THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Infrared Open-Path Monitor**		
APPLICATION:	**MONITORING AIR QUALITY**		
TECHNOLOGY NAME:	**SafEye 227 Infrared Open-Path Monitor**		
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The U.S. Environmental Protection Agency (EPA) has created 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 substantially 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.

ETV works in partnership with recognized standards and testing organizations; with stakeholder groups that consist of buyers, vendor organizations, and permitters; and with the full participation of 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 or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance 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 technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of optical open-path monitors used to determine pollutants in outdoor air. This verification statement provides a summary of the test results for the Spectrex Inc. SafEye 227 infrared (IR) open-path monitor.

VERIFICATION TEST DESCRIPTION

The test was designed to challenge the SafEye 227 in a manner simulating field operations. The monitor was challenged in a controlled and uniform manner, using an optically transparent gas cell filled with known concentrations of a target gas. The gas cell was inserted into the optical path of the monitor during operation under field conditions, simulating the presence of the target gas in the ambient air. The monitor was challenged with three target gases commonly measured by this monitor (methane, propane, and a gas mixture) at known concentrations, and the measurement results were compared to the known concentration of the target gas. The verification was conducted by measuring the three gases in a fixed sequence over three days. National Institute of Standards and Technology-traceable or commercially certified standard gases, a calibrated gas diluter, and a supply of certified high-purity dilution gas were used to supply the target gases to the gas cell.

Target gases were measured at different path lengths, integration times, source intensities, and numbers of replicate measurements to assess minimum detection limit (MDL), source strength linearity, concentration linearity, accuracy, precision, and sensitivity to atmospheric interferences. The test procedures were nested, in that each measurement was used to evaluate more than one of the above parameters. Cells were flushed periodically with high-purity nitrogen. The MDL was calculated for each target gas by supplying pure nitrogen to the gas cell in the optical path of the monitor and taking a series of 25 single-beam spectra using integration times of 1 and 5 minutes. Two types of linearity were investigated during this verification: source strength and concentration. Source strength linearity was investigated by measuring the effects on the monitor's performance by changing the source intensity. Concentration linearity was investigated by challenging the SafEye 227 with each target gas at varying concentrations, while the path length and integration time were kept constant. Accuracy of the monitor relative to the gas standards was verified by introducing known concentrations of the target gas into the cell. The procedure for determining precision was very similar to the procedure for determining accuracy. The effects of interfering gases were established by supplying the gas cell with a target gas and varying the distance (i.e., the path length) between the source and detector of the monitor.

Quality assurance (QA) oversight of verification testing was provided by Battelle. Battelle QA staff conducted a data quality audit of 10% of the test data. Battelle testing staff also conducted a performance evaluation audit, which was reviewed by QA staff. In addition, during previous verifications of optical open-path monitors, EPA QA staff conducted an independent technical systems audit of the procedures used in this verification.

TECHNOLOGY DESCRIPTION

The SafEye 227 is an alarm system that detects hydrocarbons with a high-frequency IR flash source and two absorbed band sensors centered at the 3.4-µ wavelength. This design also employs a dual-band reference that minimizes environmental factors such as moisture and other background gases to maintain a high signal-to-noise ratio. Other performance features include three levels of logic, four levels of automatic gain control, four built-in calibrations, two span settings, and four flash rates. Operational integrity can be maintained with up to three degrees of misalignment and/or up to 90% signal obscuration. The SafEye 227 is made up of two components: a flash source and a detector. These components can be separated to measure ambient gas concentrations over a path length from 1 to 140 meters. The flash source projects a wavelength (specific for the type of gas to be measured) to the detector over an unobstructed line of sight. The beam is attenuated when a hazardous gas traverses it at any point along its path. The detector measures the amount of attenuation by means of two narrow-band sensors and compares this information to a third reference sensor input that is not affected by the subject gas or environmental factors. The detector's microprocessor software interprets the data and provides output signals in terms of lower explosive limit meters (LEL*m). The detector transmits the data via a 4 to 20 mA signal or an RS485 port; or, if a pre-set gas concentration is exceeded, closes one of three contacts. All the SafEye models (ultraviolet and infrared) are approved for industrial applications by international standards: CENELEC explosion-proof enclosures (per EN 50014, 50018, and 50019), Underwriter's Laboratory, and Factory Method (Class I Division 1, Groups B, C, and D and Class II Division 1, Groups E, F, and G).

VERIFICATION OF PERFORMANCE

Minimum Detection Limit: The SafEye 227 MDL for the three gases tested ranged between 0.003 and 0.012 LEL*m for methane, between 0.001 and 0.008 LEL*m for propane, and between 0.001 and 0.008 LEL*m for the mixture. No consistent trend was found when changing path length. However, increasing the integration time from 1 to 5 minutes reduced the MDL.

Source Strength Linearity: There was little to no degradation of monitor performance with source strength reductions of up to 62%. Near zero slopes for both the 1 and 3 LEL*m tests showed little effect as a result of source strength reduction.

Concentration Linearity: The SafEye 227 had a regression slope of 0.98 and an r^2 value of 0.99 for methane; a regression slope of 0.66 and an r^2 value of 0.76 for propane; and a regression slope of 0.83 and an r^2 value of 0.99 for the mixture over ranges of 1 to 5 LEL*m.

Accuracy: The SafEye 227 had a relative accuracy of between -3.8 and -13% for methane, -23 and 28% for propane, and -6.5 and -12% for the gas mixture.

Precision: Precision results showed that methane data had a relative standard deviation (RSD) of 0.340%, propane data had an RSD of 0.705%, and the mixture data had an RSD of 0.326%.

Interferences: Analysis of the effects of the interferences of water and carbon dioxide on the measuring ability of the SafEye 227 showed that neither the accuracy nor the MDL was affected consistently by the changing concentrations of water and carbon dioxide in the atmosphere. Variations in MDL and relative accuracy were similar to those found during other measurements made under normal operating conditions and no consistent interference effect could be inferred.

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