The widespread use of portable gas monitors for the protection of hazardous gases has spawned much interest as well as confusion about the sensing technologies behind the scenes. Gas detection and monitoring systems are used as safety devices to alert workers to the potential danger of poisoning by toxic gas exposure, suffocation due to lack of oxygen and fire or explosion caused by combustible gases. The sensors in any gas monitor are the heart of the instrument, and the foundation of gas detection.

Review of Sensor Technologies Used in Portable Gas Monitors

By Herman Kramer and Kay Mangieri

What is the life span and shelf life of my sensor?
Why are some sensor types used for certain gases, but not others?
What is the response time for my sensor?
What is the sensitivity of my sensor?
What is the selectivity of my sensor?

To help answer these questions and more, each sensor technology will be described in terms of general principles, common uses, advantages and disadvantages. After determining which sensor options are best suited for your application, there are additional considerations when it comes to the features of the gas monitor itself.

Catalytic

The catalytic sensor, also referred to as the catalytic bead sensor, is commonly used to detect and measure combustible gases and vapors from 0-100% LEL (Lower Explosive Limit). The sensor’s response to a combustible gas depends on the chemical composition, the molecular weight and vapor pressure of the gas. Also, a minimum oxygen concentration of 5-10% by volume in the mix of diffused gas is generally required for the sensor to operate properly. The catalytic sensor is less sensitive to temperature and humidity effects, offers repeatable performance and is relatively stable. It is, however, susceptible to poisoning or inhibition from some gases, which may decrease its sensitivity or damage the sensor beyond recovery. The catalytic sensor is used in both portable and fixed gas detection systems.

Electrochemical

Electrochemical sensors are widely used for the detection of toxic gases at the PPM level and for oxygen in levels of percent of volume (% vol). Toxic gas sensors are available for a wide range of gases, including sensors for carbon monoxide, hydrogen sulfide, sulfur dioxide, nitrogen dioxide, chlorine and many others. Although the sensors are designed to be specific to each gas, there are often some cross interferences with other gases present. Electrochemical sensors are usually small (typically ≤ 1 inch diameter) and require little power usage which is beneficial for portable gas monitors. The sensors can be used over a wide temperature range (−20°C to +60°C is common), though for improved accuracy temperature compensation is often built into the instrument electronics. Overall, electrochemical sensors offer very good performance for the routine monitoring of toxic gases and percent of volume oxygen presence in both portable and fixed gas monitors.

Thermal Conductivity

For many years, the thermal conductivity sensor has been used in instruments for measuring combustible gases above the % LEL range and for leak detection. The thermal conductivity sensor does not require oxygen to operate, and it is not susceptible to poisoning. One drawback is that it cannot measure gases with thermal conductivities similar to the reference gas (i.e. Nitrogen). Thermal conductivity sensors are used primarily in portable gas leak detectors.

Non-Dispersive Infrared Absorption (NDIR)

The non-dispersive infrared sensor, commonly referred simply as the infrared sensor, can detect gases in inert atmosphere (little or no oxygen present), are not susceptible to poisoning, and can be made very specific to a particular target gas. The limitation of NDIR technology for gas detection is dependent on the uniqueness of the absorption spectrum of a particular gas. NDIR sensors are also extremely stable, quick to respond to gas and can tolerate long calibration intervals. Infrared sensors are commonly used to detect methane, carbon dioxide and nitric oxides in both portable and fixed gas detection instrumentation.

Metal Oxide Sensors (MOS)

A variety of MOS sensors are available for the detection of combustible gases, chlorinated solvents and some toxic gases, such as carbon monoxide and hydrogen sulfide. MOS sensors, also referred to as solid-state, are inherently non-specific, and as a result are quite useful in applications where the atmospheric hazards are unknown. The output of the MOS sensors varies logarithmically with the gas concentration. This limits the accuracy of the sensor and the overall measuring range of the sensor. Changes in the oxygen concentration, humidity and temperature also affect the sensor performance. Although MOS sensors are relatively low cost, the stability and repeatability of the sensor are poor. Power consumption is high due to the heating of the element, which restricts the use of this sensor in portable devices. MOS sensors are commonly used in low cost, hard-wired fixed gas detection systems.

Photoionization Detector (PID)

Photoionization detectors are often used in situations where high sensitivity (sub-PPM levels) and limited selectivity (broad-range
in size and big in value. Confined space kits. Weighing just 8.6 ounces and carrying an all-inclusive 2-year warranty, the M40 is small and ‘Quick Cal’ calibration. Each M40 monitor comes equipped with a charger, nylon carrying case, cell-monitor into confined spaces, you realize that there is a good chance that they will be bumped or dropped, stored in a hot truck, or hit with a strong blast of gas. These factors affect the sensor’s ability to react to gas at the maximum accuracy possible.

The importance of regular instrument calibration is critical to prevent inaccurate readings. Using a known concentration of test gas, the instrument reading is compared to the actual concentration of the gas and then adjustments are made to the readings if they do not match. Today, most direct-reading instruments offer quick, push-button calibration with electronic corrections in place of older potentiometer adjustments.

Conversely, the FID is very sensitive and provides a linear response across a wide variety of combustible gases. The ionization energies of a flame ionization detector are lower and have a large spread that results in a response for all gaseous hydrocarbons such as methane and ethene, up to and including the heaviest fuel oils. As the response factors are limited, an FID reading has a better representation of the actual gas concentrations, while a PID does not. The technical side of an FID is somewhat more complex than a PID as hydrogen is needed for service the sample and it must be of high purity. Changing or filling the hydrogen cartridges is a high-pressure operation that requires training. However, calibration is less frequently required, while a PID requires calibration and a zero adjustment before taking the measurements in the field to compensate for background conditions. Due to the nature of the technology flame ionization detectors tend to be considered for specialized applications and are more costly than the other detection devices.

Multi-gas instruments with interchangeable sensors provide flexibility of monitoring for a variety of applications. However, sensor technologies are not suitable for all gas types and crossinterferences may inhibit some sensor combinations. Any sensor technologies in the same package to accommodate the best total solution for environments with multiple gas hazards.

The M•Cal automatically charges the M40’s lithium-ion battery, and its two-printer is available for printing the calibration/bump test results. Upon completion of the calibration, the unit will also automatically print or download the results via a computer. LED indicators let you know whether or not the instruments have passed or failed the desired function. The unit will also verify the instrument’s ability to react to gas at the maximum accuracy possible.

Sensors and Calibration

Contrary to what you may have been led to believe, there is no electronic method for compensation or a full self-calibration of sensors that will correct the effects of drifts, shocks, or extreme exposure to gas or temperatures. When you think about a typical industrial environment and the multiple workers that carry the monitors into confined spaces, you realize that there is a good chance that they will be bumped or dropped, stored in a hot truck, or hit with a strong blast of gas. These factors affect the sensor’s ability to react to gas at the maximum accuracy possible.

The importance of regular instrument calibration is critical to prevent inaccurate readings. Using a known concentration of test gas, the instrument reading is compared to the actual concentration of the gas and then adjustments are made to the readings if they do not match. Today, most direct-reading instruments offer quick, push-button calibration with electronic corrections in place of older potentiometer adjustments.

With the latest operating systems, many instruments provide the option to track and display the last calibration date and/or the next date the instrument is due for calibration. This feature allows the user to be certain that the instrument has been calibrated and maintained within an acceptable time frame.

There is no global standard or universal procedure written to direct companies, mainly because many types of instruments are used in various environments and use conditions. The best way to ensure regular instrument calibration is to develop a procedure that includes a schedule for bump testing and full calibration for all gas detectors in a company’s fleet.

Automated Calibration Systems

Until recently, the manual process for routine tasks command either on-shift or outsourced service technicians to handle the maintenance schedule for a fleet of instruments. Many companies have discovered the convenience and cost savings of automated calibration stations or full function instrument management systems, such as the Docking Station™ from Industrial Scientific. These instrument docking systems enable automated function or “bump” testing, calibration, battery charging, record-keeping, data warehousing and instrument management. Previon successors and colleagues acceptance support the benefits of automated fleet management, scheduled instrument maintenance, footstep record-keeping, and associated reduction of liability.

Low-Cost M40 Multi-Gas Monitor Provides Industrial Strength Features

The M40 is a versatile multi-gas detector capable of measuring carbon monoxide, hydrogen sulfide, oxygen and combustible gases for a wide variety of confined space and personal monitoring applications. Built with the durability and simplicity found in every Industrial Scientific instrument, the M40 is a low-cost alternative for simultaneous monitoring and display of any combination of one to four gases.

The M40’s rugged composite case is immune to radio frequency and electromagnetic interferences may inhibit some sensor combinations. Although some of the technology platforms date back fifty years, research and development efforts continually challenge and improve the performance of sensors used for gas detection.

Marrying the best-suited sensor technologies with a solid electronic design gives you the ideal result for best personal protection against hazardous gases. Today’s life-preserving gas monitors are technically advanced and purpose-built with features that are designed to deliver superior performance and longevity. Not only are the instruments built with your choice of sensor options, the cases and maintenance can be fully automated which ultimately saves time and money.

Automatic Calibration and Bump Testing Now Available for the M40 Multi-Gas Monitor

Industrial Scientific has made managing your fleet of Multi-Gas Monitors easier and more cost effective with the M4Cal™ Calibration Station. The M4Cal automatically charges the M40’s lithium-ion battery, and its two-button operation allows you to quickly and easily perform function tests or calibrations.

Once a calibration or function test is complete, bright LED indicators let you know whether or not the instrument was passed or failed the desired function. The unit will also automatically print or download the results via a standard PC/printer interface. An optional aerial data printer is available for printing the calibration/bump test certificates, which are ideal for confined space entry permits or long-term record-keeping.

The M4Cal is available in two single-unit versions and several six-unit versions that can accommodate M40s either in a diffusion mode or with the optional SP40 sampling pump attached.