Guide To Atmospheric Testing In Confined Spaces

This application note is intended to provide general information and to act as a reminder of the dangers associated with atmospheric hazards in a confined space. It outlines the following:

- What is a confined space?
- Atmospheric hazards found in a confined space.
- RAE Systems products for confined space entry.

What Is a Confined Space?

The confined space entry standard was established by *OSHA 29CFR 1910.146* in April 1993. The standard was developed to provide a defined work plan for confined space entry. Confined space entries are part of a daily routine throughout the industrial workplace.

A Confined Space Is Defined as a Space That:

- Is large enough for an employee to enter and perform work.
- Has limited or restricted means for entry or exit.
- Is not designed for continuous human occupancy.

A Permit-Required Confined Space Is Defined As:

A confined space, plus one of the following:

- Contains, or has a known potential to contain, a hazardous atmosphere.
- Contains material with the potential for engulfment.
- Has an internal design that could entrap or asphyxiate the entrant.
- Contains any recognized safety or health hazard.

Examples of confined spaces:

- Storage tanks and vessels
- Sewers and manholes
- Underground utility vaults
- Agriculture silos
- Railcar tanks
- Marine vessel storage and fuel tanks
- Tunnels
- Grain elevators
- Manure Pits

Atmospheric Hazards in Confined Spaces

Atmospheric hazards in a confined space are those that expose entrants to a risk such as death, entrapment, injury, or acute illness from one or more of the following causes:

Oxygen

An atmospheric oxygen concentration below 19.5% (oxygen deficiency), or above 23.5% (oxygen enrichment).

Potential Effects of Oxygen Enriched and Deficient Atmospheres

Oxygen Content (% by Vol.)	**Effects and Symptoms** (At Atmospheric Pressure)
> 23.5%	Oxygen enriched, extreme fire hazard
20.9%	Oxygen concentration in normal air
19.5%	Minimum permissible oxygen level
15-19%	Decreased ability to work strenuously; may impair coordination and may cause early symptoms for persons of coronary, pulmonary or circulatory problems
10-12%	Respiration further increases in rate and depth; poor judgment, blue lips
8-10%	Mental failure, fainting, unconsciousness, ashen face, nausea, and vomiting
6-8%	Recovery still possible after four to five minutes. 50% fatal after six minutes. Fatal after eight minutes.
4-6%	Coma in 40 seconds, convulsions, respiration ceases, death

These values are approximate and vary, due to an individual's state of health and physical activity.

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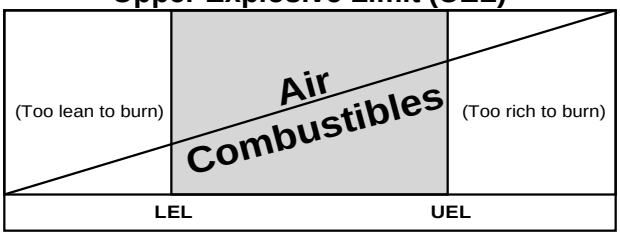
Combustible Gases

A flammable gas or vapor in excess of 10% of its lower explosive limit (LEL) yet still remaining below the upper explosive limit (UEL).

Lower Explosive Limit (LEL) Vs. Upper Explosive Limit (UEL)

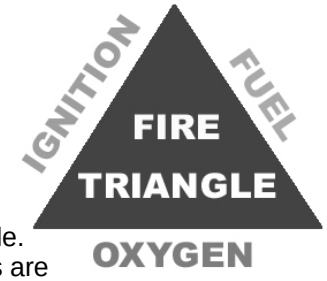


- The lowest concentration (air-fuel mixture) at which a gas can ignite is called lower explosive limit (LEL). Concentrations below this limit are too lean to burn.
- The highest concentration that can be ignited is its upper explosive limit (UEL). Above that concentration, the mixture is too rich to burn.

The Fire Triangle

For combustion to occur, there must be three elements:

1. Fuel
2. Oxygen to support combustion
3. Heat or a source of ignition



This is called the fire triangle. If any of the three elements are missing, combustion cannot occur.

Combustible Gas - Percent By Volume

RAE Systems' one- to five-gas VRAE surveying monitors read out in both % LEL and % by volume.

For example, the LEL of methane is 5% by volume, and the UEL is 15% by volume. When the atmosphere in a confined space reaches 2.5% methane by volume, this is equal to 50% LEL. (5% methane by volume is 100% LEL.) Between 5% and 15% by volume, a spark could cause an explosion.

LEL varies by gas. That is, different gases have different percentage by volume concentrations to reach 100% LEL. Some examples are:

Propane's LEL is 2.1% by volume; Pentane's LEL is 1.5% by volume; Hexane's LEL is 1.1% by volume, and gasoline's LEL is 1.3% by volume.

Toxic Gases

An atmospheric concentration of any toxic containment above the permissible exposure limit established by OSHA, NIOSH or ACGIH. Here are examples of common toxic gases found in a confined space.

Toxic Gas	TWA	STEL	Ceiling	IDLH
Ammonia	25 ppm	35 ppm	--	500 ppm
Carbon monoxide	25 ppm	--	200 ppm	1,500 ppm
Chlorine	0.5 ppm	1 ppm	--	30 ppm
Hydrogen cyanide	--	--	4.7 ppm	50 ppm
Hydrogen sulfide	10 ppm	15 ppm	--	300 ppm
Nitric oxide	25 ppm	--	--	100 ppm
Sulphur dioxide	2 ppm	5 ppm	--	100 ppm

Note: ***TWA*** *is Time Weighted Average Exposure,* ***STEL*** *is Short Term Exposure Limit,* ***Ceiling*** *is the Threshold Limit Value(TLV) Ceiling and* ***IDLH*** *is Immediate Danger to Life and Health*

Life-Threatening Effects: CO & H_2S

Effects Of Carbon Monoxide (CO) Exposure		
PPM	**Time**	**Effects & Symptoms**
35	8 hours	Permissible Exposure Level
200	3 hours	Slight headache, discomfort
400	2 hours	Headache, discomfort
600	1 hours	Headache, discomfort
1000-2000	2 hours	Confusion, discomfort
1000-2000	½ - 1 hour	Tendency to stagger
1000-2000	30	Slight heart palpitations
2000-2500	30	Unconsciousness
4000	> 1 hour	Fatal

Effects Of Hydrogen Sulfide (H_2S) Exposure		
PPM	**Time**	**Effects & Symptoms**
10	8 hour	Permissible exposure level
50-100	1 hour	Mild eye and respiratory irritition
200-300	1 hour	Marked eye and respiratory irritation
500-700	½-1 hour	Unconsciousness, death
>1000	Minutes	Unconsciousness, death

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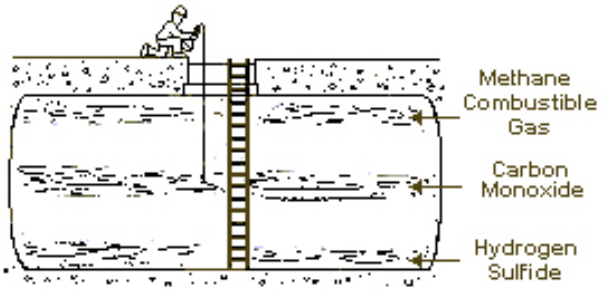
Monitoring Confined Spaces for Atmospheric Hazards

Monitoring the air inside a confined space is required prior to entering. Testing a confined space for atmospheric hazards should be done in this order:

- **Oxygen.** Ensure that proper oxygen levels are present.
- **Combustible gases.** Ensure that combustible gases are not present
- **Toxic Gases.** Ensure that toxic gases are below the OSHA permissible exposure limit. Common toxic gases in a confined space could be hydrogen sulfide (H_2S) and carbon monoxide (CO), but other toxic compounds could be present. RAE Systems offers monitors to evaluate all these gases either individually or simultaneously.

In a confined space, it is important to take samples at the top, middle, and bottom to locate varying concentrations of gases and vapors. There are some gases lighter than air (for example, methane and other combustible gases) that can be found at the top of a confined space. There are other gases that are heavier than air (for example, hydrogen sulfide) that can settle near the bottom of a confined space. Still other gases are the same weight as air (for example, carbon monoxide) that can be found throughout a confined space.



Take air samples at several levels within the confined space and continuously monitor the space, because conditions can change.

As the remote air monitoring is completed and the area is judged safe for entry, confined space entry permits should be completed and followed. After the initial entry, monitoring the air in the confined space should be continuous. A confined space entry attendant or hole watch should carry out the continuous monitoring. Conditions in a confined space can change without warning, due to leakage, toxic vapor release, or disturbing the contents of the space.

Monitors for Confined Space Entry

RAE Systems offers the latest and most innovative monitors available for Confined Space Entry (CSE). Datalogging, storing data for later evaluation, is an option on all our multi-gas monitors.

QRAE II - Confined Space Entry Monitor

The QRAE II and QRAE II Pumped CSE Monitor are pre-set as easy-to-use tools to comply with the atmospheric testing required by *OSHA 29CFR 1910.146*. The QRAE II offers the flexibility to work effectively in a confined space while remaining protected from combustibles, hydrogen sulfide, carbon monoxide, and high or low oxygen levels.

Oxygen Concentration
OSHA levels between 19.5% and 23.5%. The MultiRAE has user-selectable preset alarms (low, 19.5%, and high, 23.5%) to warn of hazardous conditions.

Combustible Gases
Concentrations below 100% of the LEL. The MultiRAE Plus has a pre-set alarm at 10% LEL of combustible gases, and a high alarm set at 20% LEL. These alarm set points are user selectable.

Toxic Gases:
Alarms pre-set at the OSHA permissible exposure limit. The MultiRAE Plus has preset alarms for H_2S at 10 ppm low alarm, and 20 ppm high alarm. CO alarms are at 35 ppm low alarm and 200 ppm high alarm. These alarm set points are user selectable. The MultiRAE also offers several other toxic gas sensors.

MultiRAE Toxic Gas Monitor With PID

The MultiRAE is an excellent personal protection monitor. It combines the traditional security of standard electrochemical and catalytic sensors with the next-generation, broad-band protection of a photoionization detector (PID). Unlike the QRAE II, this monitor offers a wide variety of interchangeable toxic sensors with the additional

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protection of a PID for applications such as confined space entry.

AreaRAE - Wireless Multi-gas Monitor with PID

The AreaRAE Toxic gas monitor is the big brother to the MultiRAE Plus, it offers Oxygen and LEL sensors as well as a PID and two toxic gas sensor sockets that can accommodate more than 10 different sensors. The Wireless capability lends this instrument to applications where there are multiple confined spaces being monitored in applications such as refinery or chemical plant turn-arounds, retrofits or upgrades.

VRAE - One- to Five-Gas Toxic Gas Surveyor

The VRAE's powerful internal pump, combined with RAE Systems' wide selection of toxic sensors, presents a highly effective, continuous surveying monitor. The VRAE can monitor combustibles in percent of LEL or in percent by volume.

Single-Gas Monitors

RAE Systems also offers a complete line of single- gas monitors for breathing zone, worker specific, confined space entry applications. is a full-featured gas monitor providing continuous, digital display of the gas concentration, STEL, TWA, and Peak values as well as high, low, TWA, and STEL alarms Single toxic gases sensors offered include: Ammonia (NH_3), Carbon Monoxide (CO), Chlorine (Cl_2), Chlorine Dioxide (ClO_2), Hydrogen Cyanide (HCN), Hydrogen Sulfide (H_2S), Nitric Oxide (NO), Nitrogen Dioxide (NO_2), Oxygen (O_2), Phosphine (PH_3), Sulfur Dioxide (SO_2)

Additional information:

Federal Register
29 CFR 1910.146
Permit Required Confined Spaces for General Industry
http://cos.gdb.org

OSHA
U.S. Department of Labor
http://www.osha-slc.gov

OSHA Regulations (Standards - 29 CFR) - 1910.146 - Permit-required confined spaces OSHA Regulations (Standards - 29 CFR) - 1910.146 - Permit-required confined spaces . 1910.146 - Permit-required confined spaces. Standard Number: 1910.146 .Standard Title: Permit-required confined spaces.
www.osha-slc.gov/OshStd_data/1910_0146.html

OSHA Regulations (Standards - 29 CFR) - 1910.146 App C - Examples of Permit-required Confined Space Programs OSHA Regulations (Standards - 29 CFR) - 1910.146 App C - Examples of Permit-required Confined Space Programs . 1910.146 App C - Examples of Permit-required Confined Space Programs. Standard Number: 1910.146 App C .Standard Title: Examples.
www.osha-slc.gov/OshStd_data/1910_0146_APP_C.html

OSHA Regulations (Standards - 29 CFR) - 1910.146 App A - Permit-required Confined Space Decision Flow Chart OSHA Regulations (Standards - 29 CFR) - 1910.146 App A - Permit-required Confined Space Decision Flow Chart . 1910.146 App A - Permit-required Confined Space Decision Flow Chart. Standard Number: 1910.146 App A .Standard Title:
www.osha-slc.gov/OshStd_data/1910_0146_APP_A.html

Disclaimer:

This application note contains only a general description of atmospheric testing in a confined space and equipment used to monitor a confined space. Under no circumstances should a confined space be entered or monitoring equipment used except by qualified and trained personnel, and after all instructions have been carefully read and understood and all precautions followed.

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