Homeland Security

Science and Technology

Summary

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 operational tests 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?"

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Photoionization Detectors for Vapor Chemical Constituents

In support of the Department of Homeland Security (DHS) Standards Portfolio, a team including the Idaho National Laboratory, Neptune and Company, and Science Applications Intelligence Corporation (SAIC) conducted Incident Commander (IC) interviews to determine the efficacy, reliability, maintainability, and training of agent detection equipment used by their organizations. The interviews were conducted between January 2005 and October 2006, and the data were collated in November 2006. The report does not provide an analysis of equipment, but does collect the issues and concerns of a regionally diverse group of ICs as well as the non-specific adequacies and deficiencies of the equipment on hand. The report does not provide an analysis of equipment, but does not collect the issues and concerns of a regionally diverse group of ICs as well as the non-specific adequacies and deficiencies of the equipment on hand. The report also provides a description of photoionization detectors (PIDS) and manufacturer-provided PIC information.

Background

PIDs are low-cost, lightweight, and easy to use. PIDs are field instruments that provide rapid information about volatile organic compounds (VOCs) in air samples. A stand-alone PID is usually classified as a total organic vapor (TOV) analytical method. This means PIDS provide information about the relative magnitude of contamination, but are unable to directly distinguish specific compounds. First responders have numerous uses for PIDs. PIDs are used in combination with other tests to ensure first responders have appropriate measurement technologies for evaluating incident scenes in the early phase of a field investigation.

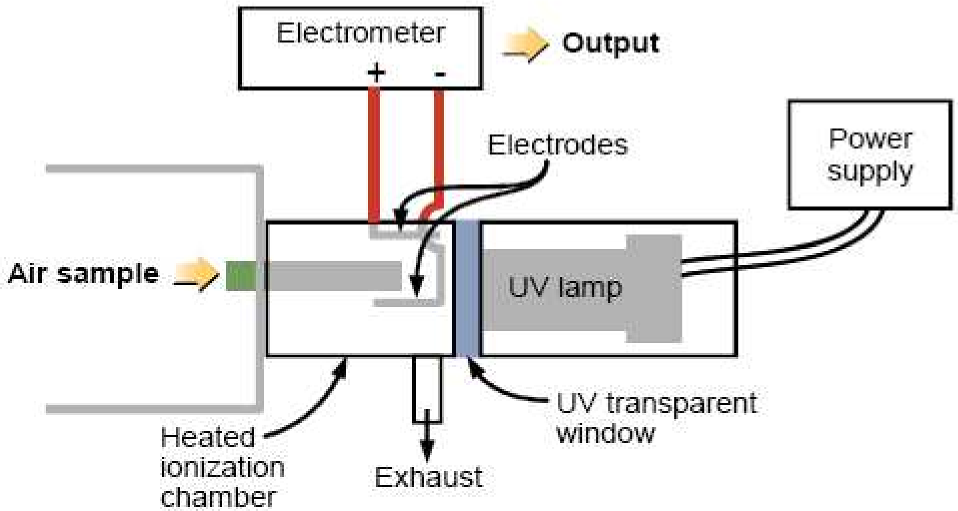

Figure 1. PID Instrument Diagram

The critical component of a PID is a lamp, which produces photons in ultraviolet (UV) energy range. The sample is collected by a small air pump and introduced into the PID where it passes in front of the lamp and is exposed to UV radiation. Atoms and molecules in the sample that have an ionization potential (IP) lower than the energy of the UV lamp are ionized with some efficiency. An electric field then pulls ions to the appropriate electrode where a current can be measured. It is the measurement of this current that allows the user to determine chemical vapors in the air.

See figure 1 for a diagram of a PIC instrument.

A benefit of using PIDs includes the ability to work in both high humidity and low oxygen environments, but there is a calibration process that must be implemented to ensure proper results.

Manufacturers and Models

First responder practitioners reviewed the PID market and identified the following PIDs:

- *Aerion Technologies, AIM 450 PID*
- *Gray Wolf Sensing Solutions, Direct Sense ™ TdVOC-PPB Multi-Gas PID Monitor, Industrial Scientific, VX500 PID*
- *Ion Science, FirstCheck 5000 PID*
- *Mine Safety Appliances, Sirius ™ Multigas Detector with PID*
- *Photovac, 2020PROPlus Photoionization Monitor*
- *PID Analyzers, Model 102 Snap-on PID ™ Photoionization Analyzer*
- *RAE Systems, Area RAE*
- *RAE Systems, MiniRAE 2000*
- *RAE Systems, ToxiRAE Plus PID*
- *RAE Systems, ppbRAE Ples*
- *RAE Systems, MultiRAE Plus*

Thermo Electron, TVA-1000B Toxic Vapor Analyzer These PIDs are readily available to the emergency response community, as well as others that were not reference in the report. Based on previous assessments of these models, it was determined that all instruments assessed, as reported by their manufacturers, performed adequately. Dynamic range is a discriminator, with two instruments capable of measuring constituents in the lower parts per billion (ppb) ranges, while most cover high ppb to part per million (ppm) ranges. Cost ranged from $1.5K to $7K. Battery life for most instruments was roughly 1 to 2 days, while one instrument claimed 160 hours. Most instruments were very light and portable, with two exceptions that weighed more than 8 pounds.

The report also provided a chart (table 1) on information provided by PID manufacturers for first responders to use as a reference.

Assessment Plan

ICs from several U.S. and Canadian communities were interviewed to determine the emergency responder's perspective on instrumentation available for measurement of vapor threats. The summary of these interviews was presented as an appendix to the same series of questions and those answers were recorded as part of the appendix.

Results

Based on generalized questions in the interviews of nine ICs, the results and answers varied, but several overall conclusions can be made based on their answers.

Questions were asked about maintenance and training issues. In summary, the interviews revealed that:

- A critical metric for ICs is false negative findings. ICs have indicated that false positives will short themselves out, since follow-up analyses are always necessary to evaluate a finding's importance.
- Instrument manufacturers have sometimes oversold the capabilities of their instruments, resulting in the purchase of ineffective or inadequate instrumentation. Independent third party evaluation of instrument capabilities is an important need.
- Instruments used by first responders were originally designed for other purposes. ICs would like to see instruments specifically designed to meet first responder needs and specifications.
- Exotic chemicals such as chemical warfare agents (e.g., VX, GB, mustard) are viewed as less likely terrorists threat than fertilizer/fuel bombs and large volume transporters of chlorine gas, gasoline, and other fuels.

Instrumentation Conclusions

It was determined that two no two ICs reported their jurisdictions as using the exact same detection equipment, although many used the same type of PID, detector tube, and/or test papers. All ICs felt the information received from the equipment was accurate, but there were a few key issues with the equipment that create issues for the ICs and their jurisdictions. Those issues include:

- Abilities claimed by manufacturers rarely match the performance of the equipment; therefore, there is a need for a truly independent considering field performance using conditions established by first responders. There is a need for a repository of non-manufacturer-provided information on equipment that ICs can access to determine what equipment should be purchased.
- The equipment used by the jurisdictions interviewed cannot specifically identify what the vapor is; it merely identifies that a vapor

exists, and frequently, the equipment used

cannot determine the concentrations that are

Manufacturer/Instruments	Precision (variability, re-peatability, etc.)	Dynamic Range	Response Time (sec)	Humidity Range (% rh)	Display	Data log	Wireless	Weight (lbs)	Battery life in Single Field Use
Aerion Technologies www.aimsafety.com									
AIM 450 PID	10%			0-80			Numerical LED	3.2	8
GrayWolf Sensing Solutions, LLC www.wolfsense.com									
Direct Sense TVOC-ppm MultiGas PID Monitor		0.1-5,000 PPM	60	0-90					180
Direct Sense TVOC-ppb Multi-Gas PID Monitor		0.02-20	60	0-90					180
Industrial Scientific Corporation www.indsci.com									
VX500 Photoionization Detector		0.1-5,000 ppm	3	0-90	Yes	1,800	No	1.6	18
Ion Science, Ltd www.ionscience-americas.com/pages/first.htm									
FirstCheck 6000	5%	0-10,000 ppm	1	0-99			LCD numerical and 20,000 point data log	1.3	10 to 16
FirstCheck 5000	5%	0-10,000 ppm	1	0-99			LCD numerical and 20,000 point data log	1.3	10 to 16
Mine Safety Applications Company www.msanet.com									

Table 1. PID Manufacturer-Provided Information

Manufacturer/Instruments	Precision (variability, repeatability, etc.)	Dynamic Range	Response Time (sec)	Humidity Range (% rh)	Display	Data log	Wireless	Weight (lbs)	Battery life in Single Field Use
Passport PID II Monitor									
Passport PID II Organic Vapor		0-10,000 ppm		0-100			Numerical or graphical		
Sirius Multigas Detector	10% or 2 ppm, whichever is greater	0.1-2,000 ppm	20 sec normal: 30 sec ppb range	0-95	yes	Optional	LCD, data logging	1.45	6 to 11
Photovac, Inc www.photovac.com									
2020PRO Photoionization Monitor	10% or 2 ppm, whichever is greater	0.1-2,000 ppm	3				LCD numerical 15,000 points	1.9	8
PID Analyzers, LLC www.hnu.com									
Model 102 PID analyzer	1%	0.1-3,000 ppm	1		Yes	7,000 point	No	1.9	
RAE Systems, Inc www.raesystems.com									
Area RAE	+/- 2 ppm or 10% @ <550 ppm	0.1-2,000 ppm	10	0-95	Yes	10,000 point	Yes	8.5	18
Area RAE Wireless									18

Table 1. PID Manufacturer-Provided Information[a] (Continued)

Manufacturer/Instruments	Precision (variability, repeatability, etc.)	Dynamic Range	Response Time (sec)	Humidity Range (% rh)	Display	Data log	Wireless	Weight (lbs)	Battery life in Single Field Use
MiniRae 2000	+/- 0.5 ppm or 10% @ <2,000 ppm	0-10,000 ppm	3	0-95	Yes	10,000 point	No	1.25	8
RAE Systems, Inc	+/- 0.5 ppm or 10% @ <5000 ppm	0.1-2,000 ppm	20	0-95	Yes	4,000 point	No	0.5	8
PpbRAE	+/- 40 ppb or 10% of reading	0.1-2,000 ppm	5	0-95	Yes	16,00 point	No	1.3	8
MultiRAE Plus	+/- 2 ppm or 10% @ <500 ppm	0.1-2,000 ppm	10	0-95	Yes	10,00 point	No	1	8
Thermo Electron Corporation www.thermo.com									
Photovac 20202 PID Monitor	10% or 2 ppm, whichever is greater	0.5-2,000 ppm	3	0-100		1,000	No	1.75	10
TVA-1000B Toxic Vapor Analyzer	1%	0.1-2,000 ppm					No	12	8

Table 1. PID Manufacturer-Provided Information [a] (Continued)

Note:
[a] If space in blank, then data were not reported by the manufacturer

present.

There is a need for other responder agencies within the jurisdiction (i.e., hazardous material [HAZMAT]) to aid in identification/detection, since the equipment used is limited in its abilities.

The following list of equipment shortcomings is not specific to one type of equipment of one manufacturer, but instead, verify that jurisdictions across the United States and in Canada have shared in some concerns over the equipment used. These shortcomings include, but are not limited to:

- The calibration and maintenance of the equipment
- The overall cost of procuring the equipment
- The amount of training required of first responders to adequately operate the equipment
- False positives due to human error, poor readability, false positives, and/or false negatives
- Battery and sensor life

Incident Scene Conclusions

All agencies have internal procedures in place in order to properly respond to incidents pertaining to release/spills. Additional testing with different methods and meters are used and the assistance of local/mobile laboratories acts as a confirmation tool. Personal protective equipment is chosen through several standards including Standing Operating Procedures, First Responder Operations, National Fire Protection Agency, Occupational Safety and Health Administration, and Environmental Protection Agency (EPA). Pre-arrival information, location of the incident, and on-scene evaluations aid in determining causes, treatment, decontamination, as well as identification of the chemical spill/ release. Additional aid to first responders comes in a myriad of forms, and includes, but is not limited to, emergency response teams (i.e., HAZMAT, Alert teams, Civil Support teams), and EPA laboratories. Additional information can be collected through MSDSs and contacting manufacturers/shippers.

Decision-Making Conclusions

All agencies interviewed participate in a network of ICs, but the majority of the ICs interviewed only do so informally. The ICs in Canada, Los Angeles, and Washington D.C. are part of formal IC networks. Those in the formal networks determine what technologies to use based on national specifications and Authorized Equipment lists. Those without formal networks base their equipment decisions on state and/or country level decisions, or the IC makes the decision locally. Most information on preference and/or quality is provided by the manufacturer and all additional in-depth, on-scene analysis is determined by the IC in coordination with other agencies. All ICs are dependant upon laboratories for in-depth analysis, and most ICs desire more accurate ways of identifying bio-agents.

Maintenance and Training

All ICs interviewed commented that there were programs in place for replacement/ maintenance of equipment, but not all agencies represented in the interviews had non-toxic challenging agents to calibrate equipment of all the training required to properly operate, maintain, and calibrate the equipment. The vendor/manufacturer conduct most training and on-the-job training is then conducted in-house. The majority of ICs interviewed consider their knowledge adequate for assessing what equipment should be used on-scene, but several were not confident and rely on special operations personnel for help. One IC cited the need for an online *Consumer Reports* type repository for information on equipment.