The Basics of Gas Monitors

It wasn’t that long ago that miners carried canaries down into the mine with them to monitor the atmosphere.

Rob Vajko
6/1/2009
The Basics Gas Monitors

It wasn’t that long ago that miners carried canaries down into the mine with them to monitor the quality of the air around them. The principle was that the small bird because of his size and sensitivity to gases would pass out and die thus letting the workers know that they needed to get out because the atmosphere wasn’t healthy. We have, fortunately for canaries the world over, come a long way. Needless to say, it’s fortunate for workers too as some of the gases that might be present are potentially slow to affect the body and or so dangerous that by the time the canary was noticed, workers would be dropping right along with the canary.

Today, gas monitoring measures in the PPM range (parts per million) in order to make sure that no one is being exposed to even minute amount of harmful gases or chemicals; Gas monitoring can be done remotely to ensure that the area is clean before a worker has to go in and gas monitoring can be fixed and permanent to allow for instant detection of leak in potentially hazardous areas.

Before we look at the different types of gas detection available, let’s start by defined the terms we are going to need in order to speak intelligently about this issue.

Defining the Terms

**Ambient** – A term used to refer to the normal state of the surrounding atmosphere.

**IDLH** – Immediately Dangerous to Life and Health. The is used to designate an environment in which a worker would not be able to survive unharmed for 30 minutes without a breathing apparatus.

**Combustibles** – Any gas or particle that is capable of igniting or burning.

**Flammability Range** – This is the range between the LEL and the UEL at which flammable can burn if a source of ignition is present.

**Flashpoint** – This is defined as the temperature at which a combustible liquid vaporizes enough to produce an explosive condition.

**LEL** – Lower Explosive Limit. This is the smallest amount of the gas at which combustion may occur.

**PEL** – Permissible Exposure Limit. This number is set by OSHA as the legal limit of exposure for a worker.

**PPM** – Parts Per Million
TLV – Threshold Limit Value. This level refers to the duration of time that a worker can be exposed to a particular chemical or gas without any adverse effect resulting. Three different types of TLVs are defined:

- **TLV - TWA** – Time Waited Average. This is a measure of the TLV that gives the average concentration at which a worker can be exposed to a chemical for 8 hours a day, 5 days a week over a lifetime without adversely affecting his health.
- **TLV - STEL** – Short Term Exposure Limit. This measure of the TLV defines the maximum concentration over a period of 15 minutes. This level of exposure cannot be exceeded more than 4 times in a day.
- **TLV-C** - Ceiling. This is a measure of the TLV. Concentration cannot exceed this value at any time.

UEL – Upper Explosive Limit. The UEL means that the concentration of gas is so high that there is now not enough oxygen present to allow a reaction to occur.

**Vapor Density** – This is the weight of a vapor as compared to air. Gases that are lighter than air tend to rise while gases that are heavier than air tend to sink and displace the Oxygen.

**What is the difference between gases and vapors?**
A gas is a gas at room temperature and pressure and can be made to return to its liquid form by lowering the temperature and increasing the pressure. Vapors, on the other hand, are in a liquid state at room temperature and pressure.

**Why are Gas monitors necessary?**
A gas monitor is used for one of three reasons:

1. **It is needed to detect oxygen deficiencies or enrichment.** When the oxygen level drops too low the human body cannot function. The individual in an oxygen deficient environment will get drowsy or, if the deficiency is high, will pass out. Unless the oxygen level is restored, the individual will die. Oxygen deficiencies are actually a lot more common than you might realize. Many gases are heavier than air and displace the oxygen. When these gases are clear, the deficiency isn’t noticeable. An atmosphere is considered deficient when the concentration of \( O_2 \) is less than 19.5%.
   Additionally, an environment that has too much oxygen in it is equally dangerous. An atmosphere is considered enriched when the concentration of \( O_2 \) is over 23.5%.
   A gas monitor that measures the \( O_2 \) level becomes indispensable in the detection of oxygen.
deficient environments.

2. **It is needed to detect gases that are harmful (Toxic) to the human body.** \( \text{H}_2\text{S} \) is a classic example of this. \( \text{H}_2\text{S} \) is given off by bacteria when it breaks down nonorganic matter and, because it is heavier than air can not only displace air but is, additionally harmful to the human body and is considered a broad-spectrum poison (one that affect a number of different organs in the body). It is beyond the scope of this article to go into the effects of \( \text{H}_2\text{S} \) but a quick glance through Wikipedia is all that’s needed to convince that this is not something that any of us want to inhale. While \( \text{H}_2\text{S} \) does have a distinctive odor it is certainly not something that one can simply trust one’s nose to protect against. Gas monitors can pick up and alert users to the presence of \( \text{H}_2\text{S} \) long before it has the potential to harm.

3. **It is needed to detect flammable (combustible) gases.** The dangers that can be averted with a gas monitor are not only the dangers from inhaled gases. Flammable gases are also a potential hazard. A gas with an LEL sensor detects and warns against flammable gases. Below is a list of the most common gases and the explosive limit. Gas monitors are typically set to sound an alarm when the limit reaches 10-20% of the LEL.

According to OSHA, a hazard exists when the combustible gas concentration exceeds 10% LEL but, depending on the situation, the alarm levels may need to be set at 5% LEL or lower in order to allow workers to get out in time.

### Common Combustible Gas LEL's

<table>
<thead>
<tr>
<th>Gas</th>
<th>LEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone (CH(_3))(_2)CO</td>
<td>2.15%</td>
</tr>
<tr>
<td>Acetylene C(_2)H(_2)</td>
<td>2.5%</td>
</tr>
<tr>
<td>Benzene C(_6)H(_6)</td>
<td>1.2%</td>
</tr>
<tr>
<td>Butadiene C(_4)H(_6)</td>
<td>1.1%</td>
</tr>
<tr>
<td>Ethane C(_2)H(_6)</td>
<td>3.0%</td>
</tr>
<tr>
<td>Ethyl Alcohol CH(_2)H(_5)OH</td>
<td>3.3%</td>
</tr>
<tr>
<td>Ethyl Ether (C(_2)H(_5))(_2)O</td>
<td>1.7%</td>
</tr>
<tr>
<td>Ethylene C(_2)H(_4)</td>
<td>2.7%</td>
</tr>
<tr>
<td>Hexane C(_6)H(_14)</td>
<td>1.1%</td>
</tr>
<tr>
<td>Hydrogen H(_2)</td>
<td>4.0%</td>
</tr>
<tr>
<td>IsoButane C(_4)H(_10)</td>
<td>1.8%</td>
</tr>
<tr>
<td>Isopropyl Alcohol (IPA) (CH(_3))(_2)CH(_3)OH</td>
<td>2.0%</td>
</tr>
<tr>
<td>Methane CH(_4)</td>
<td>5.0%</td>
</tr>
<tr>
<td>Methanol CH(_3)OH</td>
<td>6.0%</td>
</tr>
</tbody>
</table>
Pentane        C5H12        1.5%
Propylene      C3H6        2.0%
Toluene        C7H8        1.2%

It is important to note that because different gases have different densities, they will tend to form layers in confined spaces or areas where there is little air movement. When monitoring the air in these spaces it is important to make sure and monitor all levels.

What factors should I take into consideration when purchasing or renting a gas monitor?

1. Do you need datalogging? Do you only need to have the alarm go off if there is a problem or do you want a complete record of all levels present at all times? Datalogging comes in several different formats with some only recording the data for the past 30 minutes and others recording for much longer. Find out which one you will need and make sure that your instrument can do what you need it to.

2. How often am I going to use the instrument? Are you only going to use it a couple of times a month or daily?

3. Do I want rechargeable batteries or disposable batteries to power the instrument? If one has its advantages and drawbacks and you need to be sure and make sure that the one that you choose will match the application you will have for the instrument.

4. Do I know what I am looking for or will there be unknown elements present? Entering a certain room where there might be a CO gas present is a completely different job than entering a sewer system where any number of potential hazards might be present. In the former case a single gas monitor to detect CO might be all that is needed, in the latter case a four, five or six gas monitor will probably required to ensure the safety of the worker.
Types of Gas Detectors

Catalytic Sensors (also known as “Hot Bead” sensor)
This sensor ionizes the combustible gas and measures the change in resistance that results from the change in temperature.

CMS (Chip Measurement System)
This method is similar to the detector tubes below, except that it utilizes an electronic optical reader.

Detector Tubes
This consists of Individual glass tubes through which the air is pulled. In the tubes is a reagent that changes color as it reacts to the specific chemical.

Electrochemical Sensors
This sensor utilizes electrodes. The gas passes through a gas permeable membrane to produce a chemical reaction with the electrode which results in an electric current. This current is then read and measured in order to identify the compound as well as the concentration.

Flame Ionization Detector (FID)
The instrument burns the sampled gas using a hydrogen flame. An electrode collects the organic compounds and measures the generated current.

Infrared Detectors (IR)
This sensor measures light, more specifically the absorption of infrared light to identify carbon dioxide $O_2$)

Photo Ionization Detector (PID)
This sensor measures VOCs (Volatile Organic Compounds) using ultraviolet light to ionize the gas.

Sample Collection and Analysis
This method draws air through a sampling media. The media is then analyzed in a lab to determine contaminants and levels.

Portable vs. Fixed Systems

When would a fixed system make sense?
There are many instances where it does not make sense to have every employee walking around with a gas monitor clipped to his or her belt all day long. When normal atmospheric conditions prevail but there is the potential for exposure to a certain chemical(s) or substance(s) it makes sense to set up a fixed system to detect when a problem arises. Food processing plants that freeze their product are a good example here. Food processing uses Ammonia in cold storage. Ammonia is highly toxic even in very
minute quantities. A fixed system that would detect a leakage is a very effective way to monitor the plant to make sure that no one is ever at risk. Sensors placed at strategic locations and set to detect very small amounts of ammonia will alert operations to any leak that might be present. There is no other atmospheric hazard present so there is no need to monitor for other potential problems.

Parking garages are another great application for fixed systems. Because cars are going in and out all day, there is a potential for CO to built up in areas that might not be properly ventilated or where the ventilation might not be working properly. Strategically located CO monitors would alert operations to a buildup of CO that might become a problem.

The two most common gases and what you need to know about them

**Carbon Monoxide**

Carbon Monoxide is the leading cause of accidental poisoning in America. CO is produced when combustion is present and is a result of incomplete combustion from cars and other combustion engines. Even small amounts of CO can be harmful and fatal. CO bonds to the blood cells in the human body and block the transport of oxygen essentially starving the body of O₂. Because CO is colorless and odorless and has almost the same density as air it often isn’t detected until it is too late.

**Hydrogen Sulfide**

H₂S is produced by bacterial breakdown of organic material such as sewage, compost, sediment, etc... It is highly toxic even at low concentrations. Though colorless, it has the smell of rotten eggs at low concentrations (1-100 PPM) but that distinct odor decreases as the concentration increases (over 100 PPM). It is heavier than air and tends to displace oxygen. Even at concentrations as low as 500 PPM it can be fatal within 30 minutes to an hour.

**When should I be using a gas monitor?**

A gas monitor should be used in any situation where there might be an impure atmosphere. Confined spaces, where gases may accumulate are an obvious example of such a situation (See “The Basics of Confined Space” for further information).

**Calibration**

It is important to make sure that the instrument you are going to be using has been calibrated and is functioning properly. Follow manufacturer recommendations and guidelines with regards to the frequency of a full calibration.
Additionally, you will need to “Zero” the instrument in fresh air prior to each use. Do not make the mistake of zero adjusting in an atmosphere that you are not certain is fresh air. Many accidents have occurred when a user has zero adjusted the instrument in an environment that really had some level of toxicity.

There are some great options to make this a very simple and automated process. Docking stations with automatic calibration ensure that the instruments are always fully charged and calibrated at all times. This is especially interesting for companies that have multiple gas monitors to track, maintain and calibrate.

**What is a “bump” test?**
A “bump” test simply involves exposing the sensors to a known concentration of gases in order to make sure that the sensors detect those concentrations correctly.

**What is the difference between a “bump” test and a calibration?**
A bump test only makes sure that the sensors are working properly within a certain margin of error while a full calibration includes adjustments to account for and rectify the degeneration that many sensors experience as they get older.

**Other pertinent information regarding gas monitors**

- Be aware that certain compounds can “poison” sensors and cause them to read inaccurately or alarm when they shouldn’t. Silicone or silicone based products are one of the main culprits in this regard. We have had many instances where companies have complained that the sensors were failing only to find out that the instruments had been cleaned with silicone based cleaners or had been exposed to silicone in some other manner. Other “poisons” include Hydrogen Sulfide, Phosphates and Lead. Additionally Freon, trichloroethylene and methylene chloride can cause the sensors to fail.

- Be aware also that the nature of the work being done can often change the nature of the atmosphere. Compressors, welding, etc... can produce fumes and vapors that can rapidly render the air hazardous. Continued monitoring is essential.

- It is important to understanding the nature of the potential hazards and to adequately prepare for them. This means setting alarm setpoints low enough to allow workers to get themselves out of danger before the atmosphere become hazardous. It also means planning escapes to allow plenty of time.
Conclusion
It is beyond the scope of this document to go into the various types of gases, vapors and other hazards. Anyone who is going to be using a gas monitor should be properly trained in the nature of the hazards that they might be encountering as well as in the use of the gas monitor in order to insure that they are safe at all times.

This document is only a “basics of...” and there is much, much more that goes into fully understanding and using gas monitors and dealing with atmospheric hazards.

Additional training classes and continued education is highly recommended.
Appendix A

Some examples of various types of gas monitors

Multi-Gas Monitors

GasAlertMicro 5 by BW Technologies

Providing protection from up to five potential atmospheric hazards including oxygen, combustible and toxic gases, GasAlertMicro 5 is unparalleled in its versatility, capability and overall value. BW’s newest addition to its water-resistant line of portable gas detectors has transformed the market with its matchless array of features. Continuously monitoring and displaying concentrations of up to five gases, the compact and lightweight GasAlertMicro 5 was designed and engineered with an extensive host of applications in mind.

Features

- Integral concussion-proof boot
- Optional integral motorized pump option for remote sampling
- Powered by three AA alkaline batteries or a hot-swappable rechargeable battery pack
- Triple alarms (audible, visual and vibrating)
- Multi-language support in English, French, German, Spanish and Portuguese
- Large, user selectable backlit LCD
- Four alarm levels: Low, High, TWA and STEL
- Compatible with MicroDock II Automatic Test and Calibration Station
- Datalogging models store and recall event information
- Wide range of user selectable field options including password protection, safe and stealth modes.

Self-Tests

- Full function self-test confirms sensor, battery and circuitry integrity and audible/visual alarms on activation
Single-Gas Monitors

GasAlertClip Extreme Single Gas Monitor

BW Technologies has raised the bar for maintenance-free detection with the new GasAlertClip Extreme. Providing two years of protection from H2S, SO2, CO or O2, the water-resistant GasAlertClip Extreme has a built-in concussion-proof boot and is ideal for amphibious operations and high-moisture environments.

Equipped with two alarm levels and an internal vibrator, the GasAlertClip Extreme now features four visual LEDs, and a high-output audible alarm. The large, alphanumeric display provides instant notification of gas alarms, test status, life remaining (months then days then hours) and peak (maximum) exposures encountered.

The GasAlertClip Extreme’s advanced microprocessor performs a full function self-test automatically on startup and on demand to verify sensor, circuit and battery integrity, as well as audible/visual alarm operation.

Generating a permanent record of gas alarm events has never been easier. The GasAlertClip Extreme allows for effortless transmission of stored event data to a cordless printer or a PC for review and analysis.

Despite being loaded with features, the GasAlertClip Extreme is compact and light, which makes it comfortable to wear. Clip it to your lapel, pocket, belt or hardhat for unequalled protection.

Available as a 3-year monitor for CO or a 2-year monitor for H2S, CO SO2 or O2
Fixed Systems

**BW Technologies Rig Rat III**

**Rig Rat III wireless, multi-point detection system**

The Rig Rat III wireless multi-point system continuously monitors for toxic gases, combustibles and oxygen hazards. The self-contained, intrinsically safe site controller is equipped with built-in alarms for instant notification. Independent power, wireless digital signal transmission and plug-in options provide total flexibility. Engineered for maximum cost-effectiveness, the Rig Rat III transmits real-time digital data as far as 1.8 miles (3 km). Installation costs are reduced by up to 75% through eliminating the need for cabling, wiring, conduit and trenching. The solar-capable Rig Rat III is completely modular in design, with plug-in ports for all field interfaces, including remote sensors, remote alarms and relays. Add, change or reconfigure system components as your requirements evolve.

The Rig Rat III's microprocessor-based operation and forefront sensor technology assures peerless reliability and performance. The Rig Rat III is the ultimate in stand-alone detection.

**Field Tough:** Rig Rat III provides unwavering performance in extreme conditions, from deserts to the Arctic.

**Easy Installation:** Equipped with a rugged weatherproof stainless steel enclosure and built-in mounting flanges, simply mount the detector to the wall and supply power.

**Facility Monitoring:** Multi-point systems can be expanded to 100 or more individual monitoring points, with each detector coded to a separate channel.

**Perimeter Monitoring:** The most cost-effective solution to perimeter monitoring.

**Portable Monitoring:** The only portable, multi-point monitoring system in the world--field-proven on mobile work sites, such as drilling/service rigs, HAZMAT and disaster response teams.

**Detector Sub-Site Controller:** The detector can activate remote relays and a solenoid driver to control emergency shutdown devices (ESD), building ventilation systems and other field interfaces.

**Features**
- Independent power and radio signal transmission
- Microprocessor operation ensures performance and reliability
- Flexible power choices--battery, solar, 110/230 VAC
- Encoded digital signal transmission up to 1.8 miles (3 km)
- Real-time LCD readouts for all detectors and sensors
- Simple, straightforward, user-friendly operation
- Modular engineered design
- Status panel advises all features and functions
- Plug-in ports for remote sensors and options
- Dual alarm levels for each sensor (adjustable)

**NOTE:** Listed below are all the parts and pieces of the Rig Rat III. This is primarily designed for users who already have a unit in service and are looking for replacement parts or looking to expand their already existing system. Because there are so many different options and features, we highly recommend that a facility that is looking at installing a new system from scratch call our instrumentation specialist at 1-800-213-7092 so that we can assist you.

**Additional links to:**
- [Detection Tubes](#)
- [CMS Electronic Detector Tube System](#)
- [Sample Collection](#)