

Atmospheric Meters for Operations

PANW

Pipeline Association of the NW

Idaho

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Atmospheric Meters for Operations

WELCOME!

My name is Jason Rickey. I'm an instructor for the Pipeline Association of the Northwest. We teach pipeline responses training free of charge, covering Washington, Oregon, and Idaho.

If you would like to sign up for free response training, please visit <https://panw.pipelineawareness.org/>. Classes are up to 4 hours and include hazmat operations instruction that meets most states' Hazmat Operations mandatory annual training requirements, as well as state-specific Insurance Rating requirements.

Classes include emergency response orientation, local gas utility orientation and involvement, hazardous materials strategy and tactics, and basic command and control elements. Each class includes refreshments and meals.

A little bit about me, I am a captain in a department in Pierce County, Washington, with 30 years as a professional firefighter, 25 as a hazmat technician. My current position is a deputy fire marshal overseeing inspections and investigations. My previous positions include engine/truck officer, paramedic, special operations instructor, and hazmat team leader.

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Thanks for attending!

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WHY USE METERS?
AT THE OPERATIONS LEVEL

Safety

- Immediate and ongoing
- Establishment and confirmation of exclusion zones
- Allowing public to re-occupy

Plan and Confirmation of Strategy/Tactics

- Is and/or ruling out hazardous atmospheres
- Enabling continued safety during tactics
- Allows for strategic shifts due to changes in atmospheres

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2024
OPERATIONS
POSTER

INTENT

Opening slide outlining the need for atmospheric metering not only to confirm that the initial arriving units are working in a safe environment, but also to practice a continued evaluation of the atmosphere for both knowns and potential unknowns.

Safety

- Primary reason for everything we do.
- Enables arriving units to evaluate for basic atmospheric hazards – **IT DOES NOT CONFIRM THEY ARE SAFE, AS NO METER COVERS ALL HAZARDS.**
- Used to establish initial and ongoing isolation distances for exclusion zones and can be used to expand or retract the established zones as ID'd by the ERG. – **PRODUCTS MUST BE KNOWN!**
- Enables a better understanding of whether the atmosphere is safe to evacuate the public.
 - Evacuations can include situations where the atmosphere is completely free of contaminants, meters enable the responder to quantify the concentrations that are below PEL (permissible exposure limits), well below the flammable range, or under the acceptable energy level (rad) to safely move the public within it.

Plan and Confirmation of Strategy/Tactics

- Establishing strategy and associated tactics in hazardous materials incidents requires understanding the hazards of the incident before deployment. In most cases, meters are the only tool enabling the ability to quantify (or get close to it) the hazards.
- Continuous evaluation of the incident's hazards is required (it's the law) to enable safe operations during an incident. Any unanticipated changes (for the worse) should stop operations and consider a change of strategy until the situation can be brought back into a safe condition.

Identification/Quantification of Atmosphere


- Using multiple technologies (sometimes all of them) may be needed to ID the product. Sometimes, all that is needed to "rule out" hazards without actually ID'ing the specific product.
- Meters are used to confirm assumed products while ruling out unknowns, as much as the technologies used have the capability.
- **At the operations level, meters are critical in decision-making regarding allowing our public to reoccupy structures following an event.**

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GENERALIZED PRACTICES/PRINCIPLES

- Understand the advantages and disadvantages of the equipment
- Manufacture recommendations
 - Proper storage, handling, use practices
- PPE regardless of immediate readings
- Vapor Density – understand and apply
- T90 Times – understand and apply
- Cross Sensitivities and Correction Factors – understand and consider
- Meter Scaling - PPM, % of atmosphere, % of LEL

✓ NO SINGLE PIECE OF EQUIPMENT CAN IDENTIFY AND/OR QUANTIFY ALL HAZARDOUS MATERIALS



INTENT

General overview of metering application with emphasis on the fact that one meter can't and won't do it all, and to follow the manufacturer's recommendations. This should be a repeated concept throughout the lecture.

- Most concepts within the bullets are new and will be covered throughout the lecture.

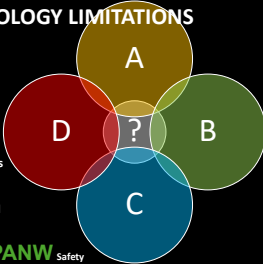
Slide
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SINGLE TECHNOLOGY LIMITATIONS

No single meter will enable the ID of an Unknown

Overlapping Technologies for Unknowns

- Establish
 - "Bulle Outs" of products and hazards
- Allows for a Zeroing in on the needed product for the specific material.



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INTENT

The concept of overlapping technologies enables making the unknown "circle" smaller. Doing so decreases the need for a wide span of attention to unnecessary technologies and enables focus on the necessary ones.


Considerations When Selecting Meters

- Mission of the operation.
- Suspected hazards.
- Portability and user friendliness.
- Instrument reaction time.
- Sensitivity and selectivity.
- Calibration.
- Training.

Slide
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PUMP VS DIFFUSION METERS

- Type does not make a difference in performance without attachments
- Diffusion is quieter
- Diffusion uses less battery (longer life)
- Pump is required when utilizing probes and/or hoses
- Same sensors used



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INTENT

Introduction to the options of diffused and pump type meters, and a brief overview of their characteristics

- Meter performance is the same between pump and diffusion-type meters. Response (T90) times are not affected unless remote hoses are applied to pump-type meters.
- When adding remote hoses to pump meters, you must follow the manual on extended response times (it takes time for the sample to move through the hose).
- Typical operational level meters utilize diffusion type meters due to being cheaper, having fewer parts, being quieter, and the batteries last longer.
- Typical technician-level meters utilize pump-type meters for the use of remote hoses (sampling below ground).

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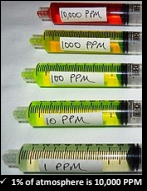
METER SCALE - PPM

Parts Per Million (PPM):
 Comparative measurement that compares the of gas/vapor in air to a comparable 1 million parts of clean air.

- May describe the concentration of a gas or vapor in air or the concentration of a specific material in a liquid or solid.
- Describes the relative abundance of a specific material.

Examples:

- The number of molecules of gas found within a million air molecules.
- The number of molecules of a hazardous material found in a million molecules of a liquid.
- 1 ppm is 1" divided out evenly in 16 miles of road



✓ 1% of atmosphere is 10,000 PPM

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INTENT

PPM is typically used for meter sensors other than LEL and O2, making the need to understand the concept critical.

- May describe the concentration of a gas or vapor in air or the concentration of a specific material in a liquid or solid.
- Describes the relative abundance of a specific material.
- Examples:
 - The number of molecules of gas found within a million air molecules.
 - The number of molecules of a hazardous material found in a million molecules of a liquid.
- 1% of 1million is 10,000 so 1% of atmosphere (1million of 1million) is 10,000ppm

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METER SCALE - PERCENTAGES

PERCENTAGE IN ATMOSPHERE
Volume of gas/vapor in atmosphere presented as a percentage

- Uncommon in response (except O₂)
- More common in industrial hygiene

PERCENTAGE OF LEL
Volume of gas/vapor in atmosphere presented as a percentage of the calibrated gases LEL (more detail coming up)

- It's a percentage of a percentage
- A 100% reading signifies the atmosphere is at the calibrated gases LEL

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INTENT

The percentage scale is used for LEL and O₂ sensors. It seems like a straightforward concept except when used in LEL, which is typically a percentage of the LEL, a commonly misunderstood concept.

Percentage in Atmosphere

- Typically, only used with O₂ sensors in emergency response.
- Basic percentage of the calibrated gas of the sensor in the atmosphere.

Percentage of LEL

- Typical of emergency response LEL sensors.
- The reading on the meter is a percentage of the calibration gas LEL (which is a percentage of the atmosphere).
- It's a percentage of a percentage.
 - More on this in the LEL section.

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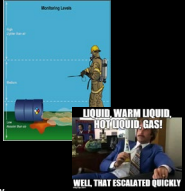
ATMOSPHERIC SAMPLING AND VAPOR DENSITY

VAPOR DENSITY
The measurement of weight/density of a vapor or gas as it is related to air

<1 = Rise
>1 = Sink

- Atmospheric meter must take place at all levels for unknowns and at specific levels for known products.
- Temperatures effect VD
 - Colder than 70F – may present as a lower VD
 - Warmer than 70F – may present as a higher VD
- ✓ Atmospheric meters only sense vapors and gases

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INTENT

VD is a physical characteristic that demands understanding, so you understand "where" to look for a gas/vapor and problem-solve potential confined spaces.

Atmospheric Sampling and Vapor Density

- Because vapor densities vary, and air currents can move hazardous gases and vapors in unexpected ways, samples must be taken at different heights.
- Consider the effects of air currents and vapor/gas temperature.
- Vapor Densities can be found in the NIOSH Pocket Guide as well as other resources.

When VD Is Not Given

- Most resources give a VD for gases, but we know liquids produce vapors at higher temperatures or lower pressures.
- Atmosphere Molecular Weight is roughly 29.
 - If the liquid's MW is less than 29, the vapors will rise
 - If the liquid's MW is greater than 29, the vapors will sink
- ✓ **ALL FLAMMABLE VAPORS ARE HEAVIER THAN AIR**

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ACCURACY - SENSOR RESPONSE TIMES


Warm Up
Time that it takes the sensors to warm their elements to start showing readings

Stabilization
Once warmed up the sensors will show fluctuations in readings while the system stabilizes

Reaction Time (T90)
The time needed for the sensor to reach 90% of the atmosphere it is placed in

Sensor/Gas	Time
Altair 5x Gas Alert Warm Up and Stabilize	80 seconds
CO T90	<15 seconds
H2S T90	<15 seconds
LEL Methane	<10 seconds
HCN T90	<30 seconds
O2 T90	<10 seconds

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INTENT

To decipher between warm-up/stabilization times and T90 times.

Sensor Response Times

- Most meters will not function or "lock out" until the warmup time and stabilization time have been met. MSA uses this time to show action levels, calibration data, and what time is left over; it will show a sand hourglass with "please wait".

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TERMS - METER SPECIFIC

ACTION LEVEL
OSHA designated levels (concentration) of toxic or dangerous atmospheres that require corrective actions represented as Alarms on your meter

Product	First Alarm	Second Alarm
O2	19.5% in Atmos.	23% in atmos
CO	25 PPM	100 PPM
LEL	10% of LEL	20% of LEL
H2S	10 PPM	15 PPM
HCN	4.5 PPM	10 PPM

LOW ALARM
First alarm identifying the approach to the sensors designated action level (not good)

HIGH ALARM
Second alarm identifying the entrance to the sensor's designated action level (Bad). Typically latching.

OVER LIMIT (OL)

- Concentrations beyond the capabilities of the sensor identified by "OL" or "X" in place of the actual reading.
- Also known as "sensor saturation" and requires calibration
- Do not turn off, run meter for hours to allow sensors to normalize

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INTENT

To understand action levels (alarms) that should trigger an "action" from you.

Action Level

- OSHA-designated levels (concentration) of toxic or dangerous atmospheres that require corrective actions.
- Level meters start alarming

Low Alarm

- First audible/visible/vibrating alarm identifying the approach to the sensors designated action level (not good).

High Alarm

- Second audible/visible/vibrating alarm identifying the entrance to the sensor's designated action level (Very Bad).

Over Limit (OL)

- Concentrations beyond the capabilities of the sensor are identified by "OL" in place of the actual reading.
- Also known as "sensor saturation" and requires calibration.

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ATMOSPHERIC ACTION LEVELS

When an action level (or action point) is reached, it may trigger:

- Removal of unprotected or unnecessary personnel
- Additional monitoring
- Alteration or adjustment of PPE
- Ventilation of the environment
- Total area evacuation

✓ Action levels demand action!

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INTENT

Action levels should trigger an "action" of the response team.

Atmospheric Action Levels

- Action levels can be defined as a response to known or unknown chemicals or products that will trigger some action.
- When an action level (or action point) is reached, it may trigger:
 - Removal of unprotected or unnecessary personnel.
 - Additional monitoring.
 - Alteration or adjustment of PPE.
- Total area evacuation.

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METER CALIBRATION

Once calibrated to a certain gas, the sensor will only "think" it is sensing that gas when in effect it is sensing others which can have a different effect on the sensor giving false high or low readings.

LEL


- Methane/Pentane

Toxi Sensors and O2

- Sensor specific gas

✓ When sensor gases that are not the calibration gas, the meter accuracy (+/-) will be off

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INTENT

To introduce the concept of calibration and bump testing, and emphasize the need to follow the manufacturer's recommendations regarding the two. Some manufacturers promote the option of not having to calibrate, which isn't a good practice given the criticalness of the incident (allowing the public to reoccupy).

- Once calibrated to a certain gas. The sensor will only "think" it is sensing that gas when, in fact, it is sensing others, which can have a different effect on the sensor, giving false high or low readings.
 - Methane
 - Isobutylene
- Most meters have the ability to change the "sensing" gas to the known gas that is in the atmosphere.
- Must use the Correction Factor if not an option

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CALIBRATION VS BUMP TESTING



CALIBRATION

- Completed PMR or prior to deployment (tech)
- Can take >10 minutes
- Corrects meter sensitivity
- Uses a lot of gas

BUMP Test

- Typically per shift or prior to deployment
- Takes minutes
- Forces meter to react to gas for confidence
- If automated, can fail bump and go to calibration
- Uses a lot less gas than calibration

✓ Always run your meter after bump or calibration to clean out your sensors of cal gas

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INTENT

Further details on the concepts.

Meter Calibration

Meter calibration must follow manufacturers' specifications and typically also takes place before deployment on an incident.

- Calibration is a common step in the field deployment of meters.
- Per manufacturer's specs.
 - Exposing sensors to calibrated gases.
 - Comparing gas specs to meter readings.
 - Adjusting the meter to reflect gas specs.
- It can take 10 minutes per meter.
- Calibration gas is expensive.

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CROSS SENSITIVITIES AND CORRECTION FACTORS

CROSS SENSITIVITIES

Sensors are designed to sense specific chemicals but are susceptible to other chemicals giving false readings in both positive and negative readings.


- Positive readings
- Negative readings
- Zero readings

CORRECTION FACTORS

Sensor manufacturers provide Correction (or correlation) Factor charts to "correct" readings.

- Gas has to be known (all of them)
- Typically used for LEL sensors
- Significant error factor

✓ It's critical for Operations Level responders to understand the concepts so they consider the impacts. It is not common for operations level to apply correction factors



INTENT

Introduce the typically unknown concept of cross-sensitivities and correction factors. Meter sensors are not perfect, and understanding their limitations enables safer responses and better decision-making.

Cross Sensitivities

- The effect of a "non-calibrated" gas being exposed to a sensor and getting a reading (+/-) that is not representative of the actual atmosphere.
- Cross-sensitivities can cause positive or negative readings
- Multiple products affecting a sensor can result in zero reading (one is positive, one is negative).
- Cross-sensitivities can give false high or low readings of known products in the atmosphere (1000ppm of CO in the atmosphere, meter showing 500 due to a negative cross-sensitivity of an unknown or known additional product in the atmosphere).

Correction Factors

- A known cross-sensitivity with an assigned correction factor (multiplier)
- Typically seen with LEL and PID sensors and some toxi-sensors
- Typically have significant error factors
 - LEL is cal'ed to Methane. The meter is introduced to hydrogen and gets a reading of 5%. The manufacturer has a documented correction factor of 1.5. The actual LEL reading for hydrogen is 7.5%. **(MSA has a +/- 20% error factor for all correction factors)**
 - Not to be used as a quantitative tactic.

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LOWER EXPLOSIVE LEVEL (LEL) SENSOR
COMBUSTIBLE GAS INDICATORS (CGIS)

Combustible gas indicators (CGIs) measure the amount of flammable vapors and gases in one of three ways:

- Percentage of gas per volume of air.
- Percentage of the lower explosive limit (%LEL).
- Parts per million (ppm).

- Measures the amount of flammable vapor in the atmosphere
- Usually one of several sensors within a meter
- Common sensing gases
 - Methane (operations)
 - Pentane (techs)
- Percentage of the lower explosive limit is by far the most common measurement

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INTENT

Continuation of the concept

Combustible Gas Indicators (CGIs)

Measure the amount of flammable vapors and gases in one of three ways:

- Percentage of the lower explosive limit (%LEL).
- Parts per million (ppm).
- Percentage of gas per volume of air.
- The percentage of the lower explosive limit is by far the most common measurement.

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COMBUSTIBLE GAS INDICATORS (CGIS)
PERCENTAGE OF LEL

- Percentage of a percentage
- Allows for cross-sensitivities
- Some meters can be easily changed to Percentage in Atmosphere
- KNOW YOUR SETTINGS

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INTENT

To introduce (talked about earlier) the concept of "Percentage of a Percentage" of LEL sensors. Typically misunderstood. This is one to remember!

Combustible Gas Indicators (CGIs) Percentage of LeL

- Percentage of a percentage
- Allows for cross-sensitivities
- Some meters can be easily changed to Percentage in Atmosphere
 - KNOW YOUR SETTINGS
- First alarm is 10% (on meter screen) of LEL, so the percentage in atmosphere is .53%
- Second alarm is 20% (on the meter screen) of LEL, so the percentage in the atmosphere is 1.05%
- The reason for such low amounts for the alarms is correction factors and unknown flammable vapors/gases in the atmosphere.

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CGIS SPECIFIC PRINCIPLES

- Accuracy requires proper O2 levels, always look at O2 after LEL when getting readings
- Typical CGIS sensor are calibrated to methane and set to % or LEL
- When sensor products other than NG accuracy will be off and correction factors take effect
- Any readings in open air should demand attention
- Readings of 2-3% in enclosed areas should trigger concern and tactics to change the atmosphere
- First Action alarms at 10% of the LEL, giving a 90% safety factor due to correction factor potentials

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INTENT

Overview of LEL sensor and emphasis on the need for O2 for proper readings. If you are looking at your LEL reading, you should be equally looking at your O2 reading in a confined space.

CGIs Require Oxygen

- Many CGIs use a combustion chamber to burn the flammable gas.
 - Therefore, the atmosphere must have enough oxygen to support combustion.
- Too much oxygen can exaggerate readings or even damage sensors.
- For these reasons, responders should monitor oxygen levels concurrently while using CGIs.

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% OF LEL VS. PPM

- FD meters typically are set up for % of LEL and present in whole numbers
- Gas First Responders typically are set up for PPM then switch to % of LEL at higher levels

% of LEL of Methane	PPM
.25% of LEL (below meter capability)	125 PPM
.5% of LEL (below meter capability)	250 PPM
1%	500 PPM
2% of LEL	1,000 PPM
5% of LEL	2,500 PPM
10% of LEL (First Action Level)	5,000 PPM
20% of LEL (Second Action Level)	10,000 PPM
100% of LEL (very bad)	50,000 PPM

Methane (NG) Flammable Range

- LEL= 5% in atmosphere
- UEL 15% in atmosphere

✓ It's a common occurrence for FD members to believe their meter is broken because it is showing zero's in LEL when the GFIS meter is showing levels in the 100s when in actuality the two meter are using two different measuring scales.

INTENT



To compare and contrast the concept of PPM LEL sensors (typically used in the gas industry) to the percentage of LEL typically used by emergency responders.

- A common complaint is that the emergency responder's meter "isn't doing anything" when the gas responder's meter is showing several hundred PPM. My response usually is "yup!" This is because our LEL meters need 500ppm to show 1% on our LEL sensor.
- Most LEL meters do not give readings less than 1%.

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LEL (CATALYTIC BEAD) SENSOR PROS AND CONS

<p>Pros</p> <ul style="list-style-type: none"> Long life Low temperment to temperature, humidity and pressure changes Fast response Wide range of flammable gas/vapor 	<p>Cons</p> <ul style="list-style-type: none"> Subject to poisoning Requires O2 Shortened life with frequent and continuous exposure to high LELs
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INTENT

Pros and Cons of Catalytic Bead Sensors – from MSA Gas Detection Handbook


- Cat bead sensors typically have the same characteristics regardless of the manufacturer.
- Typical sensor errors and failures are due to saturation of the sensor, and then shutting the meter off.
 - It is recommended to run the meter for a battery cycle when sensors are OL or exposed to extremely high levels.

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OXYGEN METERS/SENSORS

Oxygen meters detect the percentage of oxygen in the air and are typically electrochemical type

- Typically, one of several sensors in a meter
- Consider why the high or low reading
 - Oxidation/consumption in a confined area?
 - Displacement by something worse?
- LEL sensors are dependent on proper O2 levels for proper function
- Very sensitive to sensor poisoning materials



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INTENT

Introduction of O2 sensors and emphasis on their criticalness, with the function of the other sensor.

Oxygen Meters/Sensors

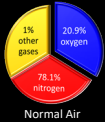
- Oxygen meters detect the percentage of oxygen in the air.
- Typically, one of several sensors in a meter.
- Consider why the high or low reading
 - Oxidation in a confined area?
 - Displacement by something worse?
- Consider what else am I carrying that is dependent on proper O2 levels?

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LOW OXYGEN READINGS

Oxygen readings below 20.9% indicate that a contaminant is displacing oxygen or oxidation is taking place

- A contaminant may exist at toxic or extremely hazardous levels.
- Even if oxygen levels are not low enough to trigger an alarm, reduced levels of oxygen potentially represent a significant hazard.
- Wear SCBA in these circumstances even if oxygen levels are above 19.5%.



CAUTION: 1% drop in oxygen is = up to 50,000 ppm of potentially something else in the air.

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INTENT

What does it mean when you have a low or high reading?

Low Oxygen Readings

Oxygen readings below 20.9% indicate that a contaminant is displacing oxygen or oxidation is taking place.


- A contaminant may exist at toxic or extremely hazardous levels.
- Even if oxygen levels are not low enough to trigger an alarm, reduced levels of oxygen potentially represent a significant hazard.
 - Wear SCBA in these circumstances even if oxygen levels are above 19.5%.
- ✓ **CAUTION:** 1% drop in oxygen is = up to 50,000 ppm of something else in the air.

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CHEMICAL/TOXIC GAS SPECIFIC METERS

Toxic and chemical-specific meters contain only one sensor or a toxic sensor can be included in a multi-sensor meter

- Some sensors produce two readings
 - CO and H2S
- Carbon Monoxide (CO)
- Hydrogen Cyanide (HCN)
- Hydrogen Sulfide (H2S)
- Ammonia (NH3)
- Chlorine (Cl)



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INTENT

Introducing toxic sensors.

Chemical/Toxic Gas Specific Meters

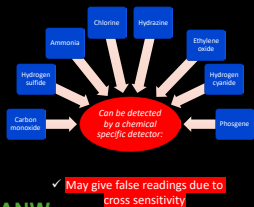
Toxic and chemical-specific meters contain only one sensor, compared to a multi-sensor meter (commonly called a 4-gas – 4-sensor or 3-gas – 3-sensor meter). They are used for known, specific atmospheres or where the sensor has significant cross-sensitivities and a high potential of failing/saturation in a normal deployment of a multi-sensor meter.

- Consider cross-sensitivities
- Consider multiple meters and multiple technologies to confirm readings.
- Consider response times (T90) of the sensor.
- Remember, not all specific chemical sensor specifications (T90, cross-sensitivities) are the same across manufacturers.
- Can be detected by a chemical-specific detector:*
 - Carbon monoxide
 - Hydrogen sulfide
 - Ammonia
 - Chlorine
 - Hydrazine
 - Ethylene oxide
 - Hydrogen cyanide
 - Phosgene
- Keeping in mind that although they are specific to a given gas, they can sense other specific gases and give readings (false) on those gases; these are called cross-sensitivities.

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CHEMICAL/TOXIC GAS SPECIFIC METERS

- Consider cross sensitivities
- Consider multiple meters and multiple technologies to confirm readings.
- Consider response times (T90) of the sensor
- Remember not all specific chemical sensor specifications are the same across manufacturers (T90, cross sensitivities)



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INTENT

To emphasize the value of a single sensor meter when dealing with corrosive environments or situations where it is known that the atmosphere is poisonous to a sensor in your meter.

Chemical/Toxic Gas Specific Meters

Typically, a technician-level concept, but when the atmosphere is known and corrosive or toxic to sensors, it is a good practice to utilize single-gas meters so only one sensor is poisoned or contaminated, compared to 5 sensors in a single meter at \$200-\$500 each for a sensor.


INTENT

Pros and Cons of metal oxide sensors – from MSA Gas Detection Handbook

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ELECTROCHEMICAL SENSOR PROS AND CONS

<p>Pros</p> <ul style="list-style-type: none"> Common gas sensors are fairly cheap Easily replaced/supplied Wide variety of gases sensed Multiple gases can be sensed by a single sensor. 	<p>Cons</p> <ul style="list-style-type: none"> Susceptible to saturation If over saturated the sensor can be destroyed Susceptible to corrosive products Exotic Gas sensor are expensive and have short life span (HCN, NH3, CL2) Have inherited T90 times
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FLAMMABILITY VS. TOXIC VALUES

1% of the Atmosphere = 10,000PPM

Product	LEL-UEL	PEL/TWA*	STEL**	IDLH
Gasoline	1.4 – 7.6%	300 ppm	500 ppm	10% LEL 1400 ppm
Carbon Monoxide	12.5-74%	50 ppm	200 ppm	1200 ppm
Propane	2.1-9.5%	1000 ppm	NE	10% LEL 2100 ppm
Acrolein	2.8-31%	0.1 ppm	0.3 ppm	2 ppm
Hydrogen Cyanide	5.6-40%	10 ppm	NA	50 ppm
Ammonia	15-28%	50/25 ppm	35 ppm	300 ppm
Chlorine	NF	0.5 ppm	1 ppm	10 ppm

***PEL/TWA**
 • Permissible Exposure Limit/Time Weighted Average
 • Max allowable for 8 hrs./day, 5 days/wk.

****STEL**
 • Short Term Exposure Limit
 • Max allowable for 15 min during a work day

INTENT

To discuss the situation where a gas/vapor that is toxic and flammable will always get to its toxic level before it gets to its LEL.

Flammability vs. Toxic Values

- 1% of Atmosphere = 10,000PPM
- 1% change in an O2 sensor can = 50,000ppm
 - It is very common for flammable gases and vapors to reach their toxic levels well before they reach their flammable range.

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IN SUMMARY

- Maintain, use and store meters in a condition respective of sensor poisoning
- Calibrate meters per manufactures recommendations
- Respect meters capabilities and limitations – cross sensitivities and correction factors
- Confirm critical readings with additional meters
- Know how to use it before you use it
- Understand sensor scaling – PPM, % in atmosphere, % of LEL

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INTENT

Summary of the concepts covered and emphasis on true-life situations and challenges.

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Thank you for attending.

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Pipeline **PANW** Safety
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Thank You!