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 PARTICLATE MASS IN AMBIENT AIR**
TECHNOLOGY NAME:	**FH 62 C14 Ambient Dust 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 Thermo Andersen FH 62 C14 ambient dust 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. 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, 2001. Specific performance characteristics verified in this test include inter-unit precision, agreement with and correlation to time-integrated reference methods, effect of meteorological conditions, influence of precursor gases, and short-term monitoring capabilities. The FH 62 C14 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 systems audit for Phase I and Phase II. EPA QA staff conducted an external technical systems audit during Phase II.

TECHNOLOGY DESCRIPTION

The FH 62 C14 monitor measures the concentration of particulate matter in ambient air. The FH 62 C14 monitor uses the principle of beta attenuation through particulate matter collected on a moveable filter tape using a C_{14} source. When a new section of the filter tape moves into the measuring position, ambient air is pulled through the inlet and the sample tube. Airborne dust particles are deposited on the filter, and a single filter spot remains in the chamber for particulate collection and measurement. The filter section moves out, and a fresh filter section moves into the measuring position. A new cycle starts with an automatic zero adjustment. The chamber for particulate collection and measurement is between the source and the detector. The beta beam passes through the filter and the accumulated dust layer. The intensity of the beta beam is attenuated with increasing dust mass load, leading to a decreasing count rate from the detector. The FH 62 C14 monitor consists of a central unit, a sampling system, a rotary vane pump, and a recording unit. Different preseparators allow various particle sizes to be detected. The FH 62 C14 monitor operates at 100 to 240 volts alternating current and is 315 mm high x 450 mm wide x 320 to 400 mm deep. Measured values can be read from a liquid crystal display or printed. The duplicate FH 62 C14 monitors were each operated with a conventional PM_{10} head and $PM_{2.5}$ sharp cut cyclone to provide size selection.

VERIFICATION OF PERFORMANCE

Inter-Unit Precision: During Phase I the 5-minute readings of the duplicate FH 62 C14 monitors showed recurring negative artifacts apparently associated with condensation of moisture in the early morning hours. The unit-to-unit regression of the 5-minute data gave results [slope = 0.565 (0.019), intercept = 9.5 (1.2) $\mu g/m^3$, r^2 = 0.374, where the values in parentheses are 95% confidence intervals] that were undoubtedly affected by those artifacts. Regression analysis of the 24-hour FH 62 C14 averages showed an r^2 value of 0.875 for the duplicate monitors, with a slope of 0.948 (0.183) and an intercept of -1.29 (5.9) $\mu g/m^3$. At the 95% confidence level, the slope was not significantly different from unity, and the intercept was not significantly different from zero. The calculated coefficient of variation (CV) for the 24-hour average data was 20.6%. During Phase II, inter-unit regression analysis showed r^2 values of 0.987 and 0.999 for the 30-minute readings and the 24-hour averages, respectively. The slopes of the regression lines were 1.002 (0.006) and 1.005 (0.012) for the 30-minute data and 24-hour averages , respectively, indicating no inter-unit bias; and the intercepts were 0.69 (0.65) $\mu g/m^3$ and 0.29 (1.34) $\mu g/m^3$, respectively. The calculated CV for the 30-minute data was 15.4% and for the 24-hour data the CV was 4.4%.

Comparability/Predictability: During Phase I, comparisons of the 24-hour averages with $PM_{2.5}$ FRM results showed r^2 values of 0.856 and 0.802 for Monitor 1 and Monitor 2, respectively. The slopes of the regression lines for Monitor 1 and for Monitor 2 were 1.60 (0.35) and 1.56 (0.41), respectively, indicating a positive bias of about 60% relative to the FRM. No statistically significant intercept was observed in either case at 95% confidence level. Comparison of the 24-hour averages with $PM_{2.5}$ FRM results during Phase II showed the r^2 values of 0.958 and 0.953 for Monitor 1 and Monitor 2, respectively. Slopes of the regression lines for Monitor 1 and Monitor 2 were 1.23 (0.10) and 1.22 (0.11), respectively, indicating a positive bias of about 23% relative to the FRM. No statistically significant intercept was observed in either case at the 95% confidence level.

Meteorological Effects: The multivariable 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 readings of one of the monitors relative to the FRM at 90% confidence. Similarly, barometric pressure and total precipitation were ascribed a statistically significant influence on the other monitor. The overall magnitude of these effects was ~4% for Monitor 1 and ~15% for Monitor 2, on average. Multivariable analysis of the 24-hour average data during Phase II ascribed to relative humidity a statistically significant influence on the readings of one of the monitors relative to the FRM, at a 90% confidence level. However, the average magnitude of the effect during Phase II was negligible (i.e., ~0.1%).

Influence of Precursor Gases: The measured precursor gases had no effect on the results of either monitor relative to the FRM at the 90% confidence level during either Phases I or II.

Short-Term Monitoring: In addition to 24-hour FRM samples, short-term sampling (3-, 5-, and 8-hour intervals) was performed on a five-sample-per-day basis in Phase II. The FH 62 C14 results were averaged for each of the sampling periods and compared with the gravimetric results. Linear regression of these data showed slopes of 1.25 and 1.24, respectively, for Monitor 1 and Monitor 2, when all short-term intervals are included. These results indicate a positive bias of about 25% relative to the FRM data, which is consistent with the result noted above from comparison of 24-hour FRM data in Phase II. The intercepts of the regression lines were 5.0 (4.2) and 4.8 (4.3) $\mu g/m^3$; respectively, and the r^2 values were 0.931 and 0.927, respectively.

Other Parameters: Approximately 10 days of data were lost at the beginning of Phase I owing to insufficient memory of the two monitors. Other than data loss associated with that cause, 100% data recovery was achieved by each of the FH 62 C14 monitors during Phase I. No operating problems arose during Phase I of testing, and no maintenance was performed on either monitor during this phase. During Phase II of the verification test, 100% data recovery was achieved. No maintenance was performed, and no operating problems arose for either monitor.

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