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:	**Series 1400a TEOM® Particle Monitor**
COMPANY:	**Rupprecht & Patashnick, Co.**
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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 Rupprecht & Patashnick, Co. Series 1400a TEOM 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. 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 Series 1400a TEOM monitor 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 Series 1400a TEOM monitor can be configured with appropriate separation devices to measure ambient particulate mass concentrations in real time of any of the following: PM_{10}, $PM_{2.5}$, PM_1, or TSP (total suspended particulates). In this verification test, the Series 1400a TEOM monitors were configured with PM_{10} heads and $PM_{2.5}$ sharp cut cyclones. A tapered element oscillating microbalance, which is a patented inertial mass measurement technique, directly measures particle mass collected on a filter. Mass concentration data are reported in micrograms per cubic meter. The Series 1400a TEOM monitor has exposed collection filters that can be analyzed for heavy metals using standard laboratory techniques. Active volumetric flow control maintains a constant volumetric flow rate by using density-adjusted mass flow control that incorporates ambient pressure and temperature sensors. The Series 1400a TEOM monitor is a gravimetric instrument that draws ambient air through a filter at a constant flow rate, continuously weighing the filter and calculating rolling 10-minute smoothed mass concentrations. The Series 1400a TEOM monitor computes the total mass accumulation on the collection filter, as well as 30-minute, one-hour, eight-hour, and 24-hour averages of the mass concentration. Hydrophobic filter material and sample collection at above-ambient temperature eliminates the necessity for humidity equilibration. Both analog and RS-232 outputs are available. Input/output capabilities include a menu-driven user interface, seven analog input channels for receiving external data with conversion to engineering units, vector-based averaging for wind speed and direction, internal data logging of system and external information, three user-defined analog output channels, two contact closure alarm circuits, and advanced RS-232 support for the retrieval of current and logged information. The Series 1400a TEOM monitor is 35.56 cm (14 in.) wide, approximately 99.36 cm (39.12 in.) high, and 27.94 cm (11 in.) deep.

VERIFICATION OF PERFORMANCE

Inter-Unit Precision: Regression analysis of the data from the duplicate Series 1400a TEOM monitors showed r^2 values of 0.851 and 0.949, respectively, for the hourly data and 24-hour average results during Phase I. The slopes of the regression lines were 0.879 (0.027) and 0.901 (0.080), respectively, for the hourly data and 24-hour averages, where the values in parentheses are 95% confidence intervals. An intercept of 1.22 (0.66) $\mu g/m^3$ was observed for the hourly data, and 0.87 (1.73) $\mu g/m^3$ for the 24-hour averages. The calculated coefficient of variation (CV) for the hourly data was 22.5%, and for the 24-hour averages, the CV was 9.0%. Regression analysis showed r^2 values of 0.998 and 0.9995, respectively, for the hourly data and 24-hour average results during Phase II. The slopes of the regression lines were 0.986 (0.004) and 0.992 (0.008), respectively, for the hourly data and

24-hour averages, and the intercepts were -0.50 (0.17) µg/m^3 and -0.73 (0.33) µg/m^3, respectively. The calculated CV for the hourly data was 12.1%; and, for the 24-hour average data, the CV was 3.2%.

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 0.964 (0.096) and 0.911 (0.099), respectively; these slopes were not significantly different from unity at the 95% confidence level. The regression results show r^2 values of 0.945 and 0.935 for Monitor 1 and Monitor 2, respectively. The intercepts of the regression lines were 2.21 (1.94) and 1.85 (2.01) µg/m^3, respectively, for Monitor 1 and Monitor 2. 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 0.463 (0.055) and 0.459 (0.054), respectively, indicating a negative bias relative to the FRM. The respective intercepts were -0.31 (4.6) and -1.1 (4.5) µg/m^3, and both TEOM 1400a monitors gave r^2 values of 0.915 relative to the FRM.

Meteorological Effects: Multivariable model analysis was used to determine if the meteorological conditions had an influence on the readings of the Series 1400a TEOM monitors relative to the FRM results. This model ascribed to total precipitation, wind speed, and the variability in wind direction a statistically significant influence on the Series 1400a TEOM monitors relative to the FRM in Phase I, at the 90% confidence level. The model ascribed to the variability in wind direction, relative humidity, and solar radiation a statistically significant influence on the readings of the two monitors relative to the FRM in Phase II, at 90% confidence. However, the apparent effects on the Series 1400a TEOM monitors were small under the average conditions of each phase (approximately 5 to 7% effect in Phase I, and approximately 1% in Phase II), relative to the linear regression against FRM results alone.

Influence of Precursor Gases: The measured precursor gases had no influence on the results of either monitor relative to the FRM at the 90% confidence level during Phase I. During Phase II, the model ascribed to the concentration of nitric oxide a significant effect on the two Series 1400a TEOM monitors relative to the FRM. Under typical conditions during Phase II, this effect was approximately 1%.

Short-Term Monitoring: In addition to 24-hour FRM samples, short-term monitoring was performed on a five-sample-per-day basis in Phase II. Considering all short-term results together, linear regression of these data showed slopes of 0.555 and 0.552, respectively, for Monitor 1 and Monitor 2. The intercepts of the regression lines were -6.2 and -6.9 µg/m^3, respectively; and the r^2 values were 0.798 and 0.806, respectively. The observed negative bias relative to the short-term reference samples is consistent with the negative bias relative to 24-hour FRM results in Phase II.

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

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