System Assessment and Validation for Emergency Responders (SAVER)

Portable Flame Ionization Detectors Market Survey Report

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FOREWORD

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. The SAVER Program mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency response equipment
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use, and maintain emergency response equipment.

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 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. As a SAVER Program Technical Agent, the National Urban Security Technology Laboratory (NUSTL) has been tasked to provide expertise and analysis on key subject areas, including chemical, biological, radiological, nuclear, and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation, and technologies. In support of this tasking, NUSTL developed this report to provide emergency responders with information gathered during a market survey of commercially available portable flame ionization detectors, which fall under AEL reference number 07CD-01-DPFI titled Flame Ionization Detectors, Portable.

For more information on the SAVER Program or to view additional reports on flame ionization detectors or other technologies, visit www.firstresponder.gov/SAVER.

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1. INTRODUCTION

Portable flame ionization detectors (FIDs) are used by emergency responders to detect the presence of potentially flammable or toxic gases and vapors at hazardous materials (hazmat) incident sites. FIDs are the most widely used detectors in gas chromatographic (GC) instruments for measuring hydrocarbons and other organic species. However, GC instruments designed for laboratory use are not appropriate for use in the field due to their large sizes and high fuel requirements. Hence, portable FIDs were developed for emergency responders. Portable FIDs are 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 volatile organic compounds (VOCs) and inorganic compounds. To provide emergency responders with information on portable FIDs and on an instrument containing a dual FID/PID, the System Assessment and Validation for Emergency Responders (SAVER) Program conducted a market survey.

This market survey report is based on information gathered between June 2014 and August 2014 from manufacturers, vendors, Internet research, industry publications, and a government-issued Request for Information (RFI) that was posted on the Federal Business Opportunities website (https://www.fbo.gov). For inclusion in this report, the portable FIDs and dual FID/PID instrument had to meet the following criteria:

- Commercial-off-the-shelf (COTS)
- Handheld
- Capable of measuring total concentrations of chemical compounds including hydrocarbons and VOCs
- Capable of being operated on internal battery power
- Intended primarily for use by emergency responders.

Due diligence was performed to develop a report that is representative of products in the marketplace.

2. PORTABLE FID AND PID OVERVIEW

Portable FIDs are used by first responders to detect the presence of organic species including hydrocarbons and 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 hazmat incidents. Portable FIDs are designed for field use, relatively rugged, simple to operate, inexpensive to purchase, and require little maintenance. They can measure many hydrocarbons (e.g., methane, ethane, propane, hexane, etc.) over very wide concentration ranges. The concentration readings provided by these instruments represent the total concentration of all ionizable chemicals present in the samples. FIDs do not distinguish between individual substances. Readings may vary from the actual air concentrations depending on the ionization potential of the compound. Users can read total concentration directly on the instrument display.

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.

2.1 Current Technologies

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 2-1). 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 which 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 milligrams per cubic meter. Most portable FIDs use igniters that can immediately reignite the flame if it should go out.

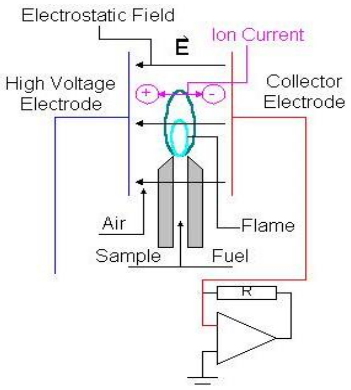

Figure 2-1. Principle of Flame Ionization Detector
Photo courtesy of J.U.M. Engineering

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 photons. In addition, the readings from PIDs are affected by environmental moisture, while FIDs are unaffected by ambient levels of water vapor. Unlike FIDs, PIDs do not require hydrogen or other fuels for operation.

An instrument that combines both FID and PID has recently become available. This dual FID/PID instrument is capable of detecting a wide range of chemical compounds, both organic and inorganic. For certain applications, a dual FID/PID instrument may be more convenient to use and maintain than separate FID and PID instruments.

2.2 Applications

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. In addition, portable FIDs can be used to 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 2-2). They are also used for checking the atmosphere in a confined

space before entry, and for natural gas leak detection, fugitive emissions monitoring, hazardous waste site evaluation, and leak detection in fuel and chemical storage tanks.

Most portable FIDs used by first responders automatically record and store data in an onboard data logger. Some models use wireless technology for downloading data to a device, such as a computer or mobile phone.

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

Portable FIDs require a hydrogen fuel source; usually the hydrogen is stored as a metal hydride in a low-pressure fuel cylinder. Mixtures of hydrogen and air are flammable. Safety precautions need to be taken when refilling the hydrogen supply tank and igniting the flame. Portable FIDs should be certified intrinsically safe for use. Other factors that should be considered when selecting portable FIDs for field use include the capacity of the fuel supply and the operating life of the battery. Portable FIDs should be calibrated daily to adjust the meter readout to correspond to the value of calibration gas.

Limitations of portable FIDs are:

- FIDs completely combust the sample, which cannot be used for further analyses.
- FIDs detect only compounds containing carbon.
- FIDs respond poorly to certain organic compounds containing nitrogen, oxygen, or halogen atoms.
- FIDs cannot detect inorganic compounds, such as ammonia, which does not have carbon in its molecular structure.
- FIDs should not be used in areas with high ground moisture, which can cause the FIDs to flame out or not ignite at all.
- FIDs do not detect carbon monoxide and carbon dioxide.

Some of these limitations can be overcome with dual a FID/PID instrument that can be used for a broader range of applications—including site remediation, landfill monitoring, and surveying chemical spills— than instruments that use only a single FID or PID.

2.3 Standards/Calibration

Manufacturers of some commercial instruments claim performance and specifications consistent with protocols of the U.S. Environmental Protection Agency (EPA) Method 21 for the determination of VOC leaks in process equipment. Method 21 does not specify the type of instrument detector, but catalytic oxidation, infrared absorption, flame ionization, and photo ionization detectors are included. The detector specifications and performance given in Method 21 are: (1) the detector shall respond to the compounds being processed, (2) the instrument shall be capable of measuring the leak definition concentration (the local VOC concentration at the surface of the leak source) specified in the applicable regulation, (3) the scale of the instrument meter shall be readable to ±2.5 percent of the specified leak definition concentration, (4) the instrument shall be equipped with an electrically driven pump to ensure that a sample is provided to the detector at a constant flow rate, which normally shall be 0.1 to 3.0 liters/minute (0.004 to

0.1 cubic feet/minute), (5) the instrument shall be equipped with a probe or probe extension for sampling not to exceed 6.4 millimeters (0.25 inches) in outside diameter, with a single end opening for admission of sample, and (6) the instrument shall be intrinsically safe for operation in explosive atmospheres.

ASTM International standards exist for flame ionization detectors (e.g., ASTM E594), but these are intended primarily for laboratory applications involving gas or supercritical fluid chromatography.

FIDs and dual FID/PID instruments need to be calibrated by the user at intervals of every 6 months or as otherwise specified by the manufacturer. The calibration certification is usually provided by the manufacturer or supplier with the instrument when purchased.

3. PRODUCT DATA

This section provides information on two portable FIDs and one portable dual FID/PID that range in price from $9,600 to $15,000 and include the certifications as intrinsically safe for use. Table 3-1 provides product features and specifications, and the following sections describe each product. Product information was obtained directly from manufacturers, their websites, and the government-issued RFI. The information has not been independently verified by the SAVER Program. Clarification of product features and specifications in Table 3-1 is provided below, listed in column order:

Company	The name of the product manufacturer or distributor
Product	The name of the specific product
Size	Length, width, and height of the product in inches (in)
Weight	Weight of the product in pounds (lbs)
Measurement Range	Concentration range in parts per million (ppm)
Response Time	Response time for detection in seconds (sec)
Temperature Range	Temperature range over which the product can be operated in degrees Fahrenheit (^{o}F)
Data Upload	Means of uploading data to a personal computer (PC)
Battery Life	Operating life of the battery in hours (hrs)
GPS	Whether or not the product includes a Global Positioning System (GPS)
Detector Type(s)	Whether or not the product has a single detector (FID) or dual detector (FID/PID)
GSA	Whether or not the product is available on the GSA Schedule
Price	Unit cost of the product as quoted by the manufacturer or vendor in U.S. dollars ($)

Table 3-1. Product Comparison Matrix

Company	Product	Size (in)	Weight (lbs)	Measurement Range (ppm)	Response Time (sec)	Temperature Range (°F)	Data Upload	Battery Life (hrs)	GPS	Detector Type(s)	GSA	Price ($)
INFICON, Inc.	MicroFID II	13 x 12 x 3	11	0.1 - 50,000	3	32 - 122	Bluetooth® Wireless	13	No	FID	Yes	12,000
INFICON, Inc.	DataFID	13 x 12 x 3	11	0.1 - 50,000	3	32 - 122	Bluetooth Wireless	13	No	FID	No	15,000
Thermo Fisher Scientific, Inc.	TVA2020	11.5 x 9 x 4	9.4	0 - 30,000	3.5	14 - 113	Direct-cable, Bluetooth Wireless	10	Yes	FID/PID	No	9,600 - 14,000*

* Price depends on features and accessories selected

Information in the table is based on data gathered from manufacturers and their websites between June 2014 and August 2014

3.1 INFICON, Inc.: MicroFID II

The MicroFID II is designed for hazmat detection, confined space entry, and soil gas monitoring. It provides measurements over a range of VOCs between 0.1 and 50,000 ppm, which helps to define the severity of the hot zone, the area that is considered to be dangerous. The MicroFID II is certified as intrinsically safe by Underwriters Laboratories, Inc. (UL) for use in potentially explosive environments. The MicroFID II is portable, lightweight, and has an oversized carrying handle. The instrument has a conveniently mounted sampling inlet with an optional telescoping probe, large keypad, backlit display, and rapid sampling response time.

An earlier model, the MicroFID, is no longer in production and has been replaced by MicroFID II.

MicroFID II

Photo courtesy of INFICON, Inc.

3.2 INFICON, Inc.: DataFID

The DataFID is used to measure VOCs in potentially hazardous environments. Its design includes an external Bluetooth antenna to increase wireless coverage and provide connectivity with a datalogging Personal Digital Assistant (PDA). The DataFID can be used with a Leak Detection and Repair (LDAR) probe that is compatible with Guideware® or LeakDAS® software for leak detection and repair operations. It uses a low-pressure hydrogen supply weighing only 105 grams. Additionally, the Hydrostik™ metal-hydride hydrogen fuel cylinder provides high-purity, low-pressure (80 psi) hydrogen to the DataFID for continuous VOC monitoring. The refillable cylinder provides 10 hours of hydrogen supply and is small enough to easily fit in a pocket. It is approved by the International Civil Aviation Organization (ICAO) to be shipped via air cargo or hand-carried (limit of two per person) onto an aircraft. The DataFID is equipped with a nickel-metal hydride (NiMH) battery that provides 13 hours of continuous operation when fully charged, easily allowing users to monitor for a full shift. The long-life battery, internal detector, high-purity, low-pressure hydrogen fuel supply, and the ruggedized electronics in the DataFID provide continuous, accurate, and repeatable total VOC measurements between 0.1 and 50,000 ppm. The DataFID is also certified as intrinsically safe by UL.

DataFID

Photo courtesy of INFICON, Inc.

3.3 Thermo Fisher Scientific, Inc.: TVA2020

The TVA2020 includes both flame ionization and photo ionization detectors and can be configured either as an FID only or dual FID/PID instrument. The TVA2020 can be used to quickly measure organic and inorganic compounds to detect chemical leaks at processing plants, industrial facilities, and hazardous waste sites, and to monitor landfills and remediation sites. The TVA2020 weighs 9.4 pounds and is certified intrinsically safe by FM Approvals® of FM Global. With its dual FID/PID detectors, the TVA2020 enables users to detect both organic and inorganic compounds and eliminates the expense of purchasing and maintaining two separate instruments. Key features include fast response time, GPS capability, and fast reading of data compared with single-detector technology. Price depends on the features and accessories selected, such as GPS module, carrying case, hydrogen refill assembly, an enhanced probe featuring an LCD display, multiple sampling probe configurations, and Bluetooth connectivity.

TVA2020

Photo courtesy of Thermo Fisher Scientific, Inc.

The TVA2020 replaces two earlier models, TVA1000 and TVA1000B, which were discontinued by the manufacturer.

4. VENDOR CONTACT INFORMATION

Additional information on the portable FIDs and dual FID/PID included in this market survey report can be obtained from the vendors listed in Table 4-1.

Table 4-1. Vendor Contact Information

Vendor	Product	Address	Contact Information
INFICON, Inc.	MicroFID II, DataFID	2 Technology Place East Syracuse, NY 13057	www.inficon.com reachus@inficon.com (315) 434-1100
Thermo Fisher Scientific, Inc.	TVA2020	27 Forge Parkway Franklin, MA 02038	www.thermoscientific.com orders.aqi@thermofisher.com (866) 282-0430

5. SUMMARY

Portable FIDs are used by emergency responders to detect the presence of potentially flammable or toxic gases and vapors at hazmat incident sites. FIDs measure hydrocarbons over wide concentration ranges, but they 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 a FID. An instrument using a dual FID/PID can measure a wider range of organic and inorganic compounds than instruments that use a single FID or PID.

This market survey report focuses primarily on portable FIDs and includes three products from two manufacturers. Product features/specifications and purchase prices are listed in Table 3-1. One of the included instruments uses a dual FID/PID. Careful assessment of the features, specifications, capabilities, and limitations of the various commercially available products will allow agencies to acquire the equipment best suited to their particular needs. Prices, features/specifications, and capabilities may change with time; therefore, agencies should contact equipment manufacturers to obtain the most up-to-date information before choosing to purchase specific equipment. The products generally come with a warranty of 1 year from the date of shipment.

6. REFERENCES AND RESOURCES

Highlight: Photo-Ionization and Flame-Ionization Detectors, U.S. Department of Homeland Security, SAVER, September 2006
http://www.firstresponder.gov/SAVER/Documents/PhotoFlameIonDetect_HLT.pdf

Inficon DataFID operating manual
http://products.inficon.com/GetAttachment.axd?attaName=5a207b8d-1e39-4266-ac6c-a3ee6709c8a3

Inficon MicroFID II operating manual
http://products.inficon.com/GetAttachment.axd?attaName=01654655-d89b-48d1-8fad-28f31c208654

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

Thermo Fisher Scientific TVA2020 instruction manual
http://www.thermoscientific.com/content/dam/tfs/ATG/EPD/EPD%20Documents/Product%20Manuals%20&%20Specifications/Air%20Quality%20Instruments%20and%20Systems/Ambient%20Gas/EPM-manual-TVA2020.pdf