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 commercial equipment and systems and provides those results along with other relevant equipment information to the emergency response community in an operationally useful form. SAVER provides information on equipment that falls within the categories listed in the DHS Authorized Equipment List (AEL).

The SAVER Program is supported by a network of technical agents who perform assessment and validation activities. Further, SAVER focuses primarily on two main questions for the emergency responder community: "What equipment is available?" and "How does it perform?"

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

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NUSTL

Flame and Photo Ionization Detectors, Portable

Portable Flame Ionization Detectors (FIDs) are used by first responders to detect the presence of organic compounds, including hydrocarbons and volatile organic compounds (VOCs). These substances may be toxic or form flammable or explosive mixtures with air, so it is important for responders to be aware of their presence in order to assess the danger when responding to hazardous materials (HazMat) incidents. Portable FIDs are designed for field use, relatively rugged, simple to operate, inexpensive to purchase, and can measure many hydrocarbons over very wide concentration ranges. Photo Ionization Detectors (PIDs) are similar to FIDs but use a different type of detector. PIDs can detect substances for which FIDs are not effective, including some toxic VOCs and inorganic compounds.

How Portable FIDs Work

A portable FID uses a hydrogen-air flame to combust the sample in a carrier gas (usually air) and detect its concentration by measuring the generation of liberated ions (charged atoms or molecules). The flame is surrounded by a high polarizing voltage produced by two electrodes located near the flame (Figure 1). The polarizing voltage creates an electrostatic field that causes the positively and negatively charged ions generated by combustion of the sample to migrate towards the electrodes, producing a current. The magnitude of the current is directly proportional to the concentration of organic species in the sample gas stream. The current is measured with an ammeter circuit, and an output device produces a reading, which is displayed as a total concentration in parts per million (ppm) or mg/m^3.

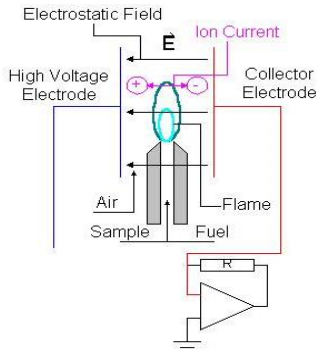

Figure 1. Principle of Flame Ionization Detector
Photo courtesy of J.U.M. Engineering

Portable FIDs measure the total concentration of all ionizable chemicals present in the sample but do not distinguish between individual substances. FIDs detect only compounds containing carbon; they do not respond to inorganic compounds. Simple saturated hydrocarbons (e.g., methane, hexane, ethane, propane, etc.) produce the highest response. However, FIDs are less sensitive to organic compounds that contain nitrogen, oxygen, sulfur, or halogen atoms. In general, the magnitude of the response depends on the chemical structure of the organic compound. Information about FID responses to various organic compounds can be found in the Resources section.

How Portable FIDs Are Used

Simplicity of operation, high sensitivity, and a wide measurement range are the major advantages of portable FIDs. For example, many hydrocarbons can be measured over a range of 0.1 to 50,000 ppm. Portable FIDs can detect VOCs (e.g., benzene, solvents, and pesticides) and many other carbon-containing compounds, including toxic compounds such as hydrogen cyanide. Portable FIDs are used by HazMat emergency response teams in chemical response incidents to detect the presence of potentially flammable, explosive, or toxic substances (Figure 2). They are also used for natural gas leak detection, fugitive emissions monitoring, hazardous waste site evaluation, and leak detection in fuel and chemical storage tanks.

Figure 2. Detecting Leaks from a Chemical Drum Using a Portable FID
Photo courtesy of INFICON, Inc.

Portable FIDs are usually calibrated daily to adjust the meter readout to correspond to the value of a calibration gas. Most FIDs used by first responders automatically record and store data in an onboard data logger. Some incorporate wireless technology for downloading data to another device, such as a computer or mobile phone.

FIDs require a hydrogen fuel source; usually the hydrogen is stored as a metal hydride in a low-pressure fuel cylinder. Because mixtures of hydrogen and air may be flammable, precautions need to be taken when refilling the hydrogen supply tank and igniting the flame. A factor that may influence the selection of a portable FID is whether the FID has been certified as intrinsically safe by Underwriters Laboratories, Inc.

FID Limitations and PIDs

Portable FIDs are relatively rugged and resistant to misuse, inexpensive to purchase and operate, require little maintenance, and can measure many organic compounds, especially hydrocarbons, at very low and high concentrations. They do have a limited operating time for continuous use, which depends on the capacity of the fuel supply and the life of the battery.

However, as noted above, FIDs do not respond well to organic compounds that contain nitrogen, oxygen, sulfur, or halogen atoms, and they cannot detect inorganic compounds, such as ammonia, which does not have a carbon atom in its molecular structure. These compounds might best be measured using another type of detector, such as a PID, instead of an FID.

PIDs use a high-energy ultraviolet (UV) light source to ionize the molecules in a sample collected by an air pump. The ions produce an electric current, which is converted to a concentration reading. Unlike FIDs, which completely burn the sample collected, PIDs ionize only a small portion of the sample, so the remaining sample can be further analyzed with another type of detector. PIDs detect only those substances that can be ionized by the UV photons. This includes chlorinated hydrocarbons, formaldehyde, amines, methanol, aromatic compounds, some toxic VOCs, and some inorganic compounds, such as ammonia and hydrogen sulfide, all substances for which FIDs are not effective. PIDs cannot detect methane, the principal component of natural gas, because this substance is not ionized by UV.

Unlike FIDs, PIDs do not require hydrogen or other fuels for operation. Instruments that combine both FID and PID (Figure 3) are capable of detecting a wide range of chemical compounds, both organic and inorganic, and may be more convenient to use and maintain than separate FID and PID instruments.

Figure 3. Portable Dual FID/PID Analyzer
Photo courtesy of Thermo Fisher Scientific, Inc.

Resources

TVA1000 Response Factors
http://www.petersonenvironmental.com/ThermoTVA1000ResponseFactors.pdf, 2000.

Technical Note: Response factors for Flame Ionization Detector Operation
http://www.raecorents.com/products/gasmonitoring/Photovac-Inficon-MicroFID-II/FID-response-factors-diaf56a1-2012.pdf, 2012.