balance. Workers may also trip over chords, pipes or other objects.

Precautions must be taken to prevent objects from falling and striking workers in a confined space.

Measures need to be taken to avoid having objects fall on workers down below in confined spaces. Loose and unsecured objects should be kept away from the entrance to the space.

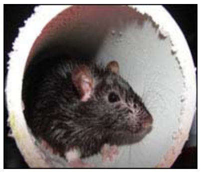


Safeguards must be used to prevent workers from falls while entering, working in, and exiting confined spaces.

These precautions include barriers around the entrance of a space to prevent unintentional entry. Ladders and other means of entering a space must be secure. Fall arrest systems should be used.

Biological hazards of various kinds can be found in confined spaces.

Different types of animals could be in a confined space.



Animals of many types could be in a confined space. Snakes, rats and other rodents, and insects can cause injuries through bites or by contact with feces.

There are also microscopic organisms that can cause illnesses.

As with chemicals, infectious agents can enter the body through the same routes of entry as chemicals and other hazards. Germs can be inhaled, particularly in dry dusty conditions. Infectious agents can be swallowed, especially if workers do not have hand washing facilities and other sanitary measures.

While the skin provides a very effective protective barrier against infectious agents, germs can also enter the body through mucous membranes. Mucosa is moist tissue that lines some organs and body cavities throughout the body, including your nose, mouth, lungs, and digestive tract. And infectious agents can enter through breaks in the skin.

Bacteria

There are also potential microscopic organisms that can cause illnesses, especially in confined spaces containing wastewater.

- Staphylococci (staf-*uh*-l*uh*-**kok**-i) can cause stomach and intestinal problems, fever, nausea, vomiting, headache and diarrhea. It can also cause skin infections as well as lung and respiratory disease.
- Salmonella (sal-m*uh*-**nel**-*uh*) causes diarrhea, fever, and abdominal cramps 12 to 72 hours after infection. Although salmonella is usually spread through contaminated food, the bacteria can be found in animals, including reptiles such as lizards and snakes.
- Shigella (shi-**gel**-*uh*) can produce intestinal symptoms and distress, including high temperatures, vomiting and bloody stools.
- Leptospirosis (lep-toh-spahy-**roh**-sis), or Weil's disease, can produce intestinal symptoms, liver and kidney disease, eye problems and jaundice. It is especially common where rats are present.
- E. coli causes diarrhea, vomiting and fever.

Viruses

- Hepatitis A is a virus that attacks the liver. The infectious agent is found in feces that can be swallowed if hands are not washed before eating, smoking or drinking. Hepatitis A causes fever, abdominal discomfort, nausea and jaundice (yellowing of the skin).
- Hepatitis B and C, by contrast, are spread through contact with blood or other body fluids containing blood and can also cause serious and evening fatal liver disease.
- HIV/AIDS (Human Immunodeficiency Virus) is the virus that causes and is also spread through contact with blood. Acquired Immune Deficiency Syndrome (AIDS). HIV destroys the body's immune system, leaving those infected at risk of developing "opportunistic" infections.

Fungi (also called molds)

Fungi are primitive organisms that grow in decaying material. Workers in dusty sludge composting areas are exposed to fungi that may cause respiratory and other health problems. For more information see the IUOE Manual, *Protecting Ourselves From Mold: Awareness Training for Operating Engineers.*

Parasites

Parasites feed off other living organisms. Infection can occur when workers swallow these parasites and their cysts or if they touch their mouths, smoke with dirty hands or swallow contaminated food. Tapeworms, hookworms and roundworms are examples of parasites.

Workers suffer back injuries and other repetitive strain injuries (RSIs) when working in confined spaces.

Ergonomics means changing the job to fit the needs of the worker. Workers develop back and other repetitive strain injuries (RSIs) when they are exposed to conditions that put undue stress on muscles, joints, and other parts of the musculoskeletal system.
A risk factor is a working condition that increases the chance of developing a repetitive strain injury, or RSI. Each of the risk factors can cause problems by themselves. However, it is often the case that workers are exposed to more than one risk factor at a time.

Awkward postures, such as bending, twisting and reaching increase the chances of injuries.

Whether standing or sitting, there is a neutral position for the back, neck, arms and hands. This is the position that puts the least amount of physical strain on the particular part of the body. Postures that differ from the neutral position increase stress on the body.

There are other important risk factors that cause RSIs.

- ***Repetitive motion*** refers to performing the same motion or motion pattern every few seconds or on a continuous basis for hours at a time.
- ***Forceful movement*** is the effort or pressure workers need to perform various tasks. Forceful movements include lifting a heavy object, unscrewing a rusted bolt, or squeezing an object in your hand.
- ***Duration*** is the amount of time, or duration, workers perform a motion or movement pattern during the workday.
- ***Recovery time*** is rest or a break from a risk factor.
- ***Vibration*** can affect particular parts of body, such as the hands, when using power tools. This is known as localized vibration. Workers who operate heavy equipment, drive trucks or work with jackhammers are exposed to whole body vibration.
- Uncomfortable ***environmental conditions*** can be dangerous as well as unpleasant. Workers use more force to grip tools when their hands are cold. High temperature and humidity can make workers drowsy and less alert. Excessive noise damages hearing.
- ***Work organization*** refers to the way jobs are organized. These factors include staffing levels, scheduling workload and job pacing.

Common Repetitive Strain Injuries and Their Causes		
Repetitive Strain Injury	**Symptoms**	**Risk Factors**
Back injury	pain, restricted movement and mobility	awkward posture, repetition, force, duration
Carpal Tunnel Syndrome	pain, numbness, tingling in the hands, weakness and clumsiness of the hands	repetition, working with wrists bent, and/or forceful hand movements
Ganglion Cysts (“Bible Bumps”)	swelling that forms a lump on the wrist	repetition and working with wrists bent
DeQuervain’s Disease	pain and inflammation at the base of the thumb	repetition of a “clothes-wringing” motion
Raynaud’s Syndrome “white finger”	loss of control and feeling in fingers and hands, numbness or tingling in the fingers	forceful gripping, vibration, cold and/or wet environment
Trigger Finger	pain and inflammation on the palm side of index finger	forceful gripping of hard/sharp edges, repetition
Tendinitis	pain and inflammation in any joint such as elbows, wrists, knees, etc.	repetition and awkward posture
Tennis Elbow (epicondylitis)	pain and inflammation in elbow	repetition, rotation of forearm, or force
Rotator Cuff/Tendinitis	pain and restricted motion in shoulder, may lead to arthritis	repetition, overhead work, or working with arms in a "winging motion"

Confined spaces at disaster sites pose extra dangers.

Take extra care at disaster sites. Disaster sites are unique work areas. Unknown and chaotic situations add to the risk of confined space hazards you may face. Damaged structural integrity, collapsed structures, compromised and unstable ground may create confined spaces as well as contain issues that would lead to permit required confined spaces. Many times, these spaces are a product of the disaster and can only be controlled by demolition and cleaning the debris. Structural integrity also adds another level of risk; not only may it have created a confined space but, it can further affect your safety and health by affecting the space you are working in.

Structures may shift or collapse, entrapping you or damaging chemical containers, utilities or other previously contained hazards. Adjacent work may also cause debris piles or structures to become agitated and potentially shift or collapse.

One problem seen during the World Trade Center clean up were employees and equipment falling through their work surface or debris piles into voids because equipment was pulling or shifting debris some distance away from the workers who fell. Also, the disaster may have created a void that was undetected until something or someone fell through it.

Electrical, chemical and other utilities may be unsecured at disaster sites. The presence of these hazards may cause serious injury or death, especially if you encounter them in a confined space. Learn how to discover and evaluate a disaster site for confined spaces and develop a site safety plan that addresses those specific site confined space issues.

Some hazards that you may encounter while working in confined spaces on disaster site may include:

- Weak structural integrity resulting in space shifting or collapse
- Sharp debris
- Unsecured electrical issues
- Unsecured chemicals
- Water (potentially grey and black water)
- Falls
- Voids
- Gases and vapor created by the natural environment
- Extreme heat or potential for fire
- Hot work issues
- Trapped personnel, potentially injured or deceased
- Increased feelings of claustrophobia and anxiety due to the stressors of the disaster site (including lack of sleep, proper food and fluids, depression, etc.)

NEVER enter into a confined space on a disaster site if it has not been properly evaluated for atmospheric, structural and other hazards.

Module 4: How is the air in confined spaces monitored?

Objectives

After completing this section you will be able to:

- ✓ Name different types of air monitors that are used in confined spaces;
- ✓ Explain when and where to monitor the air in a confined space;
- ✓ Describe the readings of air monitors for oxygen content and other gases and vapors; and
- ✓ List two methods other than air monitoring that can be used to find hazards in confined spaces.

The key is to find out if there are any hazards BEFORE entering a confined space.

In the last section we discussed a large number and wide variety of hazards that could be present in a confined space. In fact, some of the conditions pose situation that are immediately dangerous to life or health, or IDLH. It is critical that hazards and potential dangers are identified BEFORE a worker enters a confined space.

In this section we are will cover air monitoring and other methods that are used to find hazards and inform workers of dangers that are present.

Remember, an entry occurs if *any* part of the body passes through an opening of a confined space.

That means steps must be taken to find out if there are any hazards before the entry begins. For example, it is not a safe or permissible action to poke your head into a space to 'have a look' without first testing the air. If there is something toxic in the air at the top of the confined space, the worker will inhale it and maybe get very sick or even worse.

There has been much improvement since the first types of air monitoring systems.

You have all probably heard about the early warning system used by miners. When the canary in the cage keeled over, it was time to get out of the mine. Fortunately, our methods to detect atmospheric hazards have greatly improved.

Rule # 1: Your nose is not an adequate air monitor.

Don't depend on your nose to detect dangerous conditions in the atmosphere. Your nose cannot tell if there is too little or too much oxygen in the air. Carbon dioxide and carbon monoxide are colorless and odorless. Relying on your sense of smell is dangerous even if a hazardous chemical has an odor. For example, hydrogen sulfide smells like rotten eggs at low levels. At higher levels, hydrogen sulfide deadens your sense of smell so that you cannot smell it when concentrations have reached a point that will kill a person. The situation in which exposure overwhelms the ability to smell something is called *olfactory fatigue*. Still with other substances, you will not be able to smell a hazardous substance until you are already being exposed at a dangerous level.

OSHA says there are two "distinct purposes" for testing the air in a confined space. What are they?

Write your answers below.

Here is the exact language from OSHA's Appendix B to 1910.146:

"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.
(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.

Who does OSHA recommend to do the testing?

OSHA language from 1910.146 Appendix B:

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.
Examples of "technically qualified professional":

- Certified Industrial Hygienist
- Registered Safety Engineer
- Certified Safety Professional
- Certified Marine Chemist

OSHA requires testing the air in the following order before entering a confined space. Why?

Write your answers below. Don't look on the next page, please.

Air monitoring is performed to answer three questions before entering a confined space. Testing to answer these questions must be done in the following order:

1. Is the amount of oxygen safe?
2. Are there explosive gases and vapors?
3. Are there toxic gases and vapors?

The order of sampling is absolutely critical because if there is insufficient oxygen, the combustible gas sensor, which relies on a wheatstone bridge, will not work. This means that a space could be oxygen deficient AND full of an explosive gas, like methane, and a combustible gas monitor may indicate no hazard. Toxic vapors are last to be checked because the potential of an explosion is considered more critical by OSHA.

Procedures for Atmospheric Testing - 1910.146 App B, 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 gases 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 gases and vapors. If tests for toxic gases and vapors are necessary, they are performed last.

Oxygen Content

In the section on hazards we learned the dangers of too little or too much oxygen in a confined space. A concentration of less than 19.5% oxygen is considered to be oxygen deficient. As the amount of oxygen in a space decreases, the risk of injury and death increases. Too much oxygen in a confined space also presents a danger. An oxygen level over 23.5% is oxygen enriched and increases the chances of fires and other dangers.

A confined space that is completely oxygen-deficient is the deadliest work environment possible. Why? How do they occur?

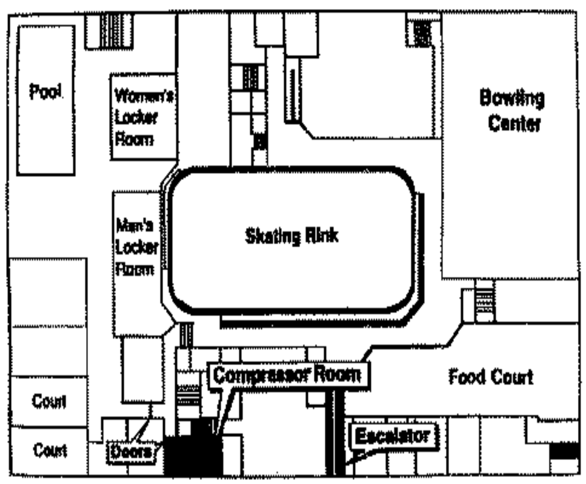
Write your answers below.

A confined space that has almost no oxygen is much deadlier than even one containing a poisonous atmosphere because the first breath causes the worker to blackout. How do they occur? Nature abhors a vacuum, but many tanks and processes are purposely covered with an inerting gas to keep oxygen from causing rust or other damage to metal structures and components. Additionally, biological processes can generate enough methane or hydrogen sulfide to create a very low oxygen concentration in sewers, septic tanks and manure pits.

Case study of an oxygen-deficiency fatality (NIOSH, 1991)

An assistant ice rink manager (the victim) died of asphyxiation when he attempted to stop a leak of refrigeration system gas (chlorodifluoromethane 22 or CFC-22) inside the compressor room at a mall complex. The refrigeration system had been leaking for an extended period of time when the victim, a maintenance supervisor, and a maintenance worker entered the compressor room through self-closing doors.

FACE 91-13
Figure



All three individuals became unconscious and collapsed. The maintenance worker and supervisor were rescued and resuscitated by emergency rescue personnel. Since the victim was not in plain sight and rescue personnel were unaware of his presence, the victim was not immediately removed from the room. After being informed by a witness that a third person was in the room, rescue personnel reentered the room and extracted the victim. He could not be resuscitated. The victim and the maintenance supervisor wore air-purifying respirators, however, this type of respirator was inappropriate for the oxygen-deficient atmosphere. During the rescue, an emergency medical technician entered the room without wearing any respiratory protection. **Cause of death:** The medical examiner listed the cause of death as asphyxiation by oxygen displacement with refrigerant (CFC-22).

What could have been done to prevent this? Write your answer below.

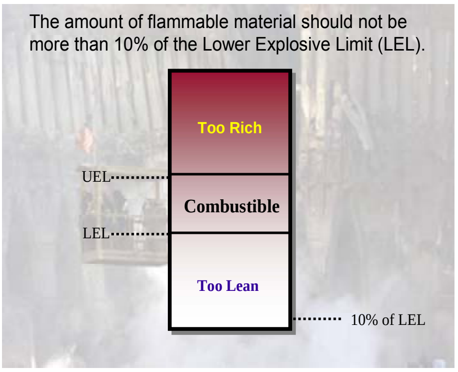
Recommendations on prevention: Employers who operate refrigeration systems should ensure that workers are protected from harmful exposure to refrigerants. Appropriate engineering controls should be used when necessary to prevent harmful exposures. According to the American Society of Heating, Refrigeration and Air-conditioning Engineers, Inc. (ASHRAE) Standard (ANSI/ASHRAE 15-1989), the following control measures are required for this type of refrigeration system. None of these controls were in place before this incident occurred: "Emergency remote controls to stop the action of the refrigerant compressor shall be provided and located immediately outside the machinery room." In this incident the shutoff switch to the compressor was located inside the compressor room.

Machinery rooms "... shall have continuous ventilation or be equipped with a vapor detector that will automatically start the ventilation system and actuate an alarm at the lowest practical detection levels not exceeding the volume percent limits ..." (or when CFC-22, or other Group I refrigerants cause the volume of oxygen to fall below 20%). "The vapor detector shall also initiate a supervised alarm so corrective action can be initiated. Mechanical ventilation "... shall be by one or more power- driven fans capable of exhausting air from the machinery room at least in the amount given in the formula in paragraph 10.13.6.2." To provide adequate ventilation, the exhaust air intake should be located in an area where refrigerant vapor from a leak is likely to concentrate. The exhaust air intake should therefore be located near the floor level for CFC-22 and other refrigerants heavier than air. In this incident the exhaust air intake was located approximately 8 feet above the compressor room floor.

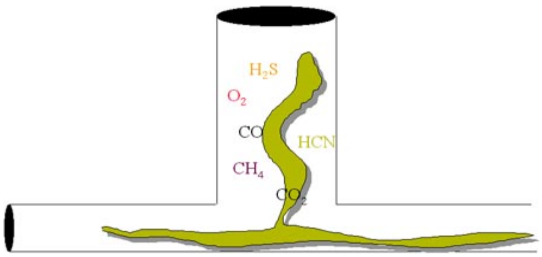
"Emergency remote controls for the mechanical means of ventilation shall be provided and located outside the machinery room." In this incident the exhaust ventilation power switch was located inside the compressor room.

The second test is to look for combustible gases and vapors.

This diagram is a reminder that a particular substance will burn if it is present between the upper and lower explosive limits. The air must be tested to make sure it is below ten percent of the lower explosive limit. The ten percent figure provides a margin of safety from potential fire and explosion hazards. Spaces containing more than ten percent of the LEL must not be entered. It is important that the oxygen is measured first. If there is not enough oxygen, the reading for explosive gases and vapors may not be accurate. When the air contains less than 15% oxygen, the measurement for explosive gases or vapors may be falsely low.



There are many possible toxic gases and vapors that can lurk in a confined space.



Finding out if there are dangerous gases or vapors in a confined space can be very difficult. Some toxic chemicals such as hydrogen sulfide are produced as sewage or other organic material is broken down. Chemical spills, dumping or runoff are examples of how hazardous materials can find their way into confined spaces.

Testing for toxic substances poses greater challenges than monitoring for oxygen. Each chemical must be measured. In addition, chemicals can interact with each other causing even greater dangers.

Direct-reading air monitors provide a quick answer to what is in the air.

Workers need to be aware of the oxygen content and presence of explosive and flammable substances before entering a confined space. They also need to be alerted right away if safe conditions change while they are in the confined space. Direct-reading monitors are used in confined spaces to test the air at that particular moment. The most common types of direct-reading monitors test for oxygen, explosive and toxic vapors and gases. These instruments have a limited ability for test for toxic gases and vapors.

Oxygen sensors use electrochemical cells to detect oxygen in the atmosphere. The conditions at the time the instrument is used can cause faulty readings. For example too much moisture or humidity or temperatures below freezing or above 104 degrees Fahrenheit can affect the sensor. The presence of some chemicals can also trigger false readings. Combustible-gas indicators (GCIs) use sensors that measure the total amount of explosive gas as a percentage of the lower explosive limit.

There are only a small number of chemical sensors available for direct-read air monitors. These include:

- ammonia
- carbon dioxide
- carbon monoxide
- chlorine
- hydrogen cyanide
- hydrogen sulfide
- nitrogen oxide
- ozone

Obviously, there are many more hazardous substances that could be in a confined space.

A monitor must be checked, or calibrated, to make sure it will provide an accurate reading.

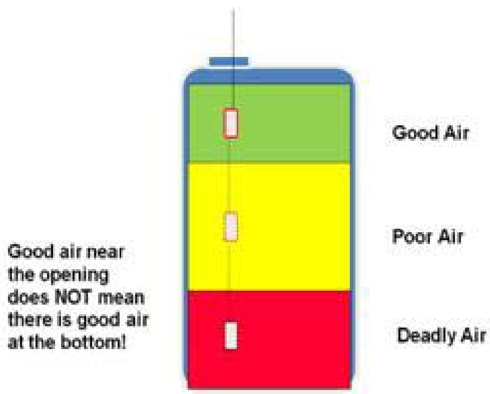
Before an air monitor is used it must be checked to make sure it will provide an accurate reading. Air monitors should be bench calibrated at least once every six months. Bench calibration is done in the factory or by a certified technician. The date of the bench calibration should be noted on the outside of the instrument.

Air monitors also need to be calibrated before each use. Field calibration is performed with a special gas. If an air monitor is used for more than eight hours it may need to be field calibrated more than once during that day.

Toxic gases and vapors may rise or sink in a confined space.

Gases that are lighter than normal air will rise to the top of a confined space and heavier ones will sink. Two common hazards in confined spaces are methane and hydrogen sulfide. The methane, which is an explosive hazard, rises to the top of the space. Hydrogen sulfide, a toxic gas, is found in the lower depths of the space.

Test the air at different levels to be sure the entire space is safe.



Because toxic substances may be at different levels in the confined space, it is necessary to test the air in different places in the confined space. Begin monitoring from outside the space. If there is a cover, leave it in place. Collect the air sample by inserting a sampling probe into the space. If the first test shows that the air is safe, remove the cover to the space if there is one and test the air every four feet down.

Attach the probe to a long sturdy pole. Since the air within a confined space may not be evenly mixed, it is necessary to sample at various levels. Sampling every four feet ensures that you will detect gases and vapors that have accumulated in the confined space. The amount of time it takes to get a reading will depend on the type of monitor that is being used. The air within a confined space can change rapidly. Therefore, the air should be monitored on an ongoing basis while a worker is in the space. Monitors can be worn on a belt or in a pocket. If possible, the tubing should draw air near the worker's nose and mouth, which is the worker's breathing zone.

There are other types of devices that can be used to measure toxic gases and vapors.

Detector tubes can be used to measure hundreds of substances. Since each tube is made to find a specific chemical, you must know the gas or vapor you are looking for. The colorimetric tubes are used with a pump. Air is drawn in by the pump and passes through the tube. A chemical reaction will take place if the substance is present and will cause a color change in the tube. Air is drawn by a pump through a cassette that is worn in the worker's breathing zone. The cassette must then be sent to laboratory to be analyzed. Therefore, this type of equipment cannot give the worker timely information about hazards that might be present.

Here are the correct procedures for using detector tubes in a confined space:

1. Select the tube to match the substance you are testing for.
2. Check the expiration date on the tube to make sure it is still good.
3. Break both ends of the tube before using.
4. Make sure the pump passes a leak test.
5. Draw the correct amount of air for each sample.
6. Collect the samples from where the entrant will be working in the confined space.

Personal air sampling is of limited value for confined spaces.

Workers need to be aware of the oxygen content and presence of explosive and flammable substances before entering a confined space. They also need to be alerted right away if safe conditions change while they are in the confined space. That is why direct reading instruments are used.

Personal air sampling equipment is of limited value. Air is drawn by a pump through a cassette that is worn in the worker's breathing zone. The cassette must then be sent to a laboratory to be analyzed. Therefore, this type of equipment cannot give the worker timely information about hazards that might be present. Personnel air sampling equipment provides data about the worker's exposure to a substance over a work shift. This information can be useful in tracking a worker's exposure to hazardous substances or selecting equipment and procedures that might be used.

Why might personal sampling in a confined space be difficult for *this* worker? Write your answers below.

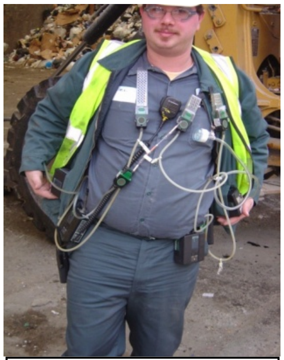


Photo courtesy
Wheelabrator Corp.

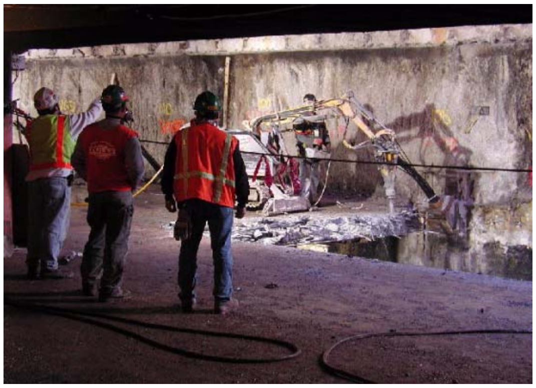
Other methods must be used to monitor for hazards in and near confined spaces.

In addition to testing for atmospheric hazards, there is equipment to detect other problems. As discussed in the previous section, a dosimeter is used to measures noise levels.

Hazard assessment: There are methods other than air monitoring that can be used to alert workers of dangers in a confined space.

Disasters can add to the hazards that may already be present in a confined space. Contaminated air, water or soil from a natural disaster or accident can find their way into places near and far away from the sight of the incident. Therefore, entering a confined space as part of an emergency response or cleanup may require extra caution and measures to find out what may be lurking inside.

Emergency response actions can pose additional challenges.



Unexpected situations can add urgency to tasks that need to be performed. However, it is still necessary to identify hazards before entry and follow safe permit-required entry procedures. This piece of remote-controlled equipment is being used at the WTC to jackhammer concrete. This was field tested through the Department of Energy by the IUOE Hazmat unit.

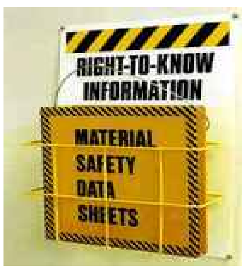
What is the advantage of this device?

The remote device allows the operator to stand away from the fall hazard.

You may be able to identify situations in the surrounding area that indicate a potential problem.

This photograph shows a pile of improperly stored chemical drums. If these containers were near a confined space or a waterway, hazardous chemicals could leak and find their way into a space a worker needed to enter.

Hazard assessment: The presence of hazardous substances in the workplace must be communicated. (1910.1200)



As we will discuss in greater detail later in this course, the employer must inform workers about hazardous substances in the workplace. This applies to confined space work as well. Employers must have a material safety data sheet available for workers that inform them of the hazard and how to protect themselves. Labels are another method to communicate about hazards in the workplace. For example, a worker may have to enter a steam tunnel that has pipes covered with asbestos insulation. A label on the outside of the confined space provides a warning before entering the area.

Hazard assessment: Identify tasks that workers perform in a confined space that can create dangers.

The task a worker performs in a confined space can greatly increase the dangers of working in a confined space. Welding could start a fire or cause an explosion if there are combustible gases present. Welding uses use up oxygen that is in the air, causing a potential asphyxiation danger.

Module 5: How do we communicate the hazards of confined spaces?

Issues and topics for discussion:

- Why is hazard communication important?
- What are employer's responsibilities for hazard communication?
- What are HAZCOM 2012 and the Globally Harmonized System of Hazard Classification?
- How does HAZCOM 2012 classify and communicate hazards to workers?

Introduction

Employees have both a need and a right to know the identities and hazards of the chemicals they are exposed to when working. They also need to know how to protect themselves from the adverse effects from exposure. The HazCom standard provides language that protects the worker from health hazards that may be encountered when the worker is exposed to even small amounts of a chemical.

What is hazard communication?

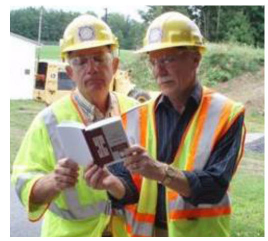


Figure 4.1 Workers strudy the Hazard Communication Standard on the job.

Hazard Communication (Hazcom) is the communication of chemical hazards to workers. Why is this important?

OSHA has a Hazcom standard. Why have one?

- 32 million workers work with, and are potentially exposed to, one or more chemical hazards - OSHA.
- 69,053,967 chemicals are commercially available - CHEMCATS
- Over 600 new chemicals are introduced every year - CAS
- Only 295,207 substances are inventoried or regulated-CHEMLIST
- Roughly 22% of workplace diseases and injuries are caused by chemicals- International Labor Organization

According to the International Labor Organization's (ILO) 2011 report on occupational disease, there are 41 known occupational diseases caused by chemical agents.

The Hazard Communication Standard is also known as:

- "Hazcom", also known as: "RIGHT TO KNOW"
- OSHA 29 CFR 1910.1200 or "HCS" or HCS 2012

OSHA describes the HCS as largely a performance-oriented standard that gives employers the flexibility to adapt the rule to the needs of the workplace, instead of having to follow specific, rigid requirements. Consequently, the HCS generally identifies categories of information to be included in the MSDS, including physical and chemical characteristics, physical hazards, and applicable precautions and/or control measures for handling materials safely.

The Hazard Communication Standard (HCS) is based on a simple concept: workers have both a need and a right to know the identities of the chemicals they are exposed to when working and the hazards associated with these chemicals. They also need to know what protective measures are available to prevent adverse effects from occurring. The HCS is designed to provide employees with the information they need.

Knowledge acquired under the HCS will help employers provide safer workplaces for their workers. When employers have information about the chemicals being used, they can take steps to reduce exposures, substitute less hazardous materials, and establish proper work practices. These efforts will help prevent the occurrence of work-related illnesses and injuries caused by chemicals.

The HCS addresses the issues of evaluating and communicating hazards to workers. Evaluation of chemical hazards involves a number of technical concepts, and is a process that requires the professional judgment of experienced experts. That's why the HCS is designed so that employers who simply use chemicals, rather than produce or import them, are not required to evaluate the hazards of those chemicals. Hazard determination is the responsibility of the producers and importers of the materials. Producers and importers of chemicals are then required to provide the hazard information to employers that purchase their products.

Employers that don't produce or import chemicals need only focus on those parts of the rule that deal with establishing a workplace program and communicating information to their workers. This course is a general guide for such employers to help them determine what's required under the rule. It does not supplant or substitute for the regulatory provisions, but rather provides a simplified outline of the steps an average employer would follow to meet those requirements.

29 CFR 1910.1200 contains 11 paragraphs and 6 appendices

a. Purpose
b. Scope
c. Definitions
d. Hazard classification
e. Written hazard communication program
f. Labels and other forms of warning
g. Safety Data Sheets
h. Employee information and training
i. Trade secrets
j. Effective dates
k. Other standards affected
App. Appendix: A through E

The HCS helps to ensure that workers and employers understand the hazards of chemicals they use or work around. HCS Appendices list mandatory requirements for hazard characterization, labels, SDS, trade secrets and non-mandatory guidance for carcinogens.

Requirements in the Hazcom standard protect workers

- Written Hazcom Program
- Chemical inventory and control
- Hazard classification of chemicals
- SDSs available for hazardous substances in the workplace
- Labeling of hazardous chemicals
- Training workers
- Makes required information available

What is a Hazcom Program?

Employers must develop, implement, and maintain a written, comprehensive Hazcom program at the workplace. A program is the employer's procedure for meeting the requirements of a particular regulation. Workers have the right to review the Hazcom program on work time.

The OHSA Hazard Communication Standard of 2012 incorporates GHS. The Hazard Communication Standard in 1983 gave the workers the 'right to know,' but the new Globally Harmonized System gives workers the 'right to understand.'

New changes to the Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard are bringing the United States into alignment with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS), further improving safety and health protections for America's workers. Building on the success of OSHA's current Hazard Communication Standard, the GHS is expected to prevent injuries and illnesses, save lives and improve trade conditions for chemical manufacturers. The Hazard Communication Standard in 1983 gave the workers the 'right to know,' but the new Globally Harmonized System gives workers the 'right to understand.'

The new hazard communication standard still requires chemical manufacturers and importers to evaluate the chemicals they produce or import and provide hazard information to employers and workers by putting labels on containers and preparing safety data sheets. However, the old standard allowed chemical manufacturers and importers to convey hazard information on labels and material safety data sheets in whatever format they chose. The modified standard provides a single set of harmonized criteria for classifying chemicals according to their health and physical hazards and specifies hazard communication elements for labeling and safety data sheets.

Benefits: The new standard covers over 43 million workers who produce or handle hazardous chemicals in more than five million workplaces across the country. The modification is expected to prevent over 500 workplace injuries and illnesses and 43 fatalities annually. Once fully implemented it will also:

- Enhance worker comprehension of hazards, especially for low and limited-literacy workers, reduce confusion in the workplace, facilitate safety training, and result in safer handling and use of chemicals;
- Provide workers quicker and more efficient access to information on the safety data sheets;
- Result in cost savings to American businesses of more than $475 million in productivity improvements, fewer safety data sheet and label updates and simpler new hazard communication training; and
- Reduce trade barriers by harmonizing with systems around the world.

Rulemaking background: OSHA published a Notice of Proposed Rulemaking to update the Hazard Communication Standard in September 2009 and held public hearings in March 2010.

Major changes to the Hazard Communication Standard:

- **Hazard classification:** Chemical manufacturers and importers are required to determine the hazards of the chemicals they produce or import. Hazard classification under the new, updated standard provides specific criteria to address health and physical hazards as well as classification of chemical mixtures.
- **Labels:** Chemical manufacturers and importers must provide a label that includes a signal word, pictogram, hazard statement, and precautionary statement for each hazard class and category.
- **Safety Data Sheets:** The new format requires 16 specific sections, ensuring consistency in presentation of important protection information.
- **Information and training:** To facilitate understanding of the new system, the new standard requires that workers be trained by December 1, 2013 on the new label elements and safety data sheet format, in addition to the current training requirements.

Changes from the Proposed to the Final Rule: OSHA reviewed the record and revised the Final Rule in response to the comments submitted. Major changes include:

- Maintaining the disclosure of exposure limits (Threshold Limit Values [TLVs]) established by the American Conference of Governmental Industrial Hygienists (ACGIH) and carcinogen status from nationally and internationally recognized lists of carcinogens on the safety data sheets;
- Clarification that the borders of pictograms must be red on the label;
- Flexibility regarding the required precautionary and hazard statements to allow label preparers to consolidate and/or eliminate inappropriate or redundant statements; and
- Longer deadlines for full implementation of the standard (see the chart below).

What you need to do and when:

- **Chemical users:** Continue to update safety data sheets when new ones become available, provide training on the new label elements and update hazard communication programs if new hazards are identified.
- **Chemical Producers:** Review hazard information for all chemicals produced or imported, classify chemicals according to the new classification criteria, and update labels and safety data sheets.

Effective Comple-tion Date	Requirement(s)	Who
December 1, 2013	Train employees on the new label elements and SDS format.	Employers
June 1, 2015* December 1, 2015	Comply with all modified provisions of this final rule, except: Distributors may ship products labeled by manufacturers under the old system until December 1, 2015.	Chemical manufacturers, importers, distributors and employers
June 1, 2016	Update alternative workplace labeling and hazard communication program as necessary, and provide additional employee training for newly identified physical or health hazards.	Employers
Transition Period	Update alternative workplace labeling and hazard communication program as necessary, and provide additional employee training for newly identified physical or health hazards.	All chemical manufacturers, importers, distributors and employers
* This date coincides with the European Union implementation date for classification of mixtures.		

Table 4.1

Other U.S. Agencies: The Department of Transportation (DOT), Environmental Protection Agency, and the Consumer Product Safety Commission actively participated in developing the GHS. DOT has already modified its requirements for classification and labeling to make them consistent with United Nations transport requirements and the new globally harmonized system.

Global implementation: The new system is being implemented throughout the world by countries including Canada, the European Union, China, Australia, and Japan.

Additional information: More information on the hazard communication standard, including the link to the Federal Register notice, can be found on OSHA's hazard communication safety and health topics page at www.osha.gov/dsg/hazcom/index.html.

Why was GHS created?

Figure 4.2 GHS creates a global standard. Compare these two images representing before and after compliance to the GHS.

GHS uses hazard classification criteria and a harmonized hazard communication system to protect workers

Classification Criteria

- Health and Environmental Hazards
  - Acute Toxicity
  - Skin Corrosion/Irritation
  - Serious Eye Damage/Eye Irritation
  - Respiratory or Skin Sensitization
  - Germ Cell Mutagenicity
  - Carcinogenicity
  - Reproductive Toxicity
  - Target Organ Systemic Toxicity – Single and Repeated Dose
  - Hazardous to the Aquatic Environment

- Physical Hazards
  - Explosives
  - Flammability – gases, aerosols, liquids, solids
  - Oxidizers – liquid, solid, gases
  - Self-Reactive
  - Pyrophoric – liquids, solids
  - Self-Heating
  - Organic Peroxides
  - Corrosive to Metals
  - Gases Under Pressure
  - Water-Activated Flammable Gases

- Mixtures
- Hazard Communication
  - Labels
  - Safety Data Sheets

Figure 4.3 Sample warning labels can be found on construction materials.

Hazard classification under the HCS protects workers by applying mandatory hazard classification criteria

Now let us go to the core of GHS – the classification criteria for chemicals.

Chemical manufacturers and importers must classify each chemical they produce or import. The major steps in hazard classification are presented below:

- Determine the appropriate hazard classes and associated hazard categories
- Base this on an evaluation of the full range of available data/evidence on the chemical (no testing is required)
- Use Appendix A for health hazard criteria and Appendix B for physical hazard criteria
- The introduction to Appendix A provides the general approach to classification, including bridging principles (which is the approach used to determine classification of mixtures)

The GHS has set criteria for classification of chemicals according to 3 major hazards - physical, health and environmental hazards.

The hazard classification approach in the GHS is quite different from the performance-oriented approach in the HCS 1994. The GHS has specific criteria for each health and physical hazard, along with detailed instructions for hazard evaluation and determinations as to whether mixtures of the substance are covered. OSHA has included the general provisions for hazard classification in paragraph (d) of the revised rule, and added extensive appendixes that address the criteria for each health or physical effect. Mandatory Appendices A and B provide classification guidance for Health Hazards and Physical Hazards, respectively. The hazard classification criteria contained in the HCS 2012 is test method-neutral. That is, the person classifying a chemical or substance should use available data and no additional testing is required to classify a chemical. Please refer to the Summary and Explanation of the Final Rule to gain a better understanding of the changes.

(d)(1) Chemical manufacturers and importers shall evaluate chemicals produced in their workplaces or imported by them to classify the chemicals in accordance with this section. For each chemical, the chemical manufacturer or importer shall determine the hazard classes, and where appropriate, the category of each class that apply to the chemical being classified. Employers are not required to classify chemicals unless they choose not to rely on the classification performed by the chemical manufacturer or importer for the chemical to satisfy this requirement.

(d)(2) Chemical manufacturers, importers or employers classifying chemicals shall identify and consider the full range of available scientific literature and other evidence concerning the potential hazards. There is no requirement to test the chemical to determine how to classify its hazards. Appendix A to §1910.1200 shall be consulted for classification of health hazards, and Appendix B to §1910.1200 shall be consulted for the classification of physical hazards.

(d)(3) Mixtures.

(d)(3)(i) Chemical manufacturers, importers, or employers evaluating chemicals shall follow the procedures described in Appendices A and B to §1910.1200 to classify the hazards of the chemicals, including determinations regarding when mixtures of the classified chemicals are covered by this section.

(d)(3)(ii) When classifying mixtures they produce or import, chemical manufacturers and importers of mixtures may rely on the information provided on the current safety data sheets of the individual ingredients except where the chemical manufacturer or importer knows, or in the exercise of reasonable diligence should know, that the safety data sheet misstates or omits information required by this section.

Hazard Communication Standard Labels

OSHA has updated the requirements for labeling of hazardous chemicals under its Hazard Communication Standard (HCS). As of June 1, 2015, all labels will be required to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. A sample revised HCS label, identifying the required label elements, is shown on the right. Supplemental information can also be provided on the label as needed.

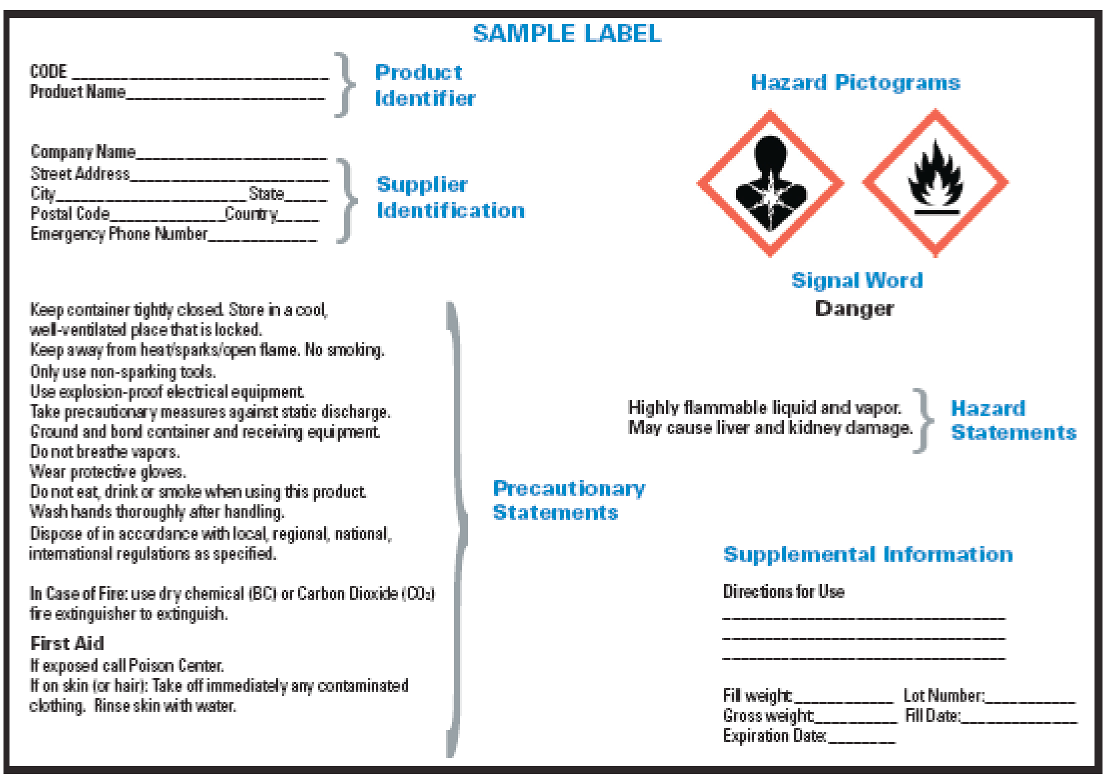


Figure 4.4 Sample label

Single words are used to emphasize hazard and to discriminate between levels of hazard

Another item that must appear in the labels is the signal word.

A signal word refers to a word used to indicate the relative level of severity of hazard and alert the reader to a potential hazard on the label.

"Danger" is used for the more severe hazard categories.

For example, "Danger" is used for Acute toxicity Category 1, 2 and 3, while "Warning" is used for Category 4. The precedence also applies for signal word. If the signal word "Danger" applies, the signal word "Warning" should not appear.

A single harmonized hazard statement for each level of hazard within each hazard class is used

The text of all applicable hazard statements shall appear on the label, except as otherwise specified. Hazard statements may be combined where appropriate to reduce the information on the label and improve readability, as long as all of the hazards are conveyed as required.

These are the hazard statements for Acute toxicity:

- Category 1 " Fatal if swallowed "
- Category 2 "Fatal if swallowed "
- Category 3 " Toxic if swallowed"
- Category 4 "Harmful if swallowed"
- Category 5 "Maybe harmful if swallowed"

Figure 4.5 Veronica Thomas, a sheet metal mechanic, deburrs an inconel steel part for installation on the C-130 IRSS. U. S. Air Force photo by Chad Langston.

The chemical manufacturer, importer, or distributor shall ensure that each container of hazardous chemicals leaving the workplace is labeled, tagged or marked

HCS 2012 requires that labels on shipped containers contain much more information than required by Hazcom 1994, such as:

- the product identifier,
- signal word,
- hazard statement(s),
- pictogram(s),
- precautionary statement(s),
- and the name, address, and telephone number of the chemical manufacturer, importer, or other responsible party.

Labels are to be updated within 3 months of getting new and significant information about the hazards, or ways to protect those exposed. However, much of this additional information is already included on labels by manufacturers, particularly for those following the ANSI standard Z129 for precautionary labeling. These elements are intended to be the minimum information to be provided on labels by manufacturers and importers.

So, if chemical manufacturers and importers want to provide additional information regarding the hazards of a chemical as well as precautions for safe handling and use, they are free to do so as long as:

- the information is accurate, and
- does not conflict with the required label elements.

All of the label requirements by hazard class and category can be found in Appendix C

- OSHA is maintaining the current approach to allowing alternatives to labels on each stationary process container
- The exception for portable containers under the control of the person who filled them with the chemical remains the same.
- Labels on incoming containers are not to be removed or defaced unless immediately replaced by another label
- Workplace labels are to be prominently displayed and in English, although other languages are permitted as well
- Employers are responsible for maintaining the labels on the containers, including, but not limited to, tanks, totes, drums, and for training their employees on the hazards listed on the labels in the workplace.

Labels must continue to be:

- legible,
- contain the pertinent information (such as the hazards and directions for use),
- not able to be defaced, (i.e., fade, get washed off,) or removed in any way as stated in revised Hazard Communication Standard, 29 CFR 1910.1200(f)(9).

Figure 4.6 Labels must be legible, contain pertinent information, and not able to be defaced.

One of eight standard hazard symbols is used in each pictogram

There are 9 hazard symbols are used in the GHS (8 mandatory): flame, flame over circle, exploding bomb, corrosion, gas cylinder, skull and cross bones, exclamation mark, health hazard and environmental hazard (non-mandatory under OSHA HCS).

With the exception of the symbols depicting exclamation mark, health hazard and environmental hazard, all are part of the standard symbols set used in the UNRTDG.

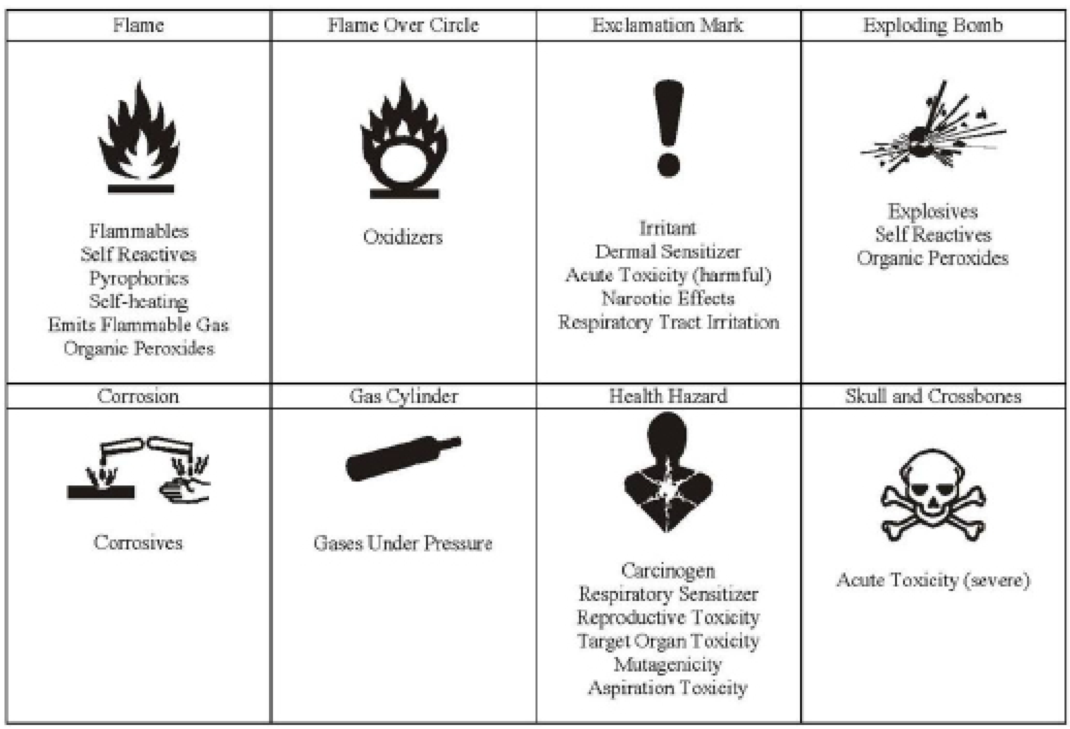


Figure 4.7 With the exception of the symbols depicting exclamation mark, health hazard and environmental hazard, all are part of the standard symbols set used in the UNRTDG.

Pictograms must have a black symbol, white background and red boarder frame

There are 9 pictograms in the GHS and only 8 under HCS 2012. The ninth pictogram (environmental) is not used under OSHA. Each pictogram is assigned to the hazard or its category or division.All pictograms should be in the shape of a square set at a point. For labels of products being supplied or distributed to clients, the pictograms have a black symbol on a white background with a red frame.

A competent authority may choose to give suppliers and employers discretion to use a black border for domestic use. The requirements for making GHS-based label include symbols or pictograms, signal words, hazard statements, precautionary statements, product identifiers/ declaration of ingredients and supplier identification.

Pictograms shall be in the shape of a square set at a point and shall include a black hazard symbol on a white background with a red frame sufficiently wide to be clearly visible. A square red frame set at a point without a hazard symbol is not a pictogram and is not permitted on the label.

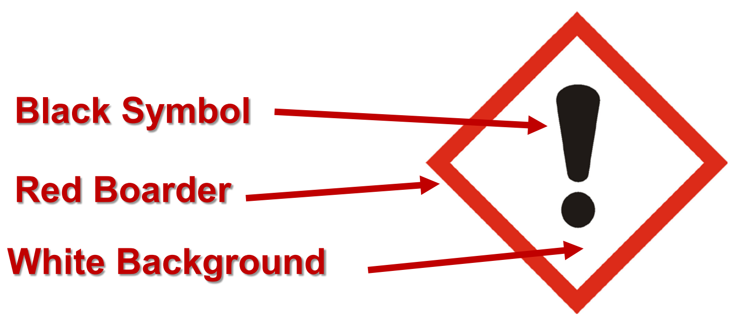


Figure 4.8

Figure 4.9

The Health Hazard pictogram looks like this and warns of:

- Carcinogen
- Mutagenicity
- Reproductive toxicity
- Respiratory sensitizer
- Target organ toxicity
- Aspiration toxicity

Figure 4.10

The Flame pictogram looks like this and warns of:

- Flammables
- Pyrophorics
- Self-heating
- Emits flammable gas
- Self-reactives
- Organic peroxides

Figure 4.11

The Exclamation Mark pictogram looks like this and warns of:

- Irritant (skin and eye)
- Skin sensitizer
- Acute toxicity (harmful)
- Narcotic effects
- Respiratory tract irritant
- Hazardous to ozone layer (non mandatory)

Figure 4.12

The Gas Cylinder pictogram looks like this and warns of:

- Gases under pressure

Figure 4.13

The Corrosion pictogram looks like this and warns of:

- Skin corrosion/ burns
- Eye damage
- Corrosive to metals

Figure 4.14

The Exploding Bomb pictogram looks like this and warns of:

- Explosives
- Self-reactive
- Organic peroxides

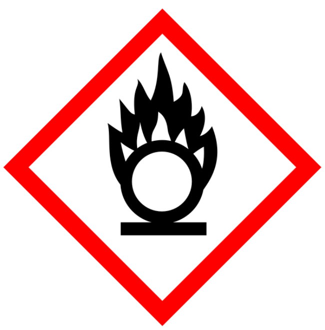


Figure 4.15

The Flame over a Circle pictogram looks like this and warns of :

- Oxidizers

Figure 4.16

The Skull and Crossbones pictogram looks like this and warns of:

- Acute toxicity (severe)

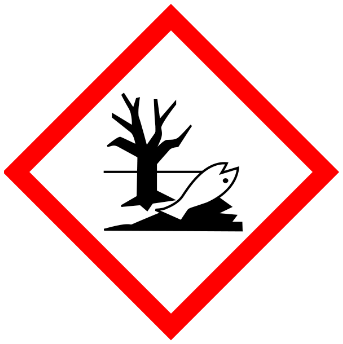


Figure 4.17

The Environment pictogram looks like this and warns of:

- Aquatic toxicity
- Chronic aquatic toxicity
- Degradation
- Bioaccumulation

This pictogram is Non-mandatory under HCS. While the GHS includes criteria on classifying chemicals for aquatic toxicity, these provisions were not adopted in the GHS Final Rule because OSHA does not have the regulatory authority to address environmental concerns. However, the "building block approach" is utilized here to provide classification and labeling guidance to support the goals of harmonization that are useful to other regulatory authorities (e.g. EPA).

Label element allocation is based severity

For the GHS, the assigned pictogram, signal word and hazard statement are given in that order for each category of the hazard class. This slide is one example of allocation of label elements for acute toxicity. Pictogram "Skull and cross bones" is assigned to Category 1, 2 and3, "Exclamation mark" Category 4, none for Category 5. Signal Word "Danger" is assigned to Category 1, 2 and 3, "Warning" Category 4 to Category 5. Hazard statement "Fatal if swallowed" is used for Category 1 and 2. Precautionary statements are not described in this table.

Category 1	Category 2	Category 3	Category 4	Category 5
				*No Symbol*
Danger	Danger	Danger	Warning	Warning
Fatal if swallowed	Fatal if swallowed	Toxic if swallowed	Harmful if Swallowed	May be harmful if swallowed

Figure 4.18 Label element allocation is based severity.

Module 6:
How are confined space hazards controlled?

Objectives

After completing this section you will be able to:

- ✓ Apply the hierarchy of controls to confined space tasks.
- ✓ Describe how to ventilate a confined space.
- ✓ Explain how to lockout/tagout equipment when working in confined spaces.
- ✓ List ways to prevent engulfment during confined space work.

After identifying current and potential health and safety problems, the next step is to select methods to protect workers. Protecting workers means reducing their risks. The way to lower risks is to get rid of or lower exposure to hazards. There are different types of controls available to reduce exposure.

Hierarchy of Controls

The hierarchy of controls is a list of methods, in order from most effective to least effective, to reduce workers' exposure to hazards. The more completely a hazard is controlled at the source, or even eliminated, the more the worker will be protected. These types of strategies should be used first where possible because they are less subject to human error. They are also less disruptive and uncomfortable for people to use.

- **Substitution and elimination -** First ask if it is necessary to enter the space at all. Is it possible to eliminate a hazard in a confined space that must be entered? For example, removing damaged asbestos pipe insulation in a steam tunnel eliminates one hazard during future entries. The most common example of substitution is replacing a toxic chemical with a much safer product.

- **Engineering controls**, or safeguarding technology, are methods to reduce exposure by keeping the hazard from reaching the worker. Ventilation is a common engineering control in confined space.

- **Administrative controls** focus on the workplace procedures and workers' actions. Warning alarms and labeling systems are used to alert workers to hazards.

- **Personal protective equipment**, or PPE, includes respirators, gloves, protective clothing, hard hats, goggles, ear plugs and other clothing and equipment that are placed on workers' bodies. PPE is the last line of defense and the least effectivemethod. If it fails, workers are directly exposed to the hazard. PPE should be used only while other more effective controls are being developed or installed, or if there are no other more effective ways to control the hazard.

Engineering controls are essential for many entry situations.

Purging vs Ventilating

While both purging and ventilating are both methods to produce a safe atmosphere, there is a difference in the terms.

Purging means to initially clear a space of contaminants by getting rid of (displacing) contaminants with air, steam, or an inert gas. To reduce the risk of fire, an inert gas such as nitrogen or carbon dioxide is often used. Regular air, by contrast, is used if there is a danger of creating an oxygen deficiency. In some situations, more than one purge cycle may be necessary.

Ventilation moves fresh uncontaminated air through a space on a continuous basis. Ventilating a space:

- dilutes and displaces air contaminants;
- maintains an adequate supply of oxygen; and
- exhausts contaminants formed by welding and other tasks.

Ventilation

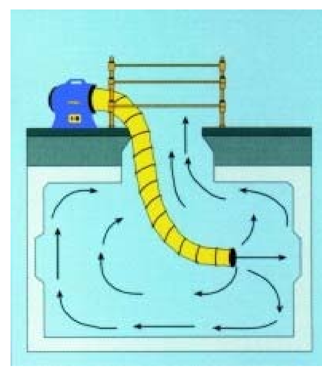
Confined spaces vary in size, shape and function. Therefore, selecting the correct method to ventilate a space must be based on the conditions presented by the particular space to be entered. The considerations for choosing how to ventilate a space include the:

- size and shape of the space
- what the space has contained
- whether there are natural drafts, the number and location of any openings.

Natural ventilation is of limited value for permit-required confined space entry work. Natural ventilation involves letting the atmosphere inside the confined space mix with the outside natural air. The effectiveness of this type of method can be affected by numerous factors. For example, wind and temperature affect air flow. Also, air toxic gases such as hydrogen sulfide are heavier than air and therefore sink and remain at bottom of a pit.

Mechanical ventilation accomplishes three goals:

1. Maintains oxygen level
2. Dilutes or removes toxic air contaminants
3. Improves comfort



General dilution ventilation reduces exposures by diluting concentrations

General dilution, like the air handling system in this classroom, circulates air throughout the entire area.

By contrast, **local exhaust ventilation** captures contaminants at the source as they are being released.

Oxygen by itself cannot be used to ventilate a space. **Why?**

OSHA does not allow oxygen or any other gas or mixtures of gases, except air, to be used for ventilation. Air must be natural air or synthesized air for breathing purpose. As discussed earlier, a higher oxygen content in the air increases the chance of a fire.

Placing a fan requires careful planning

Get as close to the source as possible

The closer a fan is to a contaminant, the more effective it will be dispersing or capturing the harmful air. Therefore, place the fan as close to the space as possible. This is even more important for exhaust fans. Make sure that the fan is not within the contaminated area. When possible, place fans at openings other than those that rescuers would use to enter the space.

Locate all openings into the space

Openings that are too small for entry may be useful as ventilation ports. Openings may have to be blocked off if they interfere with proper air flow.

Prevent recirculation

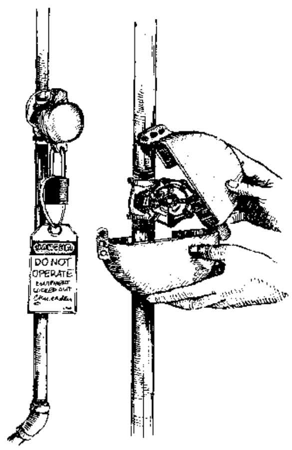
Moving air into a space creates positive pressure in the area and forces air out of the space through other openings. If there are no other openings, the air will be forced out through the opening being used to ventilate the space. If the fan is too close to where the contaminated air is exhausted, the fan will recapture it and force it back into the space.

Forcing air into an area creates negative pressure within the space. Contaminants can be drawn back into the space through the exhausts. Therefore, exhausts must be tightly sealed.

Lockout/tagout

A lockout tagout program must be used to take the space out of service and protected from all energy sources. To guard against electricity, the circuit breaker must be turned off, fuses pulled, and a lock placed on the electrical source. The power to the box must be turned off, not just the switch. After locking out the device, try turning on the power to see if it has been disabled.

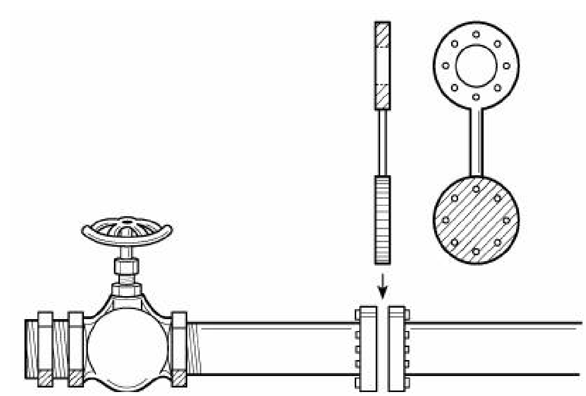
Each lock on the box should have only one key. Each entrant should put a lock on the electrical box to ensure that the power cannot be turned back on until the last person exits the permit-space. A lockout scissors, pictured here, is useful when more than one lock has to go on an energy source.



Disconnect pipes, lines and ducts that carry liquids or gases into the confined space. Liquids under pressure are a potential engulfment danger. Pipes may also contain substances that are corrosive, flammable, or toxic. Turning off a valve and locking it are not adequate measures to protect workers. The pipe needs to be blocked so that nothing can pass through to the confined space the employees are working in.

Blank and Bleed

Blanking/blinding is one method used to control the flow of liquids or gases. After bleeding the line to get rid of any pressure, the pipes are separated at a joint. A blank or blind is inserted between the two sections of pipe and are bolted together. The blanks need to fit tightly and must be strong enough to withstand four times the pressure in the line.



Spectacle blind, diagram from NFPA 1006, 2003 version

In the double block and bleed method, two in-line valves are closed and locked. A vent valve, also called a drain, is in between the two closed valves is then opened and locked.

Shoring

Engineering controls for trenching and excavation operations protect workers from being buried. Shoring the sides of a trench prevents the walls from collapsing. Another type of engineering control is a trench box that is lowered into the trench. Once again, the purpose is to prevent the walls from collapsing and causing a cave-in.

Administrative controls improve safety through better work procedures.

- **Training** is the most common administrative control. It is a necessary part of any safety plan to protect workers from confined space or any other hazard.

- **A warning sign** is an administrative control that alerts workers to hazards.
- **Communication systems** are an important administrative control. A worker in a confined space needs to be able to communicate with a person outside the space.
- **Vaccinations** are an administrative control that prevent infections. A vaccination greatly reduces or even eliminates the risk of becoming sick as the result of contact with infectious material. Workers should be up to date on their tetanus shots. Depending on their potential exposures, workers should be inoculated for hepatitis B and other diseases.

Personal protective equipment is a worker's last line of defense against workplace hazards.

Personal protective equipment is the least effective way to protect workers. However, due to the nature of some operations, such as permit-required entry work, PPE is often a necessary part of the overall strategy to reduce exposures. The next section of this course will go into much more detail about the proper use and limitations of personal protective equipment.

Module 7: Respiratory Protection

Objectives

After completing this section you will be able to:

- ✓ Give three reasons for using respirators;
- ✓ List the two main classes of respirators and explain how they work;
- ✓ State limitations for each type of respirator;
- ✓ List three main considerations when choosing a respirator type;
- ✓ Name two reasons for poor respirator fit; and
- ✓ Explain the importance of having a effective respirator program.

Why would you need a respirator to enter a confined space?

Introduction

As a confined space entrant or attendant you probably will come in close contact with hazardous chemicals. In some cases, dangerous amounts of these chemicals may contaminate the confined space. Chemicals in the air can harm you in two ways: they may have harmful effects if you breathe them in and/or they may displace oxygen from the air. Also, the process of rusting can pull oxygen into metal oxides or some biological processes may produce other types of gases that are harmful at certain levels. Two good examples of naturally occurring gases found in confined spaces are methane and hydrogen sulfide. Both of these can be toxic and can even explode at certain levels.

When engineering controls have been employed and there are still toxic levels of gases or vapors in a confined space that you must enter, respirators are often your most important means of defense. Respirators are designed to ensure that you do not breathe harmful air while working in contaminated atmospheres. Using respirators in an effective manner is a complicated business. There are many types to choose from and they must be carefully selected for each situation. Also, respirators do not always provide enough protection. OSHA has published a specific standard, 29 CFR1910.134 *Respiratory Protection*. The Respiratory Protection Standard requires employers to take all the necessary steps to ensure that respirators will effectively protect their employees.

A review of respiratory hazards

As you have seen in previous modules, there are many hazards that can considered respiratory hazards. Below is a short list of the most common respiratory hazards:

- Aerosols
- Dusts
- Mists
- Gases
- Vapors
- Fumes
- Radiation
- Low oxygen

What is Immediately Dangerous to Life and Health (IDLH)?

We briefly encountered this term in Module 3. IDLH atmospheres are the foremost hazards that claim the lives of confined spaces entrants. OSHA defines an IDLH atmosphere as one that poses an immediate threat to life, would cause irreversible damage, or would impair a person's ability to escape (29 CFR 1910.134). Oxygen levels below 19.5% are considered IDLH, which is quite possible in certain confined spaces. IDLH levels for specific chemicals are listed in the NIOSH pocket guide. All atmospheres should be considered IDLH during unknown confined space entries until tests have determined that they are not.

For IDLH situations OSHA requires:

- A full facepiece pressure demand (positive pressure) SCBA with a service life of at least 30 minutes; or
- A full facepiece pressure demand SAR with self-contained auxiliary air supply.

Safeguards must be used when entering an IDLH environment and include the following:

- At least one attendant in communication with entrant
- Employer must have a emergency rescue plan
- Appropriate retrieval equipment
- Proper PPE

Only well-trained persons should enter an area with IDLH conditions. Entering a confined space or enclosure that has chemicals above their IDLH level is a high-risk activity and the highest form of respiratory protection must be worn. Entry should only be done when there is no alternative, or when someone is injured and must be rescued. Firefighters deal with these conditions on a regular basis, but the average employee does not.

One standby person is allowed if it can be shown that the IDLH condition is well known and will remain stable, and the one standby person can adequately monitor and communicate with employees in the IDLH area and initiate rescue.

Further attention will be given to respirator selection for IDLH atmospheres later in the module.

Do not wear an air-purifying respirator in IDLH conditions or if you don't know what chemicals or how much of a chemical is in the air.

What is a respiratory protection program?

- Each employer who requires their workers to wear a respirator to reduce their risk of harm must have a respiratory protection program
- A program is the employers procedure for meeting the requirements of a particular regulation

What are the key elements of OSHA's required written Respiratory Protection Program?

The program is an employer's written plan of how the aspects of the standard will be met and should include written operating procedures for:

- Selecting appropriate respirators;
- Medically evaluating potential respirator users;
- Fit testing all tight-fitting respirators;
- Training;
- Adequate air quality, quantity and flow;
- Using respirators in routine and emergency situations;
- Maintaining respirators (cleaning, disinfecting, storing, inspecting and testing, repairing, discarding);
- Administered and maintained by a qualified person (IH, Safety Professional, etc.); and,
- Evaluating the program.

If you are required to wear respirators on the job, your employer must have these written procedures compiled in the form of a program. He or she must train you on what the procedures are. Your employer must also train you on the specific respiratory hazards at your work place.

What are the two broad classes of respirators?

There are two basic ways that respirators can provide you clean air: **atmosphere-supplying respirators** and **air purifying respirators (APRs)**. **Atmosphere-supplying** respirators provide a supply of air from a source completely separate from the air in the work area. In contrast, **air purifying** respirators work by removing the contaminant (dust, fume, mist or vapor) from the air in your work area before you breathe it in. Also, APRs do not help you if there is low oxygen!

Atmosphere-supplying respirators offer most protection

There are two types

- Air line (with or without escape bottle)
- Self Contained Breathing Apparatus (SCBA)

Respirators also differ in pressure in the facepiece

Example of regulator

A respirator can also be classified as either a **negative pressure** or **positive pressure** respirator. A **negative pressure** respirator has a lower (or "negative") pressure inside the facepiece than outside during inhalation. If the facepiece does not fit tightly or there if there is a leak, contaminated air will be sucked into the facepiece when you inhale. On the other hand, a **positive pressure** respirator maintains a higher (or "positive") pressure inside the facepiece than outside throughout the breathing cycle. The higher pressure inside the facepiece forces air out and reduces the chance of contaminated air getting in. For this reason positive pressure respirators are more protective. Air pressure in the facepiece is controlled by a regulator.

Pressure demand respirators are much more protective than demand

Atmosphere-supplying respirators are now only available in **positive pressure** modes. Positive pressure air-supplying respirators, (also referred to as **"continuous flow"** or **"pressure demand"** respirators) constantly blow air into the facepiece. There are, however, still some **negative** pressure units in circulation. (These are sometimes referred to as "demand" respirators since they only supply air when you inhale.) OSHA requires that only positive pressure air-supplying respirators can be used in emergency situations.

Respirators can be further divided based on facial coverage

A feature that is common to all types of respirators is a facepiece. A facepiece covers your nose and mouth where you breathe air. The facepiece may be loosefitting or tight-fitting. In this training we only consider tight-fitting facepieces because they are commonly used in confined space entries and confined space rescues.

Respirators may have **full facepieces** or **half facepieces**. **Full facepieces** seal across the forehead, down along the side of the face, and under the chin.

Half Facepiece

Full Facepiece

Because these parts of the face are relatively smooth, full facepieces tend to form a better seal with the face than other designs. They also protect the eyes from irritant chemicals or flying particles. The **half facepiece** fits over the bridge of the nose and tucks under the chin. The shape of the bridge of the nose is not smooth and is different for each person. For these reasons, it is difficult to design a half facepiece respirator that maintains a good seal for many different users. Because of this problem, half facepieces do not offer as much protection as full facepieces.

When using respirators for confined space entry containing toxic atmospheres, you will most likely be wearing some type of full facepiece. However, half facepieces may be used for some routine cleanup or repair procedures when exposures are low, because they are cooler and they do not limit vision.

Airline respirator

An airline respirator uses a hose to supply the worker with air. This air supply is usually supplied from an air compressor although a SCBA cascade system may be used. A small cascade system may be used on heavy equipment if the atmosphere warrants an operator to use supplied air respirators.

Continuous flow airline respirators

- With "Continuous flow" air is constantly blowing into the facepiece
- Continuous flow is found in loose-fitting airline respirators
- Often more comfortable and hoods can be worn over a beard, no need to fit test
- Cannot be used in IDLH conditions!

Limitations to airline respirators

There are limitations when using an airline respirator. The minimum hose length is 8 feet, and the **line cannot exceed 300 feet with sections of 25 feet.** It also must be tested and certified. Your air supply may not be in close proximity to where you are working because of potential chemical or contamination hazards. Additionally, damage to the air line may occur from rough or sharp surfaces or being run over by heavy equipment. Also, they require you to retrace your steps when you leave the work area, and the air line also requires supervision. SARs are not approved for immediate danger to life or health situations or in oxygen deficient areas unless they are also equipped with an escape bottle.

Air quality for air line respirators must be at least Grade D

There are three different methods that are typically used to supply air to a worker using a SAR . These compressor setups may also be used to fill SCBA bottles. The three types are:

1. Electric air pump
2. Engine compressor
3. Tank cascade system

Air compressors must be located carefully

- In an area of clean air
- Away from nearby running engines
- Away from exhaust pipe of an engine compressor

Gasoline-powered compressor

Construction and plant compressors need much scrutiny!

When using air compressors, precautions must be taken to ensure that the air reaching the worker or SCBA tank is grade D quality. This can be done buy using the following devices and work practices:

- Locate pump intake where there is clean, fresh air
- Watch out for running engines
- Do not let compressor exhaust drift toward air intake
- Use a moisture trap

Compressor filters

- Use a dust filter
- Use hydrocarbon absorbent
- For oil-lubricated compressors, use carbon monoxide alarm or high temperature alarm

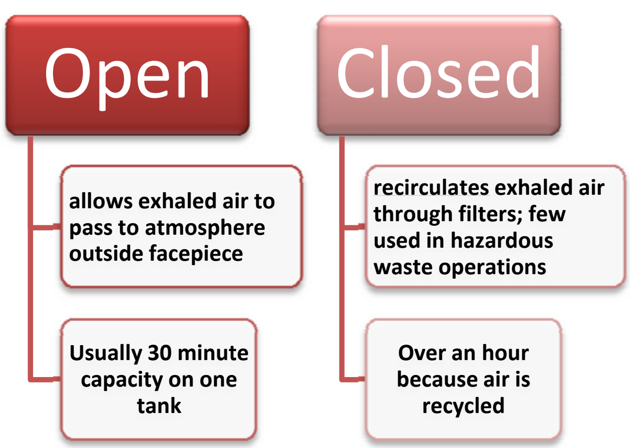
What if you encounter an IDLH condition with an air line?

Escape SCBAs or auxiliary SCBAs, are also available. These are very small cylinders usually certified for 3, 5 or 10 minutes. Auxiliary SCBA respirators should only be used to exit a hazardous work environment during an emergency.

Self contained breathing apparatus SCBAs

Self-contained breathing apparatus (SCBAs), the other type of atmosphere-supplying respirator, provide you with air from a tank that you carry on your back. Firefighters and other emergency responders often wear SCBAs. SCBAs have the highest protection factor (10,000 in pressure demand mode) of any respirator. The air tank, or cylinder, is pressurized and comes in different sizes. NIOSH assigns each cylinder a "service life"--this is an estimate of how long the air in the cylinder will last. OSHA requires that SCBAs used in emergency response have a rated service life of at least 30 minutes. Cylinders rated at 45 or 60 minutes may also be used, but cylinders rated for less than 30 minutes cannot be used for emergency response. It is important to remember that the actual amount of time the air in your cylinder lasts depends on how much oxygen your body needs, how hard you are breathing, and if the bottle was filled correctly.

SCBAs are either open or closed circuit respirators



Benefits of SCBAs

- Offers mobility
- Offers the highest level of respiratory protection

Limitations of SCBAs

- Limited amount of air
- Requires intensive training
- High maintenance
- Tank adds weight and bulk
  - Limits the movement through tight areas
  - Adds stress to the wearer

What other limitation does confined space entry pose to wearing SCBAs?

Air Purifying Respirators

Unlike atmosphere-supplying respirators, APRs do not provide you with a separate source of air. Instead, they protect you by filtering out or absorbing contaminants from the surrounding air before you breathe them in.

While there are many types of APRs, they all have a few things in common. They all use specially designed materials to capture contaminants. These materials are usually found inside a cartridge or canister. (In the case of a filtering facepiece respirator, the mask itself is the material that collects the contaminant.)

1/2 face APR without cartridges

Full face APR without cartridges

PAPR with cartridges

Powered Air Purifying Respirators

Powered air purifying respirators are often used in lead and asbestos abatement work. These respirators use an electric pump to blow air through the cartridges. This allows the wearer to breathe easier. The air pumped into the facepiece remains cooler and helps reduce fogging too. Besides a tight fitting elastomeric facepiece, other options used with PAPRs include a loose fitting hood and helmet. This allows certain users who may not normally be able to wear a tight fitting facepiec to use a PAPR for protection. Also, this eliminates the need for medical clearance and fit testing. However, PAPRs are more expensive than their counterparts by several hundred dollars.

Cartridges must be matched against the contaminant

If you use the wrong cartridge, you may not be getting any protection at all. For example, particulate filter cartridges collect aerosols (dusts, mists, and fumes) as they strike the filter. Some filters are designed to trap very fine and toxic dusts, such as lead and asbestos. But even the best filters offer no protection from gases and vapors. Cartridges for gases and vapors are filled with special sorbent materials that collect the gases by means of chemical reactions. These materials must be matched to the particular gas or vapor you want to remove from the air. Some cartridges include both a filter and sorbent materials.

Respirator cartridges have standard color coding

Atmospheric Contaminants	Colors Assigned
Acid gases	White
Hydrocyanic acid gas	White with ½-inch green stripe completely around the canister near the bottom
Chlorine gas	White with ½-inch yellow stripe completely around the canister near the bottom
Organic vapors	Black
Ammonia gas	Green
Acid gases and ammonia gases	Green with ½-inch white stripe completely around the canister near the bottom
Carbon monoxide	Blue
Acid gases and organic vapors	Yellow
Hydrocyanic acid gas and chloropicrin vapor	Yellow with ½-inch blue stripe completely around the canister near the bottom
Acid gases, organic vapors, and ammonia	Brown (Tan)
Radioactive materials, excepting tritium and noble gases	Purple (Magenta)
Particulates (dusts, fumes, mists, fogs, or smokes) in combination with any of the above gases or vapors	Canister color for contaminant, as designated above, with ½-inch gray stripe completely around the canister near the top
All of the above atmospheric contaminants	Red with ½-inch gray stripe completely around the canister near the top

NIOSH classifies particulate filters based on resistance to damage from oil in the air

Particulate filter respirators work well for airborne contaminants, but they do not protect you against gases, vapors, or oxygen deficiency. Their key component is the filter. A fibrous material in the filter captures contaminants, such as dust, fumes, and mist.

NIOSH classifies these respirators into nine classes to rate filter efficiency. Those classes are organized into three filter series based on their ability to remove particles as a result of oil aerosols in the work environment:

N = **N**ot resistant to oil
R = **R**esistant to oil
P = oil **P**roof

Oil mists are commonly found in factories where lubricants are used in great quantities. There shouldn't be a major issue with it in most confined spaces.

Then within each series are three levels of filter efficiency:

95 percent, designated 95
99 percent, designated 99
99.97 percent, designated 100

There are nine classes of particulate filters altogether

N	R	P
100	100	100
99	99	99
95	95	95

The matrix on the left shows the possible particulate combinations.

The class of filter is marked on the filter, filter package, or respirator box. Replace filters when they are damaged, soiled, or cause you to breathe noticeably harder or when they expire according to the manufacturer.

The service life of air-purifying cartridges or canisters is limited.

Particulate filters should be replaced when

- Damaged
- Soiled
- Breathing becomes harder
- They expire according to the manufacturer

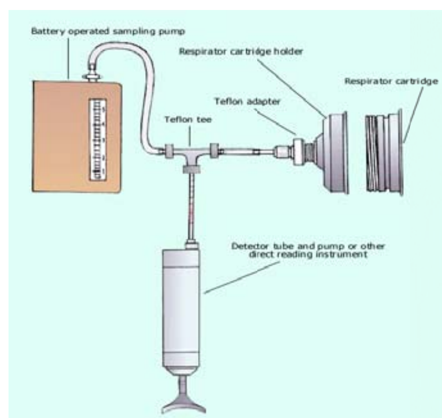
Vapor cartridges wear out so their service life must be tracked by the employer

Cartridges that protect against gases and vapors will lose their effectiveness over time as the sorbent material becomes loaded with contaminant. If the cartridges are not replaced soon enough large amounts of the gas or vapor will begin to pass directly into the facepiece. This is called **breakthrough.** The amount of time for breakthrough to occur depends on the amount of chemical in the air, your breathing rate, and environmental conditions such as temperature and humidity.

OSHA requires the employer to ensure that breakthrough does not occur. Your employer can do this by taking one of the following measures:

1. Your employer can provide NIOSH approved "end of service life indicators" (ESLIs) when appropriate and available. End of service life indicators are a device on the cartridge that responds to high levels of contamination. A sensitive material in a little window changes color when breakthrough is about to occur. Your employer should explain to the workers whether ESLIs are being used or not.

2. If there is no end of service life indicator appropriate for the job, then your employer should schedule cartridge changes based on the job duties and contaminant levels experienced. This is done to make sure cartridges are replaced before breakthrough happens. When your employer determines the cartridge change schedule, they should plan for the worst case scenario and use the respirator manufacturers and/ or chemical manufacturer's breakthrough time data. If no information about breakthrough times is available, do not use an air-purifying respirator--use an atmosphere-supplying respirator instead.



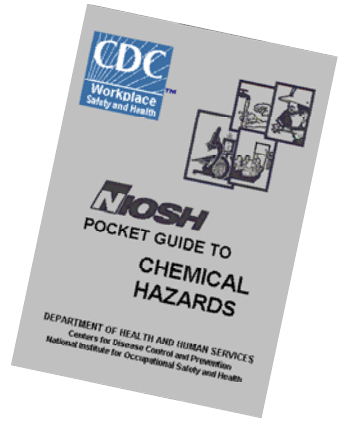
OSHA indicates how the service life schedule can be set

If you have a detector tube unit and personal sampling pumps, you can look for breakthrough at the end of a shift. If the charcoal is saturated, the vapors will be pulled through the tube by the pump and the detector tube or real-time instrument should be able to detect it.

Several factors can affect the service life

- Worker exertion level
- Amount of charcoal
- Temperature
- Relative humidity
- Multiple contaminants

How can we pick a respirator that gives the proper protection?



There are several good sources to use for selecting respirators

- NIOSH Selection Logic
- NIOSH Pocket Guide
- Protection Factors and Max Use Concentrations

The NIOSH Pocket Guide gives recommendations for respirator selection based on exposure

Your employer is responsible for selecting an appropriate respirator based upon the hazards in your work area. **The respirator must be certified by NIOSH.** Respirators and their containers must carry certification labels. An example of a certification label is shown below (Detailed requirements regarding what information the labels should contain and where the labels should be placed can be found in 42 CFR 84.)

To select an appropriate respirator you need to know what chemical or chemicals are present in the air. You also must have a reasonable estimation of the concentration of those chemicals. This means that your employer must test the air! If this information is not available, then your employer *must* assume the atmosphere is IDLH.

Second, check the **"maximum use"** concentration for the cartridge. In some specific chemical standards OSHA indicates a "maximum use" concentration for cartridges. You should never use a respirator when the concentration of the contaminant in the air is higher than the cartridge's maximum use concentration.

If the chemical has a specific OSHA standard, respiratory protection requirements will be included as part of the standard. A table, like the one below, is usually supplied which gives the highest concentration at which each type of respirator can be used. For chemicals that do not have a specific standard, **Protection Factors (PF)** can be used. The Protection Factor is a number assigned by NIOSH that indicates how effective a respirator is at reducing contaminants you breathe. The larger the PF, the more effective the respirator.

$$PF = \frac{\text{Concentration outside the mask}}{\text{Concentration Inside the mask}}$$

The PF can be used as a guide in selecting respirators. The highest level of contaminant to which a person should be exposed when using a particular respirator can be determined by using the PF. This is like the "maximum concentrations" set in OSHA standards.

The table below lists protection factors assigned by NIOSH for the different types of respirators.

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-fitting Facepiece
Air purifying respirator	5	10	50		
Powered air purifying respirator		50	1,000	25/1,000	25
Supplied air respirator, or air line respirator • Demand mode • Continuous flow mode • Pressure demand or other positive pressure mode		10 50 50	50 1,000 1,000	25/1,000	25
Self-contained breathing apparatus • Demand mode • Pressure demand or other positive pressure mode (e.g., open/closed circuit)		10	50 10,000	50 10,000	

You can calculate the maximum concentration by multiplying the respirator's PF by the OSHA Permissible Exposure Limit (PEL) of the chemical you're being exposed to:

Maximum Use Concentration = PF x **PEL**

Suppose you wanted to use a half facepiece APR with a PF of 10 (see chart above) while working with a nitrotoluene, which has an OSHA PEL of 5 ppm. The calculation to determine the maximum concentration at which it is safe to use a half facepiece for this chemical is:

Maximum Concentration Half Facepiece APR = 10 x 5 ppm = 50 ppm

You could use this half facepiece APR in any work situation where the concentration was below 50 ppm. For concentrations greater than 50 ppm you would need a respirator with a higher protection factor. A full facepiece APR could be used up to a concentration of 250 ppm nitrotoluene:

Maximum Concentration Full Facepiece APR = 50 x 5 ppm = 250 ppm

But, the IDLH level for nitrotoluene is 200 ppm. You must know the IDLH concentrations of a chemical before doing these calculations. Remember, neither an APR nor a negative pressure atmosphere-supplying respirator can ever be used in an IDLH atmosphere. Since the IDLH of nitrotoluene is 200 ppm, a full facepiece APR could not be worn above this concentration.

Let's try one: full face APR and we'll be working with xylene. What is your MUC?

Medical evaluations

Before any employee is fit tested or required to wear a respirator they must be medically evaluated. This evaluation is done to make sure that there is no medical condition that would make wearing a respirator dangerous for the user. **OSHA's requirements for medical evaluations are as follows:**

- Potential respirator users must fill out a medical questionnaire, including medical and work histories and information about specific work conditions. (OSHA provides a questionnaire in Appendix C of the Respiratory Protection Standard.)
- A licensed health care professional (PLHCP) must review these questionnaires to determine which, if any, workers need to have an examination before wearing a respirator. Employers may choose to have all prospective wearers examined and to obtain any required information during the examination.
- Additional medical evaluations must occur if: an employee exhibits signs and symptoms of chemical exposure, requested by a PLHCP, supervisor or program administrator, the initial evaluation suggests the need for one, or any change occurs in workplace conditions that may increase the physical demands on the respirator user.

Fit Testing

The effectiveness of any respirator critically depends on having a good seal around the face. You don't want any leakage around your face seal due to a poor fit. OSHA requires fit testing for all tight fitting facepieces, including both atmosphere-supplying and air-purifying types.
The purpose of fit tests is to determine which facepiece fits your face the best. Your employer is required to have a selection of different makes and models available to ensure you can find one with a proper fit. Several sizes for each model should also be available.

During the testing you are asked to perform tasks that mimic work activities. A fit test must be passed before you use any respirator in a hazardous environment. The tests must be repeated at least annually. Also a test must be done if there is some important change in the way a respirator fits -- for example, if you lose a lot of weight and your face gets thinner.

There are two types of fit tests. The **quantitative fit test** (QNFT) is the preferred method because it is the most accurate. Measuring devices are placed inside and outside the facepiece in order to compare the concentrations of contaminants. A **fit factor** is assigned to each facepiece based on these measurements. The fit factor is the ratio of the concentration outside the facepiece to the concentration inside the facepiece. A QNFT is passed if a fit factor of 100 or better is achieved for a half-face facepiece, and a fit factor of 500 or greater is reached for a full-face facepiece. (**Note: These limits are the protection factors multiplied by a safety factor of 10.**)

Portacount fit tester

The **qualitative fit test** (QLFT) is less accurate. This test requires you to stand in an enclosed space while wearing a respirator. A contaminant (banana oil, saccharin, bitrex or irritant smoke) is introduced into the space. The test is passed if you do not detect the chemical by smell or irritation at any time while performing certain required activities. OSHA only permits QLFT for respirators that will be used in atmospheres that do not exceed 10 times the PEL of the chemical(s) involved. The detailed procedures for fit testing can be found in mandatory Appendix A of the Respiratory Protection Standard [1910.134]

User seal checks must be performed every time a respirator is donned

OSHA requires that you perform a **user seal check** each time you put on a tight-fitting respirator to ensure that it has sealed against your face properly. The procedure for a seal check is given in mandatory Appendix B-1 of the standard.

Positive pressure check

Negative pressure check

When wearing a tight-fitting facepiece nothing should interfere with the face seal. This includes facial hair, glasses, or any other personal protective equipment. If, facial hair interferes with the seal you must shave, unless an appropriate loose fitting hood or facepiece can be found

You should leave the respirator use area if:

- You need to wash your face or facepiece to prevent skin or eye irritation due to respirator use;
- You detect gas or vapor breakthrough, changes in breathing resistance or facepiece leakage; or
- You need to replace a respirator, cartridge or canister.

Taking care of your gear

Cleaning and Disinfecting

Respirators should be regularly cleaned and disinfected regularly after each use.
The manufacturer's cleaning procedures or those given by OSHA in mandatory Appendix B-2 of the Respiratory Protection Standard must be used for cleaning respirators.

Storage

Respirators should be protected from damage, contamination, dust, extreme temperature, excessive moisture, and damaging chemicals. They should also be stored to avoid deformation of the face seal or inhalation valve.

Inspections

All respirators should be inspected for damage and proper function before and after each use. Respirators that are used routinely should be inspected prior to use and during cleaning. Inspections should include check of respirator function and condition of parts such as facepiece, head straps, valves, connecting hoses, cartridges, and/or canisters or filters. Facepiece straps and other elastic parts should also be tested for pliability. The inspection of SCBAs should also ensure that cylinders are fully charged (>90%) and that the regulator and warning devices are functioning.

Repairs

Pressure and flow rates must be checked to make sure that the unit is delivering the right amount of air at the right pressure. Cylinders must be checked to ensure that they are not defective. The regulator must be checked to ensure that it is not defective. Hoses and couplings must be checked for cracks or leakage. The manufacturer or someone trained by the manufacturer must perform any repairs to reducing and admission valves, regulators and alarms. Appropriately trained personnel must perform any other repairs. Only NIOSH-approved parts should be used. These parts must be designed for the respirator according to the manufacturer's specifications and recommendations.

Workers must be effectively trained in the following areas:

- Why a respirator is necessary and what affects performance;
- Limitations and capabilities of the respirator;
- Use of respirators in emergency situations;
- How to put on, remove, and use the respirator;
- How to inspect and check seals on the respirator;
- Procedures for maintenance and storage;
- Recognition of medical signs and symptoms that may limit or prevent effective or safe use of the respirator; and,
- General requirements of the Respiratory Protection Standard.

Training is required annually. Additional training must also be supplied if correct procedures are not being followed or changes occur in the workplace that effect how respirators should be used.

Respirator use presents other challenges

Glasses must be replaced with contact lenses or special lenses that do not have sidebars. OSHA places no restrictions on the use of contact lenses with respirators. However, OSHA does say that you should first practice wearing contact lenses with a respirator before doing an actual job. Some employers do not allow contact lenses to be worn if certain chemicals, such as ammonia, are present.

For example, fogging of a full facepiece may occur, particularly in cold weather. This can be controlled by using a facepiece with a nose-cup, or by using coating and attachments designed to prevent this problem. Wearing a respirator also produces physical and mental stress that may increase your risk of heat stress.

Respirator Program evaluation

Employers must evaluate the workplace as necessary to ensure the Respiratory Protection Program is being effectively implemented. Workers should be consulted regularly to obtain their views concerning how successful the program is and what problems need to be addressed.

Additional hands-on activities, if time allows

Depending on class size, have students break into two groups to complete the following.

- Everyone should practice donning a half-face or full-face APR.
- A challenge agent such as banana oil can be used to demonstrate a qualitative fit test following the OSHA protocol for one or two volunteers.
- The class can break into two groups, each with walkie-talkies, paper and a writing utensil. The groups should physically separate and then one group (one student at a time) should mention their name and favorite movie while the other group records the results, then switch. Everyone should get a turn speaking. When the class gets back together, the results can be compared.

Module 8: Personal Protective Equipment

Objectives

After completing this section you will be able to:

- ✓ Describe the 4 main levels of PPE
- ✓ Explain differences in chemical protective clothing
- ✓ Explain permeation, denigration, penetration and breakthrough
- ✓ List safety hazards of wearing PPE
- ✓ Choose the right PPE given specific confined space exposures

Introduction

Your personal protective equipment (PPE) might be all that stands between you and exposure to a chemical or other agent that could be very hazardous to you. Knowing how to select, put on, use and take off your PPE will help to ensure that you can be protected against these hazards.

What does PPE have to do with confined spaces?

Some confined spaces that you may have to enter have additional hazards in them that may not be able to be controlled through engineering, work practices or administrative controls. In these situations you will have to use PPE to protect yourself. Some examples of confined space entries where PPE may be required are entry into a chemical storage tank to clean the inside of the tank and then repaint it. Another example would be entering into a sewage digester tank to clean or fix it.

Hazards in confined spaces can range from chemical exposure to electricity to noise. You can have the same types of hazardous exposures in a confined space that you can have anywhere else, it just that there is much less space for you to avoid them.

What types of PPE might operating engineers have to wear in confined spaces?

Employers are required to train each employee who must use PPE.

Employees must be trained to know at least the following:

- When PPE is necessary;
- Which PPE is necessary;
- How to properly put on, take off, adjust and wear the PPE;
- The limitations of the PPE; and
- Proper care, maintenance, useful life and disposal of PPE.

Employers should make sure that each worker understands how to use PPE properly before they are allowed to perform work requiring it. If an employer believes that a previously trained worker is not demonstrating the proper understanding and skill level in the use of PPE, that worker should receive retraining.

The employer must document the training of each worker required to use PPE by preparing a certification containing the name of each worker trained, the date of training and a clear identification of the subject of the certification.

What is a PPE Program?

Each employer who requires their workers to wear protective clothing to reduce their risk of harm must have a PPE program in place. A program is the employer's procedure for meeting the requirements of a particular regulation.

A written PPE program guides you as an operating engineer to know what PPE is appropriate for the hazard you face. A solid PPE program identifies the hazards at the site, provides medical and environmental monitoring, and training on the selection, use, maintenance, and decontamination of your PPE. The following table shows the corresponding OSHA standards for each area of the program.

Type of Protection	Regulation
General	29 CFR 1910.132, 29 CFR 1910.1000, 29 CFR 1910.1001-1045
Eye and Face	29 CFR 1910.133(a)
Noise Exposure	29 CFR 1910.95
Respiratory	29 CFR 1910.134
Head	29 CFR 1910.135
Foot	29 CFR 1910.136
Electrical Protective Devices	29 CFR 1910.137

The PPE program isn't static either. It should be reviewed every year or if questions come up about whether it's working. The review should include a survey of each site to ensure compliance with regulations, the number of person-hours that workers wear PPE, accident and illness experience, levels of exposure, and adequacy of equipment selection, operational guidelines, decontamination, training, and recordkeeping. You as an employee also have a right to see the results of the evaluation. The evaluation should also be presented to top management to ensure changes can be made if needed.

Your employer cannot institute PPE use without performing a hazard assessment.

A first critical step in developing a comprehensive safety and health program is to identify physical and health hazards in the workplace. This process is known as a "hazard assessment." Examples of physical hazards include moving objects, fluctuating temperatures, high intensity lighting, rolling or pinching objects, electrical connections and sharp edges. Examples of health hazards include overexposure to harmful dusts, chemicals or radiation.

When the walk-through is complete, the employer should analyze the data to determine the proper types of PPE required at the worksite. PPE should be selected that will provide a level of protection greater than the minimum required to protect employees from hazards. The workplace should be periodically reassessed for any changes in conditions, equipment or operating procedures that could affect occupational hazards. This periodic reassessment should also include a review of injury and illness records to spot any trends or areas of concern and taking appropriate corrective action. The suitability of existing PPE, including an evaluation of its condition and age, should be included in the reassessment.

Documentation of the hazard assessment is required through a written certification that includes the following information:

- Identification of the workplace evaluated;
- Name of the person conducting the assessment;
- Date of the assessment; and
- Identification of the document certifying completion of the hazard assessment.

Who Pays for PPE?

OSHA requires employers to provide and to pay for personal protective equipment required by the company for workers to do their jobs safely and in compliance with OSHA standards. Where equipment is very personal in nature and is usable by workers off the job, the matter of payment may be left to labor-management negotiations.

Examples of PPE that would not normally be used away from the worksite include welding gloves, wire mesh gloves, respirators, hard hats, laser or ultraviolet radiation protection glasses, face shields, and specialty foot protection such as metatarsal shoes.

Examples of PPE that is personal in nature and often used away from the worksite include non-specialty safety glasses, safety shoes, and cold weather outerwear worn by construction workers. However, shoes or outerwear subject to contamination by carcinogens or other toxic or hazardous substances which cannot be safely worn off site must be paid for by the employer.

Chemical Protective Clothing (CPC)

Chemicals can damage your skin but may also enter your body through absorption. For instance, some chemicals burn or irritate your skin. Perhaps even more frightening are the ones you absorb without any pain or redness to indicate you've been exposed. Some of these chemicals are so dangerous once they've been absorbed that they can damage vital organs, such as your liver or your central nervous system.

Knowing the concentration and form of the chemical you're working with is critical in determining what CPC you should wear. Some materials protect against a chemical in a low concentration for a long time, yet those same materials might deteriorate quickly if they are exposed to high concentrations of the chemical. You also want to know the clothing material type and thickness and manufacturing method to determine the proper CPC. Because CPC comes in a variety of materials that offer a wide range of protection, the appropriate clothing material depends on the chemicals present and the work to be done.

Chemical Resistant Suits

Chemical suits play a major role in protecting your skin from chemical exposure. Chemical protective suits may be divided into two groups according to the protection they offer. (You will find that other CPC may be added to these suits to give more protection.)

Splash Suit

Splash suits may be two-piece pants-and-coat ensembles, or one-piece coveralls. They protect against splashes of hazardous liquids. They can be taped up with chemical protective tape to give more protection. But they are not gas-tight and so do not protect you against harmful gases/vapors. Some splash suits will cover an SCBA and protect your air supply.

What four steps are necessary to select CPC?

No single CPC item will protect against all chemicals in every circumstance. There are four important steps to take when selecting chemical protecting clothing:

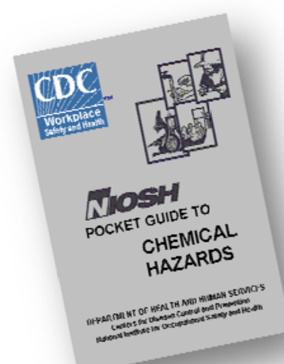
Step 1: Identify the Chemical Hazards

- Identify the chemical or chemical family.
- Identify the physical form of the threat: vapor, liquid, solid.
- Identify the harmful action upon the body.

Step 2: Evaluate the Chemical Exposure

- Evaluate how toxic the chemical is by looking at the IDLH, TLV or PEL.
- Evaluate the level to which you could potentially be exposed while doing a particular job. This means both the quantity and the frequency of the exposure. It is important to get a sense of how great a risk you face. This helps in deciding what level and type of CPC to use, as well as how to decontaminate after the exposure. This is often hard to do, but making an "educated estimate" is better than just guessing.

Step 3: Evaluating Chemical Resistance of CPC



The CPC you use should be matched to the chemical to which you are exposed. No CPC material protects against every chemical and you may be exposed to more than one chemical at a time. Even if you have the right CPC for the chemical, no material is completely successful in protecting you from exposure. Chemicals pass through CPC in three ways: permeation, degradation, and penetration.

You should consult the NIOSH Pocket Guide, MSDSs, your health and safety officer or industrial hygienist, and other sources to determine the exposure limits for the chemical. In addition, measurements should be taken from fixed or remote air monitoring instruments in order to better determine your potential exposure in the confined space.

Chemical resistance is the concept we use to rate a particular CPC item. It defines the ability of the clothing to maintain a barrier to chemicals. The time it takes a chemical to permeate a material is called the "breakthrough time." Breakthrough time depends on the material and the chemical. It may be immediate or take more than 24 hours.

You need a breakthrough time greater than the time it will take to get the job done. OSHA likes to see CPC materials withstand breakthrough for at least an hour. One way to overcome the limitation of any one CPC material is to layer different materials over each other. Many CPC suits are in fact made of several thin layers of different CPC materials. This strategy allows for lightweight suits with good permeation characteristics for a wide range of chemicals.

Step 4: Evaluating the Physical Characteristics of CPC

In addition to a CPC item's effectiveness as a barrier to chemicals, you also want to look at how sturdy the item is. CPC is of little value if it easily rips or tears. It also is of limited value if things like folding the material or leaving it in hot environments reduces its chemical resistance. Performance tests have been developed to evaluate the physical strength of different types of CPC.

Tests conducted on CPC include:

- Abrasion resistance
- Heat resistance
- Ozone resistance
- Cut resistance
- Puncture resistance
- Burst resistance
- Flexibility
- Tear resistance

The material must resist permeation, degradation, penetration and breakthrough

Permeation is when a chemical passes through CPC material. The permeation rate is the time it takes to do this. Although CPC provides a barrier, some chemicals can eventually work their way through.—and sometimes you may not even be able to detect the permeation by simply looking at the clothing.

When the fabric loses its effectiveness as a barrier because chemicals have broken it down, that's degradation. Often you can tell when the material has degraded. It might be puckered, brittle, or eroded. Chemicals, sunlight, and high temperatures all cause degradation.

Penetration is when chemicals pass through zippers, stitched seams, pinholes, or other openings in the material.

Five major factors affect the rate of permeation, degradation, and penetration:

1. Contact time
2. Concentration
3. Temperature
4. Size of contaminant materials
5. Physical state of the wastes

When mixed, chemicals can work even quicker on your CPC. Even small amounts of a chemical that is permeating quickly may provide a path that speeds up the permeation of other chemicals.

Let's look at some chemical resistance tables

Symbols to understand:
nd = not detected
nt = not tested
ID = insufficient data
NR = not recommended
T = good for total immersion
I = good for intermittent contact

Group exercise:

Which glove would you choose for acetone?______________ Why?___________________

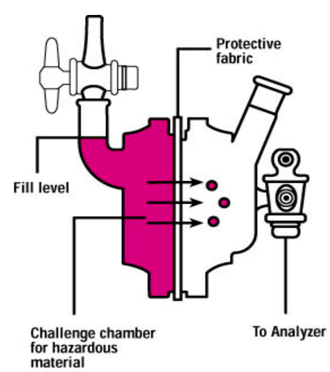
Which would you avoid?__________________ Why? _______________________________

Hazardous Chemical	North Silver Shield {4 mil}	North Viton {9mil}	North Butyl {17mil}
Acetone	>360 (nd) T	0 (281.9) NR	576 (0.066) T

- The first number given is the breakthrough time, in minutes.
- The second number, in parentheses, is the steady-state permeation rate; the higher the number the faster the chemical passes through the material.

How do they know the permeation rate?

They measure it. This is a tester that is required by the American Society for Testing and Materials under Method F739-91. The test chemical is in the left chamber that is separated from the other by the protective fabric being tested. Actual permeation of chemical into the right side is measured. (Graphic courtesy of Krister Forsberg, www.kristerforsberg.com)



What are the levels of PPE?

Now that you have looked at selecting the right materials for the chemicals in question, you have to think about how much protection you will need. Will you need only leggings, boots and gloves or will you wear an enclosed gas tight suit? Will you need a respirator? In general, we break down these issues by ranking four basic levels of protection. Each level corresponds to a CPC ensemble: a collection of different types of PPE (respirator, CPC, head protection, etc.).

The Environmental Protection Agency (EPA) offers guidelines for selecting CPC ensembles. The EPA lists four levels of protection, ranging from A (the most protective) to D (the least protective). The levels are a good starting point, but you have to tailor your final ensemble according to the situation you face.

Typically, your employer will want to avoid Level A protection if it isn't necessary because it is very expensive and also difficult on you wearing that kind of ensemble. If you're facing an unknown situation you should wear Level A protection until chemicals and exposure levels are identified. Most workers will likely never wear Level A protection.

Level A	Should be worn when the highest level of respiratory, eye and skin protection is needed.
Level B	Should be worn when the highest level of respiratory and eye is needed but a lesser level of skin protection is needed.
Level C	Should be worn when the criteria for air purifying respirators are met and some level of skin protection is needed.
Level D	Should be worn as basic work uniform where no respiratory or skin hazards are present. It provides no respiratory protection and minimal skin protection

Level A Protection Description

Level A consists of a gas/vapor tight suit with a supplied air respirator. It provides the maximum level of skin and respiratory protection against chemicals. It is designed to prevent contact of skin and body parts with hazardous vapors, liquids and solids.

Conditions that Warrant Level A include:

- High potential for splash or immersion, or potential exposure to gases or vapors that can harm or be absorbed through the skin
- Potential exposure to unknown vapors, gases, particulates
- Potential for direct skin and eye contact
- Potential for exposures above IDLH
- Effects on skin are unknown

Level A is considered necessary for work when little is known about the nature or amount of hazardous material. It is the highest level of CPC and respirator protection against hazardous chemicals. But, it is not without its own hazards: It is difficult to see, maneuver and communicate when wearing this level of protection. Heat stress is also a concern because the suits are air-tight. Therefore, it is recommended that only highly trained workers should use this level in the most extreme of circumstances.

Level B Protection Description

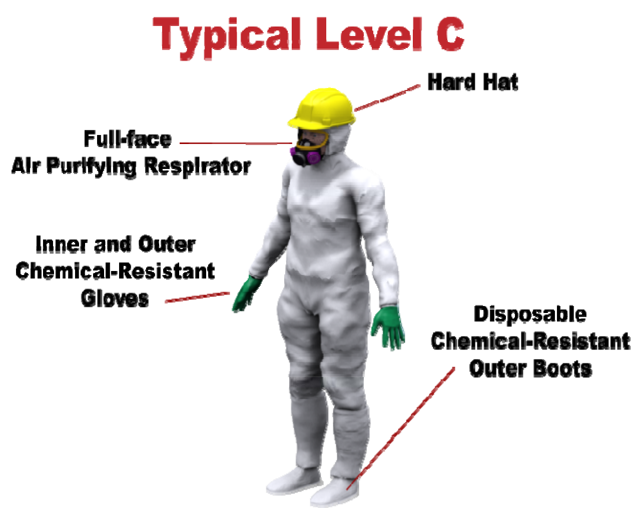
Protective clothing worn with maximum respiratory protection. Level B is designed to minimize or prevent contact of skin and body parts with hazardous substances. It will not prevent skin absorption of gases or vapors nor protect against extensive contact with hazardous materials.

Conditions that Warrant Level B include:

- Limited direct skin and eye contact with hazardous chemicals or air contaminants which will not result in severe damage or irreversible effects;
- Work function involving the potential for only minor splashes; and
- Potential exposure to IDLH or oxygen-deficient atmospheres.

Level C Protection Description

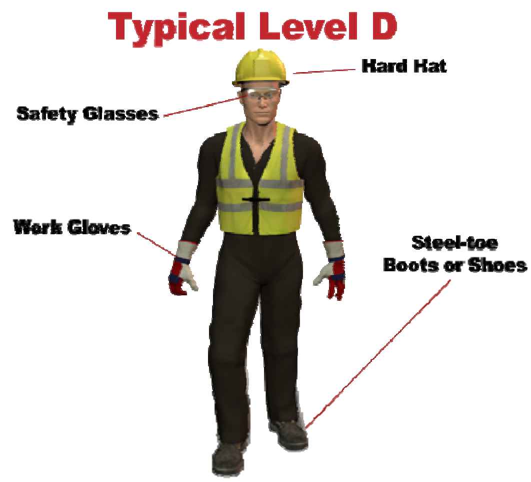
This is the same protective clothing as Level B, but is worn with air purifying respirators. It is designed to minimize contact with many hazardous substances.



Conditions that Warrant Level C include:

- Limited direct skin and eye contact with hazardous compounds or air contaminants that will not result in severe damage or irreversible effects.
- Work function involves potential for only minor splashes.
- Conditions appropriate for air-purifying respirator

Level D Protection Description



Level D protection is a basic work uniform which may include PPE such as safety glasses, safety shoes, hearing protection and work gloves. It does not offer respiratory protection and offers limited skin protection (chemical protective aprons and gloves may be used to handle minor chemical processes, such as transferring chemicals that pose a low respiratory hazard but a slight skin hazard).

Other types of PPE

Eye protection

Employees can be exposed to a large number of hazards that pose danger to their eyes and face. OSHA requires employers to ensure that employees have appropriate eye or face protection if they are exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, potentially infected material or potentially harmful light radiation.

Many occupational eye injuries occur because workers are not wearing any eye protection while others result from wearing improper or poorly fitting eye protection. Employers must be sure that their employees wear appropriate eye and face protection and that the selected form of protection is appropriate to the work being performed and properly fits each worker exposed to the hazard. Consult your industrial hygienist if you are unsure which type of eye protection you require to perform your work safely.

If you wear prescription lenses

Everyday use of prescription corrective lenses will not provide adequate protection against most occupational eye and face hazards, so employers must make sure that employees with corrective lenses either wear eye protection that incorporates the prescription into the design or wear additional eye protection over their prescription lenses. It is important to ensure that the protective eyewear does not disturb the proper positioning of the prescription lenses so that the employee's vision will not be inhibited or limited. Also, employees who wear contact lenses must wear eye or face PPE when working in hazardous conditions.

The eye and face protection selected for employee use must clearly identify the manufacturer. Any new eye and face protective devices must comply with ANSI Z87.1-1989 or be at least as effective as this standard requires. Any equipment purchased before this requirement took effect on July 5, 1994, must comply with the earlier ANSI Standard (ANSI Z87.1-1968) or be shown to be equally effective.

Head protection

Protecting employees from potential head injuries is a key element of any safety program. A head injury can impair an employee for life or it can be fatal. Wearing a safety helmet or hardhat is one of the easiest ways to protect an employee's head from injury. Hard hats can protect employees from impact and penetration hazards as well as from electrical shock and burn hazards.

Employers must ensure that their employees wear head protection if any of the following apply:

- Objects might fall from above and strike them on the head;
- They might bump their heads against fixed objects, such as exposed pipes or beams; or
- There is a possibility of accidental head contact with electrical hazards.

Whenever there is a danger of objects falling from above, such as working below others who are using tools or working under a conveyor belt, head protection must be worn. Hard hats must be worn with the bill forward to protect employees properly. In general, protective helmets or hard hats should do the following:

- Resist penetration by objects.
- Absorb the shock of a blow.
- Be water-resistant and slow burning.
- Have clear instructions explaining proper adjustment and replacement of the suspension and headband.

Protective headgear must meet ANSI Standard Z89.1-1986 (Protective Headgear for Industrial Workers) or provide an equivalent level of protection. Helmets purchased before July 5, 1994 must comply with the earlier ANSI Standard (Z89.1-1969) or provide equivalent protection.

Foot protection

Safety shoes have impact-resistant toes and heat-resistant soles that protect the feet against hot work surfaces common in roofing, paving and hot metal industries. The metal insoles of some safety shoes protect against puncture wounds. Safety shoes may also be designed to be electrically conductive to prevent the buildup of static electricity in areas with the potential for explosive atmospheres or nonconductive to protect workers from workplace electrical hazards.

All foot protection must meet ANSI minimum compression and impact performance standards in ANSI Z41-1991. Footwear purchased before July 5, 1994, must meet or provide equivalent protection to the earlier ANSI Standard (ANSI Z41.1-1967).

Hearing protection

Noise induced hearing loss is one of the most prevalent workplace diseases in the world. If engineering and work practice controls do not lower employee exposure to workplace noise to acceptable levels, employees must wear appropriate hearing protection. The OSHA PEL for noise is 90 dbA (decibels A weighted scale). The action level where your employer must institute a hearing conservation program is 85 dbA (8hr time weighted average). For a more detailed discussion of the requirements for a comprehensive hearing conservation program, see OSHA Publication 3074 (2002), "Hearing Conservation" or refer to the OSHA standard at 29 CFR 1910.95, Occupational Noise Exposure, section (c). If you think your hearing may be compromised due to high levels of noise, have an industrial hygienist check it out.

Tips for using PPE

- Only use PPE that has been properly selected for the given hazard and that correctly fits
- Make sure you have had training before donning PPE
- Always inspect PPE before use
- NEVER use damaged PPE

Donning and doffing take skill and practice

A routine for putting on the different levels of PPE, especially fully encapsulating suits and self-contained breathing apparatus, should be established and practiced periodically. Once you have the equipment on, check the fit. If it's too small, you might tear something. If it's too large, you might snag it on something and you might not be able to move as dexterously. If the fit's poor, you should be provided better fitting clothing.

In the same way you do when donning your equipment, you also should establish a routine for taking it off and practice it. Your primary concern is preventing the transfer of contaminants from the work area to your body, the decontamination assistants, and others. So, doff your PPE only after you've been through decontamination. Throughout the doffing procedure both you and any assistants should avoid any contact with the outside surface of your suit.

Inspection

A solid PPE inspection program features five different inspections:

1. Inspection and operational testing of equipment received from the factory or distributor.
2. Inspection of equipment as it is issued to workers.
3. Inspection after use or training and before maintenance.
4. Periodic inspection of stored equipment.
5. Periodic inspection when a question arises concerning the appropriateness of the selected equipment, or when problems with similar equipment arise.

Protective suits usually have a shelf life of 4-5 years. Follow the manufacturer's guidelines for the suit.

Storage

Clothing and respirators can't be stored just anywhere. They need a place that limits exposure to dust, moisture, sunlight, damaging chemicals, extreme temperatures, and impact. Storage procedures must be in place. Often equipment fails because it hasn't been stored properly. Here are some guidelines:

- Potentially contaminated clothing should be stored in an area separate from street clothing.
- Potentially contaminated clothing should be stored in a well-ventilated area, with good air flow around each item, if possible.
- Different types and materials of clothing and gloves should be stored separately to prevent issuing the wrong material by mistake.
- Protective clothing should be folded or hung in accordance with manufacturers' recommendations.

Maintenance and Repair

Only people properly trained in the manufacturer's recommended procedures should handle maintenance and repair of chemical protective clothing or other PPE.

What are the health and safety issues of wearing PPE?

- PPE is last on the Hierarchy of Controls!
- Heat stress
- Limited vision
- Limited hearing
- Limited agility and dexterity
- Claustrophobia

These factors combine to increase the likelihood of slips, trips, and falls which may cause tears in CPC. They may also increase the likelihood of suffering harm from other hazards (i.e. not hearing well could increase struck-by hazards)

These safety problems are made worse when PPE does not fit properly. Oversized or undersized PPE can create serious safety hazards. A range of different sizes should be available for all types of PPE at your workplace. If it doesn't fit, get one that does!

If you have to wear PPE

If you have to wear PPE make sure that your employer has performed a hazard assessment in accordance with the OSHA standard. There must be an established PPE program that your employer has created. You must receive training on the PPE you are expected to use, before you use it. Make sure the PPE you will be using is the right protection for the job and that it fits properly. Finally, always inspect PPE before you use it. If it is damaged in anyway, don't use it!

Hazard recognition and PPE matching exercise

If time allows, work as a group to identify the hazards in the three worksites and determine the correct PPE for working in those environments.

Module 9:
What are the fall hazards in confined spaces?

Objectives

After completing this section you will be able to:

- ✓ Describe injuries that may result from falls in confined spaces.
- ✓ State the fall protection height requirements for commercial and residential work.
- ✓ Name at least three warning signs or clues that a fall hazard exists.
- ✓ List at least five fall hazards that you may find during your work.
- ✓ Discuss at least three methods of protection for fall hazards.
- ✓ Describe some of the additional fall hazards on disaster sites.

Can you find fall hazards in confined spaces?

Confined spaces have the potential for most fall hazards.

- Think about fall hazards to access a confined space.
- Think about fall hazards in a confined space.

What in confined spaces can increase the risk of falls?

- Hazardous atmospheres
- Slippery surfaces
- Tight work areas
- Difficult entries
- Awkward structures and climbing devices

Case studies on fall hazards

Case Study #1

This is taken from NIOSH's FACE program (Fatality Assessment and Control Evaluation). The database of case studies is available at: http://www.cdc.gov/niosh/face/inhouse.html

On August 30, 2002, at approximately 12:45 p.m., a 45-year-old water soluble mixer operator died. The Nebraska Department of Labor was notified of the fatality the same day by the Occupational Safety and Health Administration (OSHA). The Nebraska FACE Investigator met with the investigating OSHA Compliance Officers (COSHAs) and company officials on September 3, 2002 at the mishap location.

The operator was killed when he apparently lost his balance and fell through an opening in an operating mixing machine. The victim was cleaning the inside of the mixer by spraying water from above through one of three top side openings covered by protective grates. The victim had not shut the mixer off. As he stepped onto the top of the mixer, he fell through the middle opening. A worker one floor below heard a sound, saw blood coming from the machine and immediately activated the emergency shut off switch. The victim was pronounced dead at the scene.

Case Study #2

On September 20, 1996, a 28-year-old male laborer/painter fell nearly 48 feet to his death while painting the inside of a empty storage silo. The interior of the silo is accessed by ascending an enclosed fixed ladder system on the outside and entering through a 20-inch opening in the top.

The victim worked for a three-employee construction company which was sub-contracted to paint the inside of the silo. On September 20, 1996, all three began work on this job at about 8:30 a.m. The victim entered the 20" opening and sat in a makeshift boatswain's chair. The chair was a substandard 21" x 5½" in size and was supported by a 3/8" plastic coated cable. The working end of the plastic coated cable was attached to the boatswain's chair support cable by two U-bolts and duct tape. The chair was lowered and raised by an electric winch powered by a large battery and a portable generator. Vise grips were used to connect the power cables to the battery.

The electric winch was secured to a 6"x 6" wood beam (not man tested) on top of the storage silo. This support timber was secured to the top of the storage silo frame by a length of chain wrapped around each end. The winch was secured upside down with a heavy chain wrapped around the support timber. When the victim entered the silo, he was wearing an old safety belt 52" x 4½" with a safety rope secured to a 10" x 4½" triangular lock ring that was frozen in the open position. The safety line was made up of two different sizes, types, and lengths of rope tied together and secured to the 6"x 6" timber on top of the storage silo.
The co-worker on top of the storage silo stated that around 2:00 p.m., when they were ending their day, he started the winch to bring the victim up to the 20" opening in the top of the tank. The victim was near the top of the silo when the co-worker heard something snap but was not

sure what it was. The next thing the co-worker knew, the victim and safety rope were plummeting 48 feet to the bottom of the silo. Investigation after the event revealed that the end of the winch line secured to the boatswain's chair had pulled out of the improperly positioned U-bolts, allowing the victim to fall.

What happens when you fall?

When a person falls they will accelerate in speed until they reach what is known as terminal velocity in which the person is no longer accelerating. This takes a long fall, such as from an airplane, but the velocity at this point can range from 120 to 200 mph! There is a common fallacy that you can catch yourself somehow during most falls. In fact, it takes most people 1/3rd of a second to even grasp they are falling and another 1/3rd of a second to react, by which time they have fallen 7 feet. By the last 1/3rd of that first second of fall, the worker has dropped 16 feet. If the ground doesn't interrupt, the worker will reach 64 feet by the next second.

How far and fast can you fall?

At Time (Seconds)	Distance of Fall (Feet)
0.5	4
1.0	16
1.5	36
2.0	64
2.5	100
3.0	144
4.0	256

What are the primary causes of fall fatalities?

Think of some examples of these causes in confined spaces. Write your answers below.

- Unprotected sides, edges and holes
- Improperly constructed walking/working surfaces
- Improper use of access equipment
- Failure to properly use Personal Fall Arrest Systems (PFAS)
- Slips and Trips (housekeeping)

Is there a “best way” to control hazards?

1. Elimination or Substitution
2. Engineering Controls
3. Administrative Controls
4. Personal Protective Equipment (PPE)

As you go down the list, you are relying more and more on workers to protect themselves. For any hazard, control should always start at the top and move down *only* after the higher level has been demonstrated to not be applicable. Workers should always think in these terms when tackling a new project. The first question is whether the task really needs to be done. Can it be eliminated? If not, what engineering controls are possible? If there are none, then administrative controls may be possible. An example would be rotating several people through a job over 8 hours when one person would be overexposed on an OSHA Permissible Exposure Limit to a harmful substance.

What is the problem with administrative controls in this case? Write your answers in the box below.

Fall hazards have a particular situation where administrative controls are LESS protective than PPE and that is the OSHA-allowed practice of having a spotter on a flat roof.

With engineering controls there are both active and passive methods. Interlocks on mechanical or electrical equipment are passive controls, you don’t have to do anything to acquire the protection; two-hand trips on power presses are active controls, you need to take action to protect yourself.

What is fall protection?

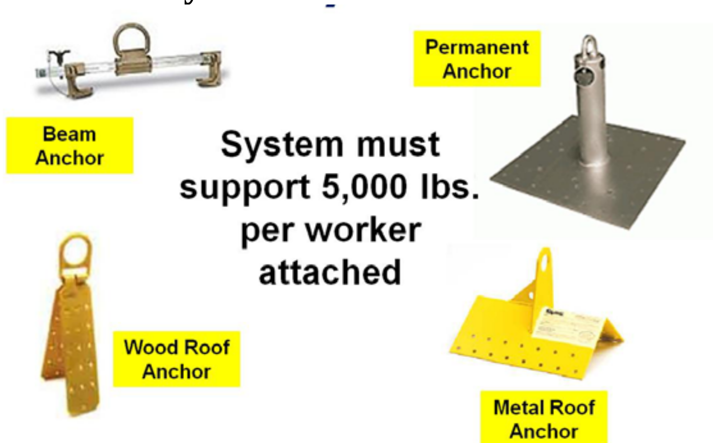
Fall protection is a system designed to protect personnel from the risk of falls when working at elevated heights.

What are examples of fall prevention and protection systems?

- Controlled access zones
- Guardrail systems
- Personal fall arrest systems
- Positioning device systems
- Safety monitoring systems
- Safety net systems
- Warning line systems
- Covers

Have you seen these before?

Anchors Away



Whatever anchor system is chosen, it must support 5,000 pounds for each worker attached to the system. As part of a complete personal fall arrest system, it must maintain a safety factor of at least two. If a self-retracting lifeline (SRL) is used that limits free fall distance to 2 feet, the anchors only need to support 3,000 pounds. All anchors must be at or above D-ring height.

Remember these fall protection basics

These fall protection basics are common sense, but can save lives. They include the following:

- Inspect your equipment daily.
- Replace defective equipment. If there is any doubt, do not use it. It is everyone's responsibility to see that damaged equipment is taken out of service.
- Replace all equipment involved in a fall.
- Ensure all equipment is inspected by a competent person at least annually.
- Use shock absorbers if the arresting forces of the lanyard alone can cause injury.
- Use the right equipment for the job.

What practices are needed when working around holes?

The OSHA standard requires that holes be covered "with materials of adequate strength." Guardrails are required to withstand a 200 pound perpendicular stress. Covers must be able to support at least twice the weight of employees, equipment, and materials that may be imposed on the cover at any one time. To prevent accidental displacement resulting from wind, equipment, or workers' activities, all covers must be secured. All covers shall be color coded or bear the markings "HOLE" or "COVER."

Of particular interest to heavy equipment operators, OSHA does require that covers of trenches and holes on construction sites where trucks and equipment may run over them must support 20,000 pounds. Trench or conduit covers and their supports, when located in plant roadways, shall be designed to carry a truck rear-axle load of at least 20,000 pounds. Manhole covers and their supports, when located in plant roadways, shall comply with local standard highway requirements if any; otherwise, they shall be designed to carry a truck rear-axle load of at least 20,000 pounds.

What is needed for wall openings?

- Guardrails
- Catch platforms
- Restraint devices
- Safety nets

Open-sided floors should be protected by one of the listed systems, but whatever the choice, the system must be properly installed, adequately sized, and continually maintained.

What do we need to know about access ways?

Self-closing swing gate on platform and vertical handrails on ladder
Photo courtesy of US Navy.

On construction projects, ladders may be used to get to higher floors and access ways must be provided to get to the ladder.

Some of the things we need to know about the access way to a ladder are:

- Ladders must be prevented from slipping, by extending them above the platform 36 inches, unless another suitable grab is provided.
- The ladderway requires fall protection with a maximum opening of 18" to the side of the ladder, or an offset entry to minimize the hazard of employees "stumbling" into the opening.
- Offset guardrails are recommended.
- The tops of ladders and stairs must be kept clear of tripping hazards.

Slip and trip hazards can be numerous in a confined space.

Slip and trip are the most common hazards on a construction jobsite and particularly on a demolition site. They include:

- Housekeeping
- Wet and slippery surfaces
- Obstacles in walkway
- Lighting
- Footwear
- Improper behavior

What are key issues with stairs?

- Stairways that will not be a permanent part of the structure and on which construction work is performed must have landings at least 30 inches deep and 22 inches wide at every 12 feet or less of vertical rise.
- Stairways must be installed at least 30 degrees, and no more than 50 degrees, from the horizontal.
- Where doors or gates open directly onto a stairway, a platform must be provided that extends at least 20 inches beyond the swing of the door.
- Except during construction of the actual stairway, stairways with metal pan landings and treads must not be used where the treads and/or landings have not been filled in with concrete or other material, unless the pans of the stairs and/or landings are temporarily filled in with wood or other material.
- Stairways having four or more risers, or rising more than 30 inches in height, whichever is less, must have at least one handrail. A stair rail also must be installed along each unprotected side or edge. When the top edge of a stair rail system also serves as a handrail, the height of the top edge must be 36 to 37 inches from the upper surface of the stair rail to the surface of the tread.
- Unprotected sides and edges of stairway landings must be provided with standard 42-inch guardrail systems.

Is this ladder being safely used to access a chemical storage tank?

How should a ladder be set up?

- Ladders should be set at a ratio of 1 horizontal foot for every 4 vertical feet.
- Ladders must be secured.
- Ladder access ways must be guarded.
- Ladders must extend 3' above the landing surface, or an adequate grabrail must be provided.
- The ladder base must be properly set.

Which way to set the base?

Firm Base
Set both feet level and on the pads

Soft Base
Set on the spikes and seat the ladder in the ground.

Scaffold requirements

- Be on a firm foundation with base plates
- Be plumb, square and adequately braced
- Have a fully planked work deck
- Have guardrails over 10 feet in height
- Be tied-in over 4:1 height to base ratioWhen a supported scaffold reaches a height that is more than four times its minimum base dimension (4:1), it must be restrained by guys, ties, or braces to prevent it from tipping. Guys, ties, and braces must be installed at locations where horizontal scaffold components support both inner and outer legs. Guys, ties, and braces must be installed according to the scaffold manufacturer's recommendations or at the closest horizontal member to the 4:1 height ratio and be repeated every 20 vertical feet for narrow scaffolds (3 feet or less in width), and every 26 vertical feet for scaffolds greater than 3 feet in width.
- Have an adequate means of access and egress

Scaffold access

OSHA requires the following for safe access to scaffolding:

- No access can be made by cross braces
- Bottom rung cannot be more than 24" high
- You must use a ladder or frames designed to be used as ladders
- Climbing the structural cross-braces of a scaffold is *unsafe*, and *specifically forbidden* by federal standards. However, OSHA permits direct access from another scaffold, structure, or personnel hoist.

Use a Competent Person

OSHA requires that a competent person, someone who has received adequate training, supervise the erection and dismantling of scaffolds. OSHA has an e-tool on scaffolding that includes the other shot.

Case Report from OSHA files

An employee was constructing the third level of a tubular, welded-frame scaffold while standing on the second level. The scaffold was constructed on a poured concrete floor and had been leveled. Each section of the framework measured 6'5" high. The working surface was solidly planked. When the employee tried to set the third level frame into the pins of the second level, the frame he was trying to position flipped to one side. The momentum of the frame thrust the employee backward off the second level. He fell to the ground, sustaining a fatal blow to his head.

Have you used a baker scaffold?

- These can be unstable and dangerous.
- Never use a double stack without outriggers.

How do you prevent objects from falling off scaffolds?

- Use toe boards at edges of platforms
- Use panels or screens when accessed from below
- Barricade areas below
- Use canopies where walkways cross underneath

Are scaffolds used in confined spaces?

The answer is yes. Some scaffolds are designed in small enough pieces that they can be carried through an 18" access portal.

How do you prevent falls from equipment?

- Do not jump from equipment
- Use three point contact at all times
- Be sure of your footing
- Do not strain your shoulders
- Be sure steps are clear of mud and ice

Working with electricity at heights

- Many falls are caused by accidental contact with electricity
- Be aware! In a confined space, lockout electricity if possible
- If electricity cannot be locked out, maintain adequate distances and use PPE

Workers need to be cautioned that the risks of electricity are greater while working at elevations because any contact with electricity, no matter how mild, can cause a physical reaction that can result in a fall. The situation is made more difficult because it may not be possible to shut off the electricity and it may be high voltage.

Apply the hierarchy of controls to working around electrical equipment. Here are some possible answers:

1. Have the electricity shut down = Engineering control
2. Maintain a safe working distance = Administrative control
3. Wear personal fall arrest system = Personal protective equipment

Fall Hazards and Controls Group Activity

1. Examine and discuss the following photographs.
2. Focus on any fall hazards that might be present.
3. Describe possible controls and the level of hierarchy that it would represent.
4. Write your answers in the boxes.

Photo 1

This tank has to be entered at the top for cleaning.

Photo 2

This vault is 10 feet deep and requires entry for maintenance work.

Photo 3

This 15 foot tank requires fall protection, but must be accessed by a ladder on the side.

Photo 4

Look at the access points for this biological scrubber. How could a worker set up access while keeping fall risks to a minimum or eliminating them all together?

Module 10: What are the roles and duties for confined space work?

Objectives

After completing this section you will be able to:

- ✓ Name the different roles for workers that are involved in confined space work
- ✓ List the duties of entrants, attendants, supervisors and rescue personnel in confined space work
- ✓ Describe the training workers need to perform for each of the roles
- ✓ Explain the issue with confined space regulation in construction work

There are 4 different roles for permit-required confined space work.

Under OSHA's confined space standard, 29 CFR 1910.146, these are the roles for personnel involved with permit-required confined space work:

- entrant,
- attendant,
- entry supervisor, and
- rescue and emergency service personnel.

The employer must provide training so that personnel can safely perform their duties.

Each person involved in confined space work must be properly trained to perform their assigned role. This course is a 2-day awareness program and **doesn't** qualify you to perform confined space entry or to perform confined space rescue.

OSHA requires that training must be provided:

- Before a worker is first assigned to confined space work;
- Before there is a change in duties;
- If a change to permit space operations occurs that the worker has not been trained to do; or
- Whenever a worker thinks the permit system is not being followed or he/she needs more training on procedures.

The employer must ensure that the training has prepared workers for confined space operations.

The training provided to workers must actually prepare them to do confined space work safely. Employers must evaluate whether the workers have been adequately trained. One method that must be used to assess the effectiveness is proficiency training. In other words, the workers must be able to demonstrate that they can correctly perform the task they were trained to do. Employers must also certify in writing that the required training has been completed.

Workers have specific duties depending on their tasks.

Entrant

The worker who enters the confined space is the *entrant*. OSHA calls them an "authorized entrant" and means an employee who is authorized by the employer to enter a permit space. Entry means that any part of the person has crossed the plane of the opening into the space.

The entrant has several duties. The entrant must:

- Know the hazards they may face during entry, including, signs symptoms and consequences of exposure.
- Be able to properly use equipment. This includes equipment for testing, monitoring, ventilating, communicating, lighting, personal protective and other equipment.
- Be able to communicate with the attendant.
- Alert the attendant whenever he/she recognizes a warning sign or symptom of exposure to a dangerous situation, or detects a prohibited condition.
- Exit the space as quickly as possible if ordered to do so, an evacuation alarm is activated, or the worker recognizes a symptom or sign of exposure.

Class Exercise

What methods could you use as an entrant to communicate with the attendant? Write your answers below.

Attendant

An *attendant* stays outside of the confined space.

The attendant:

- Knows the hazards that may be faced, including the signs or symptoms, and consequences of exposure.
- Is aware of exposure to a hazard may affect the entrant's behavior.
- Keeps an accurate count of entrants in the space and who is in the permit space.
- Remains outside the permit space during the entry operation until he/she is relieved by another attendant.
- Communicates with entrants and alerts them if it is necessary to evacuate.
- Monitors activities inside and outside the space to determine if it is safe for entrants to remain in the space
- Summons rescue and other emergency services as soon as the attendant determines the entrant may need help escaping from a permit space.
- Performs non-entry rescues.
- Does not do any other activity that might interfere with the attendant's primary duty to monitor and protect the entrants.

Supervisor

The supervisor has several specific responsibilities to make sure confined space operations are done safely. The "entry supervisor," as OSHA calls them, must:

- Know the hazards that may be faced.
- Verify that tests have been done and all equipment and procedures are in place.
- End the entry and cancel the permit.
- Make sure that rescue and emergency services are available.
- Keep unauthorized persons away.
- Determine if acceptable entry conditions are maintained, even if responsibility for operation is transferred.

Rescue and Emergency Services

Rescuers get the worker out of a permit-required confined space.

An employer that designates rescue and emergency services must:

- Evaluate the rescuer's ability to respond in a timely manner and is capable of performing the needed rescue services.
- Inform each rescue team of hazards they may confront at the site.
- Provide the rescue team with access to all permit spaces they might need.

An employer may also designate its own employees to provide rescue and emergency services. If this option is chosen, employers must:

- Provide employees, at no cost, with the PPE and training they need to safely conduct permit space rescue
- Train rescue employees in basic first-aid and CPR, and ensure that at least one member of the team holding a current certification in first aid and CPR is available.
- Ensure that the designated employees practice permit space rescues at least once per year.

What is the issue with confined space entry on construction sites?

Class Exercise: Completing a Permit

If time permits, each group will discuss actual confined entries they have seen or create a scenario and then complete the permit as much as possible. The entry permit is courtesy of the Wheelabrator Corporation from their Baltimore facility, which was awarded the OSHA Star under the Voluntary Protection Program for having an excellent safety and health program.

This exercise can be skipped and conducted in combination with the final exercise in Module 12.

PERMIT-REQUIRED CONFINED SPACE (PRCS) HAZARD EVALUATION WORKSHEET

(Attach to PRCS Entry Permit)

PRCS Name:

PRCS Location:

Number of Access Ways:

List all potential hazardous atmospheres, engulfing materials, converging walls or sloping floors, and all other potential serious safety and health hazards specific to this PRCS and then list how to eliminate these hazards.

HAZARDS	CONTROLS

Evaluation Prepared By

Printed Name ____

Signature ____

Date ____________

Location and Description of Space	Permit Number
Purpose of Entry:	Hazards: Attach Appendix B - PRCS Hazard Evaluation Worksheet

Date:	Time In:	Time Out	Expiration Date and Time:

Name of Entrant(s) (Print - use Supplemental Log if necessary)

Name of Attendant(s) (Print - use Supplemental Log if necessary)

SPECIAL REQUIREMENTS SECTION **NOTE: ATTENDANT IS REQUIRED FOR ALL PERMIT-REQUIRED CONFINED SPACE ENTRY!**

(Check Box)	NA	YES	NO	(Check Box)	NA	YES	NO
Lockout/Tagout?				Fall Protection/Life Lines Required?			
Hot Work Permit?				Hearing Protection Required			
Lines Disconnected/Blanking?				Protective Clothing Required			
Floor & Wall Openings Guarded?				Retrieval Equip./Tripod/Harness Required?			
Safe Access/Egress Provided?				Area Secure - Others in Area Alerted?			
Lighting(Explosion-proof/Low Voltage)?				Communications Established? (Note Method):			
Backup/Emergency Lighting?							
Overhead Protection?				Other (list)			

Additional Ventilation Required? ☐NO ☐YES

IF YES: ☐ Directed ventilation to point/localized sources using Fans/Blowers/Air Horns

☐Forced ventilation to entire space using: ☐Process Fan(s) ☐Other Fans/Blowers/Air Horns

Respiratory Protection: ☐NA

☐½ Face ☐Full Face

☐APR ☐SAR ☐SCBA

AIR TESTING SECTION **☐Every 12 Hrs.(min. req.) ☐Other Frequency: Every _____ Hrs. ☐Continuous**

(Use Supplemental Log if necessary)	**Acceptable Levels**	**Pre-Entry Results**	**Periodic Results**	**Initials**	**Time**	**Periodic Results**	**Initials**	**Time**
Oxygen-O2	19.5-23.5 %							
Combustibles	< 10 % LEL							
Carbon Monoxide-CO	< 25 PPM							
Hydrogen Sulfide-H2S	< 10 PPM							
Air Temperature	< 130° F							
(Other)								
(Other)								

Name of Person Conducting Pre-Entry Air Testing (Print) (Date/Time)

Air Testing Equipment: **(Model # and Serial #)**	**Calibration Information** **NOTE:**		**Emergency Rescue Section** **Contact #:** **Team Name:**	
Contractor Air Testing Coordinated? ☐ NA ☐ YES ☐ NO	Date/Time of Cal/Bump Test	Initials	Contractor Rescue Coordinated? ☐NA ☐YES ☐NO	Control Room Contact Method: ☐Radio ☐P.A. System ☐Phone(#)

Entry Supervisor Authorization - All PRCS permit conditions have been satisfied and acceptable entry conditions exist. If new hazards arise, the space must be immediately evacuated until the hazard(s) has been eliminated and the space re-evaluated.

(Print Name) (Signature) (Date/Time)

CONTRACTOR DEBRIEFING? ☐NA ☐YES ☐NO	Additional hazards encountered during PRCS entry? ☐NO ☐YES
Name of Contractor Company(s): Sun Pro	(Describe hazards-attach additional information as necessary)

Entry Supervisor Verification	(Print Name)	(Signature)	(Date/Time)

PRCS ENTRY AND AIR TESTING SUPPLEMENTARY LOG

Acceptable	Parameter	Periodic	Periodic	Periodic	Periodic	Periodic	Periodic	Periodic
	Date							
	Time							
19.5-23.5%	Oxygen%							
<10% LEL	Combustibles%							
< 25 PPM	Carbon Monoxide PPM							
<10 PPM	Hydrogen Sulfide PPM							
< 130° F	Air Temperature							
	(Other)							
	Tester (Initials)							

Attendants (List Names Below)	Date	Time On	Date	Time Off

Entrants (List Names Below)	Date	Time In	Date	Time Out

Module 11: What regulations apply to confined space work?

Objectives

After completing this section you will be able to:

After completing this section, you will be able to:

- ✓ Explain when the Occupational Health and Safety (OSHA) permit-required confined spaces standard (29 CFR 1910.146) applies.
- ✓ List the OSHA requirements for air monitoring and other hazard assessment methods.
- ✓ Name the major elements that must be included in an employer's permit-required confined space program.
- ✓ List the information that must be on an entry permit.
- ✓ Describe the rescue and emergency services needed for confined space work.
- ✓ List other OSHA standards that commonly apply to confined space work.

Applicability of standards

The latest OSHA confined space standard, 29 CFR 1910.146 covers general industry, does not apply to agriculture, construction, or shipyard employment. For the IUOE, this means that stationary engineers are probably covered under this standard, but most hoisting and portable aren't. The shipyards have their own standard, 29 CFR 1915, Subpart B. According to OSHA, a standard that will cover construction is supposedly in the works.

There is a standard that covers construction, ANSI/ASSE Z117.1-2009. Although it provides more information, it closely follows the OSHA standard. It provides good detail on sampling and ventilation.

OSHA Coverage

Before going into the OSHA regulations it is important to point out that OSHA does not cover all workers. Federal OSHA applies to private sector workers but does NOT cover state and local government workers. OSHA allows states to run their own state OSHA programs instead of being covered by the federal government. State programs approved by federal OSHA cover both the private sector and state and local government workers. Twenty-one states and Puerto Rico have federally approved OSHA programs that cover public employees (AK, AZ, CA, HA, IN, IA, KY, MD, MI, MN, NV, NM, NC, OR, SC, TN, UT, VT, VA, WA, WY). Three states, (CT, NJ, NY) have federally approved state programs that apply only to state and local government workers, and private sector workers are covered by federal OSHA. Approved state OSHA programs must be at least as effective as the federal program and provide similar protections for workers.

Several other states, such as Illinois, Wisconsin, Maine, and New Hampshire administer job safety laws that cover only state and local government workers and adopt federal OSHA standards, but they are NOT federally approved programs. A number of other states have "Right-to Know" (R-T-K) laws that require employers to provide information and training to state and local government workers about hazardous chemicals used on the job.

Federal workers are covered by their agencies under a Presidential Executive Order. Federal agencies must maintain an effective safety and health program that meets the same standards that apply to private employers. Federal agencies cannot be fined for violating health and safety standards, except for the United States Postal Service.

The OSHA permit-required confined space standard has twelve sections and six appendices.

The OSHA standard for permit-required confined space has 12 main sections plus 6 appendices. Going through the main points that are required by OSHA also provides a good review of logical and safe entry procedures that have been examined in earlier sections of this course. The standard includes:

(a) Scope and application
(b) Definitions
(c) General requirements
(d) Elements of an employer's confined space program
(e) Permit system
(f) Entry permit
(g) Training
(h) Entrant's duties
(i) Attendant's duties
(j) Supervisor's duties
(k) Rescue/emergency services, and
(l) Employee participation

(a) Scope and application

The standard applies to areas that meet the definition of a permit-required confined space. 1910.146 does not apply to agriculture, construction, or shipyard work.

(b) Definitions

Section (b) includes key definitions used in the standard.

(c) General requirements

Section (c) lays out the *general requirements* an employer must follow to protect employees from permit-required confined space hazards.

The first question that needs to be answered is whether or not there are any permit-required confined spaces in the workplace. If the answer is yes, then a detailed program that includes the information, equipment and procedures covered in this course must be put in place before anyone enters a permit-required space.

The second general requirement, (c)(2), directs the employer to inform exposed workers where there are confined spaces. This is a worker's right-to- know about the locations of permit-required confined spaces and the hazards they contain. The employer must post danger signs in the workplace or use another equally effective means to communicate to its employees.

(c)(3) An employer that decides not to have its employees enter a permit space must take steps to prevent employees from entering a space.

(c)(4) states that an employer must develop and implement a written permit space program if employees will enter a permit space. The written program must be available to employees and their representatives. Employers who decide that their workers will not enter permit spaces must still take steps to prevent entry.

If there is a change in the use or shape of a non-permit required space, the employer must reevaluate it to determine if it has become a permit-required space. An employer who arranges to have another employer perform work involving a permit space must provide information about permit spaces to contractors and coordinate operations.

(c)(5) states that under certain conditions, the employer may use alternate procedures for worker entry into a permit space. For example, an employer may be exempted from some requirements, such as permits and attendants. In this case, the employer must demonstrate with monitoring and inspection data that the only hazard is an actual or potential hazardous atmosphere that can be made safe by using continuous forced air ventilation. However, even in these circumstances, the employer must still test the internal atmosphere of the space for oxygen content, flammable gases and vapors, and the potential for toxic air contaminants before any employee enters it. The employer must also provide continuous ventilation and verify that the required measurements are performed before entry.

(d) Elements of an employer's confined space program

Section (d) describes what must be included in the employer's permit-required confined space program. There are 14 requirements in all.

The first element of a permit-required confined space program is to make sure that no unauthorized person enters a space (d)(1).

(d)(2) requires a hazard assessment as was covered in Module 4. The employer must identify and evaluate hazards BEFORE any worker enters a space and then must develop and implement procedures to:

Detail entry conditions that are acceptable. Identify and evaluate hazards before there is an entry. Isolate the permit space. Ventilate the space to get rid of or control atmospheric hazards. Provide pedestrian, vehicle or other barriers to protect entrants from external hazards.

(d)(4) requires employers to provide and maintain equipment that is needed for permit-required space work to employees at NO cost. This includes, but is not limited to, equipment for air monitoring, ventilation, communication, lighting, barriers, personal protection, and rescue.

(d)(5) requires that permit space conditions be tested when entry operations are conducted. The assessment must take place before and during entry. As covered in the section on air monitoring for atmospheric hazards, first test for oxygen, then combustible gases and vapors, and then for toxic gases and vapors. Entrants and their representatives have the right to observe testing and must be provided with the results immediately.

Sections (d) (6) through (9) specify the roles and duties of different personnel for permit-required operations. There must be an attendant outside the space during the whole entry period. An attendant may monitor more than one space. However, the program must include procedures as to how an attendant will respond to an emergency affecting one or more of the spaces without interfering with the attendant's responsibility to prevent unauthorized entry into each space.

In addition to the attendant, the employer must designate authorized entrants, supervisors, and how rescue and emergency services will be summoned.

Sections (d)10 through (14) address permitting issues and coordinating operations when more than one employer is involved. The employer must develop and implement a system to issue, use and cancel permits for work in permit-required space operations. There must be coordination with employees of other employers on the same site so that workers in permit spaces are not put in danger. Finally, the employer must review the permit program using the cancelled permits to ensure that the employees are being protected from permit space hazards.

(e) Permit system

The permit system required in section (e) has 6 elements.

1) The employer documents the space is safe to enter. This means the employer has implemented procedures to detail that entry conditions are acceptable.
2) The entry supervisor signs the entry permit to authorize entry.
3) The permit is made available at the time of entry to all entrants and their representatives. This is done by posting the permit at the entry portal or other equally effective method so that entrants know that pre-entry preparations have been done.
4) The permit is only good for as long as it takes to complete the task.
5) The entry supervisor cancels the permit when the task is finished OR a condition not allowed on the permit arises.
6) Finally, the employer must keep each permit for at least one year.

(f) Entry permit

A completed entry permit includes, but is not limited to the following information:

- the name of the permit space to be entered, authorized entrants, attendants, and entry supervisors,
- test results,
- the tester's initials or signature,
- the name and signature of the supervisor who authorizes entry,
- the purpose of the entry and known space hazards,
- the measures to be taken to isolate permit spaces and to eliminate or control space hazards,
- the names and telephone numbers of rescue and emergency services and means to be used to contact them,
- the date and authorized duration of entry,
- the acceptable entry conditions,
- communication procedures and equipment to maintain contact during entry
- additional permits, such as for hot work, that have been issued authorizing work in the permit space,
- special equipment and procedures, including personal protective equipment and alarm systems, and
- any other information needed to ensure employee safety.

(g) Training

Before the initial work assignment begins, the employer must provide proper training to all employees who are required to work in permit spaces. After the training, employers must ensure that the workers have acquired the understanding, knowledge and skills necessary to safely perform their duties.

Additional training is required when:

- The job duties change,
- A change occurs in the permit space program or the permit space operation presents any new hazard, or
- An employee's job performance shows deficiencies.

In addition to this training, rescue team members need training in CPR and first aid. Employers must certify that this training has been provided.   The employer must keep a record of employee training and make it available for inspection by employees and their authorized representatives. The record must include the employee's name, the trainer's signature or initials and dates of the training.

(h) Entrant's duties

Authorized entrants are required to:

- Know space hazards, including information on the means of exposure such as inhalation or skin absorption, signs of symptoms and consequences of the exposure;
- Use appropriate personal protective equipment properly;
- Maintain communication with attendants as necessary to enable them to monitor the entrant's status and alert the entrant to evacuate when necessary;
- Alert the attendant when a prohibited condition exists or when warning signs or symptoms of exposure exist
- Exit from the permit space as soon as possible when:
    - Ordered by the authorized person;
    - He or she recognizes the warning signs or symptoms of exposure;
    - A prohibited condition exists; or
    - An evacuation alarm is activated.

(i) Attendant's duties

Attendants must:

- Know the hazards that may be faced, including the signs or symptoms, and consequences of exposure.
- Be aware of exposure to a hazard may affect the entrant's behavior.
- Keep an accurate count of entrants in the space and who is in the permit space.
- Remain outside the permit space during the entry operation until he/she is relieved by another attendant.
- Communicate with entrants and alerts them if it is necessary to evacuate.
- Monitor activities inside and outside the space to determine if it is safe for entrants to remain in the space
- Summon rescue and other emergency services as soon as the attendant determines may need help escaping from a permit space.
- Perform non-entry rescues.
- Not do any other activity that might interfere with the attendant's primary duty to monitor and protect the entrants.

(j) Supervisor duties

The supervisor has several specific responsibilities to make sure confined space operations are done safely. The supervisor must:

- Know the hazards that may be faced.
- Verify that tests have been done and all equipment and procedures are in place.
- End the entry and cancel the permit.
- Make sure that rescue and emergency services are available.
- Keep unauthorized persons away.
- Determine if acceptable entry conditions are maintained, even if responsibility for operation is transferred.

(k) Rescue/emergency services

The standard requires employers to ensure that responders are capable of responding to an emergency in a timely manner. Employers must provide rescue service personnel with personal protective and rescue equipment, including respirators, and training in how to use it. Rescue service personnel also must receive the authorized entrants training and be trained to perform assigned rescue duties.

The standard also requires that all rescuers be trained in first aid and CPR. At a minimum, one rescue team member must be currently certified in first aid and CPR. Employers must ensure that practice rescue exercises are performed yearly and that rescue services are provided access to permit spaces so they can practice rescue operations. Rescuers also must be informed of the hazards of the permit space.

(l) Employee participation

Employers must consult with workers involved in confined space work and their representatives on the development and implementation of all parts of the confined space program. Workers and their representatives have a right to all information the employer is required to develop for confined space work.

Appendices

- Appendix A is a permit-required confined space decision flow chart. The boxes on the left-hand side of the chart pose questions about the conditions faced by a worker. Each question can be answered with a yes or no. The series of boxes take you all the way through to the completion of the operation involving a confined space entry. (See next page).

- Appendix B describes procedures for atmospheric testing, which were covered in section 4 and elsewhere during this course.

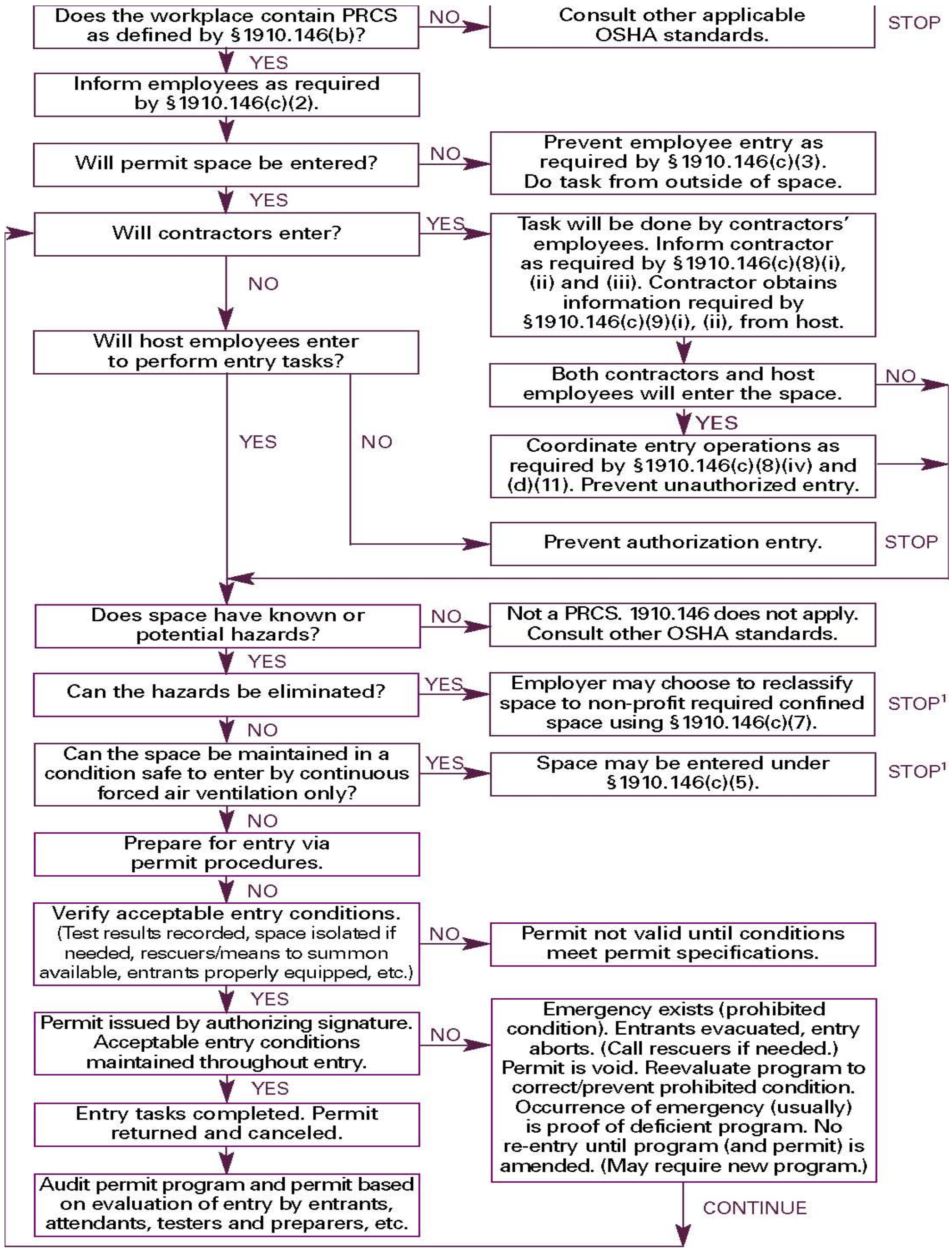
- Appendix C has examples of permit-required confined space programs.

- Appendix D has sample permits.

- Appendix E is specific to sewer system entry.

- Appendix F contains rescue team or rescue service evaluation criteria.

Appendix A



Does the workplace contain PRCS as defined by §1910.146(b)?
NO
Consult other applicable OSHA standards.
STOP
YES
Inform employees as required by §1910.146(c)(2).
Will permit space be entered?
NO
Prevent employee entry as required by §1910.146(c)(3). Do task from outside of space.
YES
Will contractors enter?
YES
Task will be done by contractors' employees. Inform contractor as required by §1910.146(c)(8)(i), (ii) and (iii). Contractor obtains information required by §1910.146(c)(9)(i), (ii), from host.
NO
Will host employees enter to perform entry tasks?
Both contractors and host employees will enter the space.
NO
YES
YES
NO
Coordinate entry operations as required by §1910.146(c)(8)(iv) and (d)(11). Prevent unauthorized entry.
Prevent authorization entry.
STOP
Does space have known or potential hazards?
NO
Not a PRCS. 1910.146 does not apply. Consult other OSHA standards.
YES
Can the hazards be eliminated?
YES
Employer may choose to reclassify space to non-profit required confined space using §1910.146(c)(7).
STOP1
NO
Can the space be maintained in a condition safe to enter by continuous forced air ventilation only?
YES
Space may be entered under §1910.146(c)(5).
STOP1
NO
Prepare for entry via permit procedures.
NO
Verify acceptable entry conditions. (Test results recorded, space isolated if needed, rescuers/means to summon available, entrants properly equipped, etc.)
NO
Permit not valid until conditions meet permit specifications.
YES
Permit issued by authorizing signature. Acceptable entry conditions maintained throughout entry.
NO
Emergency exists (prohibited condition). Entrants evacuated, entry aborts. (Call rescuers if needed.) Permit is void. Reevaluate program to correct/prevent prohibited condition. Occurrence of emergency (usually) is proof of deficient program. No re-entry until program (and permit) is amended. (May require new program.)
YES
Entry tasks completed. Permit returned and canceled.
Audit permit program and permit based on evaluation of entry by entrants, attendants, testers and preparers, etc.
CONTINUE

Other laws that apply to confined space entry operations

Many other regulations may apply to confined space entry operations:

- The OSHA standards for excavation and trenching are 29 CFR 1926.650 through 652. Notice that the trenching and excavation standards are construction standards that begin with 1926 rather than 1910 for general industry.
- The standard for control of hazardous energy, usually called lockout/tagout, is 29 CFR 1910.147.
- There are welding standards for general industry (29 CFR 1910 Subpart Q), construction (29 CFR 1926 Subpart J), and shipyards (29 CFR 1915 Subpart D). The standard that applies depends on the setting and nature of the operation.
- The OSHA hazard communication standard, or right-to-know, is 29 CFR 1910.1200.
- The OSHA standard for personal protective equipment is 29 CFR 1910.132.

Can you think of other OSHA regulations that could apply to permit-required confined space work?

There may also be environmental laws that employers and workers need to be aware of for confined space entry operations.

Activity: Using the OSHA permit-required confined space standard

Each small group of 4-6 participants breaks into pairs and answers the following questions, including the section of the OSHA standard that applies. The pairs compare answers and reach consensus for their small group.

Report back: Have one group provide their answer to question number one. Ask if any group came up with a different answer. The instructor acknowledges the correct answer was given or provides the correct answer and any explanation necessary.

1) A confined space must be classified as a permit-required confined space if any of what four conditions are present?

1. ____

2. ____

3. ____

4. ____

Section 1910.146.________________________

2) Who is responsible for ending the entry and canceling the entry permit?

____

Section 1910.146.________________________

3) An attendant may only be assigned to monitor one permit space at a time?

_____True _____False

Section 1910.146.________________________

4) Air monitoring for 3 atmospheric hazards must be performed in the following order before entering a space?

1. ____

2. ____

3. ____

Section 1910.146.______________________

5) The employer has 24 hours to provide air monitoring test results to employees.

_____True _____False

Section 1910.146.______________________

6) Which of the following elements must be included in an employer's confined space program?

Prevent unauthorized entry.
_____Yes _____No

Identify/evaluate hazards
_____Yes _____No

Provide hand washing facilities and a lunch area separate from the permit space.
_____Yes _____No

Inform contractors of hazards in permit spaces and coordinating entry operations.
_____Yes _____No

Section 1910.146.______________________

Module 12: Final Group Exercises

Objectives

After completing this section you will be able to:

- ✓ Appreciate the complexity of planning safe confined space entry.
- ✓ Analyze projects requiring confined space permits for potential hazards, needed industrial hygiene monitoring, proper PPE and positioning of attendants.
- ✓ Approach confined space planning through a group process.

This exercise is based on a series of diagrams kindly provided by Wheelabrator Environmental Systems, Inc. from one of their waste-to-energy plants. It has a 315 foot tall stack that has "BALTIMORE" painted on the southern side. This waste-to-energy facility provides dependable, environmentally safe disposal of municipal solid waste for the City and County of Baltimore, Maryland while generating clean electricity for sale to the local utility. The Baltimore facility processes up to 2,250 tons per day of municipal solid waste. At full capacity, the plant can generate more than 60,000 kilowatts of electrical energy for sale to Baltimore Gas & Electric Company. This is the equivalent of supplying all of the electrical needs of 50,000 homes. Steam is also supplied by the plant to Trigen Baltimore Corporation for the downtown heating loop.

Assignments

- Teams will be entering most areas to clean surfaces and maintain equipment
- Study the diagrams and discuss in your group the following questions
- Be prepared to have a spokesperson describe your approach

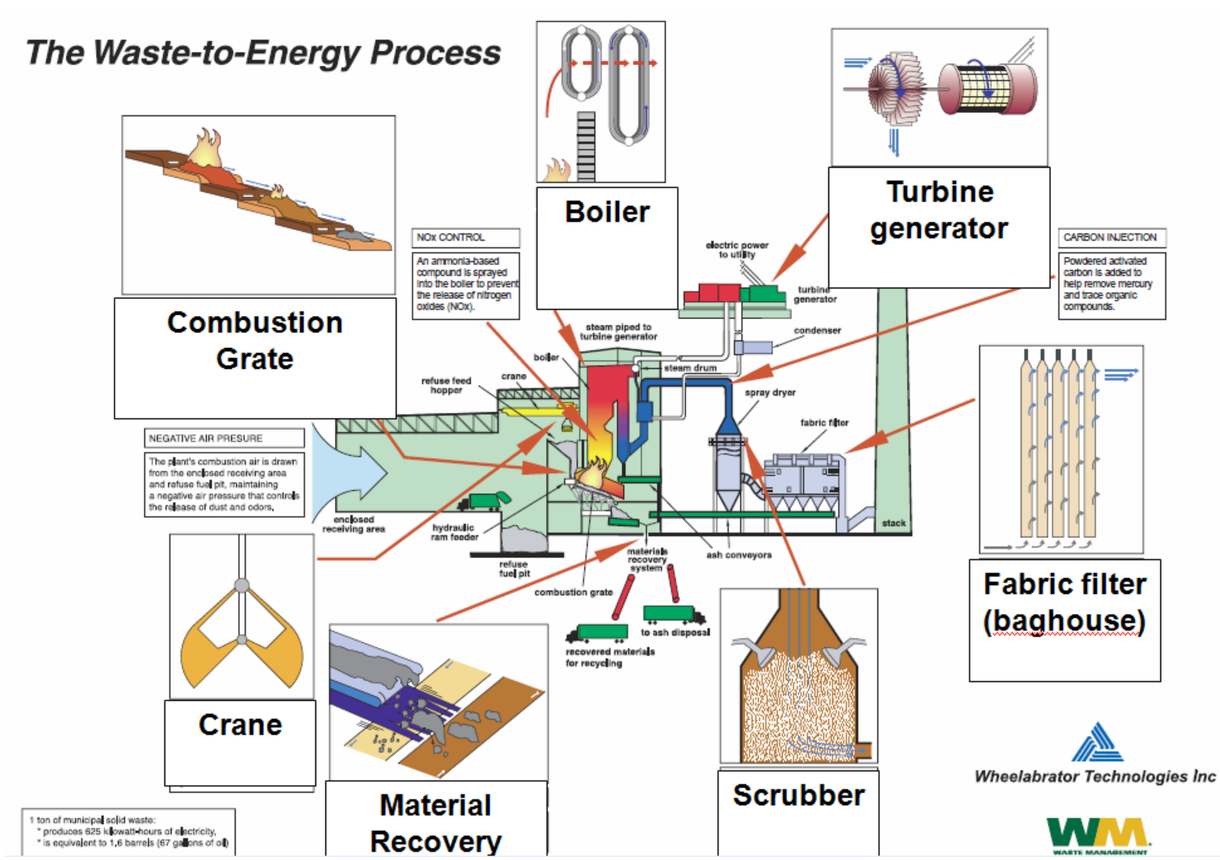
Questions to answer

Your group will have to answer these questions:

1. Is your area a permit-required space?
2. What hazards do you anticipate?
3. What monitoring will you do before entering?
4. What other steps are necessary before entering?
5. What PPE will you recommend
6. Where would you position your attendant?

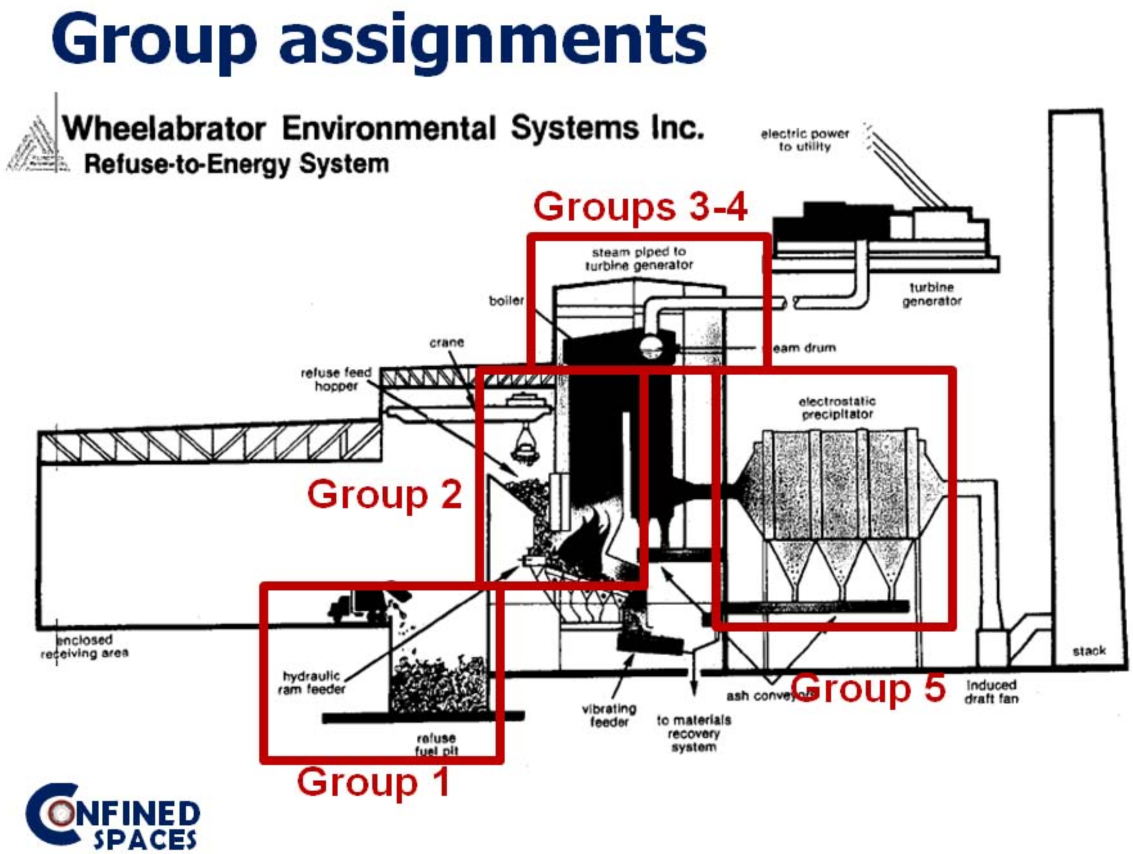
Overview of the waste-to-energy process

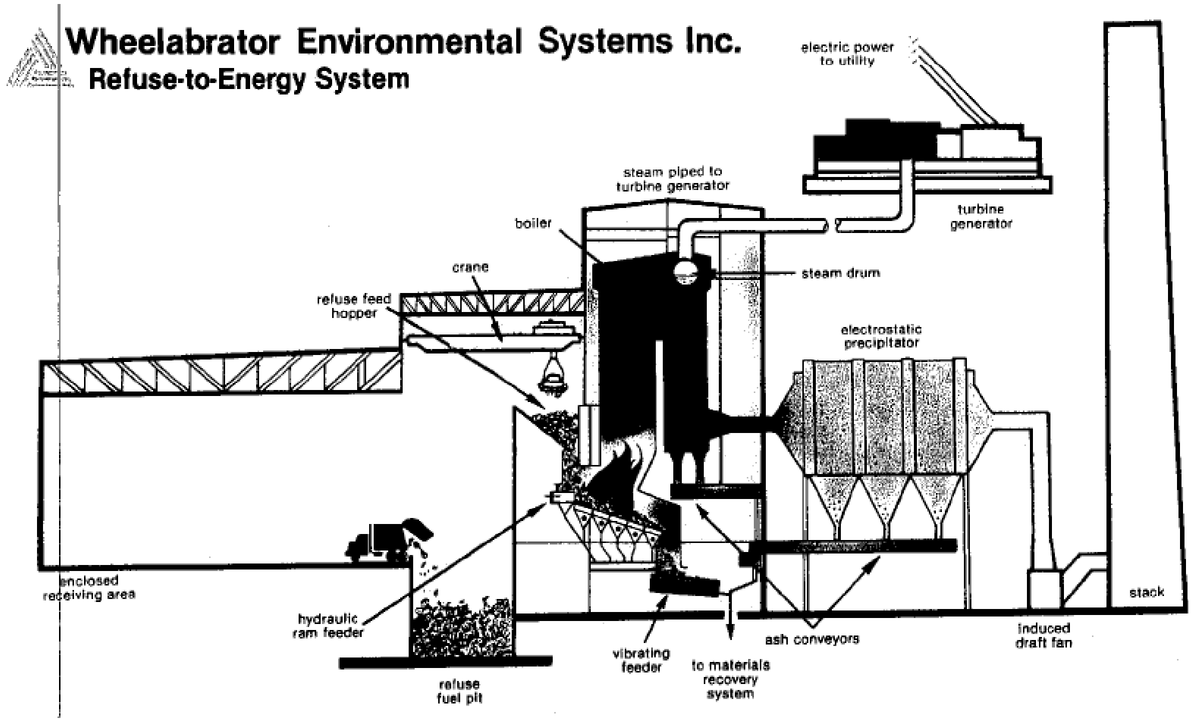
This process does not accept hazardous waste, but will accept all residential waste collected by garbage trucks in the city of Baltimore and surrounding areas.

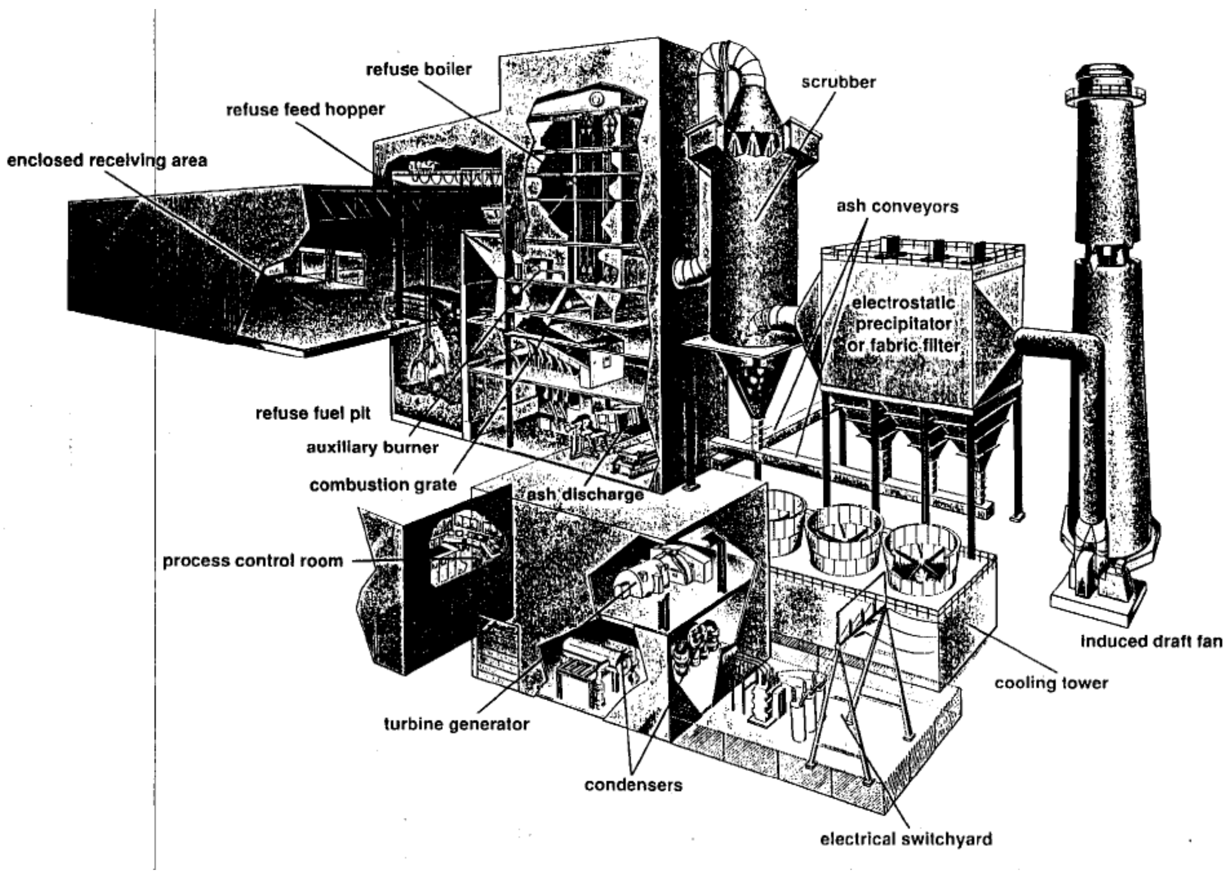


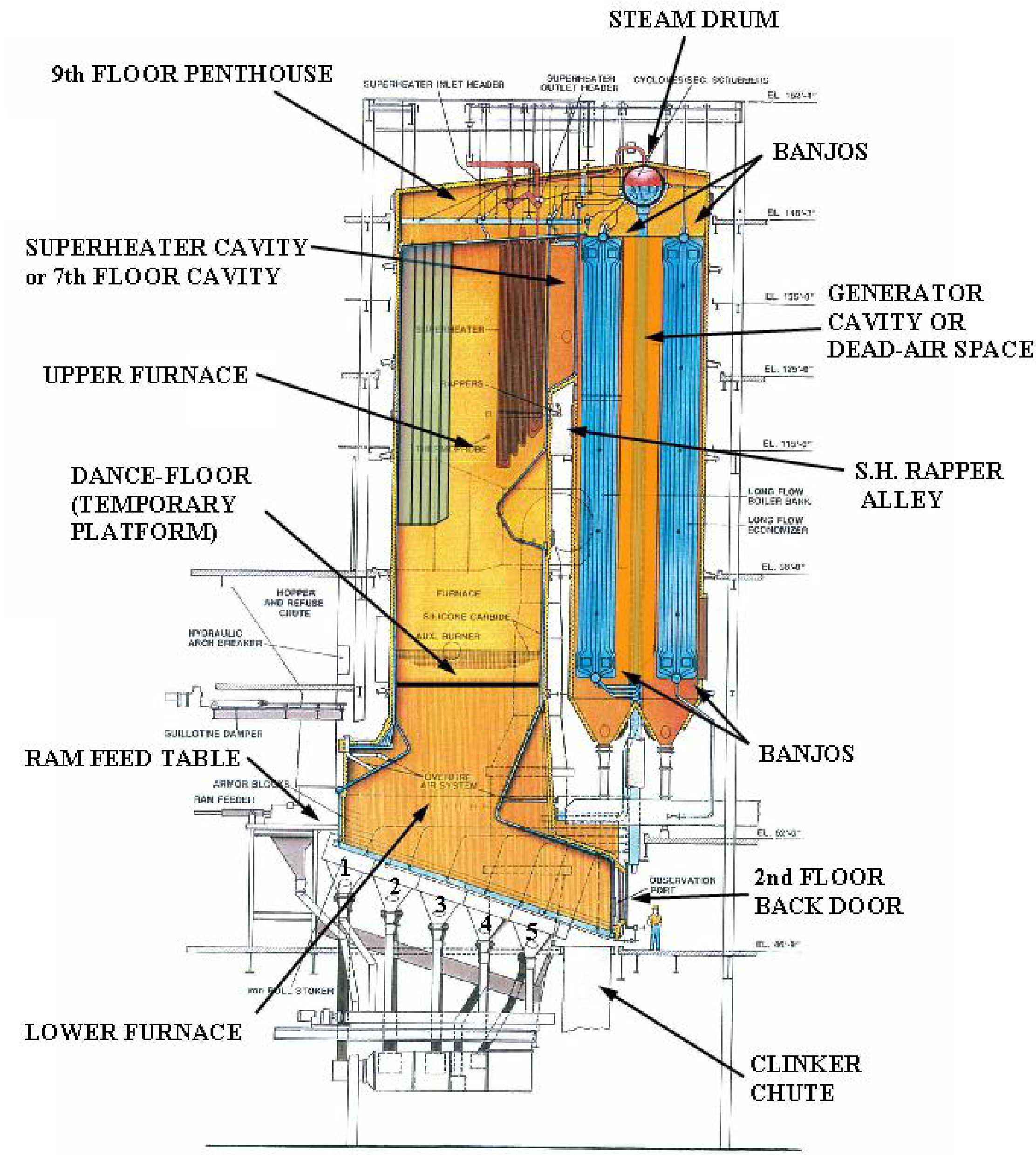
Group Assignments

- **Group 1** will enter the refuse fuel pit to inspect the condition of the floor and clean any remaining residue with high pressure water.
- **Group 2** will inspect overhead crane, refuse feed hopper and the hydraulic ram feeder operation to make sure everything is in good condition and to replace any parts on the ram that are damaged.
- **Group 3** will enter the 8th floor "banjo" area to inspect for damage and clean the ribs with steam cleaning.
- **Group 4** will enter the 9th floor penthouse to inspect and clean the steam drum.
- **Group 5** will enter the electrostatic precipitator to inspect and replace damaged units.




Wheelabrator Environmental Systems Inc.
Refuse-to-Energy System
electric power to utility
steam piped to turbine generator
turbine generator
boiler
steam drum
crane
refuse feed hopper
electrostatic precipitator
enclosed receiving area
hydraulic ram feeder
vibrating feeder
to materials recovery system
ash conveyors
induced draft fan
stack
refuse fuel pit


refuse boiler
refuse feed hopper
scrubber
enclosed receiving area
ash conveyors
electrostatic precipitator or fabric filter
refuse fuel pit
auxiliary burner
combustion grate
ash discharge
process control room
induced draft fan
cooling tower
turbine generator
condensers
electrical switchyard


STEAM DRUM
9th FLOOR PENTHOUSE
BANJOS
SUPERHEATER CAVITY or 7th FLOOR CAVITY
GENERATOR CAVITY OR DEAD-AIR SPACE
UPPER FURNACE
S.H. RAPPER ALLEY
DANCE-FLOOR (TEMPORARY PLATFORM)
BANJOS
RAM FEED TABLE
2nd FLOOR BACK DOOR
LOWER FURNACE
CLINKER CHUTE
1
2
3
4
5

Group Exercise 2: Painting the underside of a water ride tank

Two painters have to scrape and sand-blast the W beams under the ride tank.
After they have completed scraping and sand blasting the support beams for the tank they must apply epoxy paint to the beams. In the past the employer has turned the area under the tank into an enclosed storage area. The approximate size of the area is sixteen feet by thirty feet. The area has one entrance through a standard 2-8 door.

The safety manager wrote a scope of work requiring the team members to:

- Wear Tyvek outer garments taped and sealed
- Use combination HEPA and organic cartridge respirator
- Wear rubber under leather gloves taped and sealed
- Wear rubber boots over the Tyvek
- Replace cartridges every two hours or when needed

The safety manager also required the painters to:

- Work in teams
- Take appropriate breaks if they start feeling too hot
- Keep a supply of drinking water outside of the work area
- Notify their supervisor when they enter and leave the work area
- Keep all extra materials outside of the work area

The job was successfully completed.

- This area has not been identified as a permit required confined space or even as a confined space
- The work progressed at an acceptable pace
- The painters painted the beams as per the engineers specifications

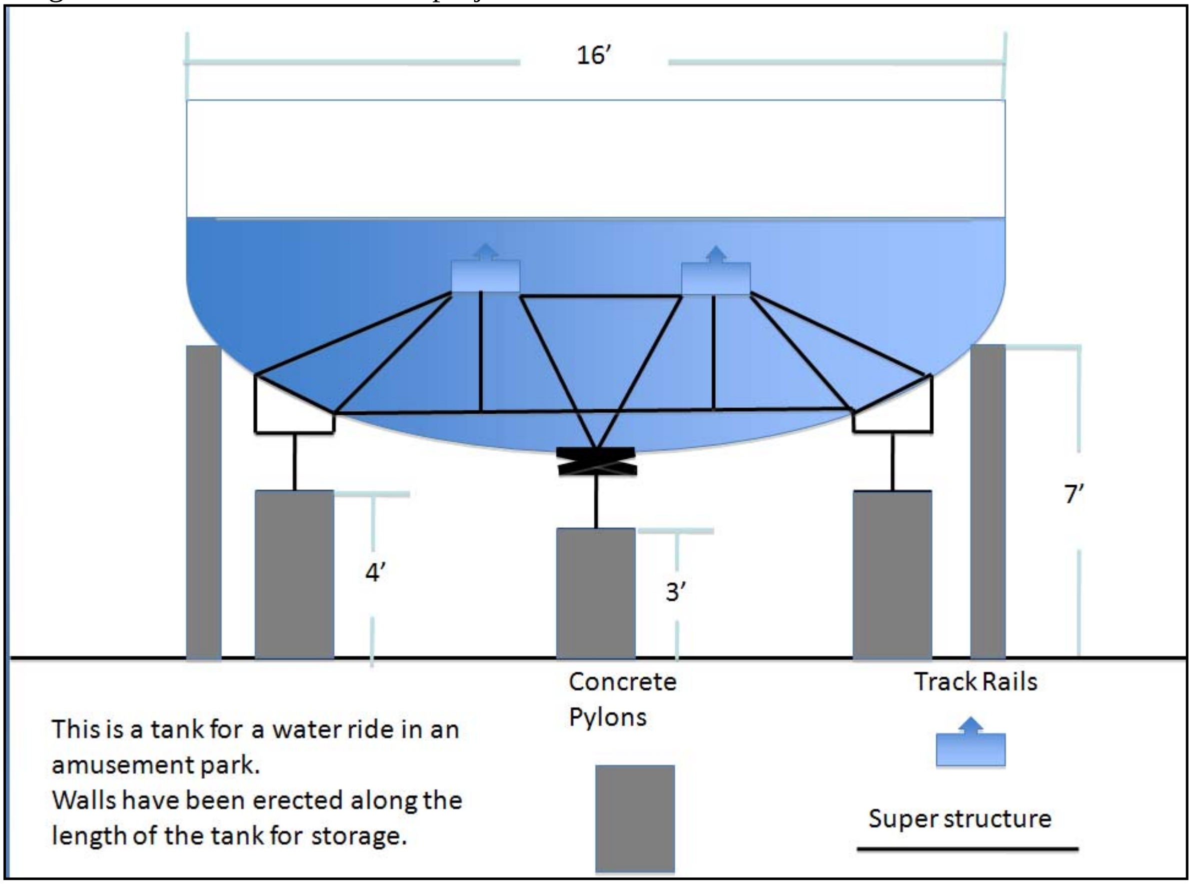
The odor from the job caused problems, however:

- An employee in another department complained about the odor emanating from this work space when he/she walked by
- When the employees supervisor did not respond to the complaint, the employee called OSHA

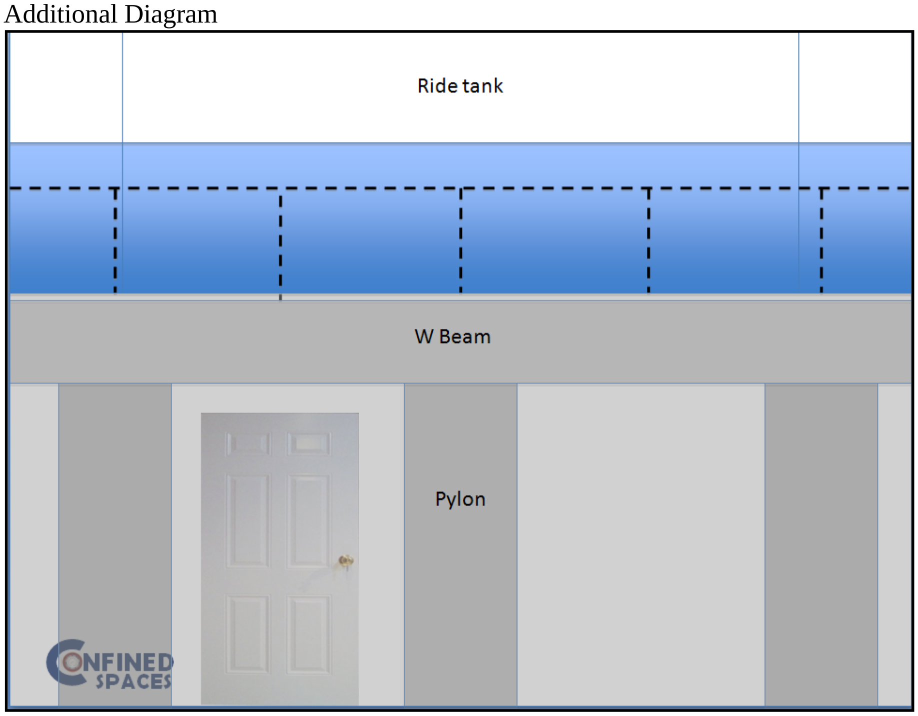
Answer the following questions:

1. Was the employer in violation of any standards?
2. Did the safety manager overlook any possible hazards?
3. Would you have cited the employer if you were an OSHA compliance officer and, if so, for what?

Diagram of the Water Tank Ride project



Additional Diagram



Document Legacy Log

Status (Baseline/ Revision/ Canceled)	**Document** **Revision** **Control Number** M/C/D/F-XXX-20XX.XX	**Effective Date** Month/Year	**Description of Changes**
Baseline	M-070-2010	3/2014	Replaced Module 5: Hazard Communication

Confined Space Awareness

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