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Confined Spaces:

The Occupational Safety and Health Administration (OSHA) defines a confined space as an area that:

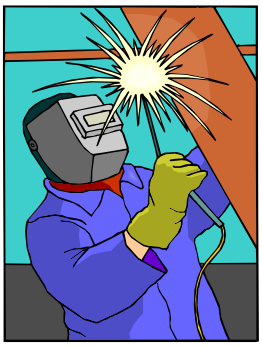
1. Is Large enough and so configured that an employee can bodily enter and perform assigned work; and
2. Has limited or restricted means for entry or exit and
3. Is not designed for continuous employee occupancy.

In addition, a permit-required confined space is defined as a confined space that has one or more of the following characteristics:

1. Contains or has a potential to contain a hazardous atmosphere;
2. Contains a material that has the potential for engulfing an entrant;
3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section; or
4. Contains any other recognized serious safety or health hazard.

A major step in confined space safety is to identify and properly mark a confined space. Typical confined spaces include but are not limited to:

- Storage Tanks
- Sewers
- Holds of Ships
- Underground Utility Vaults and Storage areas
- Boilers
- Manholes
- Pipelines
- Truck and Railroad Tank Cars
- Silos
- Digestors
- Pits
- Ditches
- Wells



Atmospheric Hazards

Common Atmospheric hazards in confined spaces are:

- Oxygen Deficiencies
- Oxygen Enrichment
- Presence of Combustible Gases
- Presence of Toxic Gases

As these atmospheric hazards cannot be seen, it is essential that atmospheric monitoring be performed to reduce safety hazards.

Oxygen Hazards

Air is a mixture of gases. Normal air contains 20.9% Oxygen by volume. Deviations from this level, either higher or lower, are a major concern in confined spaces.

Oxygen Deficiency

An Oxygen deficiency, with the high risk of asphyxiation, is a common problem in confined spaces. Oxygen levels below 19.5% by volume are considered unsafe and can result from either the consumption or displacement of ambient Oxygen. Oxygen deficiency can be caused by:

- Decomposition of Organic Matter (Rotting foods, plant life and fermentation)
- Oxidation of Metals (rusting)
- Inerting
- Combustion (Welding and cutting torches)

In storage tanks and pipelines, for example, Oxygen can be displaced when inert gases (Nitrogen, carbon dioxide, helium, or steam) are used to purge them of residual chemicals, gases or vapors.

Oxygen Enrichment

When the Oxygen level exceeds 23.5% by volume, a different danger presents itself. Known as an oxygen-enriched atmosphere, this condition represents a serious fire hazard.

Flammable materials like clothing and hair will burn very rapidly in an oxygen-enriched atmosphere. Unattended or leaking Oxygen lines or cylinders can increase the Oxygen concentration to unsafe levels and should be recognized as hazards. The following chart shows the effect of various concentrations on humans.

Effect of Various Oxygen Levels

Oxygen by Volume	Resulting condition/Effect on humans: OSHA
23.5% and above	Oxygen enriched, extreme fire hazard: OSHA hazard level
21.0%	Oxygen concentration of "Air"
19.5%	Minimum "Safe Level": OSHA NIOSH levels
16.0%	Disorientation, impaired judgment and breathing
14.0%	Faulty judgment, rapid fatigue
8.0%	Mental failure, fainting
6.0%	Difficult breathing, death in minutes

Flammable Atmospheric Hazards

For a fire or an explosion to occur, three components must be present simultaneously: a fuel (such as a combustible gas) and Oxygen (air) in the proper proportions, and a source of ignition (spark or flame). The specific mixture of fuel and Oxygen that will ignite or explode varies with each combustible gas.

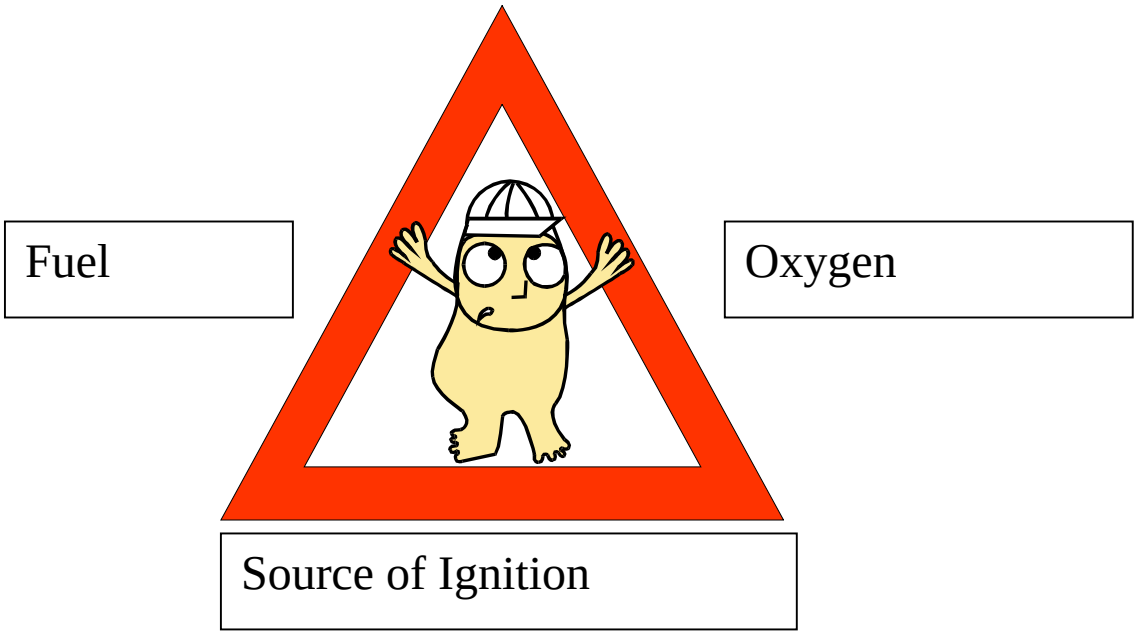
In all cases, this critical point is defined as the range between the Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL).

If the gas-air mixture is below the LEL for a gas, ignition cannot occur because the mixture is too "lean" to burn.

Ignition also will not occur if the gas-air mixture is above the UEL because the mixture is then too “rich”.

When a combustible gas concentration rises above the UEL, the atmosphere should still not be considered safe. A high gas concentration can be diluted rapidly into the combustible range by the introduction of air from outside the confined space.

Pentane and Methane provide good examples of combustible gases. As the illustration shows, these gases will burn only when the gas concentration is between 1.4% (LEL) and 7.8% (UEL) by volume for Pentane, or 5% (LEL) and 15% (UEL) by volume for Methane. However, fluctuations in the ambient Oxygen level can affect and change both LEL and UEL values for a specific gas.



Toxic Gases

Hydrogen Sulfide (H2S) and Carbon Monoxide (CO) are two of the most common toxic gases found in confined spaces. Both are life threatening.

Hydrogen Sulfide

Hydrogen Sulfide is a toxic, colorless, combustible gas that is heavier than air. It is formed by the decomposition of organic plant and animal life by bacteria. Hydrogen Sulfide poisons a person by building up in the blood stream. This toxic gas paralyzes the nerve centers in the brain, which control breathing. As a result, the lungs are unable to function and the individual is asphyxiated. Hydrogen Sulfide can be found in oil and gas

refining and production, sewers, pulp mills and a variety of industrial processes.

Hydrogen Sulfide is easily detected by a strong "rotten egg" odor in low concentrations. However, relying on this odor to warn of the presence of Hydrogen Sulfide can be very dangerous in certain conditions. High concentrations can rapidly paralyze the sense of smell. Even low concentrations desensitize the olfactory nerves, after prolonged exposure, to the point that an individual may fail to smell the presence of the gas even if the concentration suddenly increases.

Effect of Various H2S Levels

H2S level in PPM	Resulting Condition/Effect on Humans
0.13	Minimal perceptible odor
4.60	Easily detectable, moderate odor
10.0	Beginning eye irritation. Permissible exposure level, 8 hours
15.0	STEL
20.0	OSHA ceiling
27.0	Strong unpleasant odor but not intolerable
50.0 to 100	Maximum exposure: 10 minutes Coughing, eye irritation, loss of sense of smell after 2 to 5 minutes
200 to 300	Marked conjunctivitis (eye inflammation) and respiratory tract irritation after one hour of exposure
500 - 700	Loss of consciousness and possibly death in 30 minutes to 1 hour
1000-2000	Unconsciousness at once, with early cessation of respiration and death in a few minutes. Death may occur even if individual is removed to fresh air at once.

Carbon Monoxide

Carbon Monoxide is a toxic, colorless, odorless, combustible gas that is slightly lighter than air. A by-product of combustion, it can be found in almost every industry. Carbon Monoxide enters our bloodstream through the lungs. It has an extreme affinity for the hemoglobin in our bloodstream of about 200-300 time that of Oxygen. As a result, Carbon Monoxide quickly replaces Oxygen in our bloodstream and causes asphyxiation.

Effect of Various CO Levels

CO Level in PPM	Resulting Condition/Effect on Humans
35	TWA- NIOSH
50	OSHA-PEL/TWA
200	Possible mild frontal headache in 2 to 3 hours. Niosh ceiling
400	Frontal headache and nausea after 1 to 2 hours. Occipital after 2.5 to 3.5 hours
800	Headache and dizziness and nausea in 45 minutes. Collapse and possibly death in 2 hours
1200	NIOSH-IDLH
1600	Headache and dizziness in 20 minutes. Unconsciousness and danger of death in 2 hours.
3200	Headache and dizziness in 5 to 10 minutes. Unconsciousness and danger of death in 30 minutes.
6400	Headache and dizziness in 1 to 2 minutes. Unconsciousness and danger of death in 10 to 15 minutes.
12,800	Immediate effect of unconsciousness. Danger of death in 1 to 3 minutes

Atmospheric Testing

Depending on their weights, hazardous gases could be at the bottom, middle or top of a given confined space. Some gases are heavier than air, others lighter, some of the same weight. Therefore, the only safe way to test the atmosphere of a confined space is to sample all levels (top, middle, bottom) at 4-foot intervals with properly calibrated instruments.

If toxic gases, combustible gases or Oxygen deficiency/enrichment are discovered, the confined space has to be ventilated and retested before any entry is permitted.

Remember to put your trust in a properly calibrated instrument and not your senses. You can't see or smell many toxic gases, combustible gases or determine how much Oxygen is present without a reliable instrument.