THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Continuous Ambient Fine Particle Monitor**
APPLICATION:	**MEASURING FINE PARTICLE MASS IN AMBIENT AIR**
TECHNOLOGY NAME:	**SM 200 Automatic Particle 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 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 Opsis AB SM 200 automatic particle monitor.

VERIFICATION TEST DESCRIPTION

The objective of this verification test is to provide quantitative performance data on continuous fine particle ($PM_{2.5}$) 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. 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. 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 SM 200 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 FRM samplers used in the verification test. Battelle QA staff conducted an internal technical system audit for Phase I and Phase II. EPA QA staff conducted an external technical systems audit during Phase II.

TECHNOLOGY DESCRIPTION

The SM 200 (as tested) is an automatic semi-continuous particle sampler that can be equipped with a total suspended particulate, PM_{10}, or $PM_{2.5}$ head. The SM 200 can be controlled remotely and can be operated unattended because of the large number of filters in its filter magazine. The SM 200 loads filters from the clean filter magazine automatically and unloads them in the sampled filter magazine after use. After the filter is loaded, it is tested and sampling begins. A Geiger-Muller detector detects the radioactivity before the filter is unloaded. A differential technique is used to measure particle mass and accounts for air density alternations and the effects of the natural radioactivity associated with a sample. The SM 200 beta source is ^{14}C , and two interconnected microcontrollers allow sampling and measuring to be done simultaneously. The sampling tube can be heated 2 to 5 °C higher than ambient temperature, and the measurement chamber is thermoregulated to minimize air density alterations due to temperature variations. Two gravimetrically determined reference membranes ensure particle measurement quality. A serial port makes it possible to obtain available data while giving the SM 200 instructions. The serial port can be connected directly or by modem to a PC or printer. The SM 200 consists of a sampling module (430 mm long x 600 mm wide by 260 mm high), a pumping module (320 mm long 200 mm wide and 300 mm high), and a collecting module. The sampling module weighs 25 kg, and the pumping module weighs 10 kg. The SM 200 operates on 115/230 V AC, 50/60 Hz.

VERIFICATION OF PERFORMANCE

Inter-Unit Precision: Only one of the duplicate SM 200 monitors was operational during Phase I of testing so no measure of inter-unit precision is available for that period. For the Phase II results, regression analysis showed r^2 values of 0.857 and 0.931, respectively, for the hourly data and the 24-hour averages from the duplicate monitors. The slopes of the regression lines (with Monitor 1 as an independent variable) were 0.865 (0.033) and 0.882 (0.101), respectively, for the hourly data and 24-hour averages; and the intercepts were 10.1 (3.6) $\mu g/m^3$ and 7.5 (11.4) $\mu g/m^3$, respectively. The calculated coefficient of variation (CV) for the hourly data was 31% and for the 24-hour data the CV was 8.4%.

Comparability/Predictability: During Phase I, comparisons of the 24-hour measurements for the single SM 200 with $PM_{2.5}$ FRM results showed a slope of the regression line of 1.17 (0.14) and an intercept of 3.2 (3.2) $\mu g/m^3$, where the values in parentheses represent the 95% confidence interval. At the 95% confidence level, the slope was significantly different from unity, and the intercept was not statistically different from zero. The regression results show an r^2 value of 0.971 for these data. 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 1.394 (0.180) and 1.219 (0.194), respectively; and intercepts of these regression lines were -12.2 (16.0) and -2.2 (16.7) $\mu g/m^3$, respectively. The regression results show r^2 values of 0.918 and 0.870 for Monitor 1 and Monitor 2, respectively.

Meteorological Effects: The multivariable analysis model of the 24-hour average data during Phase I ascribed to wind speed, relative humidity, solar radiation, and total precipitation a statistically significant influence on the results of Monitor 1 at the 90% confidence level. Under average conditions during Phase I, these parameters had a combined effect of ~20% on the readings of Monitor 1. Multivariable analysis of the 24-hour average data during Phase II showed that relative humidity and wind speed had a statistically significant influence on the readings of Monitor 1 relative to the FRM values at 90% confidence. However, on average, these parameters had a combined effect of < 1% during Phase II. There was no effect of meteorology on the results of Monitor 2 relative to the FRM.

Influence of Precursor Gases: During Phase I, multivariable analysis of the 24-hour average data showed no statistically significant influence of the measured precursor gases on the SM 200 readings. During Phase II, multivariable analysis of the 24-hour average data indicated that the presence of NO_x influences the readings of Monitor 2 relative to the FRM. None of the measured gases had an effect on Monitor 1.

Short-Term Monitoring: In addition to 24-hour FRM samples, short-term sampling was performed on a five-sample-per-day basis. The SM 200 results were averaged for each of the sampling periods and compared with the gravimetric results. Considering all short-term results together, linear regression of these data showed slopes of 1.33 and 1.26, respectively, for Monitor 1 and Monitor 2. The intercepts of the regression lines were 1.3 and 3.3 $\mu g/m^3$, respectively; and the r^2 values were 0.845 and 0.838, respectively. These results may not be an accurate representation of the short-term performance of the SM 200 monitors due to a loss of data from excessive filter loading.

Other Parameters: Regarding instrument reliability and ease of use, one SM 200 monitor was not operational in Phase I due to a mechanical malfunction. The other SM 200 monitor in Phase I achieved 100% data recovery, excluding a period when on-site operator error caused data loss. In Phase II, data recovery of 66% and 73% was achieved for the duplicate monitors. Filter overloading led to the data loss in Phase II. Such overloading could be minimized by judicious choice of the sampling duration, filter masking, and sampling frequency. Other than filter replacement, no maintenance was performed in Phase II.

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