


# Heavy Rescue II

**Session 1**  
Meters & Chemical / Physical Properties




NEWS THIS MORNING  
DEADLY CARBON MONOXIDE LEAK  
FIRE DEPARTMENT RESPONDS



Suffolk County Fire Academy

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## House-Keeping

- Instructors
- Students
- Paperwork
- Student Manuals
- Exits
- Cell Phones and Pagers.



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## Course Overview

**5 Sessions**

- **Session 1** – Meters and Chemical / Physical Properties
- **Session 2** – Elevator Emergencies
- **Session 3** – Basic Rigging (PPE)
- **Session 4** – Cutting Torches (PPE)
- **Session 5** – Industrial Rescue / Man-In-Machine (PPE).



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### Course Objectives

- **Train in heavy rescue incidents beyond vehicle extrication / disentanglement**
- **Explain chemical / physical properties for common materials for which we meter**
- **Describe basic meters and the procedure for their use**
- **Identify components of an elevator**
- **Describe methods used to access and free victims trapped inside an elevator**
- **List tools used for basic rigging and demonstrate their operation**

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### Course Objectives (Cont'd)

- **Identify different cutting torches and their characteristics**
- **Demonstrate the lighting procedure and proper use of cutting torches**
- **Define industrial rescue and man-in-machine incidents**
- **Lists tools which may be found in a man-in-machine kit**
- **Demonstrate the use of tools found in a man-in-machine kit to free a victim.**

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### Session Overview

- **Why Meter?**
- **Chemical / Physical Properties**
- **Meter Terminology**
- **Monitoring Strategies & Common Materials**
- **Exposure Clues.**




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**Session Objectives**

- Give examples of incidents where meters may be beneficial
- Define chemical/physical properties
- Explain how chemical/physical properties effect metering
- Identify materials monitored by fire service meters
- Explain the general functionality of common fire service meters
- Describe the proper use of meters during incidents requiring atmospheric monitoring.

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***Why Meter?***




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**Why Do We Meter?**

Sometimes, just to figure out what is going on...




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### Why Do We Meter?

- PPE selection – **Respiratory Protection**
- Hazard determination
- Establish safe areas and zones
- Check for contamination
- Determining source of hazard
- Dictate safe mitigation actions.



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### What Do Meters Tell Us?

- What might be present
- What is not present
- “Clues” to what may be causing the problem.



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### What Makes An Atmosphere Hazardous?

- Oxygen displacement
- Flammable gases
- Toxic contaminants
- Corrosive vapors / gases
- Oxidizers
- Radiation.



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**Monitoring Hierarchy**

- Oxygen levels
- Radioactivity
- Corrosive vapors with flammability (LEL)
- Toxicity
- Corrosive liquids
- Other chemicals.




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**Monitoring Hierarchy**  
Confined Space

- Oxygen levels
  - Normal ≈ 21%
- Flammable / Explosive
  - 10% of LEL
- Toxicity
  - H<sub>2</sub>S – Hydrogen Sulfide
  - SO<sub>2</sub> – Sulfur Dioxide





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**Chemical / Physical Properties**




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### Physical State

**STATE OF MATTER**

SOLID      LIQUID      GAS

The condition of matter at room temperature

**Solid → Liquid → Gas**

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### Vapor Pressure

- Measurement of the amount of vapors given off by a material at standard temperature/pressure
- Measured in mmHg, ATM, or PSI
- Atmospheric pressure = **760 mmHg, 1 ATM, 14.7 psi**
- **VP < Atmospheric = solids and liquid**
- **VP > Atmospheric = gas.**

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### Vapor Density

- The ratio of molecular weight of vapor/gas compared to that of air (MW = 29 or 1)
- **VD < 1 = Lighter than air ↑↑↑↑**
- **VD > 1 = Heavier than air ↓↓↓↓**

**Propane (1.55) vs. Methane (0.6)**

**Where will you find the vapors?**

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## Volatility

- How readily a material will give off vapors
- Materials with high vapor pressures have high volatility
- Increases with an increase in temperature
- Nerve agents vs. Industrial chemical.



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## Boiling Point



The temperature at which a liquid's vapor pressure equals the surrounding atmospheric pressure.  
 (Therefore, increasing the production of vapors)  
 ↓ the boiling point, ↑ the volatility



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## Flashpoint



The **lowest temperature** at which a flammable liquid produces sufficient vapors to form an ignitable mixture with air near its surface. When an ignition source is introduced, the vapors will momentarily ignite (flash).  
 ↓ the flashpoint, ↑ the volatility



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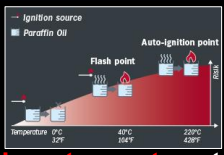
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### Auto Ignition Temperature



The **minimum temperature** at which a substance will ignite without the application of an external ignition source.

↓ the auto ignition temperature, ↑ the volatility



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### Flammable Gas



A gas, at ambient temperature, which is ignitable at 13% or less by volume with air or has a flammable range of at least 12% regardless of the LEL



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### Flammable Liquid



A liquid that has a flashpoint of 141°F or lower



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### Combustible Liquid



A liquid that has a flashpoint greater than 141°F and less than 200 °F



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### Pyrophoric



A material that will ignite spontaneously in air at temperatures below 130 °F



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### Explosive Limits

(Flammable Limits)

- **Lower Explosive Limit (LEL)**
  - **Lowest** percent concentration of gas/vapor in air that will burn
- **Upper Explosive Limit (UEL)**
  - **Highest** percent concentration of gas/vapor in air that will burn
- **Flammable Range**
  - Range between LEL and UEL.



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### Explosive Limits (Flammable Limits)

Methane - LEL: 5% by volume in Air / UEL: 17% by volume in Air

Visual example to show where on the scale % of LEL is measured

**Where our meters typically alarm (10% of LEL)**  
**The greater the explosive (flammable) range, the more likely it will explode (burn).**

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### Our Meter Reading Within LEL

10% 50% 100% \*\* of LEL

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### Lower Explosive Limit (LEL)

- Lowest % of a flammable gas/vapor, mixed with air, that can be ignited
- Below LEL = Too Lean.

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### Upper Explosive Limit (UEL)

- Highest % of a flammable gas/vapor, mixed with air, that can be ignited
- Above UEL = Too Rich.

The diagram shows a horizontal axis representing the concentration of a flammable gas in air. A vertical line on the left is labeled '100% LEL'. A vertical line on the right is labeled '17% by Volume'. A red double-headed arrow between these two lines is labeled 'Explosive Range'. Above the 17% mark, there is an illustration of a fireball. Above the 5% mark, there is a label '5% by Volume'. A red arrow points upwards from the 17% mark.

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### Oxygen Deficiency Causes

- **Aerobic Decomposition** – microbes consume oxygen and produce carbon dioxide
- **Displacement** – gases, vapors, asphyxiants
- **Oxidation** – rusting of metals
- **Combustion** – consumes oxygen
- **Absorption** – wet carbon, wet uncured concrete.

A rectangular warning sign with a red border. At the top, it says 'DANGER' in a red box. Below that is a yellow triangular hazard symbol with a black silhouette of a person falling. Underneath the symbol, it says 'Keep Out!' in bold black text, followed by 'Oxygen deficient confined space.' in smaller black text.

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### Percent vs. Concentration

**What does a 1% drop in oxygen mean as far as concentration of another substance in the atmosphere?**

- 1% = 10,000ppm
- Oxygen = 1/5<sup>th</sup> of air
- 1% drop in Oxygen = displacement by 50,000ppm of a substance
- 0.1% drop in Oxygen = displacement by 5,000ppm of a substance.

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# Meter Terminology




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## Single Gas vs. Multi-Gas


- **Single Gas Meter** – only monitors one gas
- **Multi-gas Meter** – monitors multiple gases at the same time.

**Single Gas**  
CO Meter



**Multi-Gas**  
Altair






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## Diffusion vs. Pump


- **Diffusion** – meter monitors atmosphere as it passes over the meter, unassisted
- **Pump** – meter employs a pump to draw the atmosphere into the meter.

**Diffusion**  
Altair



**Pump**  
X-am 8000






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### Atmospheric Monitoring vs. Point Detection

- Atmospheric Monitoring** – meter measures the materials that might exist in the atmosphere as a whole
- Point Detection** – meter is used to find the location of the material being released into the atmosphere



**X-am 7000 Multi-Gas**  
**TIF 8800 Single Gas**

**Point Detection To Determine Leak Source**  
**Monitors Atmosphere**

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### Explosion Proof

**Ignition source is encased in a rigid container. Flammables can enter, but explosions will be contained. Flame and hot gases will be cooled before leaving the container.**



**AP4C**

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### Intrinsically Safe (Non-incendive)

**Potential arcing is reduced by encasing components in a solid, insulating material or current/voltage are reduced to below the energy level required for ignition.**

**How can we use a meter in a flammable atmosphere that is not intrinsically safe?**



**X-am 8000**

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### Types of Sensors

- **Electrochemical** – two or more electrodes with chemical mixture sealed in housing
- **Catalytic Bead** – bowl shaped string of metal with bead of metal in middle, coated with catalytic material, to help burn gas
- **Photoionization** – ultraviolet light

Type of sensor will determine shelf life, saturation point, interferences.




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### Interferents

- Gases detected by the sensors that are not meant to be read by the sensor
- Will give false positives.





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### Range

The minimum and maximum that can be detected by a meter



0 – 1500ppm of CO




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### Scale

The meter's unit of measure. May have multiple units of measure (single vs. multi)

- % – LEL, O<sub>2</sub>
- ppm – CO, H<sub>2</sub>S
- Concentration – VOC.

100% is very different from 100ppm


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### Alarm Levels

At what level will the meter alarm? (CO as an example)

- Low Alarm
  - 35 ppm
- High Alarm
  - 100 ppm
- Action Level
  - 9 ppm.





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### Environmental Factors

- How will the meter be affected by:
  - Temperature
  - Humidity
  - Smoke
  - Corrosives
  - Dirt
- Operating temperature.




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### Verifying Results

**Meter readings should be checked by another meter.**



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### ***Monitoring Strategies & Common Materials***



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### Metering Tactics

- Meter selection
  - Single vs. multi-gas meter
- Start-up / fresh air set-up
- Battery check
- Establish background
- Monitoring priorities.



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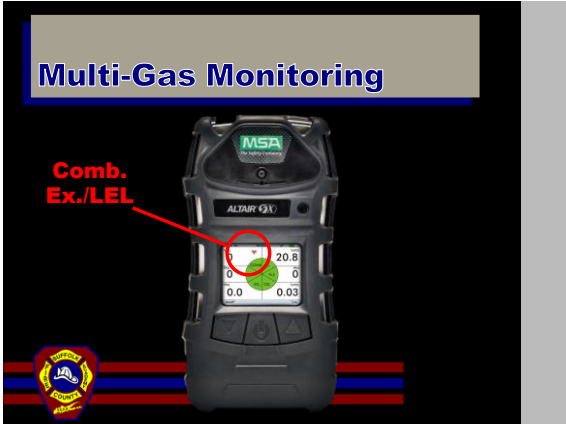
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### Explosive / Combustible Monitor

- Flammable (explosive) range
  - LEL - Lower Explosive Limit (below = too lean)
  - UEL - Upper Explosive Limit (above = too rich)
- Alarm levels
  - 0 - 100% of LEL
  - Low alarm = 10%
  - High alarm = 60%
  - Action level = 10%

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### Explosive / Combustible Methane

**Methane (Natural Gas)**

- Gas
- Flammable range = 5% - 17%
- Lighter than air (0.554 atm)
- Health Affects:
  - Irritant
  - Respiratory distress
  - Dizziness
  - AMS
  - Unconsciousness

**Do not extinguish a leaking gas fire unless the leak can be stopped.**

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### Explosive / Combustible Methane

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**Explosive / Combustible**  
Propane

**Propane (LPG)**

- Gas (liquid under pressure)
- Flammable range = 2% – 9%
- Heavier than air (1.56 atm)
- Health Affects:
  - Irritant
  - Respiratory distress
  - Dizziness
  - AMS
  - Unconsciousness

**Do not extinguish a leaking gas fire unless the leak can be stopped.**




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**Explosive / Combustible**  
Propane





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**Explosive / Combustible**  
Gasoline

**Gasoline**

- Liquid
- Flammable range = 1.4% – 7.6%
- Vapors heavier than air (3 atm)
- Health Affects:
  - Irritant
  - Respiratory distress
  - Dizziness
  - AMS
  - Unconsciousness

**A flowing flammable liquid fire must be stopped before extinguishment.**




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**Explosive / Combustible**  
Gasoline



PIX 43  
5:02 43  
Camera 04



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**Explosive / Combustible**  
Acetylene

**Acetylene**

- Gas (liquid under pressure)
- Flammable range = 2% – 100%
- Vapors lighter than air (< 1 atm)
- Health Affects:
  - Irritant
  - Respiratory distress
  - Dizziness
  - AMS
  - Unconsciousness

**Acetylene is always within its flammable range. Shipped in acetone.**



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**Explosive / Combustible**  
Acetylene



FUEL



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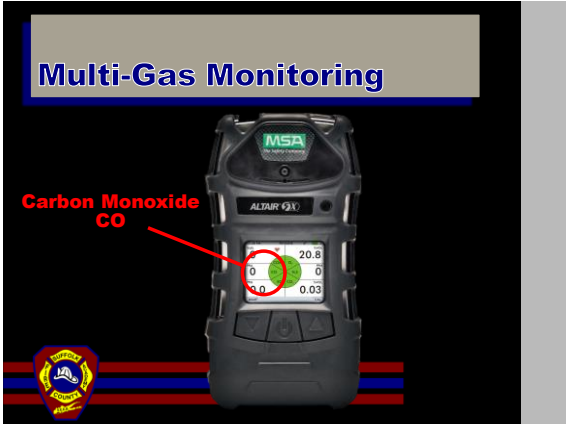
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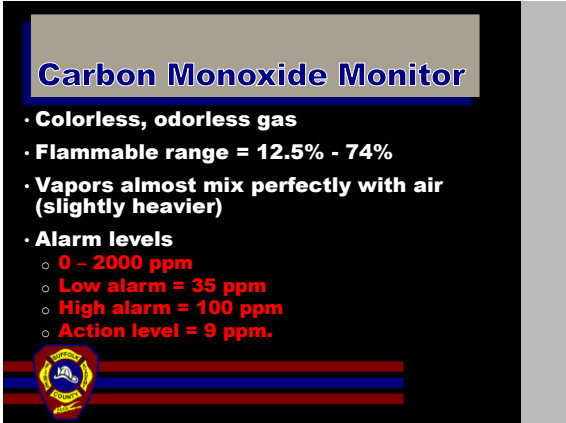
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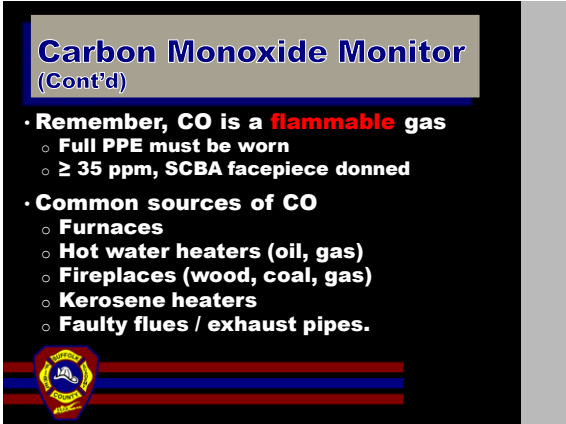
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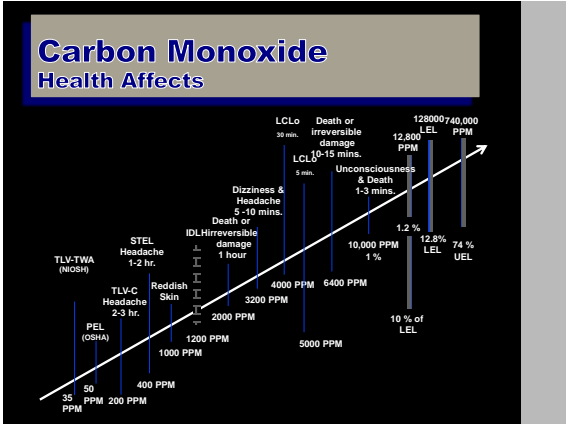
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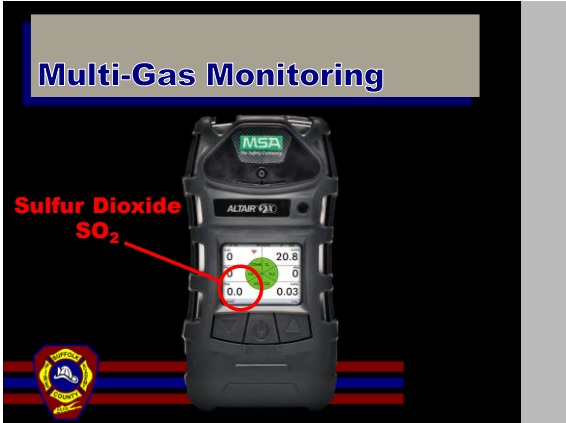
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### Sulfur Dioxide Monitor

- Corrosive, toxic gas
- May be fatal if inhaled
- May be present in confined spaces
- Vapors are heavier than air
- Alarm levels
  - 0 – 100 ppm
  - Low alarm = 5 ppm
  - High alarm = 90 ppm
  - Action level = 2 ppm.

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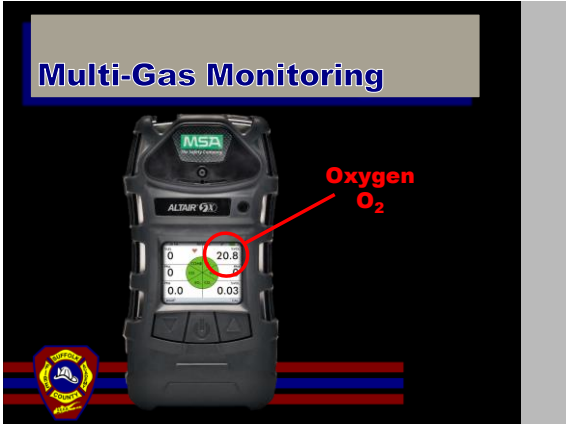
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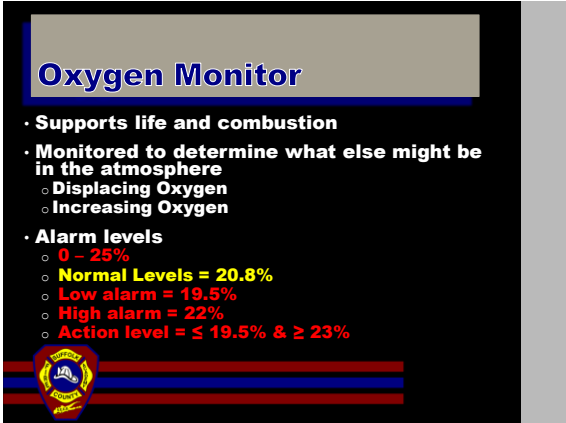
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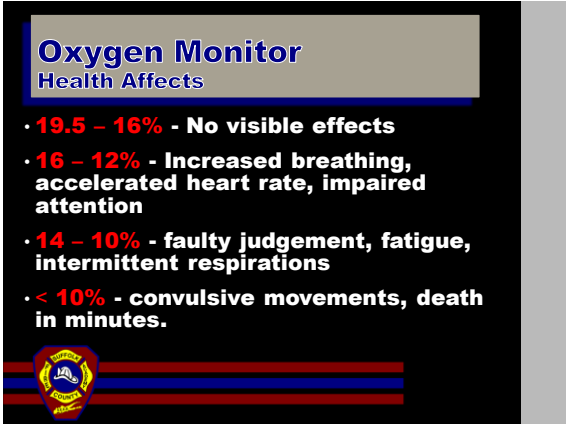
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### Oxygen Enriched Environment

- > **23.5%**
- Potential for explosive atmosphere.

21% O<sub>2</sub>      24% O<sub>2</sub>      40% O<sub>2</sub>

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### Multi-Gas Monitoring

Hydrogen Sulfide  
H<sub>2</sub>S

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### Hydrogen Sulfide Monitor

- Flammable, toxic gas
- Initial odor of rotten eggs
- May be present in confined spaces
- Flammable range = 4% - 44%
- Vapors are heavier than air
- Alarm levels
  - 0 - 500 ppm
  - Low alarm = 10 ppm
  - High alarm = 100 ppm
  - Action level = 10 ppm.

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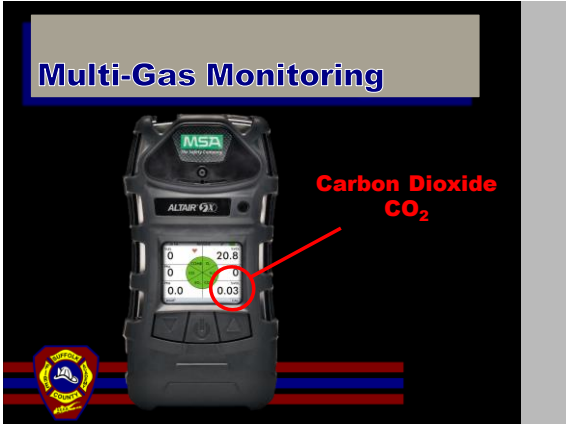
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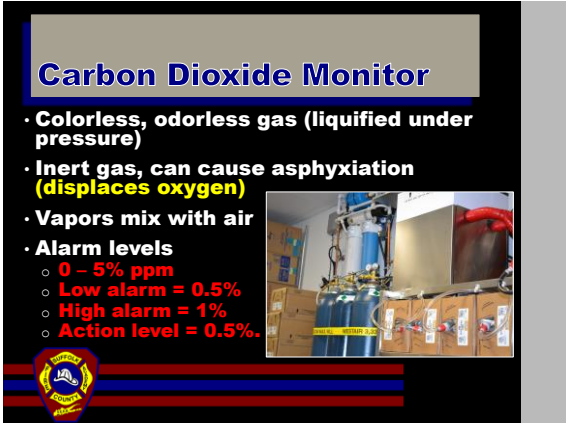
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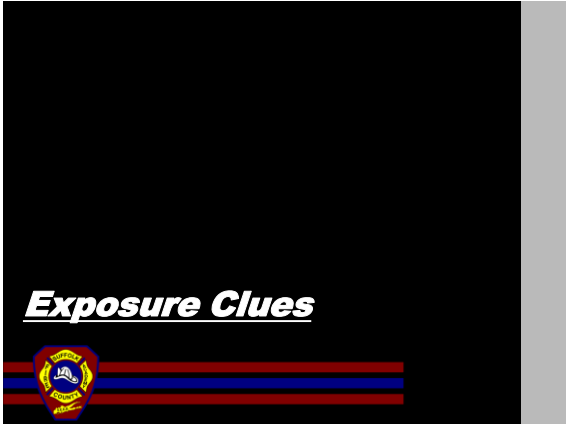
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**Exposure Clues**

**Most Health Affects Resulting From Exposure Are Similar Across Materials**

- Skin and respiratory irritation
- Respiratory distress
- Dizziness / fatigue
- Altered mental status
- Unconsciousness.

**Victim(s) condition = part of size-up.**




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**Exposure Clues**

**Do not forget what we have learned in basic hazmat operations courses**

- Container shape and size
- Type of facility
- Type of manufacturing
- Conditions surrounding response.




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**Questions?**




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