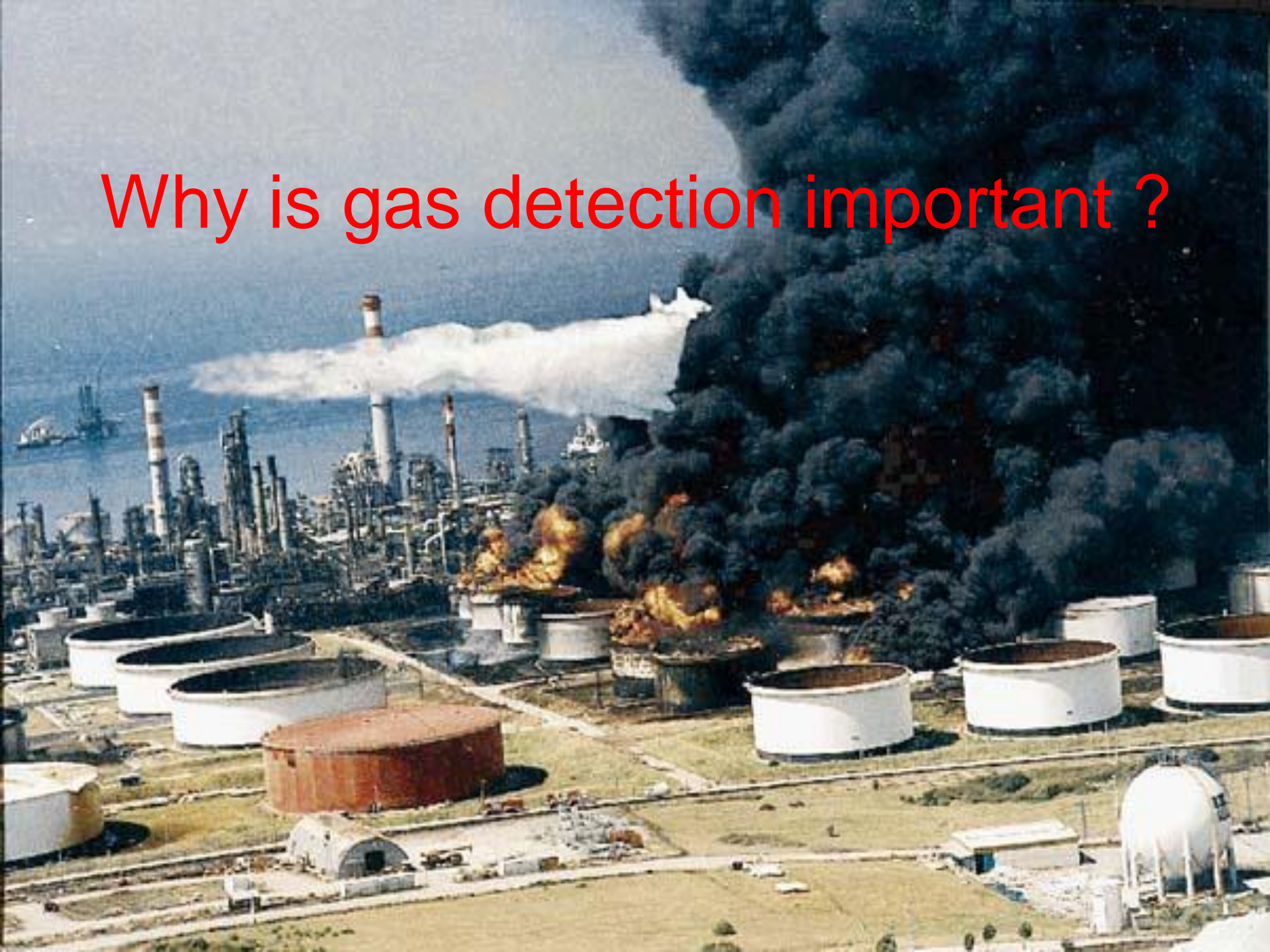


Why is gas detection important ?



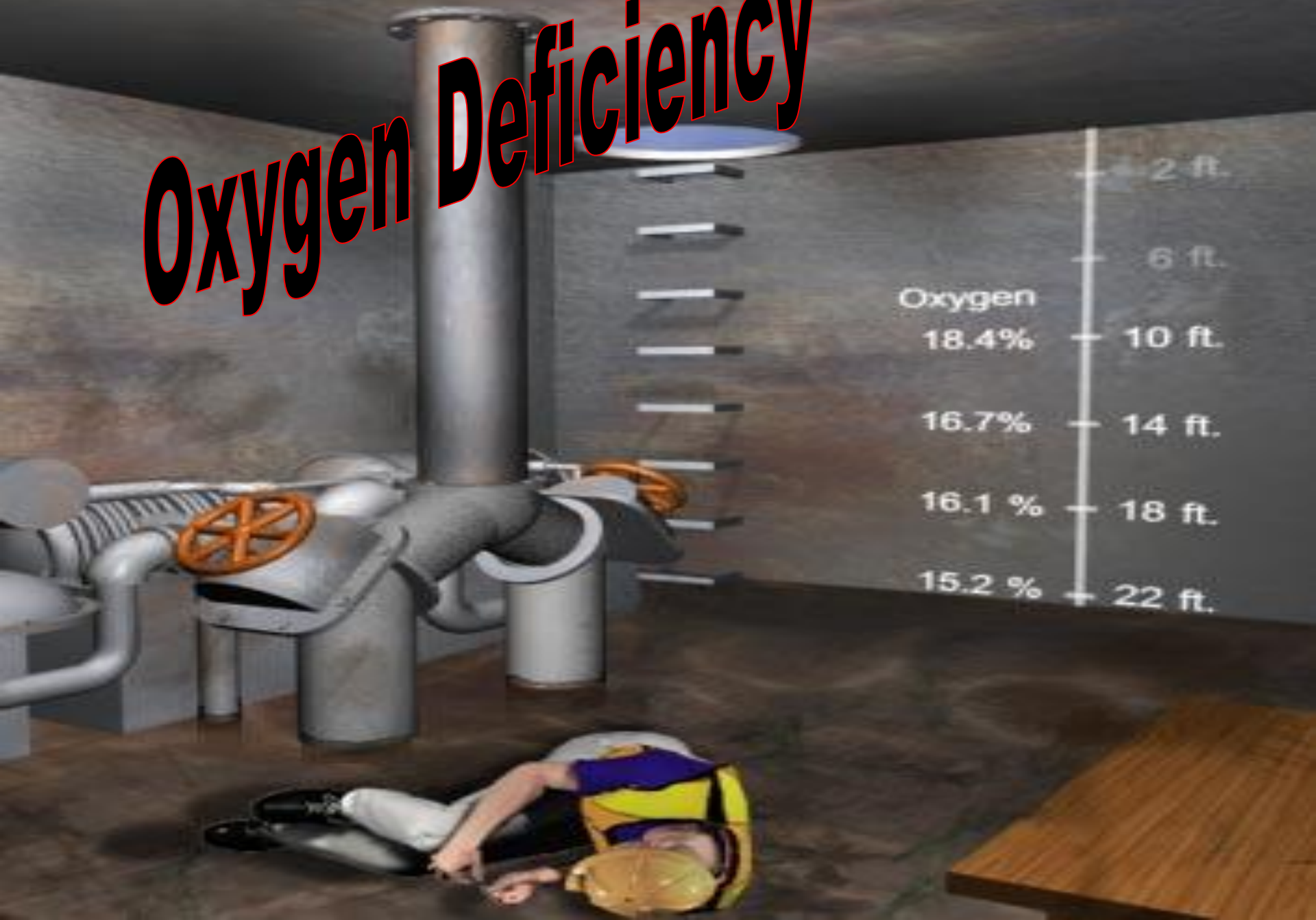
# 3 basic types of atmospheric hazards

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**Honeywell**

- Oxygen (deficiency and enrichment)
- Flammable gases and vapors
- Toxic contaminants

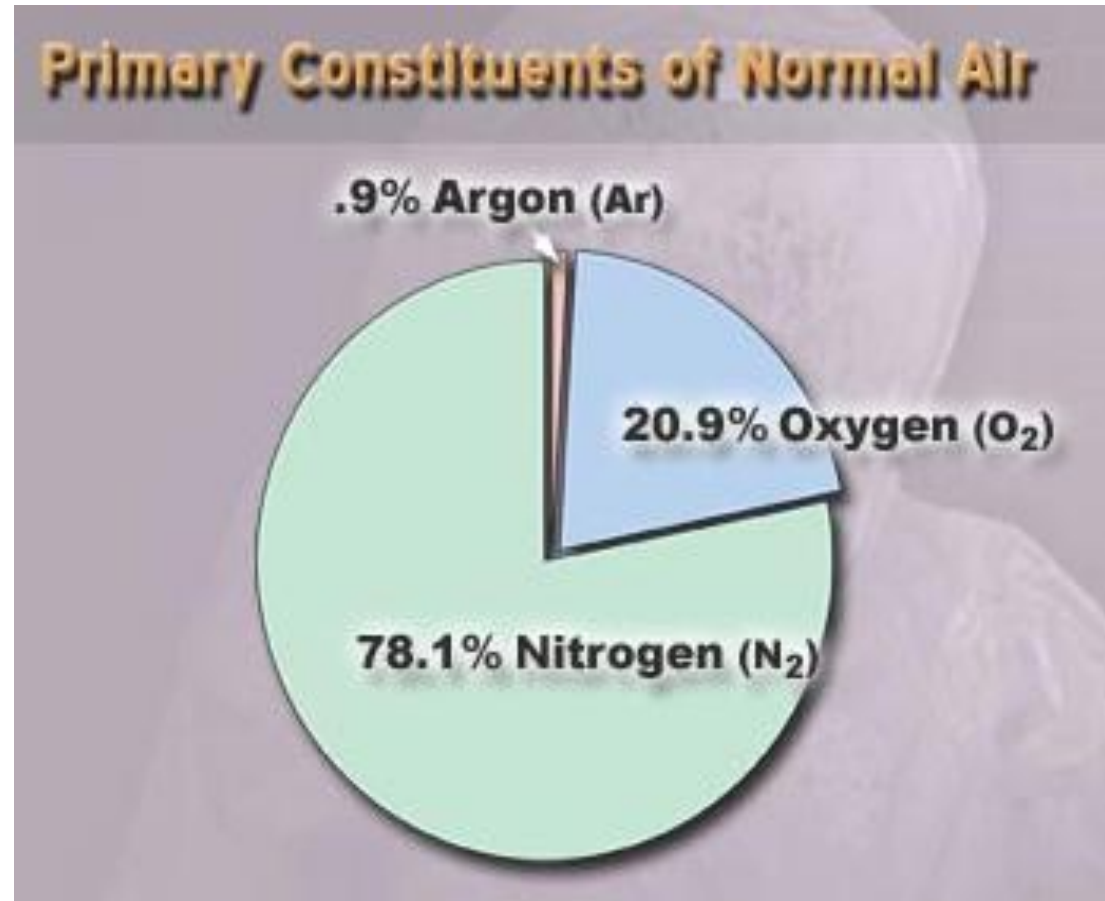
# Oxygen Deficiency



# Composition of fresh air

Honeywell

- 78.1 % Nitrogen
- 20.9 % Oxygen
- 0.9 % Argon
- 0.1 % All other gases
  - Water vapor
  - CO<sub>2</sub>
  - Other trace gases



# Oxygen Deficiency

Honeywell

## Definitions of Oxygen-Deficient Air

29 CFR 1910.146 (PRCS) < 19.5%

29 CFR 1910.134  
(Respiratory Protection) < 19.5%<sup>1</sup>

ANSI Z117.1-1995  
(Confined Spaces) < 19.5%

ANSI Z88.2-1992  
(Respirator Practices) 16.0%<sup>2</sup>

ACGIH (TLV Booklet) 18.0%

### Notes:

<sup>1</sup> Oxygen content below 16% at sea level is considered IDLH -- Oxygen deficient.

<sup>2</sup> Oxygen partial pressure <122 mmHg. Confined space with <20.9% oxygen is IDLH, unless source of oxygen reduction is understood and controlled.

- Most widely accepted definition: Air is oxygen deficient whenever concentration is less than 19.5%

# O<sub>2</sub> vs. % Vol at Varying Altitudes

Honeywell

Height		Atm. Pressure	PO <sub>2</sub>		Con.
feet	meters		mmHg	kPa	% Vol
16,000	4,810	421.8	88.4	11.8	20.9
10,000	3,050	529.7	111.0	14.8	20.9
5,000	1,525	636.1	133.3	17.8	20.9
3,000	915	683.3	143.3	19.1	20.9
1,000	305	733.6	153.7	20.5	20.9
0	0	760.0	159.2	21.2	20.9

19.5% O<sub>2</sub> at sea level = 18 kPa



# Oxygen Deficiency

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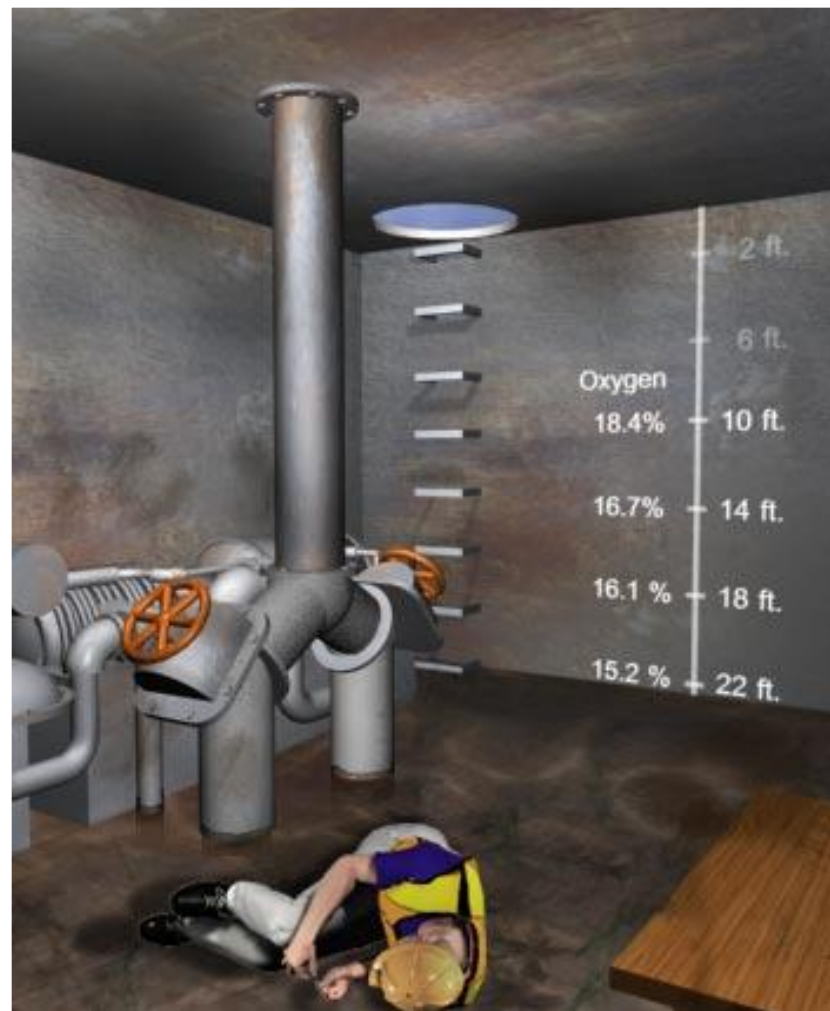
Honeywell

- Occurrence associated with:
  - Confined spaces
  - Unventilated cellars
  - Sewers
  - Wells
  - Mines
  - Ship holds
  - Tanks
  - Enclosures containing inert atmospheres

# Causes of Oxygen Deficiency

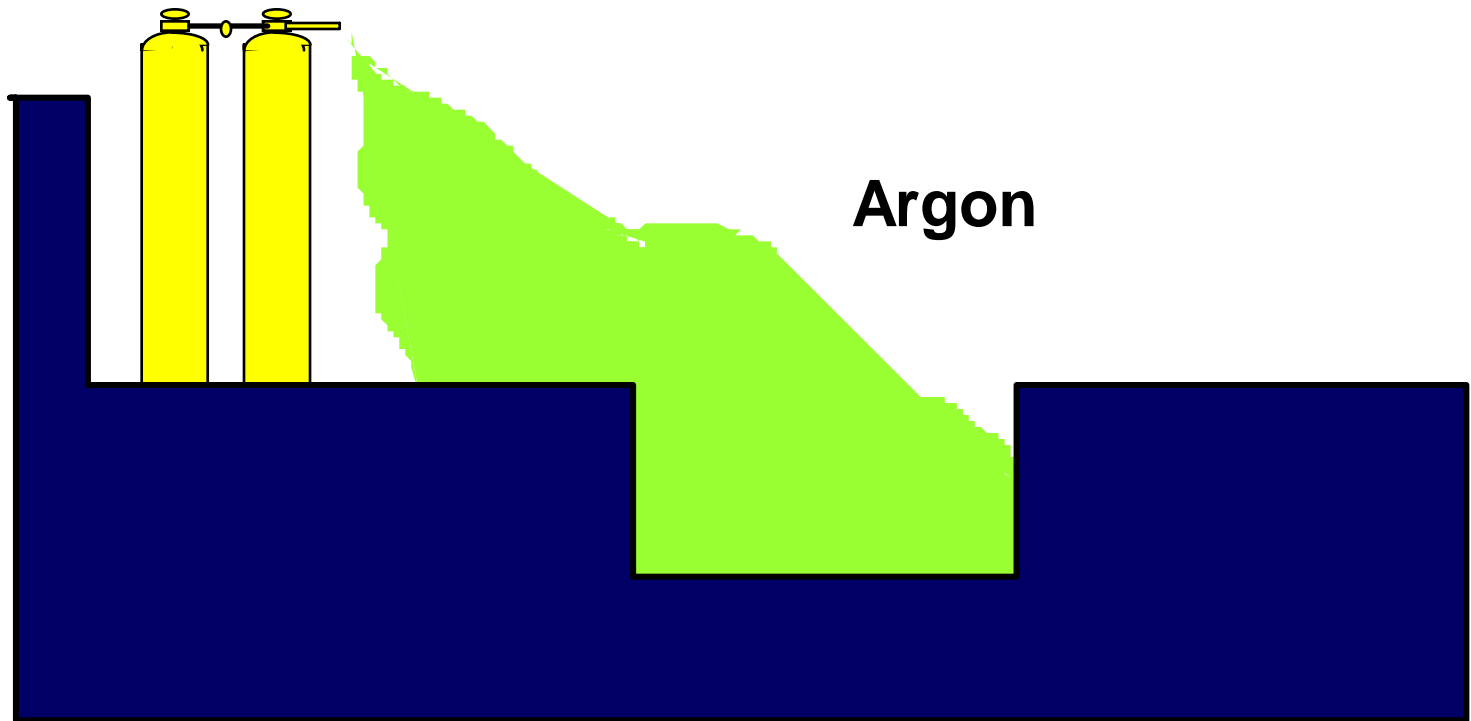
Honeywell

- Displacement
- Microbial action
- Oxidation
- Combustion
- Absorption



# Oxygen displacement in open topped confined space

Honeywell



# Symptoms of Oxygen Deficiency

Honeywell

<b>20.9 %</b>	<b>Oxygen content in fresh air</b>
<b>19.5 % - 12 %</b>	<b>Impaired judgment, increased pulse and respiration, fatigue, loss of coordination</b>
<b>12 % - 10 %</b>	<b>Disturbed respiration, poor circulation, worsening fatigue and loss of critical faculties, symptoms within seconds to minutes</b>
<b>10 % - 6 %</b>	<b>Nausea, vomiting, inability to move, loss of consciousness, and death</b>
<b>6 % - 0 %</b>	<b>Convulsions, gasping respiration, cessation of breathing, cardiac arrest, symptoms immediate, death within minutes</b>

# Oxygen Enrichment

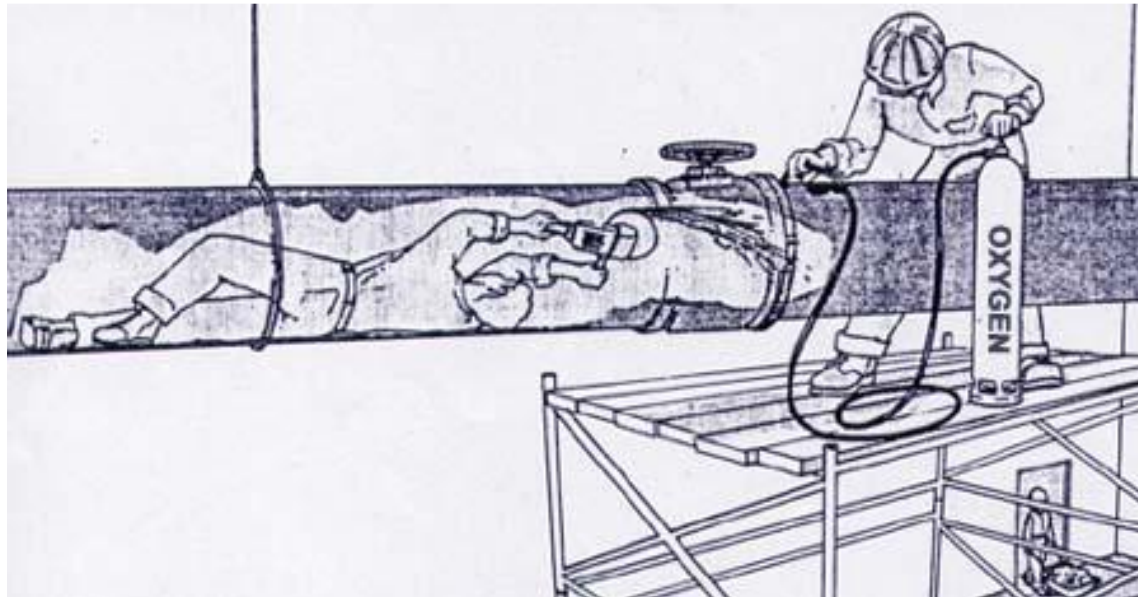
Honeywell

- Many standards (including USA 29 CFR 1910.146) Specify 23.5 % as oxygen enriched
  - Other codes (such as USA 29 CFR 1915 and NFPA guidelines) are more stringent
  - More conservative approach is to use 22.5 % as hazardous condition threshold

# Oxygen Enrichment

Honeywell

- Proportionally increases the rate of many chemical reactions
- Can cause ordinary combustible materials to become flammable or explosive





# Explosive or Flammable Atmospheres

# Lower Explosive Limit (L.E.L.)

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Honeywell

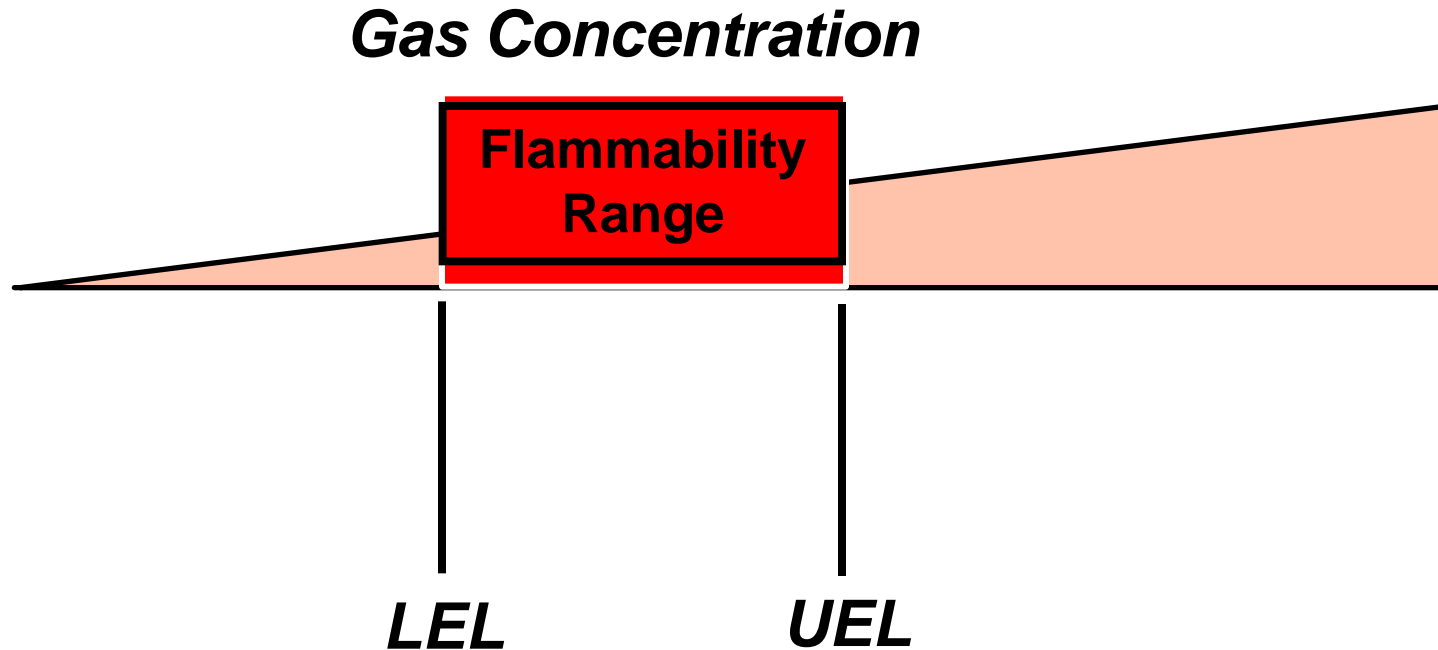
- Minimum concentration of a combustible gas or vapor in air which will ignite if a source of ignition is present

# Upper Explosive Limit (U.E.L.)

Honeywell

- Most but not all combustible gases have an upper explosive limit
  - Maximum concentration in air which will support combustion
  - Concentrations which are above the U.E.L. are too “rich” to burn

# Flammability Range



- The range between the L.E.L. and the U.E.L. of a combustible gas or liquid
- Concentrations within the flammable range will burn or explode if a source of ignition is present

# Common Flammability Ranges

Honeywell

	<b><i>LEL</i></b>	<b><i>UEL</i></b>
<b><i>Methane</i></b>	<b><i>5.0 %</i></b>	<b><i>15.0 %</i></b>
<b><i>Propane</i></b>	<b><i>2.2 %</i></b>	<b><i>9.5 %</i></b>
<b><i>Hydrogen</i></b>	<b><i>4.0%</i></b>	<b><i>75.0%</i></b>
<b><i>Butane</i></b>	<b><i>1.8%</i></b>	<b><i>8.4%</i></b>
<b><i>Pentane</i></b>	<b><i>1.4%</i></b>	<b><i>7.8%</i></b>
<b><i>Ethylene oxide</i></b>	<b><i>3.0 %</i></b>	<b><i>100.0%</i></b>
<b><i>Hydrogen sulfide</i></b>	<b><i>4.3 %</i></b>	<b><i>46.0%</i></b>

**Different gases have different flammability ranges**

# Catalytic “Hot Bead” Combustible Sensor

Honeywell

- Detects combustible gas by catalytic oxidation
- When exposed to gas oxidation reaction causes bead to heat
- Requires oxygen to detect combustible gas!

# Over-Limit Protection

Honeywell

- LEL sensor only designed to detect 0-100% LEL concentration of flammable gas
- If O2 concentration less than 10% O2, LEL sensor will not read properly
- Also, sensor may be damaged by exposure to higher than 100% LEL concentrations
- To prevent damage, sensor is switched OFF and instead of the LEL reading OL = (Over Limit) is displayed.

# Combustible sensor Poisons

Honeywell

- Silicones
  - Lubricants such as WD-40
  - Rust inhibitors
  - Hand moisturizers
  - Hand sanitizers
  - Cleaners such as ARMOR ALL
- Hydrogen sulfide and other sulfur containing compounds
- Phosphates and phosphorus containing substances
- Lead containing compounds (especially tetraethyl lead)
- Over Exposure to combustible gases

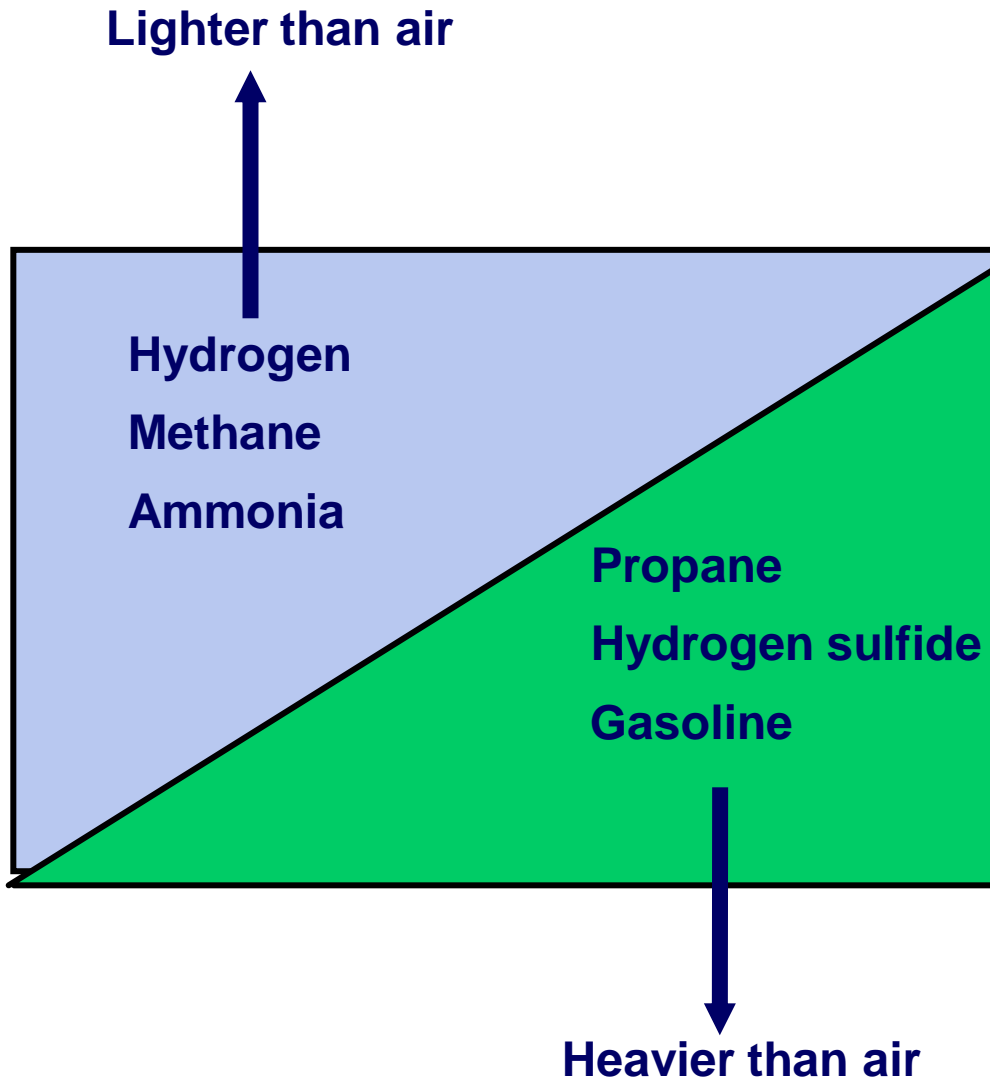


# Toxic Gases and Vapors



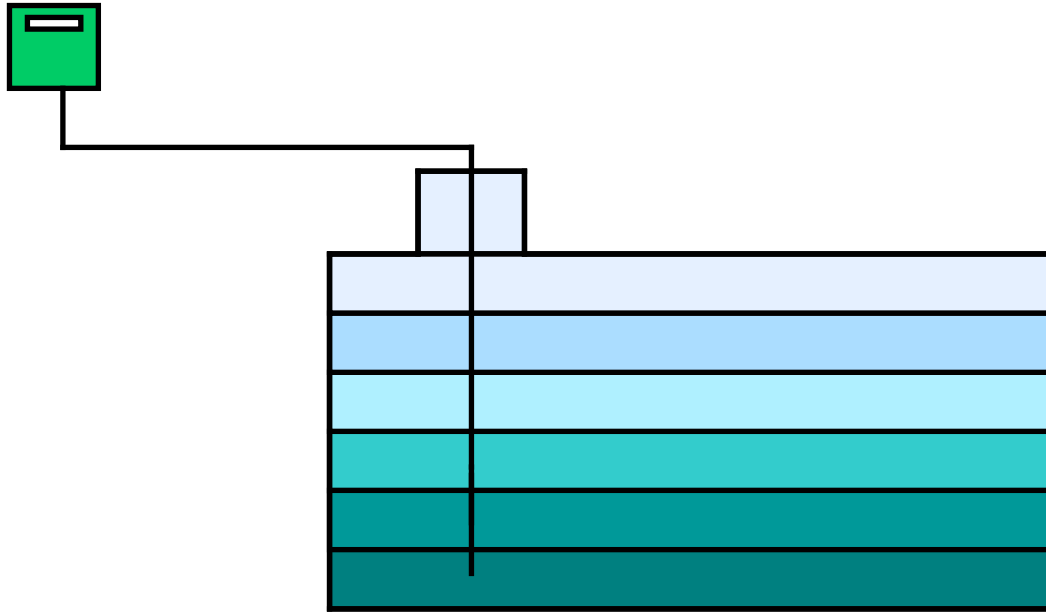
# Vapor density

Honeywell



- Measure of a vapor's weight compared to air
- Gases lighter than air tend to rise; gases heavier than air tend to sink

# Stratification



- Atmospheric hazards in confined spaces form layers
- Check all levels! Atmosphere tested (at least) a distance of approximately 4 feet (1.22 m) in the direction of travel and to each side
- Allow sufficient time for all sensors to react to each sample per level tested. Key response factors are hose length (typical 2 seconds per foot flow rate) plus T90 sensor/s response time. For Example: 10' hose x 2 seconds = 20 seconds plus most significant T90 of monitor's sensors (typically 30 seconds for standard 4-gas monitor).  **$(10 \times 2) + 30 = 50$  seconds per level**

# Toxic Gases and Vapors

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Honeywell

- Detection technologies:
  - Electrochemical Sensors
  - Photoionization detectors
  - Non-dispersive infrared (NDIR)

# Permissible Exposure Limits

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Honeywell

- “Parts-per-Million” (ppm) concentrations
  - 1.0 ppm the same as:
    - One automobile in bumper-to-bumper traffic from Cleveland to San Francisco
    - One inch in 16 miles
    - One minute in two years
    - One ounce in 32 tons
    - One cent in \$10,000

# Carbon Monoxide

- *Bonds to hemoglobin in red blood cells*
- *Contaminated cells can't transport O<sub>2</sub>*
- *Chronic exposure at even low levels harmful*

# Carbon Monoxide

- Produced as a by product of incomplete combustion
  - Associated with internal combustion engine exhaust
    - Vehicles
    - Pumps
    - Compressors

# Characteristics of Carbon Monoxide

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Honeywell

- Colorless
- Odorless
- About the same weight as air
- Flammable ( LEL is 12.5 %)
- Toxic!

# Symptoms of Carbon Monoxide Exposure

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Honeywell

- Headaches
- Fatigue
- Nausea and other "Flu-like" symptoms
- Loss of consciousness
- Brain damage
- Coma
- Death

# Toxic Effects CO

- Concentration of only 1,600 ppm fatal within hours
- Even lower level exposures can result in death if there are underlying medical conditions, or when there are additional factors (such as heat stress)

Levels of Carbon Monoxide (CO)	
10,000 ppm	Immediate unconsciousness, death in one minute
6400 ppm	Death in 10 to 15 minutes
1600 ppm	Headache, dizziness, nausea in 20 minutes, death in 1.5 to 2 hours
1500 ppm	IDLH (from NIOSH Pocket Guide, June 1990)
500 ppm	Death in four hours
200 ppm	Slight headache
50 ppm	OSHA's PEL

# Characteristics of Hydrogen Sulfide

- *H<sub>2</sub>S is a mitochondrial poison that prevents utilization of oxygen during cellular respiration, shutting down power source for many cellular processes*
- *Also binds to hemoglobin in red blood cells, interfering with oxygen transport*
- *Exposure to H<sub>2</sub>S occurs primarily by inhalation, but can also occur by ingestion (contaminated food) and skin (water and air)*
- *Once taken into the body, it is rapidly distributed to various organs, including the central nervous system, lungs, liver, muscle, as well as other organs*

# Hydrogen Sulfide

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Honeywell

- Produced by anaerobic sulfur fixing bacteria
- Especially associated with:
  - Raw sewage
  - Crude oil
  - Marine sediments
  - Tanneries
  - Pulp and paper industry

# Characteristics of Hydrogen Sulfide

Honeywell

- Half-life in air = 12 to 37 hours
- Eventually breaks down in sunlight
- During very cold and dry conditions, half-life can exceed 37 hours
- Particularly dangerous in oil production areas subject to cold winter temperatures
- Collects in pits, within protective berms, or in other low lying areas

# Characteristics of Hydrogen Sulfide

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Honeywell

- Colorless
- Smells like “rotten eggs” (at low concentrations)
- Heavier than air
- Corrosive
- Flammable (LEL is 4.3 %)
- Soluble in water
- Extremely toxic!

# Toxic effects H<sub>2</sub>S

Honeywell

*1.0 PPM*

*Smell*

*100 PPM*

*Rapid loss of smell*

*200 – 300 PPM*

*Eye inflammation, respiratory tract irritation after 1 hour, loss of consciousness with time*

*500 – 700 PPM*

*Death in 30 min. – 1 hr.*

*1000 PPM*

*Immediate respiratory arrest, loss of consciousness, followed by death*

# Calibration, Bump Testing and Verification

Honeywell

- Calibration: The adjustment of an instrument's response to match a desired value compared to a known concentration of test gas.
- Bump test: Briefly applying gas to check that each sensor responds to target gas and that the alarms are working.
- Calibration Verification: - A bump test utilizing a known concentration of a challenge gas to demonstrate that an instrument's alarms are activated and the response to the gas is within acceptable limits.
- DOCUMENT ALL TESTING.....IF IT WASN'T DOCUMENTED IT DIDN'T HAPPEN



# Make sure instrument has been calibrated!

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**Honeywell**

- Follow manufacturer recommendations at a minimum
- “Zero” instrument in fresh air prior to use
- Verify Accuracy Daily!
- Functional “bump” test sufficient
- Adjust “span” only if necessary
- Replacing a sensor requires calibration and a 5 min. stability check.

# Bump Testing

- The safest course of action is to expose the sensors to known concentration test gas before each day's use!
- Prudent to perform a bump test anytime a detector changes custody
- Bump test any time a sensor has been exposed to a gas concentration that exceeds the detection range
- Bump test any time there is doubt regarding the response of a safety gas detector
- This test is very simple and takes only a few seconds to accomplish!

# When to Calibrate?

- Functional “bump” test only provides verification of sensor performance
- Calibration includes adjustment
- Only necessary to adjust sensor sensitivity if readings are off
- Most manufacturers recommend adjustment if readings are off by more than 10% of expected values
- The BW Technologies by Honeywell factory default calibration interval is 180days

# Don't be afraid of calibration!

Honeywell

- Modern designs make calibration easy and automatic
  - All-In-One Calibration Mixtures Make Calibration and Functional Testing Easy!
  - MicoDockII stations take all the guess work out of calibration, bump testing and record keeping



# Record Keeping

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Honeywell

- Documentation is critical!
- Without good records you cannot defend or explain your procedures
- If you don't have the records to prove it was being done right -- it wasn't!

# Am I safe?

Honeywell

- Atmospheric hazards are frequently invisible to human senses
- You don't know whether it's safe until it's been tested with a properly operating gas detector!

# Questions?

**Honeywell**

The background of the slide features a light blue circular pattern with several question marks of varying sizes and colors (blue and white) scattered throughout. The word "Questions?" is prominently displayed in the center in a large, bold, black font.

# Questions?

**Answers.**