Atmospheric Meters for Operations

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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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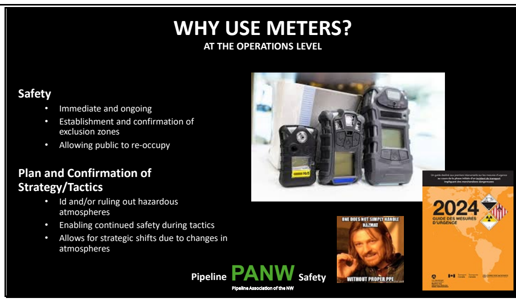

INTENT

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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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.

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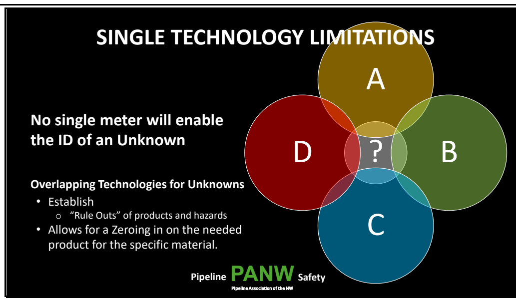

INTENT

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.

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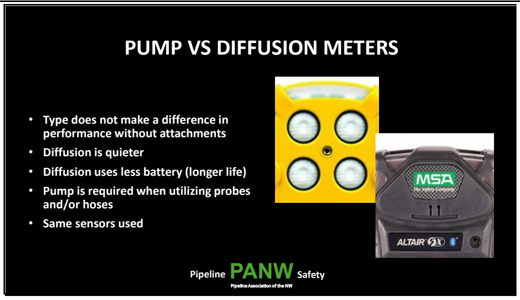

INTENT

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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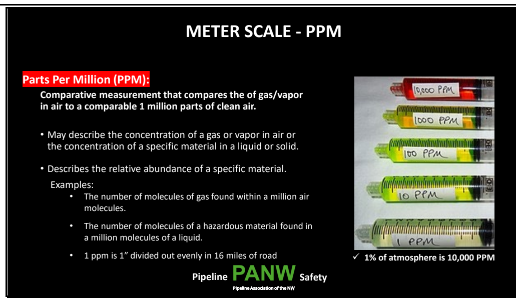

INTENT

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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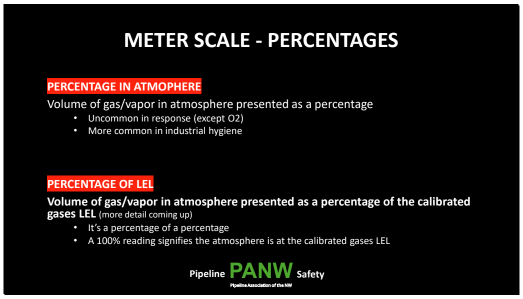

INTENT

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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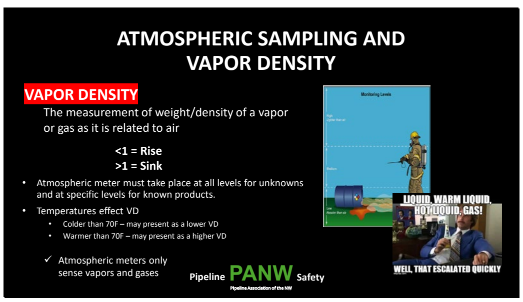

INTENT

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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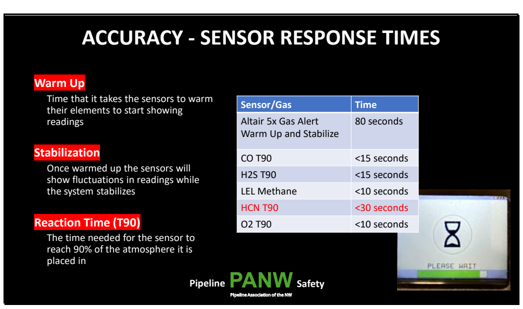

INTENT

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".

Warm Up

- The time 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 react to the atmosphere it is placed.
    - "Time to be 90% accurate)

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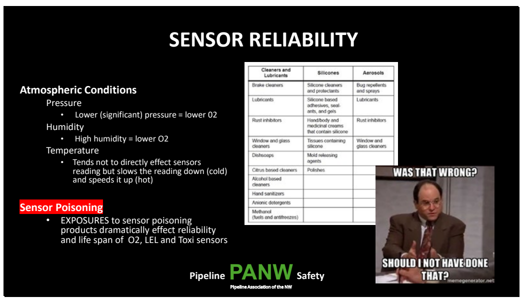

INTENT

To introduce the concept that sensors are sensitive to materials and conditions and perform differently and sometimes inaccurately, when outside of the norm. Additionally, the need to communicate how destructive poisoning materials are to sensors is critical.

Atmospheric Conditions

Pressure

- When going from an extreme pressure change atmosphere (like stepping through an airlock), the actual O2 percentage remains the same, but the meter can lower due to the lower pressure/lower volume per given space. The O2 sensor is calibrated to oxygen at a certain atmospheric pressure. Then the pressure decreases, and the percentage of oxygen in that given volume also decreases.

Humidity

- Humidity changes affect O2 readings due to the water vapor (humidity) in the air. Water vapor displaces O2, causing a decrease in O2 readings. This can reduce the O2 levels and readings by as much as .5%.
- High humidity and high temperature changes (going from low to high) can influence VOC sensors, causing them to go into low or high alarm.

Sensor Poisoning

- Sensor poisoning is the most common cause of sensor failure, sensor false readings, and shortened sensor life.
- Turning on a pump/demand meter in an engine cab (contaminants) is a common cause of sensor poisoning.
- Leaving a passive meter exposed to air in an engine cab is a common cause of sensor poisoning.
- Most common poisons (vapors)
    - Silicones – cleaners, "shine" makers like Armor All, sealants, foams
    - Alcohols – cleaners, hand sanitizers, solvents
    - Ammonia – cleaners, solvents

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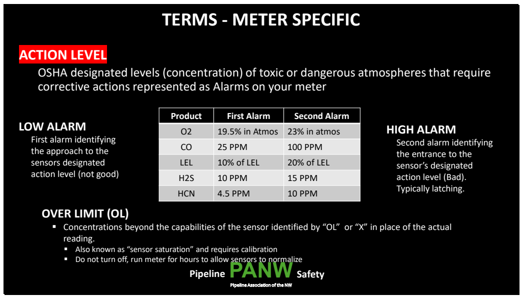

INTENT

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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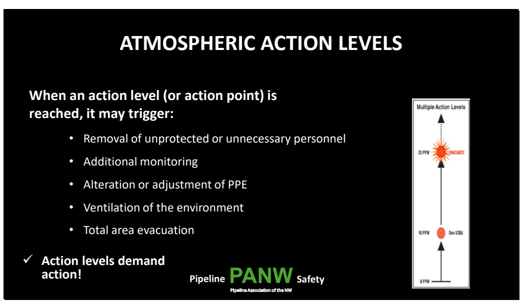

INTENT

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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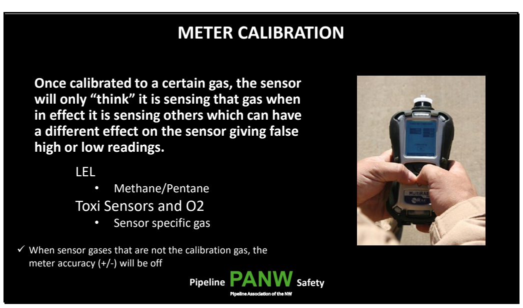

INTENT

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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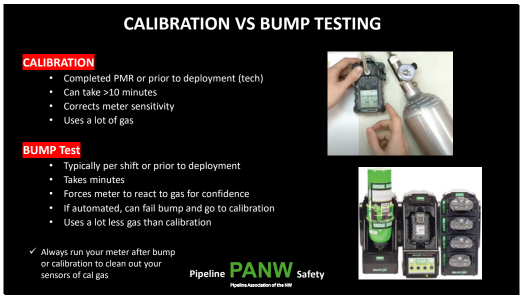

INTENT

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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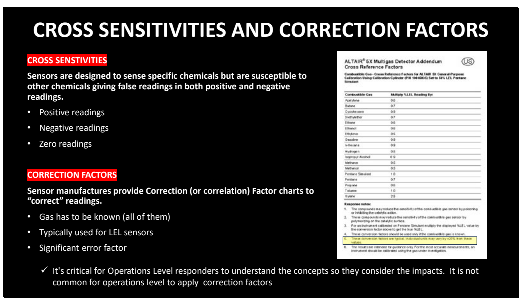

INTENT

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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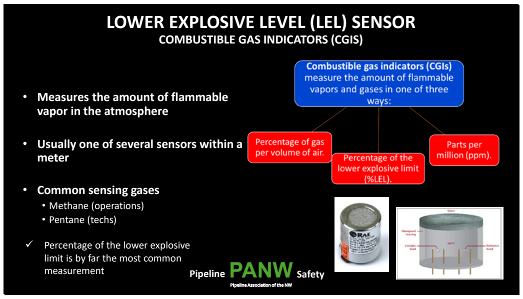

INTENT

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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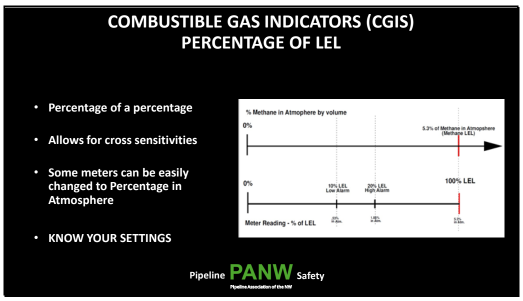

INTENT

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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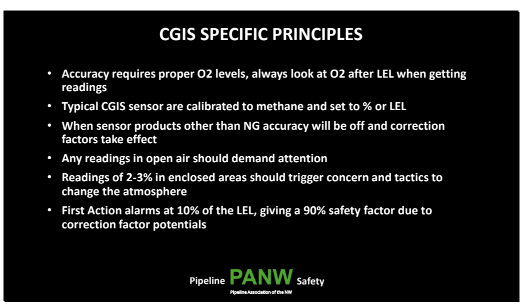


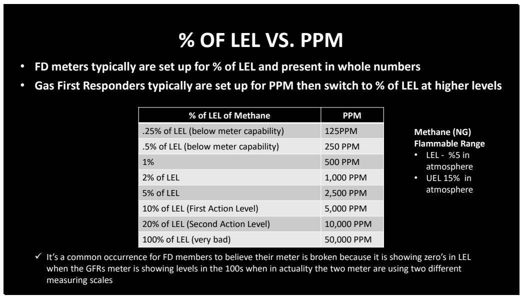
INTENT

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.

Slide 19



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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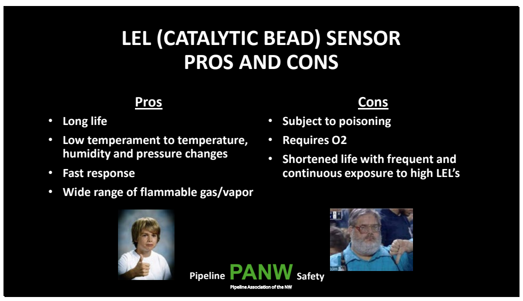

INTENT

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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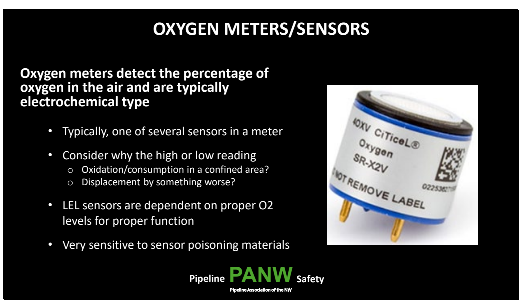

INTENT

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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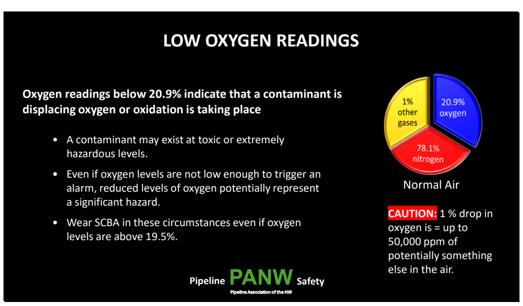

INTENT

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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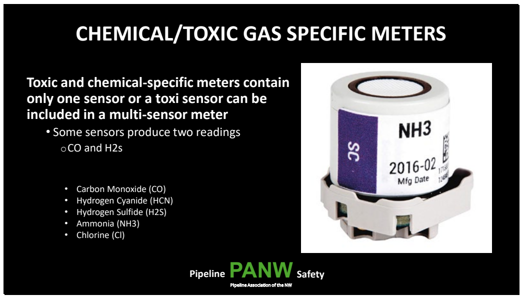

INTENT

Introducing toxi 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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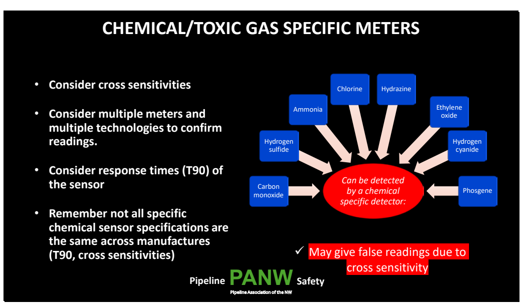

INTENT

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.

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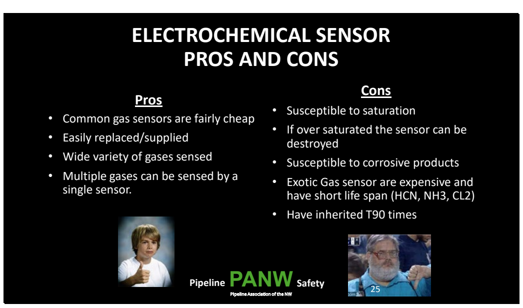

INTENT

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

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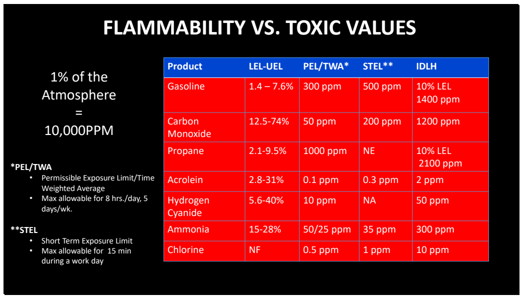

Product	LEL-UEL	PEL/TWA*	STEL**	IDLH
Gasoline	1.4 – 7.6%	300 ppm	500 ppm	10% LEL 1400 ppm
Carbon Monoxide	12.5-74%	50 ppm	200 ppm	1200 ppm
Propane	2.1-9.5%	1000 ppm	NE	10% LEL 2100 ppm
Acrolein	2.8-31%	0.1 ppm	0.3 ppm	2 ppm
Hydrogen Cyanide	5.6-40%	10 ppm	NA	50 ppm
Ammonia	15-28%	50/25 ppm	35 ppm	300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

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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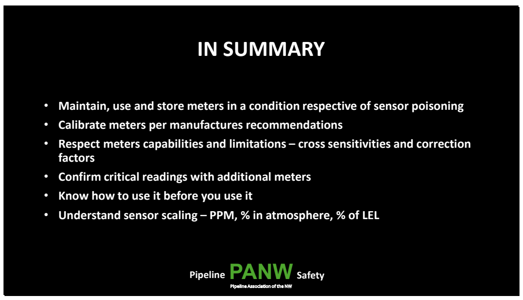

INTENT

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

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Thank You!