



# Mine Rescue Gas Detection

Pa. Bureau of Deep Mine Safety

# What do I need to know?

- What gases make up fresh air
- What are the hazards of mine gases
- Specific Gravity of each gas
- Origin of mine gases
- Explosive range
- Exposure limits
- What detection device(s) do I use

# Category of Gases

- **Noxious** – Asphyxiant due to a lack of oxygen.
- **Toxic** – Poison, either long or short term exposure.

# Physics of Gases

- **Specific Gravity** : The combinations of gases that make up air is what other gases are compared with. Air is considered to have a specific gravity of 1.0
- **Temperature**: Cold gases will diffuse slowly, hot gases will diffuse quickly.
- **Graham's Law**: The rate of diffusion, the lower the specific gravity, the faster it will diffuse.
- **Barometric Pressure**: The lower the pressure, the faster a gas will diffuse.
- **Solubility**: The ability to dissolve in water.

# Exposure Limits

- ***Threshold Limit Value (TLV)***  
*The allowable amount of gas exposure for an 8 hour day for 5 days a week without harmful effects.*
- ***Short Term Exposure Limit (STEL)***  
*The allowable amount of gas exposure for 15 minutes.*

# Measurement of Gases

**Parts Per Million (PPM)**- The most accurate measurement of a contaminant in the atmosphere.

(4)

PERCENT	PPM
1.0 .....	10,000
.1 .....	1,000
.01 .....	100
.001 .....	10
.0001 .....	1

# Mine Gases & their Components

## AIR

- **Chemical Formula:** None
- **Specific Gravity:** 1.000
- **Source:** Atmosphere
- **Characteristics:** No color, odor, or taste
- Pure dry air at sea level contains the following:
  - Oxygen..... 20.94 %
  - Nitrogen..... 78.09 %
  - Argon..... 0.94%
  - Carbon Dioxide..... 0.03%

# Oxygen

- **Specific Gravity: 1.105**
  - **Chemical Formula: O<sub>2</sub>**
  - **Oxygen will not burn or explode**
  - **Source: Atmosphere**
  - **Characteristics: No color, odor or taste**
  - **Note: When another gas is introduced into the atmosphere of an artificial environment, such as a mine, tunnel or man holes, oxygen can be displaced causing asphyxiation.**



## Oxygen Present %

- 21%
- 19.5%
- 17%
- 16.25%
- 15%
- 9%
- 6%

## Effect

Breathing Easiest

Minimum required by law

Breathing faster & deeper

Flame safety lamp will extinguish

Dizziness, buzzing noise,  
rapid pulse, headache, blurred vision

Unconsciousness

Breathing stops, cardiac arrest

# Noxious Gases (Explosive)

- **Methane**

- **Chemical Formula:** CH<sub>4</sub>
- **Specific gravity:** 0.555
- **Needs 12.5% O<sub>2</sub> to ignite**
- **Explosive Range:** 5-15%
- **Ignition Temperature:** 1100°-1300° F
- **Source:** Carbon products decaying in anoxic environment
- **Characteristics:** No color, odor or taste
- **Detection method:** Methane detector, Flame safety lamp, Chemical analysis

# Acetylene

- **Chemical Formula:**  $C_2H_2$
- **Specific Gravity:** 0.9107
- **Explosive Range:** 2.4-83%
- **Ignition Temperature:** 581°F
- **Source:** Methane heated in a low oxygen atmosphere
- **Odor:** Garlic
- **Will auto-ignite when over pressurized**

# Hydrogen

- **Chemical Formula:**  $H_2$
- **Specific Gravity:** 0.0695
- **Needs 5%** oxygen to ignite
- **Explosive Range:** 4.1-74%
- **Ignition temperature:**  $1030^{\circ}$  -  $1130^{\circ}F$
- **Source:** Water on super hot fires, battery charging

## **Noxious Gases(Non Explosive)**

- **Nitrogen**

- **Chemical formula:**  $N_2$
- **Specific Gravity:** 0.967
- **TLV:** 810,000 PPM
- **Source:** Atmosphere, released from coal seam
- **Characteristics:** No color, odor, or taste

# Carbon Dioxide

- **Chemical Formula:** CO<sub>2</sub>
- **Specific Gravity:** 1.529
- **TLV:** 5000 PPM
- **STEL:** 15,000 PPM
- **Source:** Product of complete combustion, slow oxidation of carbon products, breathing
- **Characteristics:** No color or odor, acidic taste above 10%

# Toxic Gases(Explosive)

- ***Carbon Monoxide***

- ***Chemical Formula: CO***
- ***Specific Gravity: 0.967***
- ***Needs 6% O<sub>2</sub> to ignite***
- ***Ignition Temperature: 1100°F***
- ***Explosive Range: 12.5- 74%***
- ***TLV: 50 ppm***
- ***STEL: 400 PPM***
- ***Source: Incomplete combustion, diesels, gasoline engines***
- ***Characteristics: No color, odor, or taste***
- ***Effect on the body: 300 times more attracted to hemoglobin than oxygen.***

## Toxic Gases (Explosive) con't.

- **Hydrogen Sulfide**
  - **Chemical Formula:**  $\text{H}_2\text{S}$
  - **Specific Gravity:** 1.191
  - **Ignition Temperature:** 700°F
  - **TLV:** 10 ppm
  - **STEL:** 15 PPM
  - **Source:** Sulfur dissolving in water in a poorly ventilated area, rotting mine timbers
  - **Characteristics:** Colorless, sweet taste, rotten egg smell
  - **Effect on the body:** Paralysis of respiratory system



# Toxic Gases (Non-Explosive)

- **Nitrogen Dioxide**

- **Chemical Formula:**  $\text{NO}_2$
- **Specific Gravity:** 1.589
- **TLV:** 5 PPM
- **STEL:** 10 PPM
- **Source:** Explosives after-product, diesel exhaust, welding
- **Characteristics:** Burnt powder odor, reddish brown in high concentrations
- **Effect on the body:** Forms nitric acid in lungs causing pulmonary edema

# Toxic gases(con't)

- **Sulfur Dioxide**

- **Chemical Formula:**  $\text{SO}_2$
- **Specific Gravity:** 2.264
- **Source:** Burning of sulfide ores, diesel exhaust, gob fires
- **TLV:** 5 ppm
- **STEL:** 10 PPM
- **Characteristics:** Heavy sulfur odor
- **Effect on the body:** Same as nitrogen dioxide

# Smoke



- Tiny particles of solid and liquid matter suspended in air as a result of combustion
- Diesel Particulate Matter
- By-products of burning belts
- Carbon materials
- Usually noxious and toxic gases are present
- Can be carcinogen(cancer causing)

# Mine damps

- The word damp is a derivative of the German word “**dampf**” which means vapor. It was used by the immigrant German miners in the anthracite fields to describe a certain atmosphere condition.
  - **Black damp:** Carbon dioxide, nitrogen, and low oxygen.
  - **White damp:** Carbon monoxide
  - **Fire damp:** Methane
  - **Stink damp:** Hydrogen Sulfide
  - **After damp:** By-products of a fire or explosion

# Detection Devices

- Hand held detectors
- Air Sample
- Gas Monitors
- Permanent sensor locations
- Flame Safety Lamp