



The Equipment Supply and Support People

A Look Into Confined Space Monitoring

In Support of
The Lorain County Chamber of Commerce



Why do we need to be concerned with Confined Spaces?

CONFINED SPACE STATISTICS (OSHA and other various sources)

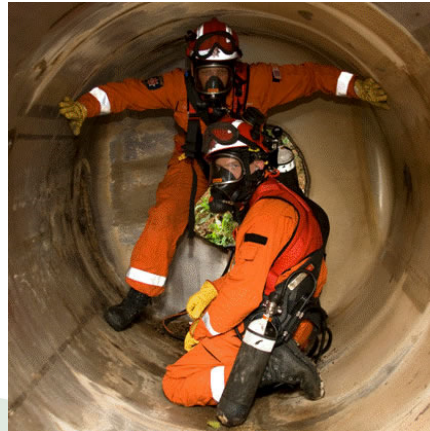
- There were 431 confined space incidents with 530 fatalities in the US due to oxygen deficient and/or toxic atmospheres from 1992-2005
- 65% of all confined space fatalities are due to hazardous atmosphere
- In 139 of these fatalities, there were no detectors nor ventilation utilized
- 25% of spaces were toxic before entry
- In 2010, there were 63 worker fatalities and 28 hospitalizations related to confined spaces.
- From 01/01/2011 to 08/01/2011, there were 22 worker fatalities and 3 worker hospitalizations related to confined spaces.
- Repair & Maintenance and cleaning & inspection activities account for almost one-quarter of confined space-related fatalities.
- Construction and manufacturing industries experience the most fatalities.



Confined Space - OSHA Defined

"Confined space" means a space that:

- Is large enough and so configured that an employee can bodily enter and perform assigned work; and
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry.); and
- Is not designed for continuous employee occupancy.



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The Equipment Supply and Support People



Permit Required Confined Space Entry - Code of Federal Regulations (29 CFR)



- **Part Number:**1910
- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** J
- **Subpart Title:** General Environmental Controls
- **Standard Number:**1910.146
- **Title:** Permit-required confined spaces
- **Appendix:** A , B , C , D , E , F





Permit Required Confined Space (PRCS) – OSHA Defined

Definition A PRCS means a CONFINED SPACE that has one or more of the following characteristics:

- Contains or has a potential to contain a **hazardous atmosphere**,
- Contains a material that has the potential for engulfing an entrant,
- Contains 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,
- Contains any other serious safety or health hazard.





Hazardous Atmosphere - OSHA Defined

“Hazardous Atmosphere” is an atmosphere that may expose employees to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a permit space), injury, or acute illness from one or more of the following causes:

- Flammable gas, vapor, or mist in excess of 10 percent of its lower flammable limit (LFL);
- Airborne combustible dust at a concentration that meets or exceeds its LFL;
- Atmospheric oxygen concentration below 19.5 percent or above 23.5 percent;
- Atmospheric concentration of any substance for which a dose or a permissible exposure limit is published in Subpart G, Occupational Health and Environmental Control, or in Subpart Z, Toxic and Hazardous Substances, of this Part and which could result in employee exposure in excess of its dose or PEL;
- Any other atmospheric condition that is immediately dangerous to life or health.

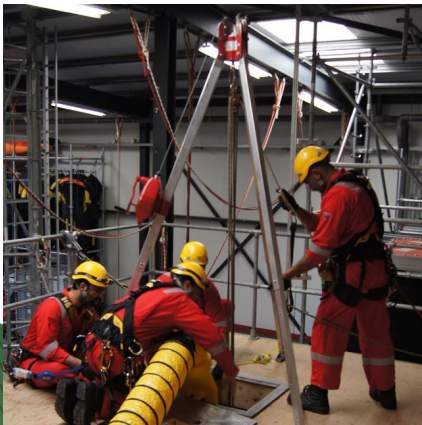




Equipment Required by OSHA for PRCS Entry

OSHA indicates that the entrant is to provide the following equipment at no cost to employees, maintain that equipment properly, and ensure that employees use that equipment properly:

- Testing and monitoring equipment needed to comply with regulations;
- Ventilating equipment needed to obtain acceptable entry conditions;
- Communications equipment necessary for compliance with regulations;
- Personal protective equipment insofar as feasible engineering and work practice controls do not adequately protect employees;





Equipment Required by OSHA (cont.)

- Lighting equipment needed to enable employees to see well enough to work safely and to exit the space quickly in an emergency;
- Barriers and shields as required by regulations;
- Equipment, such as ladders, needed for safe ingress and egress by authorized entrants;
- Rescue and emergency equipment needed to comply with regulations, and;
- Any other equipment necessary for safe entry into and rescue from permit spaces.





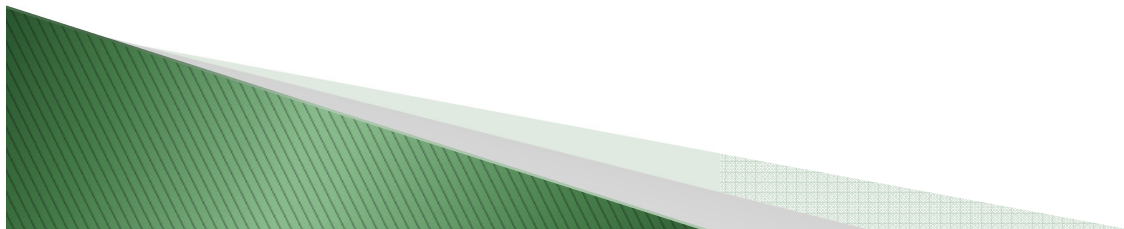
Other equipment does not replace the right equipment





Continuous Forced Air Ventilation

- The forced air ventilation should be so directed as to ventilate the immediate areas where an employee is or will be present within the space and shall continue until all employees have left the space;
- The air supply for the forced air ventilation should be from a clean source and may not increase the hazards in the space.
- The atmosphere within the space should be periodically tested as necessary to ensure that the continuous forced air ventilation is preventing the accumulation of a hazardous atmosphere.





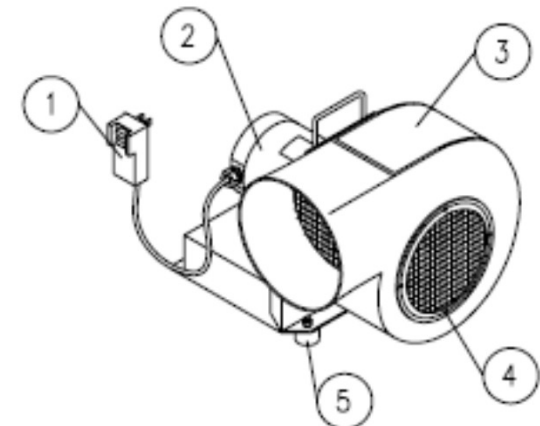
Model SVB-E8EC – Economy Electric Blower

ITEM #	DESCRIPTION	PART #
1	GFI POWER CORD	ELCB013
2	SINGLE SPEED MOTOR	MTR040
3	HOUSING	METL2000
*	BLOWER WHEEL	METL202
4	AIR INTAKE SCREEN	METL2010
5	RUBBER FEET	HDWR025



SPECIFICATIONS

MOTOR TYPE	1/2 HP (.37 kw) Electric, 115 VAC/60Hz, Single Speed, GFI Cord Installed
FULL LOAD AMPERAGE	7.9 Amps
FLOW RATES	Free Air: 1390 cfm 25 ft. Duct with One 90 degree bend: 973 cfm
INLET/ OUTLET SIZE	8" Diameter (203 mm)
WEIGHT	37 lbs.
NOISE LEVEL	76dbA @ 3 ft.



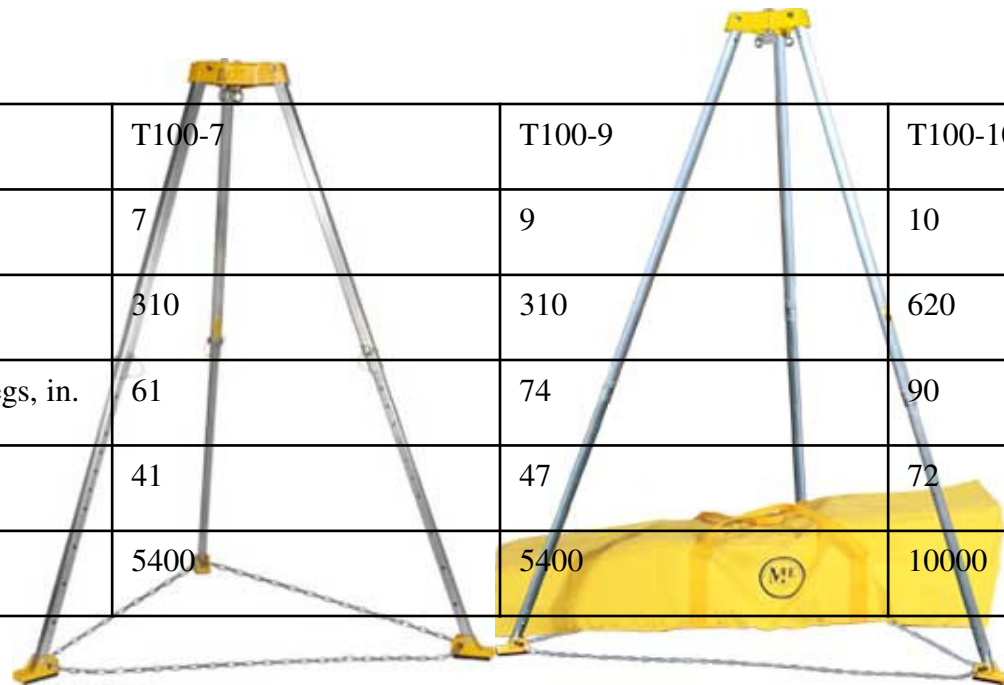


Rescue and Emergency Equipment

Tripod Rescue System (Model T-100S)

Each Tripod system is composed of a Tripod, 3-Way fall arrest device with lowering and retrieval capabilities and a Personnel or Material Winch.

Model :	T100-7	T100-9	T100-10
Height, ft.	7	9	10
Working Load, lbs.	310	310	620
Distance between legs, in.	61	74	90
Weight, lbs.	41	47	72
Tested static load	5400	5400	10000





Rescue and Emergency Equipment (Continued)

Personnel Winch (Model 142)

Designed for raising or lowering an employee into a work position or for use in rescue operations.



Working Load, lbs	310
Lifeline Cable	Galvanized, Stainless Steel, Synthetic Rope
Cable Diameter, in.	3/16
Length of Cable, ft.	50 - 100
Weight, lbs.	36
Locking Speed, ft./sec.	4-5



Personal Protective Equipment



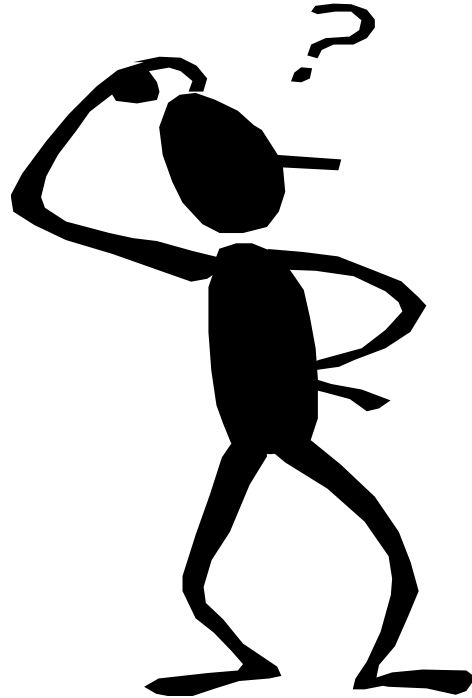
A variety of PPE may be required depending on the environment and conditions of work.

- Dupont Tyvek, Tychem, Nomex, Rainfair and Beta brand protective coveralls and suits
- Crew brand protective eyewear and goggles
- Beta and Lacrosse brand overshoe and overboot foot protection
- Microflex, Semperguard, and Best N-Dex latex and nitrile gloves
- MSA and North respirators and respirator cartridges





How to Select the Proper Instrumentation?



- To select the instruments that will most **Accurately Identify** and **Measure** those hazards, you must understand:
 - the environmental conditions and potential hazards present
 - the exposure limits and thresholds of those hazards



Atmosphere Monitoring Equipment

- Before an employee enters the space, the internal atmosphere should be tested, with a calibrated direct-reading instrument, for oxygen content, for flammable gases and vapors, and for potential toxic air contaminants, in that order.





Atmosphere Monitoring Equipment (Continued)



Evaluation Testing – Analyze atmosphere with the proper equipment to identify and evaluate any hazardous atmospheres that may arise or exist.. Have a qualified professional interpret and evaluate results to develop the proper entry procedures including other potential physical hazards

Verification Testing – Conducted at the time of entry to determine that atmospheric conditions are within the range of acceptable entry conditions prior to entry of the space.

Duration of Testing – Minimum response time for the sensors and additional tubing, hoses, or probe length

Layered Atmosphere Testing – Test at a variety of levels stratigraphically to detect for potential layers of hazardous atmosphere

Retesting and Continual Testing – Test the atmosphere frequently and/or continually to monitor for changes in atmospheric conditions.



There are many to choose from...





Common Features of Confined Space Instruments on the Market

Most units are...

- standard “4 Gas” configurations, Passive/Diffusion or Pump equipped, with O₂, LEL, CO, and H₂S sensors installed
- available with Infrared LEL sensors to operate when O₂ is absent
- compact in size and light weight for use in tight confined spaces
- supported by a separate calibration/bump test docking station for automated calibration capability (not required)
- easily calibrated by a manual process independent of docking stations
- designed to utilize a calibration gas mixture to eliminate need for multiple gas cylinders
- powered by both Lithium Ion and Alkaline batteries and continuously operate when plugged into charger or 12 V automotive adapter
- engineered with an Internal pump option to provide quick response and remote sampling with 10-12 hours of run time
- capable of data logging and storing a significant amount of information
- outfitted with a data library of response factors for wide variety of combustibles and volatile compounds



Understand the Specifications

QRAE 3

Wireless 4-Gas Monitor



SPECIFICATIONS

Instrument Specifications

Size	Diffusion: 5.5" H x 3.2" W x 1.5" W (140 mm x 82 mm x 42 mm) Pumped: 5.7" H x 3.2" W x 1.7" D (145 mm x 82 mm x 42 mm)
Weight	Diffusion: 12.9 oz (365 g with Li-ion battery and clip) Pumped: 14.5 oz (410 g with Li-ion battery, clip, and external filter)
Sensors	Up to four replaceable sensors: • LEL: Catalytic bead for combustibles (built-in Correction Factor library) • Oxygen: Liquid electrolyte O ₂ • Electrochemical sensor for Toxics
Battery	Rechargeable Li-ion
Running time	• 14 hours continuous non-wireless, diffusion • 11 hours continuous non-wireless, pumped • 10 hours continuous with wireless, diffusion • 8 hours continuous with wireless, pumped Note: All battery specifications at 68° F (20° C); lower temperatures and alarm conditions will affect runtime.
Display Graphic	Monochrome graphic display (128 x 80) Display size: 1.57" W x 1.06" H (40 x 27 mm) with backlighting Automatic or on-demand screen rotation
Keypad	Two-button operation
Direct Readout	• Real-time reading of gas concentrations • Battery status • Pump status (if equipped with pump) • Wireless on/off and wireless reception quality • STEL, TWA, peak, and minimum values • Man Down and policy enforcement indicators
Alarms	• Multi-tone 95dB buzzer (at 11.87' 30 cm, typical), vibration alarm, and flashing red LEDs and on-screen indication of alarm conditions • Alarms: latching, non latching or manual override • Additional diagnostic alarm and display message for low battery • Pump stall alarm (pumped version only) • Man Down Alarm with pre-alarm and real-time remote wireless notification
Datalogging	• Continuous datalogging (3 months for 4 sensors at 1-minute intervals) • User-configurable datalogging intervals (from 1 to 3,600 seconds)
Communication & Data Download	• Data download and instrument set-up and upgrades on PC via Travel Charger • Wireless data and status transmission via built-in RF modem (optional)
Wireless Network	Mesh RAE Systems Dedicated Wireless Network
Wireless Range	EchoView Host: LOS > 650 ft (200 m) ²

Safety Certifications	US and Canada: Classified for use in Class I, Division 1, Groups A, B, C and D Europe: ECE/ATEX (II) 1G Ex Ia IIC T4
Temperature	-4° to 122° F (-20° to 50° C) for 14 temperature code
Humidity	0% to 95% relative humidity (non-condensing)
Attachments	Stainless-steel alligator clip; Swivel belt clip (optional); Pouch (optional)
Languages	Arabic, Chinese, Czech, Dutch, English, French, German, Indonesian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Russian, Spanish, Swedish and Turkish (language must be changed through ProRAE Studio II)
Warranty	2-year warranty on device ² 3-year warranty on LEL, O ₂ , CO, H ₂ S sensors ² 1-year warranty on other sensors
Wireless Frequency	ISM license free band, IEEE 802.15.4 Sub 1GHz
Wireless Approvals	FCC Part 15, CE R&TTE, Others ⁴
Radio Module	Supports RM900

Default Sensor Specifications

Gas Monitor	Range	Resolution
Oxygen (O ₂)	0 to 30.0%	0.1%
Combustible	0 to 100% LEL	1% LEL
Carbon Monoxide (CO)	0 to 500 ppm	1 ppm
Hydrogen Sulfide (H ₂ S)	0 to 100 ppm	0.1 ppm
Sulfur Dioxide (SO ₂)	0 to 20 ppm	0.1 ppm
Hydrogen Cyanide (HCN)	0 to 50 ppm	0.2 ppm
Ammonia (NH ₃)	100 ppm	1 ppm
Phosphine (PH ₃)	20 ppm	0.01 ppm
Chlorine (Cl ₂)	0 to 50 ppm	0.05 ppm
Nitrogen Dioxide (NO ₂)	0 to 50 ppm	0.1 ppm

ORDERING INFORMATION

- Wireless¹ and non-wireless options available for all configurations
- Diffusion and pumped versions available for all configurations

MultiRAE

Wireless Portable Six-Gas³ Monitor with Advanced VOC Detection Capability



SPECIFICATIONS

Instrument Specifications⁴

Size	7.6" H x 3.8" W x 2.6" D (193 x 96.5 x 66 mm)
Weight	31 oz (880 g)
Sensors	25 intelligent interchangeable field-replaceable sensors including PID for VOCs, electrochemical sensors for toxic gases and oxygen, combustible LEL and NDIR sensors, and CO ₂ NDIR sensor
Battery Options, Runtime ² and Recharge Time	- Rechargeable Li-ion (~12-hr. runtime, <6-hr. recharge time) - Extended duration Li-ion (~18-hr. runtime, <9-hr. recharge time) - Alkaline adapter with 4 x AA batteries (~6-hr. runtime)
Display	Monochrome graphical LCD display (128 x 160) with backlighting, Automatic screen "tip" feature.
Display Readout	- Real-time reading of gas concentrations; PID measurement gas and correction factor; Man Down Alarm on/off; visual compliance indicator; battery status; datalogging on/off; wireless on/off and reception quality - STEL, TWA, peak, and minimum values
Keypad Buttons	3 operation and programming keys (Mode, Y+, and N/-)
Sampling	Built-in pump. Average flow rate: 250 cc/min. Auto shutoff in low-flow conditions
Calibration	Automatic with AutoRAE 2 Test and Calibration System or manual
Alarms	Wireless remote alarm notification; audible (95 dB @ 30 cm), vibration, visible (flashing bright red LEDs), and on-screen indication of alarm conditions - Man Down Alarm with pre-alarm and real-time remote wireless notification ¹
Datalogging	Continuous datalogging (6 months for 5 sensors at 1-minute intervals, 24/7) - User-configurable datalogging intervals (from 1 to 3,600 seconds)
Communication and Data Download	- Data download and instrument set-up and upgrades on PC via desktop charging and PC comm. cradle, travel charger, or AutoRAE 2 Automatic Test and Calibration System - Wireless data and alarm status transmission via built-in RF modem (optional)
Wireless Network	ProRAE Guardian Real-Time Wireless Safety System or EchoView Host-based Closed-Loop System
Wireless Range (Typical)	MultiRAE to RAElink3 (Z11) Mesh modem - 330 feet (100 meters) MultiRAE to EchoView Host, RAEMesh Reader or RAEPoint - 660 feet (200 meters)
Operating Temperature	-4° to 122° F (-20° to 50° C)
Humidity	0% to 95% relative humidity (non-condensing)
Dust and Water Resistance	IP-65 ingress protection rating (dust-tight and waterproof against hosing jets coming from all directions)
Safety Certifications	CSA: Class I, Division 1, Groups A, B, C and D, T4

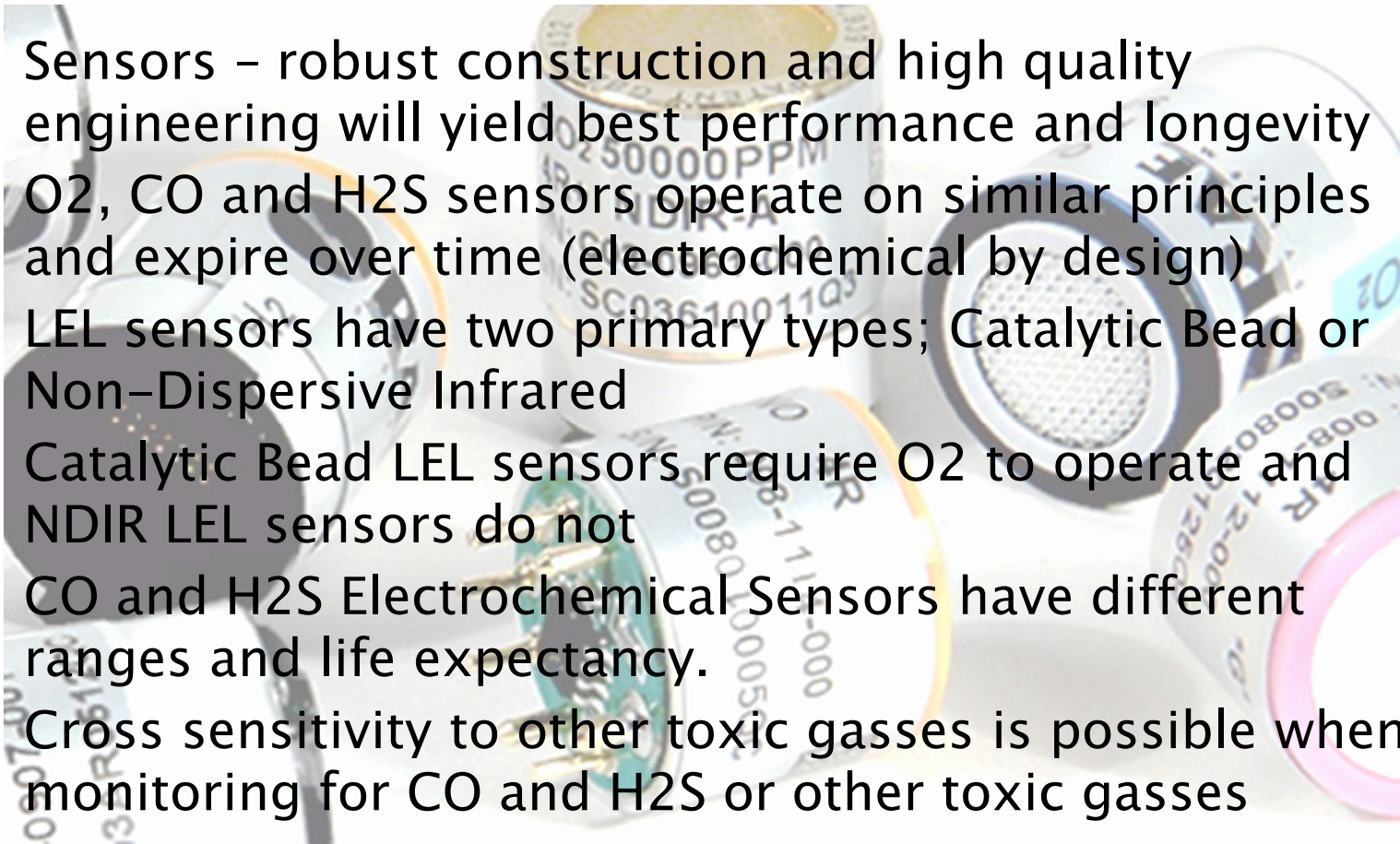
Sensor Specifications⁴

PID Sensors	Range	Resolution
VOC 10.6 eV (Ext. Range)	0 to 5,000 ppm	0.1 ppm
Combustible Sensors		
Catalytic LEL	0 to 100% LEL	1% LEL
NDIR (3-100% LEL Methane)	0 to 100% LEL	1% LEL
NDIR (3-100% Vol. Methane)	0 to 100% Vol.	0.1% Vol.
Carbon Dioxide Sensor		
Carbon Dioxide (CO ₂) NDIR	0 to 50,000 ppm	100 ppm
Electrochemical Sensors		
Ammonia (NH ₃)	0 to 100 ppm	1 ppm
Carbon Monoxide (CO)	0 to 500 ppm	1 ppm
Carbon Monoxide (CO), Ext. Range	0 to 2,000 ppm	10 ppm
Carbon Monoxide (CO), H ₂ -comp.	0 to 2,000 ppm	10 ppm
Carbon Monoxide (CO) + Hydrogen Sulfide (H ₂ S) Combo	0 to 500 ppm	1 ppm
	0 to 200 ppm	0.1 ppm
Chlorine (Cl ₂)	0 to 50 ppm	0.1 ppm
Chlorine Dioxide (ClO ₂)	0 to 1 ppm	0.03 ppm
Ethylene Oxide (EtO-A)	0 to 100 ppm	0.5 ppm
Ethylene Oxide (EtO-B)	0 to 10 ppm	0.1 ppm
Formaldehyde (HCHO)	0 to 10 ppm	0.05 ppm
Hydrogen Cyanide (HCN)	0 to 50 ppm	0.5 ppm
Hydrogen Sulfide (H ₂ S)	0 to 100 ppm	0.1 ppm
Methyl Mercaptan (CH ₃ -SH)	0 to 10 ppm	0.1 ppm
Nitric Oxide (NO)	0 to 250 ppm	0.5 ppm
Nitrogen Dioxide (NO ₂)	0 to 20 ppm	0.1 ppm
Oxygen (O ₂)	0 to 30% Vol.	0.1% Vol.
Phosphine (PH ₃)	0 to 20 ppm	0.1 ppm
Sulfur Dioxide (SO ₂)	0 to 20 ppm	0.1 ppm



The SENSORS make the difference...

- Sensors – robust construction and high quality engineering will yield best performance and longevity
- O₂, CO and H₂S sensors operate on similar principles and expire over time (electrochemical by design)
- LEL sensors have two primary types; Catalytic Bead or Non-Dispersive Infrared
- Catalytic Bead LEL sensors require O₂ to operate and NDIR LEL sensors do not
- CO and H₂S Electrochemical Sensors have different ranges and life expectancy.
- Cross sensitivity to other toxic gasses is possible when monitoring for CO and H₂S or other toxic gasses





“Got” Oxygen

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 (**still may represent an issue**)
- 15% to 19% Decreased ability to work strenuously; may impair coordination and may cause early symptoms for persons of coronary, pulmonary or circulatory problems
- 10% to 12% Respiration further increases in rate and depth; poor judgment, blue lips
- 8% to 10% Mental failure, fainting, unconsciousness, ashen face, nausea, and vomiting
- 6% to 8% Recovery still possible after four to five minutes. 50% fatal after six minutes. Fatal after eight minutes.
- 4% to 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.



The Flammable Range

METHANE

Too Lean to Burn	LEL	(Flammable Range)	UEL	Too Rich to Burn
0% (by Volume)	100% LEL or 5% by Volume		100% UEL or 15% by Volume	100% (by Volume)

Understanding the Meter Reading

Methane (ppm)	% Methane (by Volume)	% LEL Meter Reading
10,000	1.0%	20.0%
20,000	2.0%	40.0%
30,000	3.0%	60.0%
40,000	4.0%	80.0%
50,000	5.0%	100.0%

A meter reading of 2.5% would = 50% LEL (25,000 ppm Methane)

% LEL or % by Volume - You NEED to KNOW and UNDERSTAND what the instrument is displaying!



Toxic Gases

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

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



Toxic Gas Effects

Threatening Effects: CO and H₂S

Effects Of Carbon Monoxide Exposure

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



Toxic Gas Effects

Threatening Effects: CO and H₂S

Effects Of Hydrogen Sulfide Exposure

ppm	Time	Effects & Symptoms
10	8 hour	Permissible exposure level
50 to 100	1 hour	Mild eye and respiratory irritation
200 to 300	1 hour	Marked eye and respiratory irritation
500 to 700	½ - 1 hour	Unconsciousness, death
> 1000	Minutes	Unconsciousness, death



Common Occurrences and Instrument Troubleshooting

- Improper storage in harsh environments expecting no significant performance issues
- Improper training on calibration procedures and performance “bump” testing
- Poor maintenance program and understanding sensor operation
- Identifying end of life behaviors for sensors and replacing in a timely manner
- Dismissing performance issues as insignificant
- Verifying pump performance using effective measuring devices
- Identifying sensor response times when using instruments and additional tubing
- Sensor poisoning with silicone lubricants, sulfur compounds, chlorine and heavy metals
- Oversaturation of catalytic bead sensors which damages the sensors and produce false readings

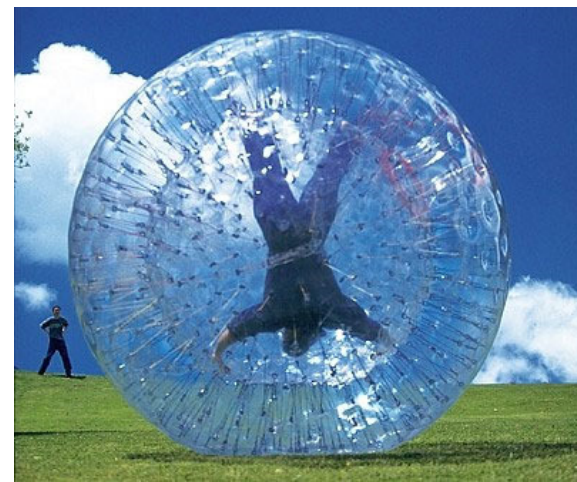


Accessories matter...

- When utilizing tubing to extend the “nose” of your instrument, remember to utilize non absorbing brands such as Tygon® or Teflon®
- Certain VOCs and other toxic gases can be absorbed by polyethylene, vinyl or silicon based tubing
- Make sure your tripods and winches are fully operable, tested and certified
- Calibration and maintenance of equipment is not an option and make sure the gasses and standards used are current and not expired.



These may be considered fun “confined spaces” ...





This is certainly not!!





PINE

Thanks for your time!
Questions or Comments?

