Review of Sensor Technologies Used in Portable Gas Monitors

GAS DETECTION

By Herman Kramer and Kay Mangieri

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 of 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.

Which sensing technology is most appropriate for my application?

Why are some sensor types used for certain gases, but not others?

What is the life span and shelf life 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° to +50°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 poisons. 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 atmospheres (little or no oxygen present), are not susceptible to poisons, 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

coverage) is desired. PID's are commonly used for detecting Volatile Organic Compounds (VOC's) such as benzene-/toluene/xylene, vinyl chloride and hexane, and provide quick response for this growing concern. Advantages of this technology include the fast response time and excellent shelf life (however sensor life is poor). Major disadvantages are that PID's suffer from sensor drift and humidity effects, making calibration requirements more demanding than other common gas detectors. PID technology is most commonly found in portable instrumentation.

Flame Ionization Detector (FID)

Flame ionization detectors are analytical devices that are used to detect hydrocarbons, and other flammable compounds. 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 ethane, 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 ionize 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.

Mixing and Matching Sensor Technologies

Over the course of the years, sensor miniaturization and advanced signal processing have enabled manufacturers to use a mix of sensor technologies in the same package to accommodate the best total solution for environments with multiple gas hazards. 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 cross-interferences may inhibit some sensor combinations. Any questions regarding suitability for use should be addressed with the instrument manufacturer.

Reliable performance of gas monitoring instruments depends on routine calibration and preventive maintenance schedule. Manufacturers have made great strides in improving calibration convenience to minimize the pain, but given the current sensor technologies in these long-lasting monitors, calibration continues to be a required practice.

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 drops, shocks, or extreme exposures 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-staff 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. Proven successes and colleague acceptance support the benefits of automated fleet management, scheduled instrument maintenance, foolproof record-keeping, and associated reduction of liability.

Summary

This summary of gas sensing technologies is not exhaustive, but hopefully is comprehensive for comparative purposes. 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 electronics design gives you the ideal match for the 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 care and maintenance can be fully automated which ultimately save time and money.

About the Author

Herman Kramer is the Manager, Integrated Systems for Industrial Scientific Corporation in Breda, The Netherlands. Mr. Kramer has a B.S. in Chemical Engineering and over 20 years experience in the safety industry. Herman has worked for Industrial Scientific for over ten years and can be reached by phone at: +31 76 542 7609, or via e-mail: hkramer@indsci.com

Kay Mangieri is responsible for planning and directing all marketing functions for Industrial Scientific Corporation. Ms. Mangieri received her M.S. degree in Industrial Administration, marketing concentration, from Carnegie Mellon University prior to joining the Company in 1992. Contact her at: +1 412 490-1869, or via e-mail: kmangieri@indsci.com

SPEC-Sensors.com代理商联系方式:

样品,报价,评估板,参考设计,技术支持

电话:0755-82565851

邮件:dwin100@dwintech.com

手机:156-2521-4151

网址: http://www.dwintech.com/Gas_Sensor_Pamphlet.html

深圳市南频科技有限公司

D-Win Technology(HongKong) Co.,Ltd