THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**ULTRAVIOLET OPEN-PATH MONITOR**		
APPLICATION:	**MONITORING AIR QUALITY**		
TECHNOLOGY NAME:	**Model AR-500 Ultraviolet Open-Path Monitor**		
COMPANY:	**Opsis, Inc.**		
ADDRESS:	**1165 Lindavista Drive,** **Suite 112** **San Marcos, CA 92069**	**PHONE:** **FAX:**	**760-752-3005** **760-752-3007**
WEB SITE:	**http://www.opsis.se**		
E-MAIL:	**paulsf86@prodigy.net**		

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; stakeholder groups which 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 12 technology areas under ETV, is operated by Battelle in cooperation with EPA’s National Exposure Research Laboratory. AMS 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 Opsis AR-500 Ultraviolet Optical Open Path Monitor.

VERIFICATION TEST DESCRIPTION

The verification test described in this report was designed to challenge the AR-500 in a manner similar to that which would be experienced in field operations. An optically transparent gas cell filled with known concentrations of a target gas (ammonia, nitric oxide, or benzene) was inserted into the optical path of the monitor, simulating a condition where the target gas would be present in the ambient air. The monitor was challenged with a target gas, and the resulting measurement was compared to the known concentration of the target gas. The gases were measured in a fixed sequence over three days at a Battelle outdoor test site near West Jefferson, Ohio.

The target gases were measured at different concentrations, path lengths, integration times, and source intensities to assess the minimum detection limit (MDL), source strength linearity, concentration linearity, accuracy, precision, and sensitivity to atmospheric interferences of the AR-500. The MDL was calculated for each target gas by supplying pure nitrogen to the test cell in the optical path of the monitor and taking a series of 25 measurements using an integration time of either 1 or 5 minutes. Source strength linearity was investigated by measuring the effects of reducing the source intensity on the monitor's performance. Concentration linearity was investigated by challenging the monitor with each target gas at path-average concentrations ranging between 12 and 200 ppb. Accuracy and precision of the monitor relative to the gas standards were verified by introducing known concentrations of the target gas into the cell. The effects of atmospheric interfering gases were established by supplying the gas cell with a target gas and varying the distance (path length) between the source and detector. Note that potential sources of the target gases near the test site, such as trains, highway traffic, and local vehicle traffic, could not be controlled. Testing was suspended during obvious periods of source activity, but it is likely that source impacts could not be totally avoided.

Quality assurance (QA) oversight of verification testing was provided by Battelle. Battelle QA staff conducted a technical systems audit and a data quality audit of 10% of the test data. Battelle testing staff conducted a performance evaluation audit, which was reviewed by QA staff. EPA QA staff also conducted an independent technical systems audit of the verification procedures.

TECHNOLOGY DESCRIPTION

The AR-500 ultraviolet differential optical absorption spectroscopy (UV-DOAS) system uses a broad-band Xenon light-source that projects a narrow beam of light across a monitoring path ranging from 1 to 1,000 meters in length. The receiver telescope focuses the light into a quartz fiber optic cable that connects to the DOAS analyzer. The AR-500 is a compact, tunable, and fast-scanning spectrometer that measures spectra in the wavelength regions of interest. The system can provide path-averaged measurements, from the light source to the receiver, of, e.g., SO_2, NO, NO_2, NH_3, O_3, benzene, toluene, p-, m- and o-xylene, styrene, HNO_2, HCHO, Hg° , and hydrogen fluoride (HF). The AR-500 is designated by the U.S. EPA as an Equivalent Method for measuring the criteria pollutants SO_2, NO_2, and O_3 in ambient air.The AR-500 evaluated in this verification test was bi-static, with separate emitters and receivers and a light beam that passed through the gas volume once. From the AR-500 monitor, the results are transferred to a data collection system for presentation and reporting. The Opsis EnviMan software suite (WindowsTM 95, 98, NT, 2000), provides the necessary functions for data analysis, presentations, and reporting. The AR-500 is designed for continuous operation and is used in a variety of applications, including ambient air quality measurements; fence-line measurements at industrial plants and airports; street-level monitoring and tunnel measurements; and industrial continuous emission monitoring (CEM) and process applications at power plants, incinerators, cement plants, and aluminum smelters. The AR-500 uses the Opsis ER-150 emitter/receiver unit for the monitoring path. Two temperature signals are logged through the signal unit: the temperature of the calibration cell and the ambient air temperature. The temperature values are used to normalize data, which are stored in the analyzer and can be extracted directly from the analyzer in ASCII format. Data also are available on a separate computer that connects to the system. The AR-500 measures 60 x 44 x 26.6 cm (23.6 x 17.3 x 10.5 inches). It weighs (including the case) approximately 50 kg (110 lb).

VERIFICATION OF PERFORMANCE

Minimum Detection Limit: The AR-500 detection limits for the three gases tested ranged between 0.9 and 1.4 ppb for NO, between 0.4 and 1.5 ppb for benzene, and between 2.8 and 5.8 ppb for ammonia.

Source Strength Linearity: There was no significant degradation of monitor performance with source strength reductions of up to 60%, as indicated by linear regression of response data against source strength at constant concentration.

Concentration Linearity: The AR-500 had a slope of 1.02 and an r^2 value of 0.9994 for NO over a range of 20 to 150 ppb; a slope of 0.95 and an r^2 value of 0.9992 for benzene over a range of 12 to 100 ppb; and a slope of 1.11 and an r^2 value of 0.9997 for ammonia over a range of 24 to 200 ppb.

Accuracy: Over the same concentration ranges used for testing concentration linearity, the relative accuracy of the AR-500 was 2.7 to 17% for NO, 2.1 to 14% for benzene, and 3.3 to 11% for ammonia. No consistent effect of path length or integration time on accuracy was observed.

Precision: The relative standard deviations of the target gas measurements were 0.46% for NO at a concentration of 150 ppb, 0.57% for benzene at a concentration of 100 ppb, and 1.53% for ammonia at a concentration of 200 ppb.

Interferences: Analysis of the effects of the interferences of oxygen and ozone showed that neither the accuracy nor the MDLs were affected by the oxygen and ozone in the light path.

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