THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

The Business of Innovation

TECHNOLOGY TYPE:	**PASSIVE INFRARED OPTICAL IMAGERS**
APPLICATION:	**LEAK DETECTION AND REPAIR TECHNOLOGIES**
TECHNOLOGY NAME:	**Sherlock® VOC Imaging Spectrometer**
COMPANY:	**Gas Imaging Technologies, LLC**

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ETV Joint Verification Statement

The U.S. Environmental Protection Agency (EPA) has established the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high-quality, peer-reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies. Information and ETV documents are available at www.epa.gov/etv.

ETV works in partnership with recognized standards and testing organizations, with stakeholder groups (consisting of buyers, vendor organizations, and permitters), and with individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field and laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Advanced Monitoring Systems (AMS) Center, one of six verification centers under ETV, is operated by Battelle in cooperation with EPA's National Risk Management Research Laboratory. The AMS Center evaluated the performance of a passive infrared optical imager for leak detection and repair. This verification statement provides a summary of the test results for Pacific Advanced Technologies, Inc. Sherlock® VOC imaging spectrometer.

VERIFICATION TEST DESCRIPTION

This verification test of the Sherlock® VOC imaging spectrometer was conducted October 20 through October 24, 2008 at the British Petroleum (BP) research complex in Naperville, Illinois (laboratory testing) and December 1 through December 5, 2008 at the Dow Chemical Company chemical plants (field testing) in Freeport, Texas. Battelle coordinated this verification test with support from BP, the Dow Chemical Company, the American Chemical Council, and the Texas Chemistry Council.

This verification test utilized simulated gas leaks of select chemicals in a laboratory environment, and under real world conditions at a chemical plant in Freeport, TX. The ability of the Sherlock® VOC imaging spectrometer to qualitatively detect gas leaks of select chemicals by visual images relative to a quantitative concentration measurement made by a portable monitoring device acceptable under U.S. EPA Method 21 was verified. Reference sampling with the portable monitoring device acceptable under U.S. EPA Method 21 was conducted to determine the mass rate of specific chemical species emitted from each leak observed with the Sherlock® VOC imaging spectrometer.

During both the laboratory and field testing, the Sherlock® VOC imaging spectrometer was operated by a representative of Industrial Scientific Corporation, a company with a partnering agreement with Pacific Advanced Technologies, Inc. for the Sherlock® VOC. This verification test utilized two additional individuals to confirm the observation of a leak in an effort to eliminate operator bias. The two additional confirming individuals were the Battelle verification test coordinator and a verification test team member. The use of three individuals to confirm a chemical leak is not standard practice when using the imaging spectrometer; typical operation relies on a single operator.

The detection of a gas leak in either the laboratory or field was determined by the spectrometer operator and the two confirming individuals that reported the results qualitatively as either a “detect” or “non-detect”. All three must have agreed on the results for the observation to be considered detectable. When all three did not agree, the observation was reported as a non-detect. A non-detect was also recorded if the imaging spectrometer operator did not observe a gas leak (i.e., no confirmation of a non-detect was performed). Each observation was conducted using the viewing screen of the spectrometer.

The test quality assurance plan (TQAP) for this verification test indicated that field testing would be conducted at two field sites. Due to production scheduling issues, a second field site could not be obtained in a timely manner and this verification test was completed using the laboratory results and the results from one field test site.

The Sherlock® VOC imaging spectrometer was verified by evaluating the following parameters:

- ***Method Detection Limit*** – The minimum mass leak rate that all three individuals observed using the spectrometer under controlled laboratory conditions. This parameter was not evaluated during the field testing phase.
- ***Detection of Chemical Gas Species Relative to a Portable Monitoring Device*** – The ability of the imaging spectrometer to qualitatively detect a gas leak by visual images relative to a quantitative concentration measurement made by a portable monitoring device acceptable under U.S. EPA Method 21. This parameter was evaluated in both the laboratory and field testing phases.
- ***Confounding Factors Effect*** – Background material, wind speed, and stand-off distance were carefully controlled during laboratory testing to observe their effects on the method detection limit. Background materials used were either curved metal gas cylinders or cement board; wind speed was controlled to zero, 2.5, and five miles per hour (mph); and stand-off distances were maintained at either 10 or 30 feet (ft). During field testing, these variables as well as meteorological conditions were recorded.
- ***Operational Factors*** – Technology ease of use, cost, user-friendliness of vendor software, troubleshooting, downtime, and other parameters such as these were recorded.

QA oversight of verification testing was provided by Battelle and EPA. Battelle QA staff conducted technical systems audits of both the laboratory and field testing, and Battelle QA staff conducted a data quality audit of at least 10% of the test data. This verification statement, the full report on which it is based, and the TQAP for this verification test are available at www.epa.gov/etv/centers/center1.html.

TECHNOLOGY DESCRIPTION

The following is a description of the Sherlock® VOC imaging spectrometer, based on information provided by the vendor. The information provided below was not verified in this test.

The Sherlock® VOC is an infrared optical imaging spectrometer that can be used for video imaging of gas leaks. The spectrometer is portable and battery operated. The Sherlock® VOC is based on patented image multi-spectral sensor technology.

The Sherlock® VOC imaging spectrometer can be used for infrared imaging purposes in many types of industries such as oil, gas, chemical, power generation, pulp and paper, and mining.

The Sherlock® VOC imaging spectrometer has a 75-millimeter focal length lens embedded in the body of the instrument. The lens has a set focal ratio (f-number or f/) of 2.5. The horizontal field of view is approximately seven degrees. The Sherlock® VOC can be carried by an operator using an optional EasyRig harness, enabling pointing and scanning while the operator looks at the liquid crystal display (LCD). This design leaves the operator free to watch for safety hazards in the environment of a processing plant.

VERIFICATION RESULTS

Method Detection Limits and Detection of Chemical Gas Species Relative to a Portable Monitoring Device. Method detection limits were determined during laboratory testing with the Sherlock® VOC imaging spectrometer. The ability of the spectrometer to qualitatively detect a gas leak by visual images relative to a quantitative concentration measurement made by a portable monitoring device acceptable under U.S. EPA Method 21 was assessed during both laboratory and field testing. After the imaging spectrometer method detection limit had been determined for a particular chemical under the specified test conditions in the laboratory, the leak was sampled by the Method 21 compliant monitoring device to determine if it was capable of detecting the chemical leak. Table 1 presents results for the imaging spectrometer and the Method 21 compliant monitoring device obtained during laboratory testing.

During field testing, a portable Method 21 compliant monitoring device was used to screen each leaking component as part of the reference sampling method used. Table 2 reports the responses of the portable monitoring device when screening components, and identifies whether the spectrometer was able to detect the chemical leak from the leaking component. The chemical-specific mass emission rate from the leaking component, determined by the reference method, is also provided.

During field testing, daily meteorological conditions were obtained from the Dow Chemical Company's on-site meteorology station. Although the wind speed and daily maximum and minimum temperatures were obtained from this station, the actual meteorological conditions at each leak location monitored on the site are unknown.

Influence of Confounding Factors. Stand-off distance, wind speed, and background material affected the performance of the Sherlock® VOC imaging spectrometer. For example, increasing the stand-off distance from the leak increased the method detection limits, and increasing wind speed also increased the method detection limits.

Table 1. Summary of Spectrometer Method Detection Limits[(a)] and Percent Agreement with a Method 21 Monitoring Device During Laboratory Testing

Compound	Method Detection Limit (g/hr) Minimum	Method Detection Limit (g/hr) Maximum	Agreement with Method 21 Monitoring Device: Total No. of Tests Performed	Agreement with Method 21 Monitoring Device: Percent Agreement
1,3-butadiene	8.1	27	4	100%
Acetic acid	1.7	81	11	100%
Acrylic acid	0.92	7.4	4	100%
Benzene	3.2	≥70[(b), (c)]	4	40%
Methylene chloride	≥70[(b)]	≥70[(b)]	No data[(d)]	
Ethylene	3.3	≥278[(b)]	2	33%
Methanol	2.1	≥69[(c)]	No data[(d)]	
Pentane	0.83	≥55[(b), (c)]	8	75%
Propane	0.88	235[(b)]	No data[(d)]	
Styrene	15	25	4	100%

(a) Minimum and maximum method detection limits were measured at a 0-mph wind speed unless otherwise noted.
(b) Measured at a 2.5-mph wind speed.
(c) Measured at a 5-mph wind speed.
(d) Percent agreement was not evaluated for methylene chloride, methanol, and propane because these compounds have an ionization potential greater than the energy which could be supplied by the Industrial Scientific IBRID MX6 with photoionization detector.

Table 2. Summary of Field Testing Results of the Sherlock® VOC Imaging Spectrometer

Leak Location	Leaking Component Type	Wind Speed (mph)	Stand-off Distance (ft)	M21 Device Screening Conc. (ppmv)	Leak Detected by Camera?	Bagging Results: Average Leak Rate (g/hr)
1	3-in Plug	8	12	>100,000	No	8.8 (methane) 4.3 (ethylene)
2	¼-in Tube	21	10 30	20,500	Yes No	0.95 (ethylene)
3	½-in Connector	21	10	>100,000	No	2.3×10^{-3} (ethylene) 7.8 (methane)
5	6-in Block Valve	21	10	>100,000	No	5.2×10^{-2} (ethylene) 8.7×10^{-3} (styrene) 0.08 (benzene)
6	8-in Block Valve	21	10	20,500	No	3.4[(a)] (benzene)
7	Control Valve Flange	18	10	17,500	No	1.9×10^{-3} (ethylene) 0.28 (benzene)
8	2-in Block Valve	18	10	8,000[(B)]	No	1.9[(b)] (1,3-butadiene)
9	1-in Valve Plug	18	10	835	No	0.35 (dichloromethane [methylene chloride])
10	6-in Pressure Relief Valve	5	10	>100,000	No	6.8 (1,2-dichloropropane [propylene dichloride])

(a) The pre- and post-bagging leak concentrations differed by 24%. This exceeded a minimum acceptance criterion for data quality indicator (DQI) in the TQAP of 20% for the DQI for the confirmation of detected leaks. Thus, the data are considered suspect and reported with this qualifier.
(b) The calibration check response for the portable monitoring device, conducted after screening this component, resulted in a 24% difference. This exceeded a minimum acceptance criterion for a DQI in the TQAP. Thus, the data are considered suspect and reported with this qualifier.

Operational Factors. The Sherlock® VOC imaging spectrometer was found to be easy to use, and ready to deploy in 10 minutes. The imaging spectrometer weighs 19 pounds with battery, and operated on batteries when performing visual screening of leaking components. Because the imaging spectrometer was operated by Industrial Scientific personnel and there were some disagreements on detections with the two other confirming individuals, the ability of the operator may influence the operation of the instrument. The imaging spectrometer is not intrinsically safe, and cannot be used in explosive atmospheres or environments.

The cost of the Sherlock® VOC imaging spectrometer is $89,000 and includes the LCD video display, a Pelican shipping case, battery, charger, personal computer, HYPAT software, and all necessary cables.

Signed by Tracy Stenner 12/1/10
Tracy Stenner Date
Manager Environmental Solutions Product Line
Energy and Environment Global Business
Battelle

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Sally Gutierrez Date
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