Honeywell BW GasAlertMAX XT II Training

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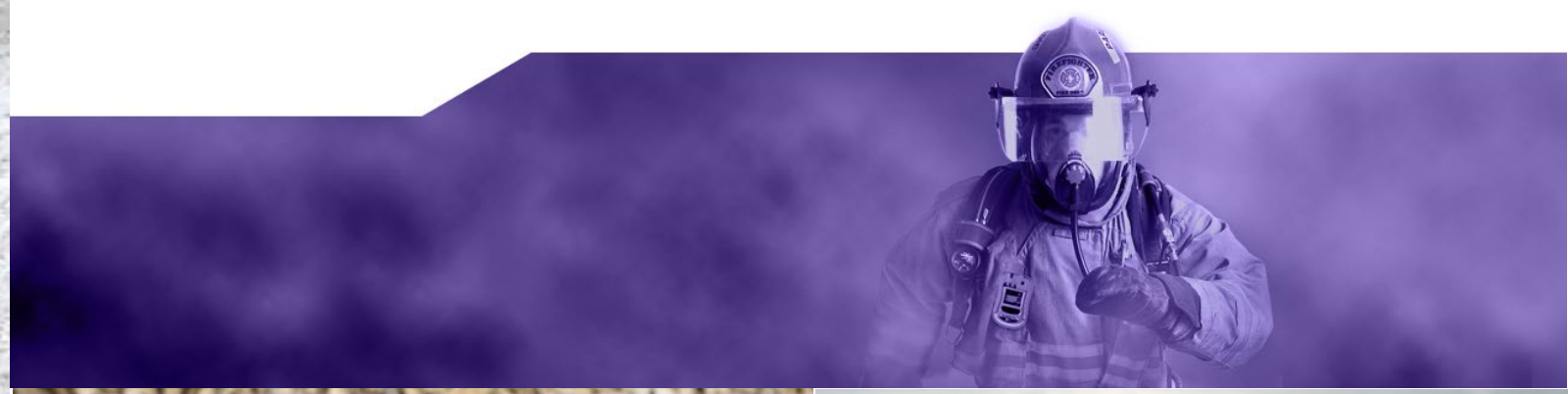


Connected Worker

WHY WE DO WHAT WE DO

Portable Gas Detection Applications, History and Sensor Technology

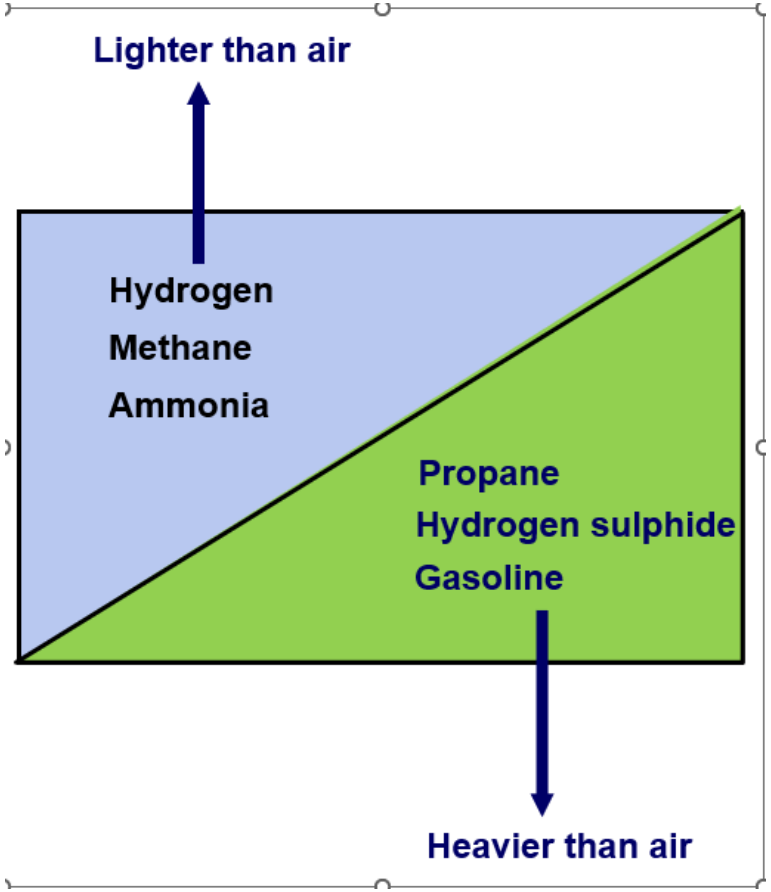
Common Gas Detection Acronyms

- **LEL/LFL** Lower Explosive Limit/ Lower Flammable Limit (synonymous)
- **UEL/UFL** Upper Explosive Limit/Upper Flammable Limit (synonymous)
- **%LEL** Percent of the Lower Explosive Limit
- **ppm** Parts Per Million (10,000 ppm = 1% v/v)
- **TWA** Time Weighted Average
- **STEL** Short Term Exposure Limit
- **IDLH** Immediately Dangerous to Life and Health toxic gas concentration
- **IP** Ingress Protection
- **IS** Intrinsic Safety (device will not generate enough energy to be the source of ignition in a combustible atmosphere)
- **T90** Refers to sensor response time - time sensor takes to reach 90% of full response

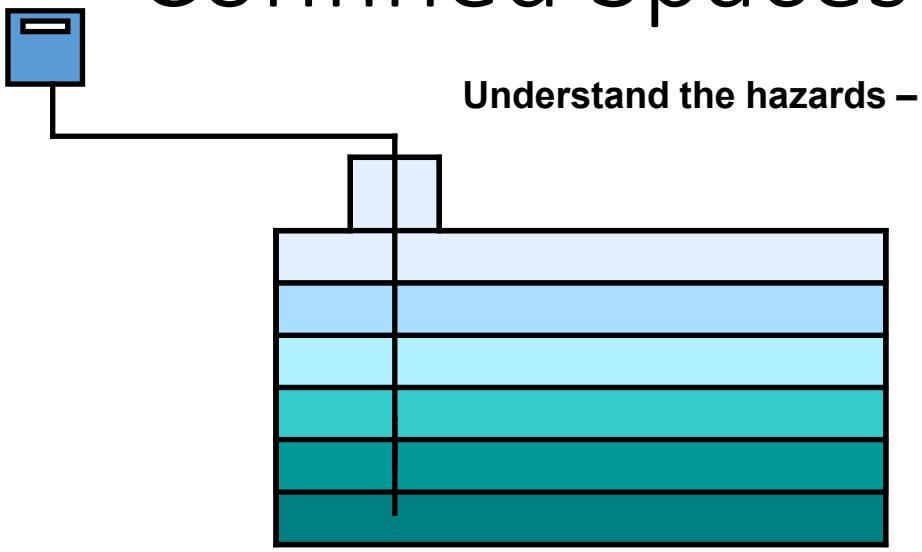
Understand the Hazards!

- **Gases are not ideal; they have different properties**

- Molecular weight of air: 28.966
- Gases lighter than air tend to rise; gases heavier than air tend to sink
- Know as much as possible about the hazards you are dealing with
- Always assume the worst-case scenario



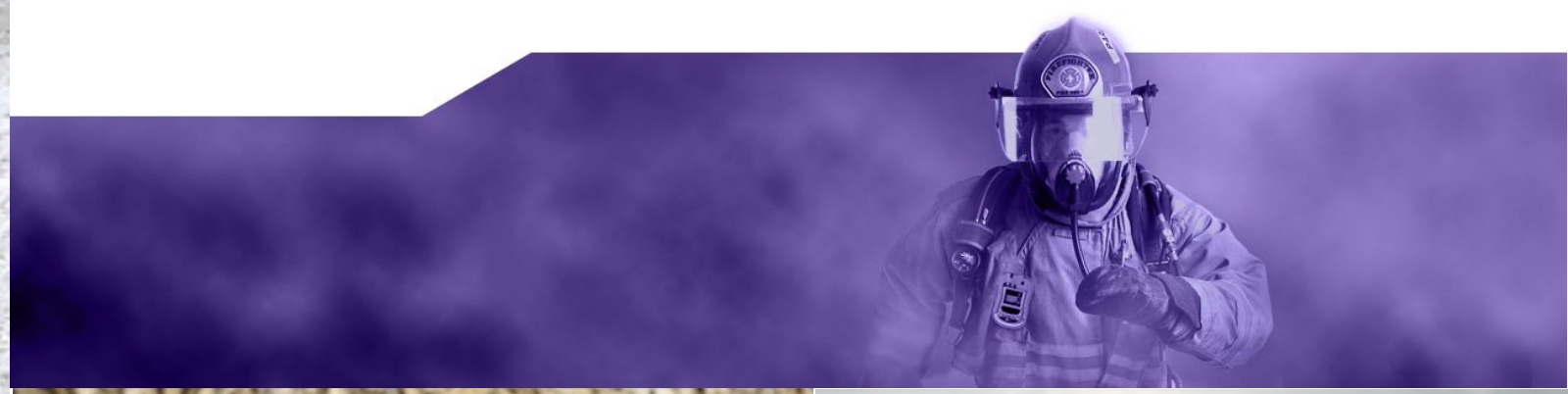
Confined Spaces are Dangerous Places!



- Atmospheric hazards in a confined space can be found at various levels
- CHECK ALL LEVELS! Atmosphere tested (at least) approximately every 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
- Example: 10 feet hose x 2 seconds = 20 seconds plus most significant T90 of monitor's sensors (approximately 30 seconds for standard 4 gas detector). (10 x 2) + 30 = 50 seconds per level minimum
- If any gas is present during sampling it is essential to continue testing until readings remain stable (T100 response)

Toxic atmospheres come from

- Microbial action on material in CS
- Products or chemicals stored in CS
- Work being performed in CS
- Areas adjacent to Confined Space



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COMBUSTIBLE GASES

LEL…if you assume, things could go KABOOM!

What is Gas?

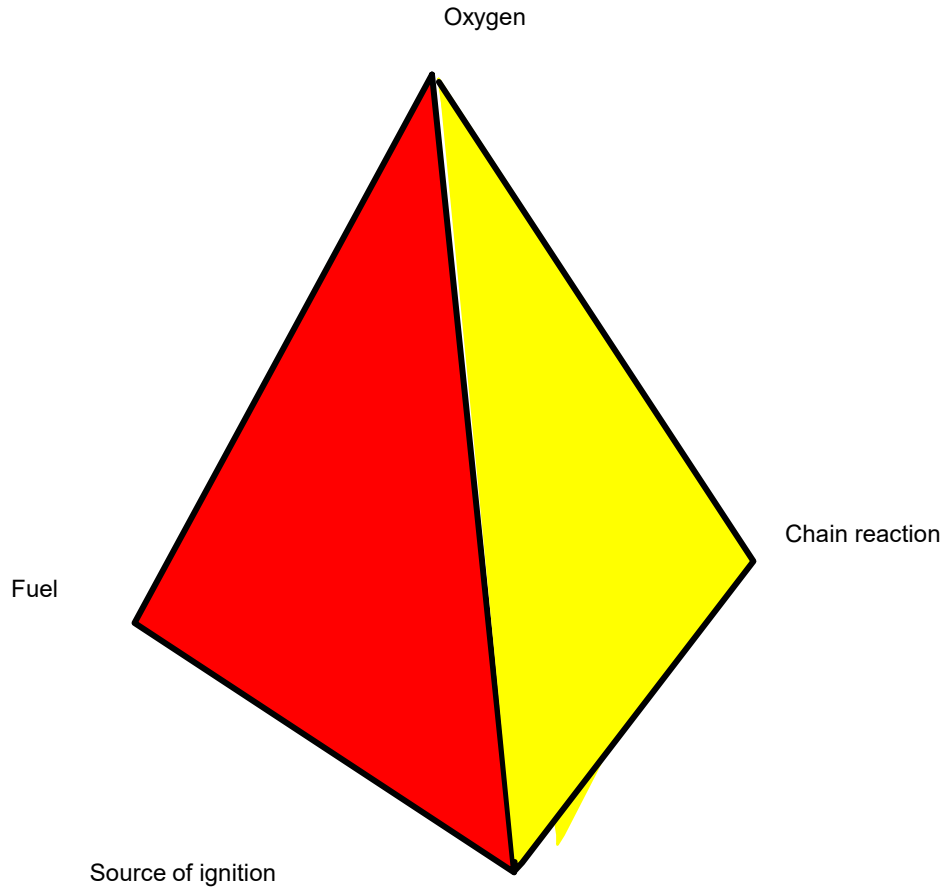
- Many gases are invisible to human senses – often we cannot smell, taste, touch, see or hear a gas – Carbon Monoxide is the most commonly encountered toxic gas and is often referred to as the “Silent Killer”

- Some gases have a distinct odor, color or taste – at low concentrations Hydrogen Sulphide smells like rotten eggs – you cannot smell Hydrogen Sulphide at high concentrations when it is most lethal - Hydrogen Cyanide has a distinct odor often described as that of bitter almond – chlorine gas has a greenish-yellow color

- However, many atmospheric gas hazards cannot be detected by human senses so a portable safety gas detector can be an important part of PPE in the workplace

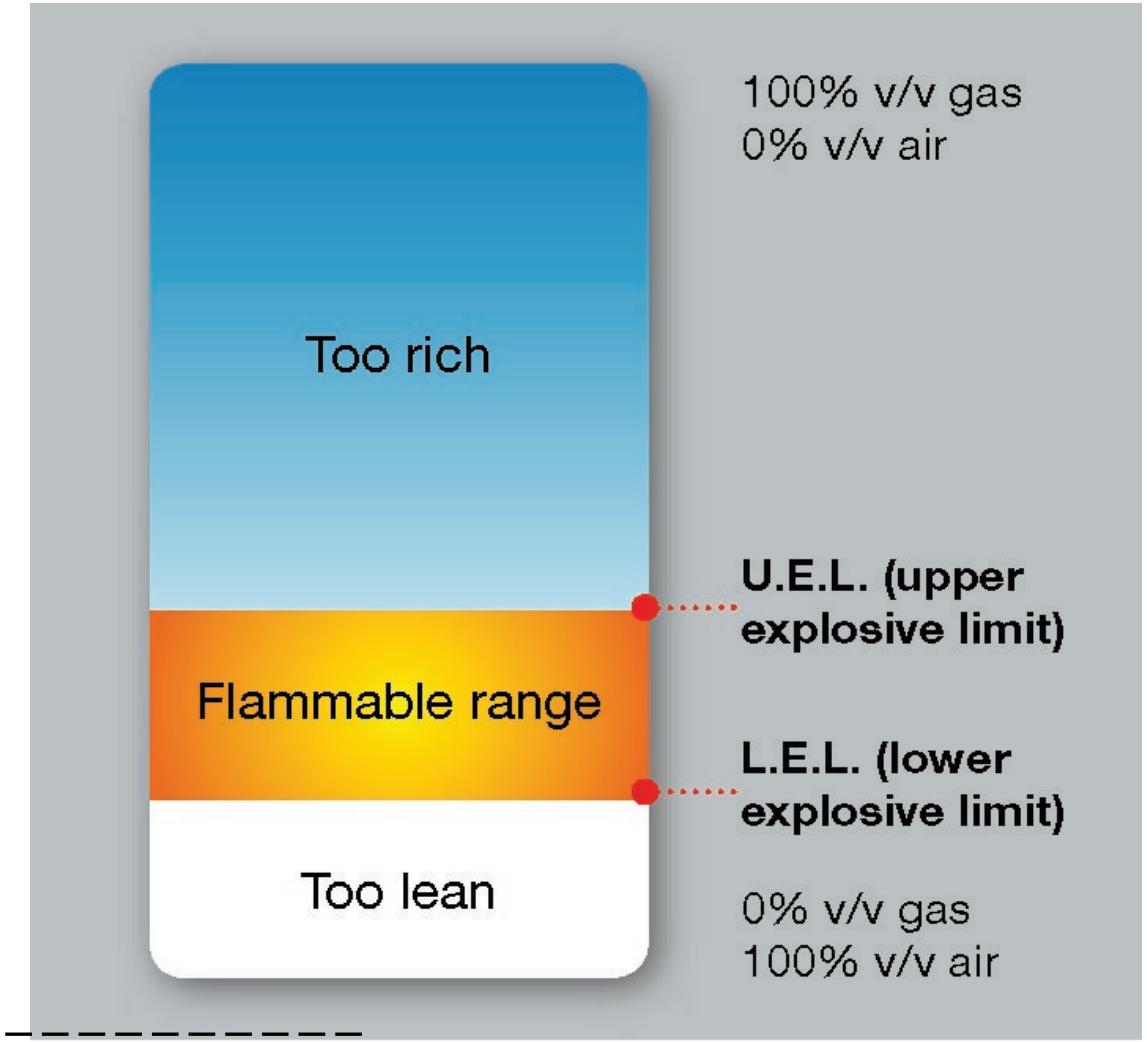
NOTE: Portable safety gas detectors are only useful for the detection of gas phase atmospheric hazards.

Combustion Tetrahedron



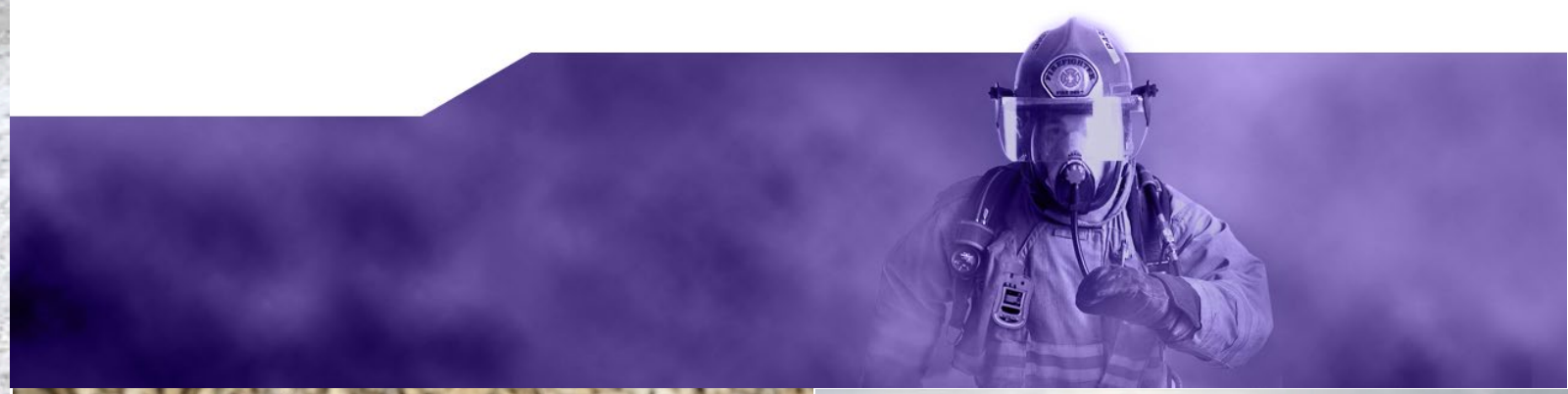
Combustible Gas Measurement

Combustible gas detectors are intended to alarm conservatively at a low percentage of the Lower Explosive Limit, e.g.: 10% LEL



Inadvertent sensor poisoning?

- **Volatile silicones:**
  - Lubricants such as WD-40
  - Rust inhibitors
  - Plastic and rubber revival products such as ARMOR ALL
  - Waxes and polishes
  - Hand lotions, personal care products and makeup with ingredients such as cyclomethicone,
  - & polydimethylsiloxanes
  - Heat transfer fluids
  - Silicone greases and oils
  - Caulking materials…
- **Hydrogen sulphide and other sulphur containing compounds**
- **Phosphates and phosphorus containing substances**
- **Lead containing compounds (especially tetraethyl lead)**
- **Over Exposure to combustible gases**



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OXYGEN

Not enough? Too much? How do I know?

A Breath of Fresh Air

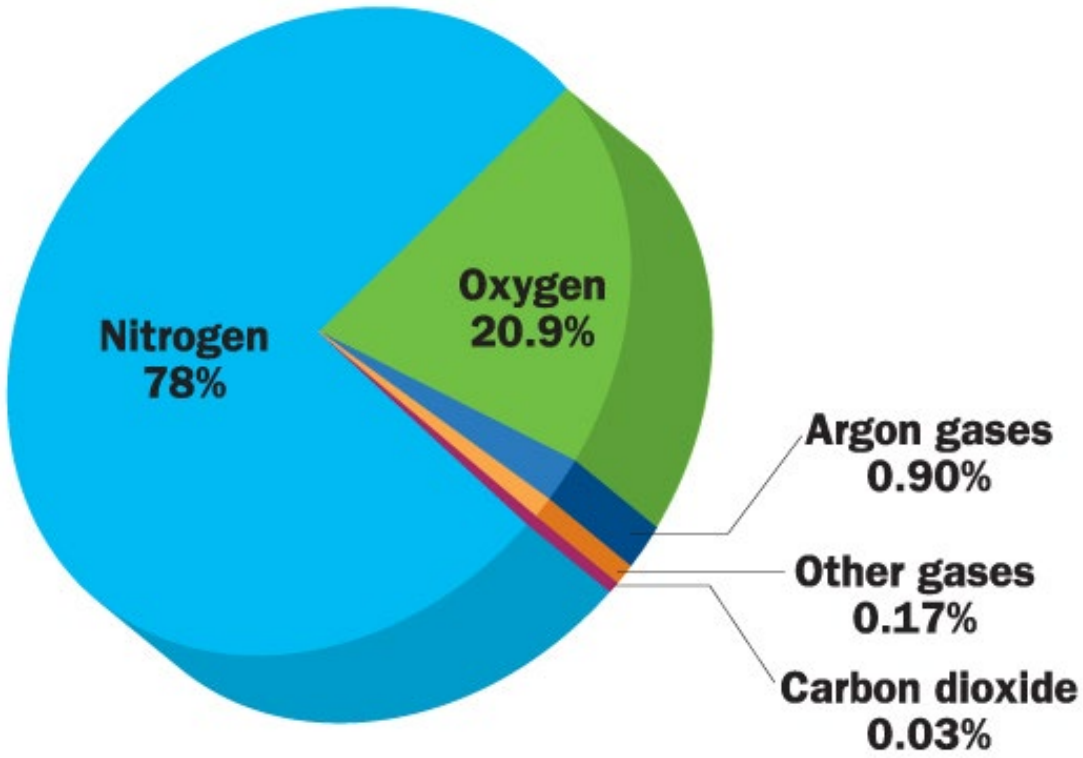
Average molecular weight of dry air is 28.97g/mol

Composition (Mole percent):

N_2	78.084
O_2	20.947
Ar	0.934
CO_2	0.0400
Ne	0.001818
He	0.000524
CH_4	0.00017
Kr	0.000114
H_2	0.000053

Other trace gases include:

O_3, CO, Xe, SO_2, NO_2, NH_3

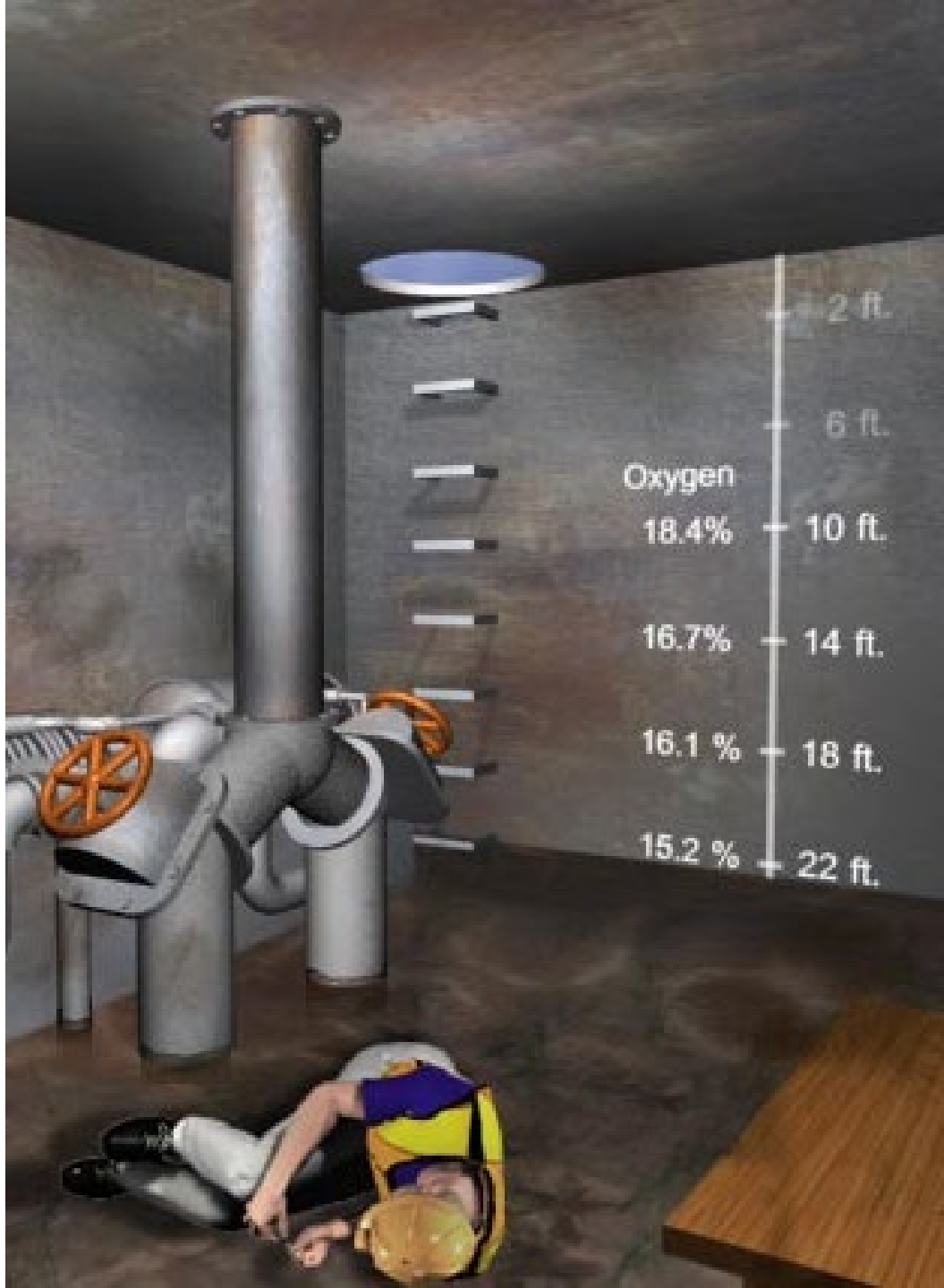


Portable safety gas detector reading in "fresh air":
20.9% v/v – oxygen
0 ppm – toxic gases
0% LEL – combustible gases

Causes of Oxygen Deficiency

- Displacement
- Microbial action
- Oxidation
- Combustion
- Absorption

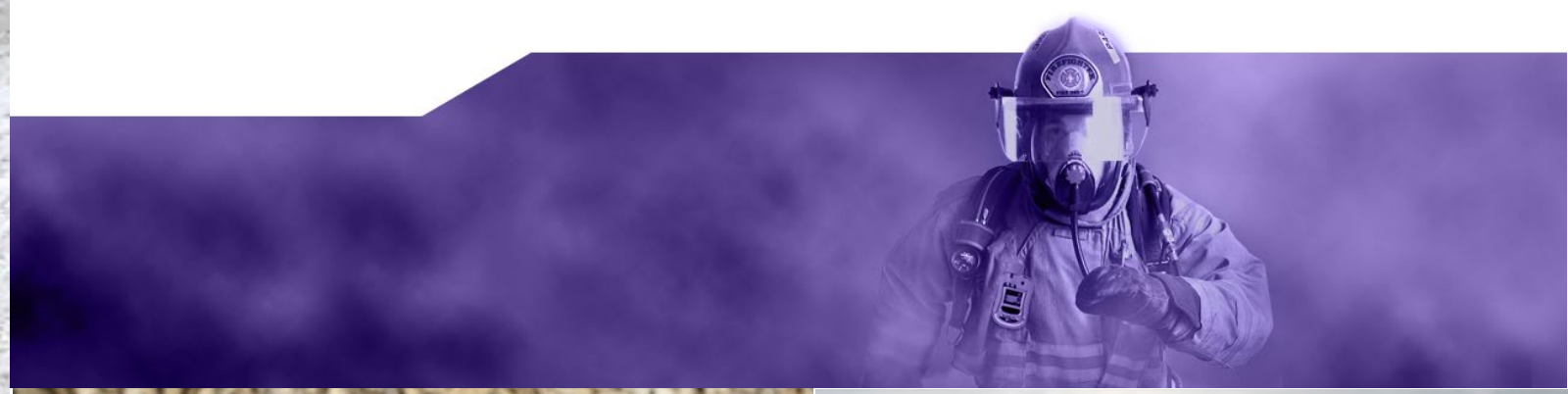
- IMPORTANT:
- the oxygen concentration may vary within a confined space
- monitoring the space at all levels prior to entry is essential
- ideally, for adequate warning of changes in atmospheric conditions each worker will be wearing a multi-gas monitor while working



Oxygen Enrichment

- Proportionally increases the rate of many chemical reactions
- Hair and clothing can catch fire easily in oxygen enriched atmospheres
- Combustion is more violent; fires more fierce and harder to extinguish

- Dartmouth General Hospital – 2014.01.14 – Fire Department feared explosion hazard – streets in vicinity closed as a precaution



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TOXIC GASES

I can smell H_2S. What do I need a detector for? CO “the silent killer”

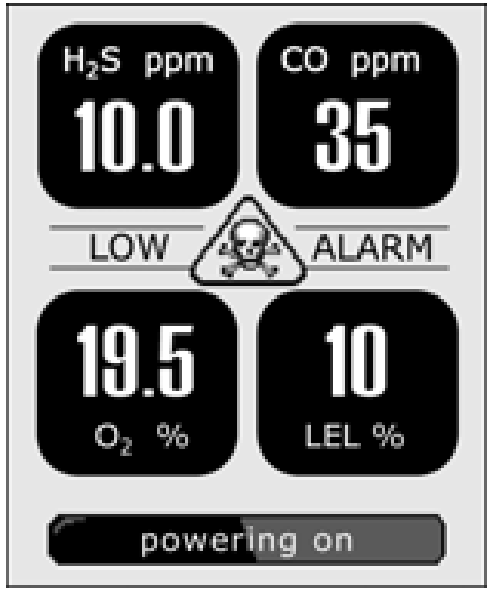
Gas Exposure Alarms

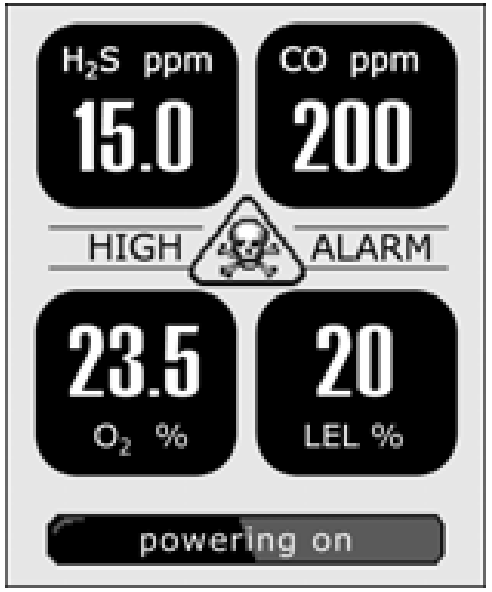
- **Oxygen:**
  - LOW oxygen concentration
  - HIGH oxygen concentration

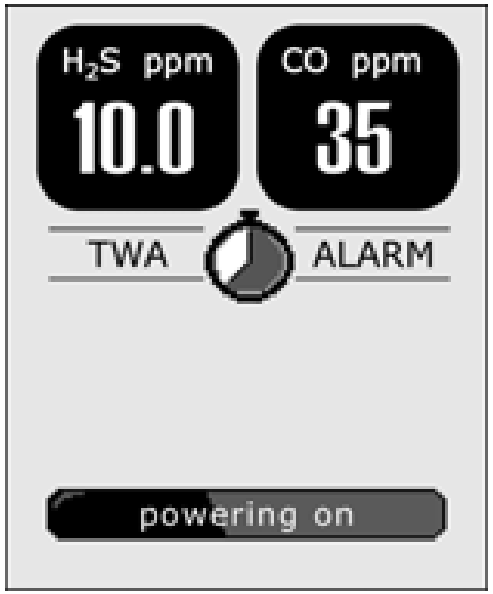
- **Combustible:**
  - Instantaneous LOW and HIGH

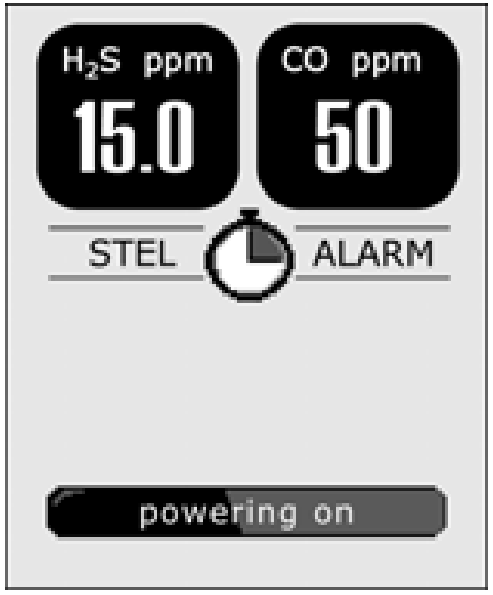
- **Toxic Gases:**
  - Instantaneous LOW and HIGH
  - TWA
  - STEL

- * Remember: gas alarm set points are set very conservative to provide early warning so workers can evacuate an area safely.









Time Weighted Average - TWA

Exposure	Concentration	TWA
4hrs	100 ppm	50 ppm
8hrs	100 ppm	100 ppm
12 hrs	100 ppm	150 ppm

- Definition:
- TWA – Time-weighted average exposure concentration for a conventional 8-hour (TLV, PEL) or up to a 10-hour (REL) workday and a 40 hour workweek.
- TWA exposure is determined by averaging readings while the detector is running
- When monitoring session less than eight hours, TWA projected for the full eight hour shift.
- When monitoring session more than 8 hours, TWA calculated on an “equivalent” 8 hour shift basis
- According to OSHA cumulative TWA exposures for an eight hour work shift are calculated as follows:
- $E = (Ca\ Ta + Cb\ Tb + ... Cn\ Tn) / 8$
  - E is the equivalent exposure for the eight hour working shift
  - C is the concentration during any period of time T where the concentration remains constant
  - T is the duration in hours of the exposure at concentration C

Short Term Exposure Limit – STEL

- Short Term Exposure Limit (STEL) is the maximum permissible gas concentration a worker can safely be exposed to for short periods of time (5 – 15 minutes maximum) Some gases and vapors have an allowable maximum Short Term Exposure Limit which is higher than the 8 hour TWA
- Many gas hazards may not have a STEL value recommendation – typically can be calculated as a multiple of the TWA value – consult local regulations for advice
- STEL values usually calculated as 15 minute, or in some cases, as 5 minute or 10 minute time weighted averages

Carbon Monoxide

- Molecular formula: CO
- Molecular weight: 28.01 g/mol
- LEL: 12.5% v/v
- UEL: 74.2% v/v
- Characteristics: colourless, odourless

- Sources of CO:
  - Automobile exhaust
  - Generators and other gasoline powered equipment
  - Worn, or poorly adjusted and maintained combustion devices such as furnaces, heaters, boilers
  - Welding equipment
  - Wood stoves, fireplaces
  - Tobacco smoke
  - Fires – house, building, wild fires

- Carbon monoxide is the most commonly encountered toxic gas hazard!

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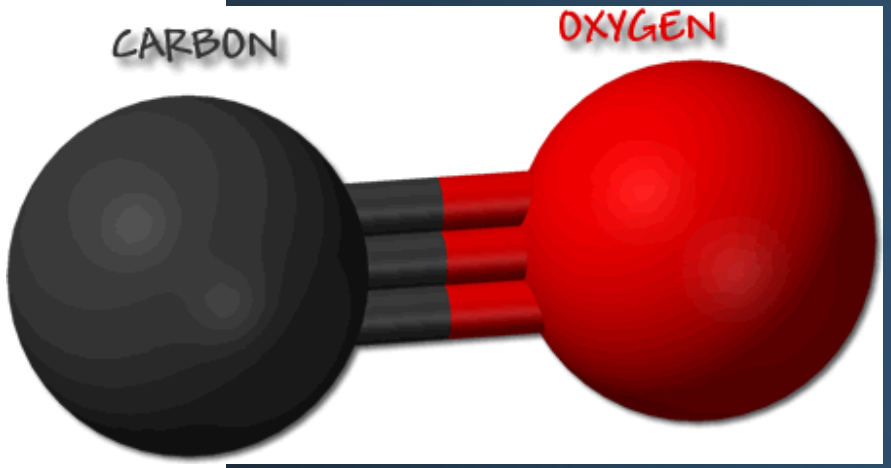
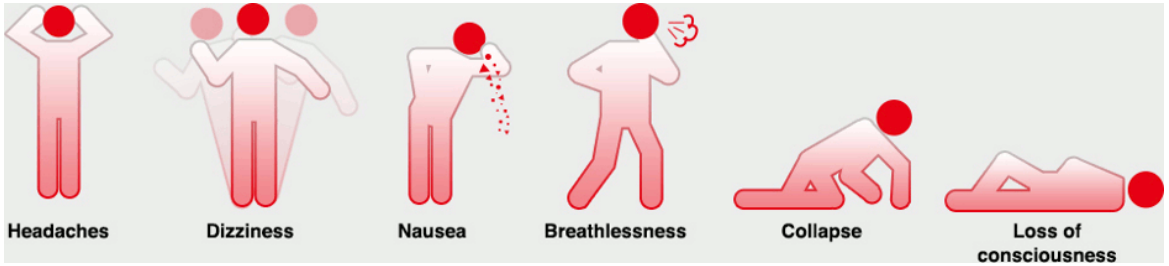


Carbon Monoxide

- **Symptoms of exposure:**
  - Headaches
  - Fatigue
  - Nausea and other "Flu-like" symptoms
  - Loss of consciousness
  - Brain damage
  - Coma
  - Death
- **Physiological effects:**
  - Carbon monoxide enters the body through inhalation. Once in the lungs the gas molecules pass through capillaries to the blood stream. In the blood stream the carbon monoxide molecules are easily absorbed by red blood cells blocking oxygen molecules from these cells which denies the body of oxygen.



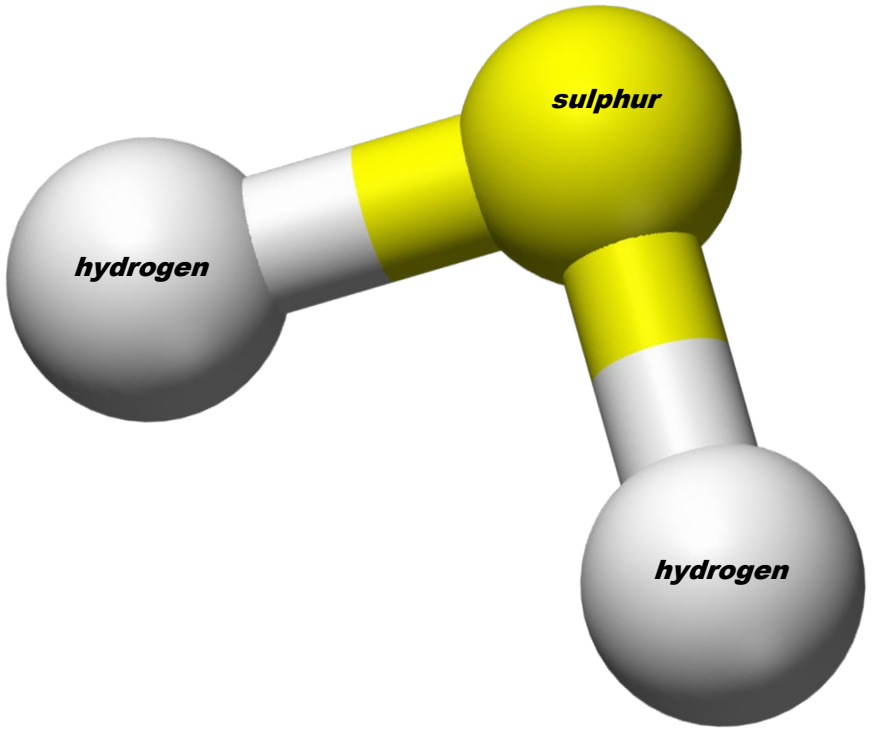
Toxic Effects CO

CONCENTRATION (PPM)	SYMPTOMS
35	Headache and dizziness within 6 to 8 hours of constant exposure
100	Headache within 2 to 3 hours of constant exposure
200	Headache and impaired judgement within 2 to 3 hours
400	Headache within 1 to 2 hours
800	Immediate headache, dizziness, nausea – convulsions within 45 minutes – incapacitation within 2 hours
1,200	IDLH concentration – CDC NIOSH Pocket Guide to Chemical Hazards
1,600	Immediate headache, dizziness, nausea – death in <2 hours
12,800	Unconciousness in 2 to 3 breaths – death in <3 minutes

Hydrogen Sulphide

- Molecular formula: H_2S
- Molecular weight: 34.08 g/mol
- LEL: 4.3% v/v
- UEL: 46.0% v/v
- Characteristics: colourless, rotten egg odour in low concentrations; odour threshold varies, but is well below 1 ppm concentrations of 150 to 200 ppm will paralyze the olfactory nerve.

- Sources of H_2S:
- Hydrocarbon deposits
- Natural gas
- Petroleum crude
- Volcanic gases
- Sulphur springs
- Sewer gases
- Landfills
- Pulp and Paper (anaerobic fermentation of pulp)



Hydrogen sulphide

- **Symptoms of exposure:**
  - Offensive odour
  - Tearing of the eyes
  - Nausea, headache, loss of appetite
  - Bronchial constriction, difficulty breathing
  - Olfactory fatigue
  - Respiratory tract irritation, inflammation of the eyes, pulmonary edema
  - Breathing cessation
  - Death
- **Physiological effects:**
- Hydrogen sulphide enters the body through inhalation. In the blood stream the hydrogen sulphide molecules are easily absorbed by red blood cells blocking oxygen molecules from these cells which denies the body of oxygen. Hydrogen sulphide effectively kills cells by neurtalizing the mitochondria and damaging cell structure. Hydrogen sulphide neutralizes the phrenic nerve which controls the diaphragm and breathing will cease. .

Toxic Effects H_2S

CONCENTRATION (PPM)	SYMPTOMS
2 to 5	Nausea, tearing, headaches
20	Possible fatigue, loss of appetite, headache, dizziness
50 to 100	Conjunctivitis, respiratory tract irritation in 1 hour
100	IDLH concentration – CDC NIOSH Pocket Guide to Chemical Hazards
100 to 150	Coughing, eye irritation, olfactory fatigue, shortness of breath, severe symptoms after prolonged exposure >2 hours
200 to 300	Severe conjunctivitis, respiratory tract irritation, pulmonary edema from prolonged exposure >1 hour
500 to 700	Loss of mobility, collapse in 5 minutes, serious eye damage within 30 minutes, death in <60 minutes
700 to 1,000	Rapid incapacitation, cessation of breathing, death within minutes