Thank You for Attending Our October Webinar

Fixed Gas Detection 101

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Providing Solutions to Detect, Measure, Analyze, and Control Your Process and Your Facility.
Agenda

• What is a Gas?
• Gas Hazards
• Gas Detection Applications
• Detection Technology: Combustible Gas
  - Catalytic Bead Sensor
  - Non-Dispersive Infrared
  - Photo Ionization (PID)
• Detection Technology: Toxic & Asphyxiate Gases
  - Electrochemical
  - Chemcassette®
• Summary
What is a Gas?
Three Types of Gas Hazards

**Flammable or Explosive**
- Property Damage
- Loss of Life
- Personal Injury
- Destruction of Environment

**Toxic**
- Physical Harm
- Loss of Life

**Asphyxiates**
- Physical Harm
- Loss of Life
Combustible Gas
Terms to Know:

**Concentration Level (Combustible Gasses)**

**UEL: Upper Explosive Level**
- Concentration level of combustible gas is too high to burn (no oxygen)

**Explosive/Flammable Range**
- Enough combustible gas AND oxygen for flame to ignite

**LEL: Lower Explosive Level**
- Concentration level of combustible gas is too low to burn
Concentration level is expressed as a % of the total volume

% \((v/v)\)
(volume of gas/volume of air)
## Examples of Combustible Gases

<table>
<thead>
<tr>
<th>Gas</th>
<th>LEL</th>
<th>UEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₃H₈</td>
<td>2.2%</td>
<td>9.5%</td>
</tr>
<tr>
<td>H₂</td>
<td>4%</td>
<td>75%</td>
</tr>
<tr>
<td>CH₃CH₂OH</td>
<td>6%</td>
<td>36%</td>
</tr>
<tr>
<td>C₂H₆</td>
<td>3%</td>
<td>12%</td>
</tr>
<tr>
<td>CH₃OH</td>
<td>3%</td>
<td>19%</td>
</tr>
<tr>
<td>CH₄</td>
<td>5%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Toxic Gas
## Terms to Know: Concentration Levels

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEL</td>
<td>Permissible Exposure Limit</td>
<td>The legal limit for exposure to a substance.</td>
</tr>
<tr>
<td>TWA</td>
<td>Time Weighted Average</td>
<td>Average exposure over a specified time, usually 8 hours.</td>
</tr>
<tr>
<td>STEL</td>
<td>Short-Term Exposure Limit</td>
<td>Average exposure over a short period of time, usually 15 minutes.</td>
</tr>
<tr>
<td>TLV</td>
<td>Threshold Limit Value</td>
<td>A worker can be exposed day after day for a working lifetime without adverse effects.</td>
</tr>
<tr>
<td>IDLH</td>
<td>Immediate Danger to Life or Health</td>
<td>Exposure level will immediately endanger life/health.</td>
</tr>
</tbody>
</table>
Terms to Know: PPM/PPB

PEL, TWA, STEL, TLV and IDLH are usually expressed in:

- PPM  Parts Per Million
- PPB  Parts Per Billion
Examples of Toxic Gases

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃</td>
<td>Ammonia</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
</tr>
<tr>
<td>CL₂</td>
<td>Chlorine</td>
</tr>
<tr>
<td>H₂S</td>
<td>Hydrogen Sulfide</td>
</tr>
<tr>
<td>NO</td>
<td>Nitric Oxide</td>
</tr>
<tr>
<td>NO₂</td>
<td>Nitrogen Dioxide</td>
</tr>
<tr>
<td>SO₂</td>
<td>Sulfur Dioxide</td>
</tr>
</tbody>
</table>
Asphyxiate Gas
Asphyxiate Gases

OXYGEN (O$_2$)

OXYGEN DEPLETION
Gas Detection Applications
Typical Areas that Require Gas Detection

- Food Processes
- Power Generation
- Water Treatment
- Cold Storage
- Laboratory / Medical
- Parking Structures and Tunnels
Using Technology to Detect Gas
Detection Technology – Combustible Gas

CATALYTIC BEAD SENSOR

Combustible Gas/Air Mixture

HOT

Cold
Detection Technology – Combustible Gas

CATALYTIC BEAD SENSOR

Sensitive Bead        Non-Sensitive Bead

Combustible Gas/Air Mixture

Resistance (Ω) is Different
Catalytic Bead Sensor Operation

Click here to replay the animation
Detection Technology – Combustible Gas

Catalytic Poisoning
Catalytic Gas Detection Pros & Cons

**Advantages**
- Relatively low cost
- Accurate and linear over sensor detection range relative to calibration gas
- Broad band sensor
- Long history, proven technology

**Limitations**
- Unable to identify type of gas detected
- Requires sufficient O₂ to support operating principle
- High power consumption
- Not fail safe
  - Poisoned by: sulfurs, silicones, Phosphors & leads
  - Inhibited by: chlorinated & fluorinated hydrocarbons
- Combustible gas readings may not reflect the true concentration of a combustible gas hazard.
Detection Technology – Combustible Gas

Non-Dispersive Infrared (NDIR)

IR Lamp  $H_2$  IR Detector

Infrared Inactive
Detection Technology – Combustible Gas

Non-Dispersive Infrared (NDIR)

IR Lamp

IR Detector
Detection Technology – Combustible Gas

Non-Dispersive Infrared (NDIR)

IR Source

Fog Rain Snow Dirt

Gas

IR Detectors

Sample & Reference signal strengths

Sample (S) vs. Reference (R)
Infrared Gas Detection Pros & Cons

**Advantages**
- Does not require presence of $O_2$
- Not affected by typical catalytic poisons
- Lower power consumption than catalytic bead sensor
- Accuracy very stable
- Sensor available for 100% v/v CH$_4$
- 5 year MTBF - lower cost of ownership over lifespan

**Limitations**
- Cannot detect hydrogen, acetylene, carbon disulfide
- High cost compared to catalytic bead sensor
- Affected more by changes in temperature and pressure.
- Response is linear to methane but non-linear to other hydrocarbons
Detection Technology – Combustible Gas

Photoionization Detector (PID)

Ionized VOC Gas

ions

electrons

UV Lamp

Gas Flow

VOC Gas

Reformed VOC Gas

Cathode Plate

Anode Electrode

ppm / ppb
Detection Technology – Combustible Gas

Photoionization Detector (PID)

Nitrogen ($N_2$) has an eV of 15.58  
Oxygen ($O_2$) has an eV of 12.08  
Argon (Ar) has an eV of 15.76  
Carbon Dioxide ($CO_2$) has an eV of 13.78  
Other constituents of Air have eV’s between 12.13 and 24.59

Ammonia has an eV of 10.2  
Benzene has an eV of 9.25  
Ethanol has an eV of 10.48  
Hydrogen Sulfide has an eV of 10.46  
Isopropanol has an eV of 10.16  
o-Xylene has an eV of 8.56  
p-Xylene has an eV of 8.45
How does a PID work?

Click here to replay the animation
PID Gas Detection Pros & Cons

Advantages
• Relatively low cost detection of a wide range of combustible VOCs, many of which are toxic
• Sensitive to PPM levels – be aware of the lowest detectable limit capability
• Accurate and linear over sensor detection range; but readings are relative to the gas used for calibration – typically isobutylene
• Does not require presence of $O_2$
• UV Tube is self-cleaning due to the creation of Ozone by the detector

Limitations
• VOCs usually detected by means of broad range sensors
• Broad range sensors provide overall reading for general class or group of chemically related contaminants
• Unable to identify type of gas being detected
• Sensor maintenance may be required
Detection Technology – Toxic Gas

**Toxic Gasses:**
- Carbon Monoxide
- Hydrogen Sulfide
- Chlorine
- Sulfur Dioxide

**Electrochemical Cell**
- Working electrode
- Counter electrode
- Housing
- Electrolyte reservoir
- Carbon filter
- Output pins
Detection Technology – Toxic Gas

Electrochemical Cell (SureCell™ Technology)

- Working electrode
- Counter electrode
- Housing
- Carbon filter
- Primary electrolyte reservoir
- Expansion reservoir
- Output pins
Electrochemical Toxic Gas Sensor Operation

Click here to replay the animation
Electro-chemical Cells Pros & Cons

**Advantages**
- Relatively low cost
- Sensitive to ppm concentration
- Accurate and linear over sensor detection range
- Typically fail safe operation

**Limitations**
- Cross sensitivities – response to gases other than the target gas
- Electrolyte contamination
- Some sensors very sensitive to humidity and temperature transients, eg: NO, ETO
Detection Technology – Toxic Gas

Chemcassette®

- 25 ppb Arsine
- 1 ppm Hydrogen Fluoride
Detection Technology – Toxic Gas

Chemcassette®

- 25 ppb Arsine
- 1 ppm Hydrogen Fluoride
Chemcassette Technology
Paper Tape Gas Detection Pros & Cons

**Advantages**
- Very sensitive measurement
- Specificity to target gas
- Accurate and linear
- Wide range of tapes available

**Limitations**
- Tapes are time sensitive
- Cost
- Temperature & Humidity
Summary

• Three types of gas hazards:
  - Combustible or flammable
  - Toxic
  - Asphyxiates

• Combustible or Flammable
  - Catalytic Bead Sensor
  - Non-Dispersive Infrared (NDIR)
  - Photo Ionization (PID)

• Toxic and Asphyxiate Gases
  - Electrochemical – SureCell™
  - Paper Tape – Chemcassette®
<table>
<thead>
<tr>
<th>Technology</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalytic bead</td>
<td>Simple, measures flammability of gases. Low cost proven technology.</td>
<td>Can be poisoned by lead, chlorine and silicones that remains an unrevealed failure mode. Requires oxygen or air to work.</td>
</tr>
<tr>
<td>Electrochemical</td>
<td>Measures toxic gases in relatively low concentrations. Wide range of gases can be detected.</td>
<td>Failure modes are unrevealed unless advanced monitoring techniques used. Requires oxygen to work.</td>
</tr>
<tr>
<td>Infrared</td>
<td>Does not require oxygen to work. Not affected by poisons or inhibitors. Accuracy very stable. Normally fails safe.</td>
<td>Cannot detect hydrogen, acetylene, carbon disulphide. High cost compared to catalytic bead sensor. Affected more by changes in temperature and pressure.</td>
</tr>
<tr>
<td>PID</td>
<td>Does not require presence of oxygen. Sensitive to PPM levels. UV Tube is self-cleaning.</td>
<td>Unable to identify type of gas being detected. Sensor maintenance may be required.</td>
</tr>
<tr>
<td>Paper Tape</td>
<td>Highly sensitive and selective for toxic gases. Leaves physical evidence of the gas exposure.</td>
<td>Can require sample conditioning and extraction systems. Complex and expensive.</td>
</tr>
</tbody>
</table>
Graphic References

- **PPM:** [https://i.ytimg.com/vi/rGRjYB DwFmU/hqdefault.jpg](https://i.ytimg.com/vi/rGRjYBDwFmU/hqdefault.jpg)
- **Fire**
  - [http://www.texturex.com](http://www.texturex.com)
- **Triangle-sign-flammable-gas**
  - [www.dreamstime.com](http://www.dreamstime.com)
- **Toxic-Gas diamond sign**
  - [www.healthcareasia.org](http://www.healthcareasia.org)
- **HOT word (with flaming letters)**
  - [www.colourbox.com](http://www.colourbox.com)
- **Cold word (with frozen letters)**
  - [www.shutterstock.com](http://www.shutterstock.com)
- **Humidity (green circle with water drop & percent sign)**
  - [www.neofarmers.com](http://www.neofarmers.com)
- **Thermometers (red & blue mercury)**
  - [www.123rf.com](http://www.123rf.com)

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