THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Continuous Ambient Fine Particle Monitor**
APPLICATION:	**MEASURING FINE PARTICULATE MASS IN AMBIENT AIR**
TECHNOLOGY NAME:	**BAM 1020**
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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 centers under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of continuous monitors used to measure fine particulate mass and species in ambient air. This verification statement provides a summary of the test results for the Met One BAM 1020 ambient fine particle monitor.

VERIFICATION TEST DESCRIPTION

The objective of this verification test is to provide quantitative performance data on continuous fine particle monitors under a range of realistic operating conditions. To meet this objective, field testing was conducted in two phases in geographically distinct regions of the United States during different seasons of the year. The first phase of field testing was conducted at the ambient air monitoring station on the Department of Energy's National Energy Technology Laboratory campus in Pittsburgh, PA, from August 1 to September 1, 2000. During the period, daily $PM_{2.5}$ concentrations ranged from 61 µg/m^3 to 36.2 µg/m^3 , with an average of 18.4 µg/m^3. The second phase of testing was performed at the California Air Resources Board's ambient air monitoring station in Fresno, CA, from December 18, 2000, to January 17, 2000. During this period, daily $PM_{2.5}$ concentrations ranged from 4.9 µg/m^3 to 146 µg/m^3, with an average value of 74.0 µg/m^3. Specific performance characteristics verified in this test include inter-unit precision, accuracy and correlation relative to time-integrated reference methods, effect of meteorological conditions, influence of precursor gases, and short-term monitoring capabilities. The BAM 1020 reports measurement results in terms of $PM_{2.5}$ mass and, therefore, was compared with the federal reference method (FRM) for $PM_{2.5}$ mass determination. Additionally, comparisons with a variety of supplemental measurements were made to establish specific performance characteristics.

Quality assurance (QA) oversight of verification testing was provided by Battelle and EPA. Battelle QA staff conducted a data quality audit of 10% of the test data, and performance evaluation audits were conducted on the BGI FRM samplers used in the verification test. Battelle QA staff conducted an internal technical systems audit for Phase I and Phase II. EPA QA staff conducted an external technical systems audit during Phase II.

TECHNOLOGY DESCRIPTION

The BAM 1020 is a beta attenuation monitor that measures the concentration (mg/m^3) of particulate matter in ambient air. The BAM 1020 may be equipped with a sharp cut cyclone $PM_{2.5}$ or a WINS $PM_{2.5}$ sampling inlet for automatic monitoring of finer particulate matter. The BAM 1020 monitor can also be configured to monitor total suspended particulate matter. An internal data logger allows up to six additional air quality or meteorological measurements. At the beginning of the sampling period, beta ray transmission is measured across a clean section of filter tape. This tape is mechanically advanced to the sampling inlet. Particulate matter is drawn into the sample inlet and deposited on the filter paper. At the completion of the sampling period, the filter tape is returned to its original location and the beta ray transmission is remeasured. The difference between the two measurements is used to determine the particulate concentration. The mass density is measured using the technique of beta attenuation. A small ^{14}C beta source (60 μCi) is coupled to a detector that counts the emitted beta particles. The filter tape is placed between the beta source and the detector. As the mass deposited on the filter tape increases, the measured beta particle count is reduced according to a known equation. The BAM 1020 consists of a detector/logger, pump, and sampling inlet. Each of these components is self-contained and may be disconnected for servicing or replacement. The BAM 1020 is designed to mount in a temperature-controlled enclosure. The sampling inlet is designed to mount through the roof of the enclosure. The BAM 1020 operates at 100 to 230 volts alternating current and is 310 mm high x 430 mm wide x 400 mm deep. All operations of the unit are displayed with an 8 line by 40 character display.

VERIFICATION OF PERFORMANCE

Inter-Unit Precision: During Phase I, the regression results from duplicate BAM 1020 monitors (Monitor 2 vs. Monitor 1) showed r^2 values of 0.873 and 0.986, respectively, for the hourly data and the 24-hour averages. The slopes of the regression lines were 0.932 (0.027) and 0.973 (0.044), respectively, for the hourly data and 24-hour averages; and no statistically significant intercept was observed in either case at 95% confidence. The calculated coefficient of variation (CV) for the hourly data was 20.6%; and, for the 24-hour data, the CV was 9.5%. During Phase II, the regression analysis showed r^2 values of 0.991 and 0.999, respectively, for the hourly data and the 24-hour averages. The slopes of the regression lines were 1.011 (0.007) and 1.018 (0.011), respectively, for the hourly data and 24-hour averages; and the intercepts were -0.0016 (0.0007) mg/m^3 and -0.0022 (0.0010) mg/m^3, respectively. The calculated CV for the hourly data was 9.9% and for the 24-hour data the CV was 6.4%.

Comparability/Predictability: During Phase I, comparisons of the 24-hour averages with $PM_{2.5}$ FRM results showed slopes of the regression lines for Monitor 1 and Monitor 2 of 1.169 (0.152) and 1.142 (0.138), respectively; and these slopes were statistically different from unity at the 95% confidence level. The regression results show r^2 values of 0.909 and 0.921 for Monitor 1 and Monitor 2, respectively. During Phase II, comparison of the 24-hour averages with $PM_{2.5}$ FRM results showed slopes of the regression lines for Monitor 1 and Monitor 2 of 1.09 (0.08) and 1.11 (0.08), respectively; both statistically different from unity at 95% confidence. No statistically significant intercept was observed in either case at the 95% confidence level. The regression results show r^2 values of 0.964 and 0.967 for Monitor 1 and Monitor 2, respectively.

Meteorological Effects: Multivariable analysis of the 24-hour average data for Phase I showed that the vertical wind speed, the relative humidity, and the solar radiation all had a statistically significant influence on the results of Monitor 1 at the 90% confidence level. Similarly, vertical wind speed, and the ambient air temperature at both 2 meters and 10 meters influenced the results of Monitor 2 relative to the FRM at the 90% confidence level. Under typical conditions during Phase I, the combined effect of these paramters was approximately 7% or less. Multivariable analysis of the 24-hour average data for Phase II showed that relative humidity had a statistically significant influence on the readings of both monitors relative to the FRM values at 90% confidence. Under typical conditions during Phase II, the effect was less than 1%.

Influence of Precursor Gases: During Phase I, multivariable analysis of the 24-hour average data showed that none of the measured precursor gases had an influence on Monitor 1 at the 90% confidence level, but hydrogen sulfide had a statistically significant, but practically negligible, influence on Monitor 2. During Phase II, multi-variable analysis of the 24-hour average data indicated that none of the measured gases had an effect on either monitor at the 90% confidence level.

Short-Term Monitoring: In addition to 24-hour FRM samples, short-term sampling was performed on a five-sample-per-day basis. The BAM 1020 results were averaged for each of the sampling periods and compared with the gravimetric results. Linear regression of these data showed slopes of 1.13 and 1.15, respectively, for Monitor 1 and Monitor 2. The intercepts of the regression lines were 0.002 and 0.000 mg/m^3, respectively; and the r^2 values were 0.939 and 0.936, respectively.

Other Parameters: No operating problems arose, and no maintenance was performed on either monitor during testing.

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