THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

EPA
U.S. Environmental Protection Agency

Battelle
. . . Putting Technology To Work

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Ultraviolet Open-Path Monitor**		
APPLICATION:	**MONITORING AIR QUALITY**		
TECHNOLOGY NAME:	**SafEye 420 Ultraviolet Open-Path Monitor**		
COMPANY:	**Spectrex Inc.**		
ADDRESS:	**218 Little Falls Road** **Cedar Grove, NJ 07009**	**PHONE:** **FAX:**	**973-239-8398** **973-239-7614**
WEB SITE:	**http://www.spectrex-inc.com/safeye**		
E-MAIL:	**spectrex@spectrex-inc.com**		

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 420 ultraviolet (UV) open-path monitor.

VERIFICATION TEST DESCRIPTION

The test was designed to challenge the SafEye 420 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 (carbon disulfide, benzene, and ammonia) 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 measurements 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 420 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 420 is an alarm system that detects ammonia, aromatics, and hydrogen sulfide, using a high-intensity UV flash source. The detector's three-sensor design includes two absorbed and one reference band sensors. Depending on the gas to be monitored, the band range of the sensors can be tailored with a dip switch to match specific absorption regions. The SafEye 420 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 parts per million meters (ppm*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 420 MDLs ranged between 0.096 and 0.515 ppm*m for carbon disulfide, 0.111 and 0.340 ppm*m for benzene, and 0.081 and 3.53 ppm*m for ammonia, at the path lengths and integration times tested. Changing the integration time from 1 to 5 minutes increased the MDL for carbon disulfide. Changing the path length from 30 to 90 meters reduced the MDL for carbon disulfide and benzene. The opposite effect was seen for ammonia.

Source Strength Linearity: There was little to no degradation of monitor performance with reductions in source strength of up to 62%. In fact, the slopes at two different test concentrations were slightly negative, suggesting that reducing the source strength may have a slight positive effect on the monitor's response over the range tested.

Concentration Linearity: The SafEye 420 had a slope of 0.56 for carbon disulfide, with an r^2 value of 0.47 over a range of 50.3 to 194 ppm*m; a slope of 0.73 for benzene, with an r^2 value of 0.59 over a range of 50.3 to 201 ppm*m; and a slope of 1.2 for ammonia, with an r^2 value of 0.95 over a range of 50.3 to 201 ppm*m.

Accuracy: Relative accuracy for the SafEye 420 was 10 to 126% for carbon disulfide, from 4 to 100% for benzene, and from -41 to 8% for ammonia. The monitor was most accurate when challenged with ammonia. Both carbon disulfide and benzene showed the best relative accuracy at the shortest tested path length (30 meters) and a concentration at the high end of the instrument's operating range (200 ppm*m in the cell); however, the same 30-meter path length also resulted in the poorest accuracy when challenged at lower concentrations.

Precision: The SafEye 420 had a relative standard deviation (RSD) of about 0.00% for carbon disulfide at a gas cell concentration of 194 ppm*m, a 3.52% RSD for benzene at a concentration of 201 ppm*m, and a 2.45% RSD for ammonia at a concentration of 201 ppm*m.

Interferences: Analysis of the effects of interferences of oxygen and ozone on the measuring ability of the SafEye 420 showed that the MDLs were not affected. However, when examining only the accuracy results from the ammonia challenge, the longer path lengths of 90 meters and 100 meters were more accurate than the 30-meter path length, indicating that the increasing presence of interfering compounds did not adversely affect the monitor's ability to measure ammonia. The results from the benzene and carbon disulfide challenges showed no consistent effects, especially in light of the large relative accuracy values found for these two gases during the accuracy test.

Gabor J. Kovacs — Date
Vice President
Environmental Sector
Battelle

Gary J. Foley — Date
Director
National Exposure Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency