THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

TECHNOLOGY TYPE:	**PASSIVE INFRARED OPTICAL IMAGERS**
APPLICATION:	**LEAK DETECTION AND REPAIR TECHNOLOGIES**
TECHNOLOGY NAME:	**GasFindIR™ Midwave (MW) Camera**
COMPANY:	**FLIR Systems, Inc.**
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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 FLIR Systems Inc. GasFindIR™ Midwave (MW) Camera.

VERIFICATION TEST DESCRIPTION

This verification test of the GasFindIR™ MW camera 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 FLIR GasFindIR™ MW camera 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 FLIR GasFindIR™ MW camera.

During both the laboratory and field testing, the FLIR GasFindIR™ MW camera was operated by a representative of FLIR. 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 FLIR GasFindIR™ camera; typical operation relies on a single operator.

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

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. Confirmation from a second field site was obtained while completing this report. Field testing at the second site occurred in March 2010. The reader is encouraged to contact either FLIR Systems or the Texas Chemical Council to obtain the results of testing completed at a second field site.

The GasFindIR™ MW camera was verified by evaluating the following parameters:

- ***Method Detection Limit*** – The minimum mass leak rate that all three individuals observed using the GasFindIR™ MW cameras 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 GasFindIR™ MW camera 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 mile 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 FLIR GasFindIR™ MW camera technology, based on information provided by the vendor. The information provided below was not verified in this test.

The GasFindIR™ MW camera implements focal plane arrays and optical systems that are tuned to very narrow spectral infrared ranges to enable the camera to detect the infrared energy emitted from certain gases. Images are processed and enhanced by the GasFindIR High Sensitivity Mode™ feature to show the presence of gases against stationary backgrounds. Gases that are detectable by the GasFindIR™ camera appear on screen as light-colored or gray smoke.

The GasFindIR™ MW camera is designed for use in industrial environments and operates in wide temperature ranges. The GasFindIR™ MW camera is a real-time infrared camera that scans at 30 hertz (30 images per second). The camera includes a 25-millimeter (mm) wide-angle lens for scanning a variety of components and operations. For longer-range needs, 50-mm and 100-mm lenses are available from FLIR Systems.

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 FLIR GasFindIR™ MW camera. The ability of the FLIR GasFindIR™ MW camera 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 camera 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 FLIR GasFindIR™ MW camera 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 monitoring device when screening leaking components and identifies whether the FLIR GasFindIR™ MW camera 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 FLIR GasFindIR™ MW camera. For example, increasing the stand-off distance from the leak increased the method detection limits and increasing the wind speed also increased the method detection limits. Changing to an optional magnifying camera lens that can be purchased separately lowered the method detection limit.

Operational Factors. The FLIR GasFindIR™ MW camera was found to be easily set up and ready to deploy in 10 minutes. The camera is light (approximately 4.6 pounds) and operated on batteries when performing visual screening of leaking components. The FLIR GasFindIR™ MW camera may also use optional lenses that can be used to further magnify the images. Because the camera was operated by FLIR and there were some disagreements on detections with the two other confirming individuals, the ability of the operator may influence the operation of the camera. The FLIR GasFindIR™ MW camera is not intrinsically safe, and cannot be used in explosive atmospheres or environments.

Table 1. Summary of FLIR GasFindIR™ MW Camera Method Detection Limits[a] and Percent Agreement with a Method 21 Monitoring Device During Laboratory Testing

Compound	Method Detection Limit (g/hr)		Agreement with Method 21 Monitoring Device	
	Minimum	Maximum	Total No. of Tests Performed	Percent Agreement
1,3-butadiene	1.3	2.7	4	100%
Acetic acid	≤ 0.02	≤ 4.6[b, c]	11	100%
Acrylic acid	0.92	1.2	4	100%
Benzene	0.35	35[c]	12	100%
Methylene chloride	4.9	> 70[c]	No data[d]	
Ethylene	0.35	278[c]	8	100%
Methanol	0.28	22[c]	No data[d]	
Pentane	≤ 0.28	28[c]	16	100%
Propane	≤ 0.44	13[c]	No data[d]	
Styrene	0.35	0.70	3	100%

(a) Minimum and maximum method detection limits shown were measured at a zero-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.

The cost of the FLIR GasFindIR™ MW camera is $64,950 and includes an intelligent battery charger and three lithium ion batteries, an alternating current power supply, a video cable, a personal video recorder and battery, audio/video cable for the personal video recorder, camera neck strap, shipping/carrying case, and operating manual.

The cost of optional 50-mm and 100-mm lenses for the FLIR GasFindIR™ MW camera is $7,500 and $9,950, respectively.

Table 2. Summary of Field Testing Results Using the FLIR GasFindIR™ MW Camera

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-inch (in) Plug	8	12	>100,000	Yes	8.8 (methane) 4.3 (ethylene)
2	¼-in Tube	21	10 30	20,500	No No	0.95 (ethylene)
3	½-in Connector	21	10 30 45	>100,000	Yes Yes Yes	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 (methylene chloride)
10	6-in Pressure Relief Valve	5	10	>100,000	No	6.8 (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, this data are considered suspect and reported with this qualifier.

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