Homeland Security
Science and Technology

TechNote

U.S. Department of Homeland Security

SAVER
System Assessment and Validation for Emergency Responders

The U.S. Department of Homeland Security (DHS) established the System Assessment and Validation for Emergency Responders (SAVER) Program to assist emergency responders making procurement decisions. Located within the Science and Technology Directorate (S&T) of DHS, the SAVER Program conducts objective assessments and validations on commercially available equipment and systems, and develops knowledge products that provide relevant equipment information to the emergency responder community.

SAVER Program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?" These knowledge products are shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state, and local responders.

The SAVER Program is supported by a network of Technical Agents who perform assessment and validation activities. This TechNote was prepared for the SAVER Program by Sandia National Laboratories.

Sandia National Laboratories

For more information on this and other technologies, contact the SAVER Program by e-mail or visit the SAVER website.

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Handheld Multi-Gas Detectors

Handheld multi-gas detectors are important tools for emergency responders when responding to calls where dangerous levels of gases may be present, such as unknown odor, fuel spill, clandestine laboratory, or arson investigations. Two challenges faced by responders in these environments are (1) whether the air is acceptable for normal, unprotected breathing, and (2) whether the air is clear of potential contaminants. Handheld multi-gas detectors are usually the first line of screening for environmental hazards such as oxygen (O_2) deficiency or enrichment and elevated levels of combustible and/or toxic gases.

Overview

Handheld multi-gas detectors are usually equipped with sensors to monitor O_2 levels and detect the presence of combustible and toxic gases in the environment. The number of sensors available on a detector varies widely and the sensors are typically interchangeable to monitor for different gases. Handheld multi-gas detectors use these sensors to analyze the surrounding air and report the concentration of monitored gases and/or general toxic risks in real time. Handheld multi-gas detectors feature visual, audible, and/or tactile alarms to warn the user when dangerous environmental conditions are present. Additional considerations include the detector's sensitivity, operating ranges, selectivity, and data logging capabilities.

O_2 Monitoring

O_2 sensors monitor O_2 levels in the environment to detect deficiency or enrichment. O_2 sensors typically display readings as a percent of O_2 by volume in the air and can also indicate whether another gas is present. For example, if there is a 1 percent drop in the normal rate of O_2 in the air, it likely means that some other gas is present. O_2 sensors are either lead wool or solid polymer electrolyte (SPE). Lead wool O_2 sensors have a lifespan of about 2 years and SPE O_2 sensors generally last 3 to 5 years. While they may last longer than lead wool O_2 sensors, SPE O_2 sensors have higher power requirements, typically shortening the battery runtime of the detector.

Combustible Gas Detection

Lower explosive level (LEL) sensors, also referred to as combustible gas sensors, monitor the environment to detect elevated levels of combustible gases. These sensors are used to measure the LEL of the gas for which they are calibrated. Most LEL sensors are calibrated for pentane (C_5H_{12}), and can also be calibrated for other combustible gases, such as methane (CH_4 [i.e., natural gas]) or propane (C_3H_8). Different types of LEL sensors are available and include metal-oxide semiconductor (MOS),

catalytic bead, and infrared (IR). MOS LEL sensors are the most sensitive and therefore perhaps most useful in determining the source of small gas leaks. Detectors with MOS LEL sensors will shut off when the LEL of a monitored gas is exceeded to protect the sensor, since the longer the sensor is exposed to gas above the LEL, the faster it will deteriorate and require replacement. Catalytic bead LEL sensors will also shut the detector off when the LEL of a monitored gas is exceeded. However, these sensors are more durable since they feature a dual-sensor construct that compensates for ambient temperature, humidity, and atmospheric pressure, all of which can shorten sensor life. Both MOS and catalytic bead LEL sensors require sufficient O_2 levels in the environment to monitor combustible gases, whereas IR LEL sensors can monitor combustible gases in O_2 deficient atmospheres. In addition, IR sensors can withstand relatively longer exposure to combustible gases than MOS or catalytic bead sensors and are therefore capable of reporting the percent by volume of a monitored gas even after levels exceed the LEL.

Toxic Gas Detection

Many multi-gas detectors feature sensors for carbon monoxide (CO) and hydrogen sulfide (H_2S), and some offer detection capabilities for additional toxic gases, such as ammonia (NH_3), chlorine (Cl), formaldehyde (CH_2O), carbon dioxide (CO_2), nitrogen oxides (NO and NO_2), sulfur dioxide (SO_2), and ozone (O_3). Toxic gases are monitored with either electrochemical toxic gas sensors, MOS toxic gas sensors, or photoionization detectors (PIDs). Electrochemical toxic gas sensors are small, easily interchangeable, consume very little battery power, and are highly specific to the target gas being monitored. A limitation of electrochemical toxic gas sensors is that gases with similar properties of a monitored gas may cause false positives. For example, when monitoring for Cl, the sensor may detect other chemicals within the halogen group that have similar properties (e.g., bromine [Br]) and provide a positive reading for Cl. MOS toxic gas sensors and PIDs are less specific and therefore able to identify a wide range of toxic gases. This low level of specificity could be an advantage in situations where unknown toxic gases may be present. Limitations of MOS toxic gas sensors include high battery consumption and the potential for false positives (i.e., mistaking some background gases for toxic ones). PIDs are more sensitive than MOS sensors and will detect toxic gases at lower levels, providing results more rapidly; however, PIDs require frequent calibration. Humidity affects the sensitivity of both MOS toxic gas sensors and PIDs. With increased humidity, PIDs become less sensitive and therefore less likely to detect the presence of a toxic gas in the environment, whereas MOS toxic gas sensors become more sensitive and may therefore overstate the presence of a toxic gas. Additionally, very low humidity can decrease the sensitivity of MOS toxic gas sensors, potentially hindering their ability to detect the presence of a toxic gas.

Additional Considerations

The sensitivity of a handheld multi-gas detector is an important consideration and refers to the lowest concentrations of chemicals in the air that are detectable. Another key consideration is the operating ranges of the sensors, which are the measurable ranges of concentrations that can be reported. The sensitivity and operating ranges will vary by sensor and thus by the type of hazard being monitored. Some multi-gas detectors can be configured to monitor one chemical or group of chemicals and ignore others. This is referred to as selectivity and permits the user to focus on particular hazards of concern with a greater degree of confidence. Some detectors are also capable of data logging and can therefore store information for transmission to a computer for further analysis. This capability allows the user to download key data to create reports, track calibration, sort and graph detection data, and archive information relative to a response.

Additional Information

For additional information on handheld multi-gas detectors and similar technologies, visit the SAVER website at www.firstresponder.gov/SAVER. SAVER documents that may be of interest include the following:

- Handheld Multi-Gas Detectors Application Note
- Multi-Sensor Meter Chemical Detectors Market Survey Report and Assessment Report
- Handheld Photoionization Detectors Market Survey Report and Assessment Report
- Portable Ion Mobility Spectrometry (IMS) Chemical Detectors Market Survey Report.