Confined Space Entry

Competent Person

INTRODUCTION

• OSHA 29 CFR 1910.146 is the General Standard for confined spaces

• WAC 296-62 Part M - This part contains minimum requirements for practices and procedures to protect employees in all industries from the hazards of entry and/or work in permit-required confined spaces
INTRODUCTION

• The OSHA standard states that 29 CFR 1910.146 does not apply to Construction and Shipbuilding.

• The WAC standard for confined spaces states that 296-62 Part M applies to all industries, pointing out the fact that some vertical standards may be more restrictive.

• This illustrates a difference between state and federal rules.

INTRODUCTION

• Many workplaces contain spaces that are considered to be “confined” because their configurations hinder the activities of any employees who must enter into, work in, and exit from them.

• In many instances, employees who work in confined spaces also face increased risk of exposure to serious physical injury from hazards such as entrapment, engulfment, and hazardous atmospheric conditions.
INTRODUCTION

• Confinement itself may pose entrapment hazards, and work in confined spaces may keep employees closer to hazards, such as machinery components, than they would be otherwise.

• For example, confinement, limited access, and restricted airflow can result in hazardous conditions that would not normally arise in an open workplace.

• OSHA estimates that about 224,000 establishments in general industry have permit spaces; 7.2 million production workers are employed at these establishments, and about 2.1 million workers enter permit spaces annually.

• OSHA anticipates that compliance with the regulations will avoid 53 worker deaths, 4,900 lost-workday cases, and 5,700 non lost-time accidents annually.
INTRODUCTION

• The term "confined" means to restrict, enclose, or restrain.
• There are many places to which this description could be lent.
• The room that you are sitting in now is a confined space according to this definition – Most places that we work in are enclosed and fit this limited definition.
• Most enclosed spaces do not pose any hazard because of their confinement however.

• There are other enclosed spaces that prove to be deadly – These are labeled "confined spaces" or "permit spaces", and are closely regulated.
• What then is the distinction between a non-hazardous (and therefore non-regulated) enclosed space and a potentially deadly (and regulated) confined space?
How to Identify Confined Spaces

- **Limited Openings for Entry and Exit**
- **Sufficient size/configuration to allow entry**
- **Not Designed for Continuous Worker Occupancy**

**Limited Openings for Entry/Exit - Sufficient size/configuration to allow entry**

- Openings as small as 18 inches in diameter
- Difficult to enter with SCBA or other life-saving equipment
- Difficult to remove downed worker in folded up or bent over position
- Exit from large openings may be difficult due to presence of ladders, hoists, etc
Not Designed for Continuous Worker Occupancy

- Most confined spaces are not designed to enter and work in on a regular basis
- **Designed to store a product**
- Enclose materials or processes
- **Transport products or substances**
- Occasional worker entry for inspection, repair, cleanup, maintenance, etc.

Dangerous Combinations

- Presence of all three confined space characteristics can complicate the situation
- **Rescue operations during emergencies**
- Worsened conditions due to work activities:
  - Welding and cutting, use of bonding agents
  - Cleaning with solvents, use of other chemicals
  - Use of gas-powered equipment
Typical Confined Spaces

- Boiler, Degreaser, Furnace
- Pipeline, Pit, Pumping Station
- Reaction or Process Vessel, Mills
- Septic Tank, Sewage Digester
- Silo, Storage Tank, Barges
- Sewer, Utility Vault, Manhole
- Trenches, Shafts, Caissons (water-tight chambers)

Categorizing Work Space

- Space large enough to enter &
- Limited or Restricted entry or exit &
- Not designed for continuous worker occupancy.

YES Confined Space

Permit-Required Confined Space

Hazardous Atmosphere

- Or

Engulfment Hazard

- Or

Configuration Hazard

- Or

Any other recognized serious hazard

YES

NO

Not a confined Space

Non Permit Required Space
Categorizing Work Spaces

- If the opening is large enough for the worker to fully enter a permit-required space, a permit is required even if the worker only performs a PARTIAL body entry.
- However, the permit would not be required for a PARTIAL body entry where the opening is not large enough for a full body entry.

INTRODUCTION

- The employer must evaluate the workplace to determine if confined spaces are present.
- A confined space must be assumed to be a permit-required space unless it can be documented to be a non permit-confined space.
Definitions

1. Abrasion - Damaging wear on rope or other gear caused by rubbing against hard material or surfaces
2. Anchors - Means of attaching the rope and all other portions of rescue equipment to something secure
3. Ascender - A mechanical device or friction knot that is used in ascending a fixed rope
4. Attendant - means an individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all attendant's duties assigned in the employer's permit space program
5. Authorized Entrant - means an employee who is authorized by the employer to enter a permit space
6. Belay - The securing of a person with a rope to keep that person from falling a long enough distance to cause them harm
7. Blanking or Blinding - means the absolute closure of a pipe, line, or duct by the fastening of a solid plate that completely covers the bore
8. Bombproof - An anchor that will not fail
9. Carabiners - Metal snap links used to connect elements of a rescue system
10. Changeover - To transfer from an ascending mode to a rappelling mode or the reverse
11. Descender - A rappel device that creates friction by a rope running through it and is attached to a rappeler to control descent on a rope
12. Emergency - means any occurrence (including any failure of hazard control or monitoring equipment) or event internal or external to the permit space that could endanger entrants

13. Engulfment - means the surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be inhaled to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction, or crushing
14. Entry - means the action by which a person passes through an opening into a permit-required confined space and includes work activities in that space - Entry is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space
15. Entry Permit (Permit) - means the written or printed document that is provided by the employer to allow and control entry into a permit space and that contains the information specified in the regulations
**Definitions**

16. **Entry Supervisor** - means the person (such as the employer, crew leader, or crew chief) responsible for determining if acceptable entry conditions are present at a permit space where entry is planned; authorizing entry and overseeing entry operations; and terminating entry as required.

17. **Hazardous Atmosphere** - means an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness.

18. **Hot Work Permit** - means the employer's written authorization to perform operations (for example, riveting, welding, cutting, burning, and heating) capable of providing a source of ignition.

19. **Immediately Dangerous to Life and Health (IDLH)** - means any condition that poses an immediate or delayed threat to life; or would cause irreversible adverse health effects; or would interfere with an individual's ability to escape unaided from a permit space.

20. **Inerting** - means the displacement of the atmosphere in a permit space by a noncombustible gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.

21. **Isolation** - means the process by which a permit space is removed from service and completely protected against the release of energy and material into the space.
Definitions

22. Kernmantle - a rope design consisting of two elements, an inner core supporting the major load portion and an outer sheath (mantle) that protects the core and bears a minor portion of the load.

23. Line Breaking - means the intentional opening of a pipe, line, or duct that is or has been carrying flammable, corrosive, or toxic material, an inert gas, or any fluid at a volume, pressure, or temperature capable of causing injury.

24. Mechanical Advantage - the relationship of how much load can be moved to the amount of force it takes to move it.

25. Oxygen Deficient Atmosphere - means an atmosphere containing less than 19.5 percent oxygen by volume.

26. Oxygen Enriched Atmosphere - means an atmosphere containing more than 23.5 percent oxygen by volume.

27. Pulley - a device with a free-turning, grooved metal wheel (sheave) used to reduce rope friction.

28. Rappelling - controlled descent of a rope using the friction of the rope against one’s body or through a descender.
29. Rescue Service - means the personnel designated to rescue employees from permit spaces
30. Retrieval System - means the equipment (including a retrieval line, chest or full-body harness, wristlets, if appropriate, and a lifting device or anchor) used for non entry rescue of persons from permit spaces
31. Rope Rescue - the performing of a rescue from a confined space where the use of ropes and related equipment is necessary
32. Safety Factor - the ratio between the maximum load expected on a rope and the rope’s breaking strength - the larger the ratio, the greater the safety factor

33. Tensile Strength - a measurement of the greatest lengthwise stress that a rope or a piece of equipment can resist without failure
34. Testing - means the process by which the hazards that may confront entrants of a permit space are identified and evaluated
Entry Permit Systems

• To ensure the safety of the individual entering the confined space the permit system has been devised.

• In reality, the permit is a mandatory check-list of the precautionary measures which need to be done prior to entry.

• It is mandatory that an employer have a functional permit program in place if they have identified any permit-required confined spaces on their premises.

• Before entry is authorized, the employer shall document that:
  1. Measures have been implemented to prevent unauthorized entry,
  2. They have identified and evaluated the hazards before employee entry, and
  3. They have developed and implemented the means, procedures, and practices necessary for safe permit space entry operations.
Entry Permit Systems

- Written permit signed by entry supervisor
- Verifies pre-entry precautions have been taken and the space is safe to enter
- Posted at entry to confined space
- Specifies apparent hazards and corrective actions taken prior to entry
- Requires termination of permit when task is completed or when new conditions exist

Entry Permit Requirements

- The permit space to be entered
- Purpose of entry
- The date and duration of entry permit
- Authorized entrants and attendants listed by name supervisors
- Entry Supervisor and their signed authorization to enter the space
- The hazards of the permit space to be entered
- Protective measures to be taken such as
  - Ventilation, Isolation, Flushing, Lockout/Tagout, & Purging
Entry Permit Requirements

• The acceptable entry conditions
• The results of initial and periodic tests performed with the names or initials of the testers and when the tests were performed
• The rescue and emergency services that can be summoned and how this will be accomplished
• The communication procedures used by authorized entrants and attendants to maintain contact during entry
• Equipment, such as PPE, monitoring equipment, communications equipment, alarm systems, and rescue equipment to be provided

• Any other information necessary for the circumstances of a particular confined space to ensure employee safety
• Any additional permits (hot work) that have been issued to authorize work in the permit space
Entry Permit Requirements

- Permits are **not** required for rescue
- The permit must be signed by the individual authorizing entry - this identifies the party responsible should any problem arise during entry
- Permits have a definite duration of effect and are cancelled when the entry is over
- A permit is also cancelled when an emergency develops and/or an evacuation of the space is necessary

Entry Permit Requirements

- The entry the permit is kept for one year
- Employers must perform a review of the permit-required confined space program within one year after each entry or perform a single annual review covering all entries during a 12-month period
- If the employer decides that its employees will enter permit required confined spaces, the employer must develop and implement a **written** permit space program that complies with the regulations
Outside Contractors

- Must show documentation of training
- Understand Company procedures
- Have an information exchange with a Company representative

Training and Education

- Provided to all workers who must enter confined spaces
- Provided to all attendants and rescue team members
- Completed prior to initial work assignment
- Retraining is required if:
  - Job duties change
  - Change in permit-space program
  - New hazards are present
  - Job performance indicates deficiencies
Hazards of Confined Spaces

- Oxygen Deficient Atmospheres
- Oxygen Enriched Atmospheres
- Flammable Atmospheres
- Toxic Atmospheres
- Temperature Extremes
- Engulfment Hazards
- Noise, Slick/Wet Surfaces, Falling Objects

Confined Space Entry - Hazards

Both animal and plant life require oxygen to live. One of the primary hazards of entering confined spaces is oxygen deficiency.

When oxygen is present in concentrations less than 19.5%, the atmosphere is said to be oxygen deficient.
Oxygen deficiency can be caused by several processes:

**Consumption:** oxygen is used up by the person who is in the confined space and turned into carbon dioxide.

**Displacement:** denser materials push the oxygen out of the occupied space.

**Reaction:** oxygen is reacted with other materials to make other compounds.

The human body requires oxygen to carry out cellular metabolism. Oxygen is brought in through the lungs and transported to cells of body organs by the red blood cells. When blood is rich in oxygen it turns red.
Given a fixed amount of oxygen as you would have in a confined space, respiration of oxygen causes carbon dioxide to increase. When oxygen decreases to less than 19.5%, the atmosphere is said to be oxygen deficient, putting occupants of the confined space at risk of losing consciousness and death.

Processes which operate by the principle of combustion use up oxygen much faster than the human respiration. Products of combustion vary with the fuel that is present and the temperature of the combustion reaction. Welding, burning natural gas, propane, gasoline, and diesel engines are examples of combustion processes.
Oxygen Deficient Atmospheres

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.5%</td>
<td>Minimum acceptable oxygen level</td>
</tr>
<tr>
<td>15 - 19%</td>
<td>Decreased ability to work strenuously, Impaired coordination, Early symptoms</td>
</tr>
<tr>
<td>12-14%</td>
<td>Respiration increases, Poor judgment</td>
</tr>
<tr>
<td>10-12%</td>
<td>Respiration increases, Lips blue</td>
</tr>
<tr>
<td>8-10%</td>
<td>Mental failure, Fainting, Nausea, Unconsciousness, Vomiting</td>
</tr>
<tr>
<td>6-8%</td>
<td>8 minutes - fatal, 6 minutes - 50% fatal, 4-5 minutes - possible recovery</td>
</tr>
<tr>
<td>4-6%</td>
<td>Coma in 40 seconds, Death</td>
</tr>
</tbody>
</table>

Confined Space Entry - Hazards

Oxygen can also be present in concentrations that are too high.

Oxygen in concentrations greater than 23.5% is too oxygen rich and can cause combustible materials to ignite very quickly.
Oxygen Enriched Atmospheres

• Never use pure oxygen to ventilate

• Never store or place compressed tanks in a confined space

Flammable Atmospheres

• 3 Critical Factors:
  - Oxygen content in the air.
  - Presence of a flammable gas, or vapor
  - Presence of dust (visibility of 5’ or less)

• Proper air/gas mixture can lead to explosion!

• Typical Ignition Sources:
  - Sparking or electric tool
  - Welding/cutting operations
  - Smoking
Flammables

Fire Triangle

Heat
Fuel
Oxygen

Flammable Range

Flammability Limits

Temp
Concentration

UEL
LEL

Flammable Range
Flammable Atmospheres

- In confined spaces the fuel is usually already in its vapor form, so the spread and intensity of a fire increases rapidly.

- Many of the flammable gases that can be found in permit spaces are vapors from stored flammable liquids or products of natural decay.

- Hydrogen sulfide is probably the most common of all confined space gases. It is the product of the natural decay of organic matter that contains sulfur.

- Methane, which is the main component in natural gas, is also generated from the rotting of organic matter.

- It is very common to find both hydrogen sulfide and methane in sewer manholes and pits.

- Carbon monoxide is the product of incomplete burning, and can often be found in industrial permit spaces.

- Other gases commonly found in permit spaces include solvent vapors, gasoline vapors, acetylene, toluene, and the vapors of carbon disulfide.
Flammable Atmospheres

- The elimination of ignition sources is also vital when dealing with flammable atmospheres.
- "Hot work" describes tasks within the permit space in which the work could provide a source of ignition - Common forms of hot work include welding, cutting, grinding, riveting, drilling, or burning.
- Coal, grain, and other combustible dusts also pose a problem - The amount of dust that is a hazard is approximated as a condition in which the dust obscures vision at a distance of 5 feet.

Toxic Atmospheres

- The regulations define Toxic Atmospheres as concentrations in the air of any substance above the PEL (Permissible Exposure Limit) or any condition that is IDLH (Immediately Dangerous to Life and Health).
Toxic Atmospheres

• One of the risks to weigh is the acute dose risk - After all, the entrant will probably not be in the permit space for very long

• The term acute means something that occurs in a short length of time - Carbon monoxide, hydrogen sulfide, and hydrogen cyanide are examples of acute exposure toxins

Toxic Atmospheres

• There are many different types of toxic materials which can be found in confined spaces

• Generally, however, they can be classified into two main groups: asphyxiants and irritants

• Asphyxiants, like carbon monoxide and hydrogen sulfide, render the body incapable of utilizing oxygen - The body literally suffocates

• Irritants like chlorine gas pose mainly respiratory and skin hazards - They produce injury and death by causing the lungs to fill with fluid and the victim essentially drowns
Manholes often remain covered for long periods of time. Naturally occurring toxins, such as hydrogen sulfide can accumulate inside of manholes. Manholes may also accumulate highly flammable gasses such as methane and ethane. Unlike the gas we receive at home, we cannot detect some of these gases with our sense of smell.

Toxic and flammable materials are sometimes illegally put into sanitary and storm sewers. Leaking tanks or spills may migrate underground causing seepage into manholes. Material can leach through soil from many miles away.
**Hydrogen Sulfide**

- Decomposition of materials
- Rotten egg odor at low concentrations
- Possibly NO WARNING at high concentrations

<table>
<thead>
<tr>
<th>PPM</th>
<th>Effect</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 ppm</td>
<td>Permissible Exposure Level</td>
<td>8 Hours</td>
</tr>
<tr>
<td>50 - 100</td>
<td>Mild irritation - eyes, throat</td>
<td>1 Hour</td>
</tr>
<tr>
<td>200 - 300</td>
<td>Significant irritation</td>
<td>1 Hour</td>
</tr>
<tr>
<td>500 - 700</td>
<td>Unconsciousness, Death</td>
<td>1/2 Hour</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>Unconsciousness, Death</td>
<td>Minutes</td>
</tr>
</tbody>
</table>

**Carbon Monoxide**

- Odorless, Colorless Gas
- Combustion By-Product
- Quickly collapse at high concentrations

<table>
<thead>
<tr>
<th>PPM</th>
<th>Effect</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>Permissible Exposure Level</td>
<td>8 Hours</td>
</tr>
<tr>
<td>200</td>
<td>Slight headache, discomfort</td>
<td>3 Hours</td>
</tr>
<tr>
<td>600</td>
<td>Headache, discomfort</td>
<td>1 Hour</td>
</tr>
<tr>
<td>1000-2000</td>
<td>Confusion, nausea, headache</td>
<td>2 Hours</td>
</tr>
<tr>
<td>1000-2000</td>
<td>Tendency to stagger</td>
<td>1 1/2 Hours</td>
</tr>
<tr>
<td>1000-2000</td>
<td>Slight heart palpitation</td>
<td>30 Min.</td>
</tr>
<tr>
<td>2000-2500</td>
<td>Unconsciousness</td>
<td>30 Min.</td>
</tr>
</tbody>
</table>
Toxic Gas Exercise

Class Handout

Toxic Atmospheres

Acceptable Atmospheric Conditions For Entry

- Oxygen Concentration: 19.5% - 23.5%
- Flammable Gas Concentration: 0 - 10% LEL on CGI
- Flammable Dust Concentration: Vision greater than 5 feet
- Toxicity: Contaminant concentration less than PEL
Engulfment

• Engulfment means the surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance
• This material is such that it can be aspirated (inhaled) and cause death by filling or plugging the respiratory system or can exert enough force to cause death by strangulation, constriction, or crushing of the body

Engulfment

• Grain, saw dust, sand, coal, and many other finely divided substances have engulfed and killed workers
• Drowning in a liquid such as water is also considered engulfment
Other Hazards

- Size limitation of entry and exit openings make movement of personnel and equipment difficult and time consuming
- Poor lighting in the space is often a problem - Any lighting device taken into a permit space must be explosion-proof if flammables are present
- Falling Objects - topside openings expose workers inside confined space to falling objects

Temperature Extremes

- Extremely hot or cold temperatures
- Steam cleaning of confined spaces
- Humidity factors - 80-100% humidity
- Extremely cold liquids - Liquid nitrogen
- Work processes inside the confined space can increase temperature extremes - welding, cutting, etc.
- Personal protective equipment - affects mobility, restricts vision and communication causes overheating of body
Other Hazards

- Excessive noise poses significant safety problems in confined spaces - hearing loss, communication problems and loss of concentration
- Slippery surfaces are dangerous especially when on ladders and walkways
- An additional problem in sewer systems is the potential for flash flood - It does not take a lot of rain to make a raging torrent in a sewer

Trenches, ravines and other excavations may also be considered confined spaces, if there is a potential for accumulation of toxic gases, engulfment and/or the depletion of oxygen.
Testing The Atmosphere

• Confined space monitoring has been going on for a long time

• Miners would use canaries in cages lowered into mine shafts to determine the presence of toxic gases - If the bird came up alive, it was assumed to be safe

• Frequently a match, cigarette, or flare was thrown into the space - If no fire or explosion resulted the space was deemed safe from a fire point of view

Testing The Atmosphere

• There are three main atmospheric hazards that cause concern - Namely, oxygen depletion, flammability, and toxicity

• Monitoring practices and instruments should be geared toward these three central hazards
Testing The Atmosphere

• Unfortunately there is no universal monitor which tests for all possible gases - Monitors are very specific
• In most spaces we should already have an idea of the hazardous gases that we would expect to find
• If you are in an industrial setting the contents of a vessel should be known - Monitors specific to the gases in that space should be used

Atmosphere Testing Shall Be Performed:

- Prior to every entry when the space is vacant;
- After a 10 minute ventilation period (if ventilation is necessary);
- At least hourly for permit-required confined spaces;
- More frequently, if conditions or suspicions warrant.
Always test the air at various levels to be sure that the entire space is safe.

Testing The Atmosphere

- Characteristics of a good monitoring device should include:
  1. Ease of operation.
  2. Readable in both light and dark conditions.
  3. Easily calibrated.
  4. Equipped with a peak-hold feature to recorded the highest concentration encountered.
  5. Equipped with audible and visual alarms for a preset concentration.
Testing The Atmosphere

- Characteristics of a good monitoring device should include:
  - 7. Equipped with fully charged batteries at all times.
  - 8. Easily protected against contamination.
  - 9. Equipped with a remote probe for non-entry testing.
  - 10. Reliable, rugged, and dependable.

Inherent Safety

- Explosion-proof - ignition source enclosed and exit gases are cooled
- Intrinsically safe - reduces the potential for arcing among components or has a “cool” arc
- Purged - an inert gas buffers the arc or flame device from the flammable atmosphere
Reliable and Useful Results

- Response time
- Sensitivity
- Selectivity
- Accuracy
- Precision

Response Time

- Is the length of time the monitor takes from when it "senses" a contaminant until it generates data.
- For direct-reading instruments, response times may range from a few seconds to several minutes.
Sensitivity

- Defined as the ability of an instrument to accurately measure changes in concentration
- Sensitive instruments can detect small changes in concentration
- It is important to use an instrument with an operating range that will measure the ambient concentrations on-site

Selectivity

- The ability of an instrument to detect and measure a specific chemical or group of similar chemicals
- Interferences from other chemicals can affect the accuracy of the instrument reading by producing a similar response
Accuracy

- The relationship between a true value (i.e., the actual concentration of a contaminant) and the instrument reading.

Precision

- A statistical measurement of an instrument's ability to reproduce a reading
- When an instrument does not receive routine maintenance the precision of the readings may change (become more random) this can affect the amount of error in the data collected.
Monitoring Equipment

Calibration

- Process of adjusting the instrument read-out so that it corresponds to the actual concentration
- Involves checking the instrument with a known concentration of a gas or vapor to see that the instrument gives the proper response
- Adjust the instrument read-out so that it corresponds to the actual concentration
- Follow manufacturer’s directions for calibration to ensure accurate field data

Oxygen Availability Monitor

- These monitors are used to evaluate the atmosphere for oxygen content
- Normal air is 20.8% Oxygen
- Oxygen deficient atmosphere is 19.5%
- Oxygen deficient atmospheres occur when it is replaced by another chemical, consumed in combustion or the area is unventilated
- > 23.5% oxygen in air, increased risk of combustion (possible oxidizer present)
**Carbon Dioxide Monitor**

- Measure concentration of flammable vapor or gas in air
- Read out in % of LEL
- Read out is relative to the calibration gas (usually methane or pentane)
- May not show actual % of LEL
- For use only in normal oxygen atmospheres
- Not for use in oxygen-enriched atmosphere
4-GAS MONITOR

MULTI GAS MONITOR
 Relative Response CGI Meter

% LEL Policy

- The employer will issue work permits when the % LEL is from 0-10% LEL
- When the LEL exceeds 10%, special approval is required in order for a work permit to be issued
- For all confined space entry permits, a 0% LEL is required

**NOTE:** Most employers including government entities have a 0% LEL policy for all operations including confined space entry
% LEL Action Level

Flammable Range

LEL UEL
0% 5% 10% 15% METHANE 0% 5% 100% LEL

Monitoring Equipment
Toxic Atmosphere Monitors

Colorimetric Indicator Tubes
- Glass tube with indicating chemical
- Chemical specific, but may be interference
- Contaminated air pumped in at predetermined rate
- Poor accuracy and precision
- Affected by temperature and humidity
- Interpretations vary
- Time consuming - 1 to 30 minutes per tube
Monitoring Equipment

Toxic Atmosphere Monitors

- Colorimetric Indicator Tubes

- Dräger Hand Pump Kit
Toxic Atmosphere Monitors

Photoionization detector (P.I.D.) - UV
ionization of outer electron- ranges
from 8.3 to 11.8 ev - calibrated to one
chemical - response to other
chemicals may vary (Styrene = 8.47,
Acetone = 9.69, Isopropyl alcohol =
10.15)

Features
- Nonspecific gas and vapor detection for
  organics and some
  inorganics
- Sensitivity is related to the
  ionization potential of
  compound
- Portable with remote sensing
  capabilities
- Response time of 90% in less
  than 3 seconds
- More sensitive to aromatic and
  unsaturated compounds than
  the Flame Ionization detector

Limitations
- Does not monitor for
  specific gases or vapors
- Cannot detect Hydrogen
  Cyanide or methane
- Cannot detect some
  chlorinated organics
- High humidity and
  precipitate will negatively
  affect meter response
- Photoionization Detectors
  are calibrated to a single
  chemical
Toxic Atmosphere Monitors

- Aerosol monitors - these instruments determine the total amount of particulates but not the type of particulate.
  - They measure dust, mist, fume, smoke, fog and spray.
Duties of the Entry Supervisor

- Know the hazards of the space
- Routes of entry for chemicals
- Signs and symptoms of exposure
- The consequences of exposure
Duties of the Entry Supervisor

- Verify all appropriate check-offs have been made on the confined space entry permit
- Verify all tests specified on the confined space procedure have been conducted
- Ensure that all confined space entry procedure conditions have been met prior to entry and authorization of the entry operation

- Find the specific confined space entry procedure in the Entry Procedure Manual and get a copy of the Confined Space Entry Permit
- Evaluate the needs
- Follow the procedures to isolate the space
Duties of the Entry Supervisor

- Have the necessary entry support equipment brought to and setup at the confined space (all necessary items will be marked on the entry permit)
- Brief all confined space entrants and attendants on the hazards associated with the confined space (each entrant and on-duty attendant will sign the entry permit)

Duties of the Entry Supervisor

- Verification that the means of summoning rescue services are operable
- Removal of unauthorized personnel who enter or attempt to enter the confined space during entry operations
- Verify the space is ready to be placed back into service
Duties of the Entry Supervisor

- Note any modifications or procedure changes for subsequent entries if warranted
- Document any problems encountered, during the de-briefing, with the entry on the entry permit

Duties of the Entry Supervisor

- Conduct a post entry de-briefing with the entrants and attendants to discuss any problems which may have occurred during the entry
- Prepare the confined space to be put back into service
Duties of Attendants

- Knowledge of the hazards
- Chemical exposure pathways
- Signs and symptoms of exposure
- Consequences of exposure

**NEVER** leaves the space unattended.
Duties of Attendants

Evacuate the space immediately if any of the following conditions become evident:

- Detection of a prohibited condition
- Detection of behavioral effects of hazard exposure in authorized entrants
- Detection of a situation outside the space that could endanger the authorized entrants

If the attendant cannot effectively and safely perform all of his/her required duties

If communication between the entrant and attendant is jeopardized in anyway
Duties of Attendants

- Summoning rescue and other emergency services if needed
- Warn unauthorized persons that they must stay away from the permit space
- Advise unauthorized persons to exit the space immediately if they have entered

- Perform non-entry rescue as specified by Company Name program
- Performing no duties that may interfere with attendant's primary duty to monitor and protect the authorized entrants
- Wear an ORANGE safety vest or similar visible notification at all times while performing attendant duties
Duties of Authorized Entrants

Demonstrate competencies in the use of the following:

- monitoring equipment
- ventilating equipment
- communications equipment
- lighting equipment
- barriers and shields
- ladders
- rescue and emergency equipment
Duties of Authorized Entrants

Entrant needs to alert the attendant whenever:

- The entrant recognizes any warning sign or symptom of exposure
- A dangerous situation develops
- The entrant detects a prohibited condition

Preparation For Entry

- Ventilation
- Energy Isolation
- Barricades
- Tools
- Personnel
Unfavorable Natural Ventilation

• Lack of air movement in and out of the space can create an atmosphere much different than the outside atmosphere
• **Deadly gases can be trapped inside**
• **Organic materials can decompose**
• **May not be enough oxygen due to presence of other gases or chemical reactions such as rusting**

Ventilation

• First option to correct problems
• **Must be aware of hazards you are trying to correct in the confined space**
• Air intake in a safe location to draw fresh air only
• **Continuous ventilation whenever possible**
• Retest the confined space before entry
Ventilation

If concentrations of materials are found to be at harmful levels, the confined space must be ventilated to remove them before entry.

Fresh outside air is blown into the space to dilute and remove contaminants, and supply oxygen.

O₂

Should the concentration of contaminants remain at harmful levels, respirators may have to be worn to assure a safe air supply.

O₂
Ventilation

- Ventilation is driven by one of two things - air pressure or differences in vapor density
- The greater the difference in vapor density the faster natural ventilation will take place
- Naturally, the reverse flow would occur if the atmosphere in the container had a vapor density greater than one
- Many of the gases that need to be ventilated are either in a fairly low concentration or have vapor densities fairly close to 1 - This means that natural ventilation is not very effective

Therefore, forced ventilation needs to be employed

- Most commonly forced ventilation involves a fan, air compressor, or other machine
- There are two types of forced ventilation - positive pressure ventilation and negative pressure ventilation
When a space is ventilated by positive pressure, air is blown into the space, thus pressurizing it.

Negative pressure ventilation is literally the reverse of positive pressure ventilation in that the fan is turned around and the contaminated atmosphere is drawn out of the container.

Positive pressure is the method commonly used especially if the air contains flammables or toxic chemicals which are drawn into the fan with negative pressure ventilation.

Beware of gas pockets in the confined space structure and the possibility of a build-back of the gas once it is ventilated.
Ventilation Precautions

1. Flowing vapors, like flowing liquid can produce static electricity - Be sure that the vessel is grounded prior to ventilating
2. If a flammable gas concentration within a space is above the UEL, ventilating will bring the concentration down through the flammable/explosive range - Positive pressure ventilation should be used in that situation
3. Intakes for positive pressure fans need to be removed from any source of vehicle exhaust or other harmful gas - Assure that only fresh air is being ventilated into the space
4. Try not to allow the ductwork for a fan to obstruct safe entry and exit from the space

5. When using a ducted fan place the ductwork near the lowest level of the space (assuming that the exhaust is going out the top). Ventilation efficiency will be greatly enhanced
6. Noise from the fan can cause communication problems - Ducting the fan will allow it to be placed a greater distance from the space entrance
7. Never use oxygen to ventilate or purge a space
Isolation of Energy Hazards

- Locking and tagging out electrical sources
- Blanking and bleeding pneumatic and hydraulic lines
- Disconnecting mechanical drives and shafts
- Securing mechanical parts
- Blanking sewer and water flow
- Locking and tagging out shutoff valves

Barricades

- Barricades around the confined space site need to be placed so that unsuspecting people do not wander into the site
- Advanced notice to employees and/or the public will save congestion and confusion once the barricades go up
- Cones, flashing lights, warning tape, or ropes need to be erected to isolate the site
- If the entry is within a building, locked and marked doors will prohibit access
- The area around the point of entry should be unobstructed and should be a minimum of three feet square
**Personnel**

- Finally, the personnel must be capable of doing the work
- Physical health and stamina, as well as familiarity with PPE and emergency procedures, should be evaluated prior to entry
- A brief pre-entry meeting reviewing the objectives of the entry, the confined space layout, possible entry problems, and emergency and rescue procedures, is highly recommended

**Entry & Work**

- Entry means the act by which a person passes through an opening into a permit-required confined space, and includes ensuing work activities in that space
- The entrant is considered to have entered as soon as any part of the entrant's body breaks the plane of an opening into the space
A means must be provided for both safe normal entry or exit, and emergency extrication. Tripods with hoist, lifeline, and full body harness are often used for emergency extrication. Ladders may be used for ordinary entry and exit.

Barriers to prevent passers-by and the curious from falling into the opening must be put in place.

Holes and openings must be closed or guarded when not attended.
Entry & Work

Place warning signs where pedestrians can see them. Signs must state the hazard and the required action.

**CAUTION**
Opening in Ground Keep Out!

Entrants must constantly monitor the confined space for toxic gases, oxygen, and combustible gases. Entrants will be issued a personal monitor to wear for this purpose.

Entrants must leave the confined space when the monitor alarm is activated.

It is the attendant’s responsibility to see that the entrant leaves the space during an alarm.

H₂S  O₂
CO  HCN
CH₄  CO₂
Should conditions develop which require extrication, and the entrant cannot get out of the confined space on their own, the attendant must call for emergency assistance at once!

When hot work is required in a confined space a special hot work permit is required. When hot work is required on a tank wall in which a lining or coating is present the lining or coating needs to be stripped away for a distance of at least four inches in all directions of the hot work. Cylinders, like acetylene and oxygen, which are required for welding and other hot work are not allowed into the confined space. Remember, hot work is not allowed in atmospheres that contain flammable gases in concentrations above 10% of the LEL or oxygen concentrations greater than 23.5%.
Exit From Confined Space

- There are a number of considerations that need to be addressed when leaving a confined space.

- It is very important that the entrant inform the attendant when exiting from the space. The attendant then can check the individual off of the list of entrants known to be within the space - This procedure provides an accountability for all personnel.

Exit From Confined Space

- It's very important to remove anything that was brought into the space.

- Tools left in the space can cause great damage to machinery and can pose a projectile hazard. Lost tools are also expensive to replace.

- If a large number of tools are used within the space, a check-list produced as the tools entered the space can be used to account for the tools as they leave the space.
Exit From Confined Space

- When temporarily leaving the space, gas lines such as oxygen and acetylene must be removed from the space.
- When leaving the space personal hygiene needs to be addressed, especially if the confined space was a sewer, manhole, or other place where microbial or chemical contamination could have taken place.
- Hand washing and clothing change (if necessary) should take place prior to eating or smoking.

Exit From Confined Space

- After the entry, each entrant needs to unlock their lockout device.
- The person in charge then concludes confined space operations by returning the space back to its original condition.
- Hand washing and clothing change (if necessary) should take place prior to eating or smoking.
- Once all of these items have been accomplished, the permit is ready to be filed for the prescribed length of time.
The purpose of chemical protective clothing (CPC) and personal protective equipment (PPE) is to shield or isolate individuals from the chemical, physical, and biologic hazards that may be encountered.

Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing.

Respiratory protection is of primary importance since inhalation is one of the major routes of exposure to chemical toxicants.

**Respirators**

- **Air-Purifying Respirators**
  - Filter dangerous substances from the air
  - Must know the type and amount of hazardous substance present in the confined space
  - NEVER use with oxygen deficiency!

- **Air-Supplying Respirators**
  - Deliver a safe supply of breathing air from a tank or an uncontaminated area nearby
  - Must be adequately monitored to ensure adequate & quality air supply
Chemical-protective clothing (CPC) is available in a variety of materials that offer a range of protection against different chemicals. The most appropriate clothing material will depend on the chemicals present and the task to be accomplished - Ideally the chosen material resists permeation, degradation, and penetration.

In addition to permeation, degradation, and penetration several other factors must be considered during clothing selection - These affect not only chemical resistance but the worker's ability to perform the required task.

**Durability**

- Does the material have sufficient strength to withstand the physical stress of the task(s) at hand?
- Will the material resist tears, punctures, and abrasions?
- Will the material withstand repeated use after contamination / decontamination?
PPE

- **Flexibility**
  - Will the CPC interfere with the workers' ability to perform their assigned tasks? (This is particularly important when considering gloves)

- **Temperature effects**
  - Will the material maintain its protective integrity and flexibility under hot and cold extremes?

PPE

- **Ease of decontamination**
  - Are decontamination procedures available on site?
  - Will the material pose any decontamination problems?
  - Should disposable clothing be used?
Compatibility with other equipment

- Does the clothing preclude the use of another, necessary piece of protective equipment (e.g., suits that preclude hard-hat use in hard-hat area)?

Duration of use

- Can the required task be accomplished before contaminant breakthrough occurs, or degradation of the CPC becomes significant?
Special Conditions

- Fire, explosion, heat, and radiation are considered special conditions that require special-protective equipment.

Safety Equipment and Clothing

- No single combination of protective equipment and clothing is capable of protecting against all hazards.
- PPE should be used in conjunction with other protective methods.
- Equipment and clothing should be selected that provide an adequate level of protection.
- Overprotection, as well as underprotection, can be hazardous.
Confined Space Rescue

- Emergency rescue from a confined space is a matter of life or death
- That pervading sense that "the clock is ticking" invades every aspect of rescue operations
- What is worse is that sense of urgency is sometimes used as an excuse for making decisions or performing actions that place others at undue risk

Confined Space Rescue

- The first priority is to keep all rescuers alive
- Do not substitute emotion for intellect - 50% of workers who die in confined spaces are would-be rescuers
- Don't take short cuts
- The person in charge may choose to isolate themselves
- Pre-planning and training are essential
Confined Space Rescue

- On-site rescue teams
- Outside rescue services

On-site rescue teams

1. Personnel assigned to an in-plant rescue team are provided with, and trained in the proper use of the personal protective equipment necessary for making rescues from the employer's permit spaces.
2. If the employer decides to use an in-plant team, the employer shall assure that the in-plant rescue team is trained to perform the assigned rescue functions and has received the training required for authorized entrants.
3. Each member of the rescue service shall be trained in basic first aid and cardiopulmonary resuscitation.
Confined Space Rescue

Off-site rescue teams

1. If the employer chooses to use outside rescue services, the employer shall inform the designated rescuers of the hazards they may confront when called to perform rescues at the employer's facility.
2. If an outside rescue service is used, their response time, their continuous availability during the entry, and their rescue capabilities need to be established prior to entry.
3. In most cases, specific phone numbers, radio frequencies, or other type of communication medium is listed on the entry permit. The attendant is responsible for that communication and should perform a communications check prior to entry.

There are three types of rescue which may be employed in the confined space setting:

1. Self-Rescue
2. Non-Entry Rescue - External
3. Entry Rescue - Internal
Self rescue is when an entrant is capable of recognizing a hazard and is able to exit from the space with no assistance.

With self-rescue, emergency rescue personnel do not have to enter the space. Risky extrication and/or removal techniques are not required if self-rescue can be employed.

Also, by virtue of the fact that the individual is still conscious, the chances that the entrant will recover from the emergency are good.

The use of retrieval systems can be very effective in assisting in the rescue of an unconscious employee from a confined space. These systems allow rescue from outside the space.

Non-entry rescue, as the name implies, is rescue performed from outside of the space. Prior to entry retrieval systems and body harnesses should be in place in the event that conditions change.

Non-entry rescue cannot be used for an individual who is entangled, trapped, or bound-up within the space.
Retrieval Rescue Methods

- Body Harness
- Tripod/winch

![Image of body harness and tripod/winch setup]
The attendant should attempt to remove the entrant from the confined space using tripods, hoist, and lifelines. Attendants are NOT TO ENTER CONFINED SPACES. Lethal hazards may be present within the confined space. Only properly equipped and trained emergency rescue personnel may enter confined spaces to make rescues.

Confined Space Rescue

- Entry rescue is clearly the form of rescue that presents the greatest risk to the rescuer - It entails actually placing an individual into the hazardous space
- Entry rescue requires a considerable amount of equipment - In addition to usual PPE, there is a need for patient packaging devices, lifting devices, multiple lifelines, and emergency medical gear as well
- Availability of the equipment and personnel needed for rescue and support must be assured
- Entry rescues should be avoided whenever possible
Medical Issues

- Everyone associated with confined space operations should have a basic understanding of the types of medical emergencies that they may encounter.
- To effectively do this, it is necessary to recognize the potential problems, be able to activate emergency medical services in your plant or municipality, and provide first aid until the arrival of medically trained personnel.

- All individuals associated with the confined space entry and/or rescue must be trained in CPR and basic first aid.
- At least one individual with current certification shall be available during rescue operations.
- All individuals associated with confined space operations also need to know the location and operation of emergency medical supplies and equipment.
Medical Issues

- It is the attendant's job to summon emergency medical assistance in the event of a medical problem.
- If an entrant has a serious medical problem the entire space should be evacuated immediately.
- Any medical affliction that occurs within the space should be assumed to have been caused by a change in the confined space until proven otherwise.

Medical Issues

- heart attack
- asphyxia
- chemical toxicity
- burns
- fractures
- lacerations
- heat stroke
Medical Issues

- If a victim has known injuries from a fall, entrapment, or something dropped on them, the person will need proper packaging.
- As a rescuer you will need to assess the situation, stabilize by performing the necessary first aid, package, and then remove the victim.

Medical Issues

- When preparing an individual for packaging the ABCs of life saving are checked: Airway open, victim is Breathing, and Circulation (heart beating).
- Stop any profuse bleeding, apply a c-collar, and splint where necessary.
Medical Issues

- Wristlets, full body harnesses and basket litters are the most common types of packaging.
- When lashing a victim in a basket litter, wrap the ankle and foot (if ankle and foot are not injured) - Care must be used to not cross the neck and constrict breathing.
- Though basket litters usually are supplied with 4 straps for securing the patient, these are not adequate when making a vertical rescue.