THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

. . . Putting Technology To Work

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Continuous Ambient Fine Particle Monitor**
APPLICATION:	**MEASURING FINE PARTICULATE MASS IN AMBIENT AIR**
TECHNOLOGY NAME:	**Electrical Low Pressure Impactor**
COMPANY:	**Dekati Ltd.**
ADDRESS:	**Osuusmyllynkatu 13 33700 Tampere, Finland**
PHONE:	**+358(0)3-3578100**
FAX:	**+358(0)3-3578140**
WEB SITE:	**http://www/dekati/fi**
E-MAIL:	**dekati@dekati.fi**

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 Dekati Ltd. electrical low pressure impactor (ELPI™) 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, accuracy and correlation relative to time-integrated reference methods, effect of meteorological conditions, influence of precursor gases, and short-term monitoring capabilities. The ELPI™ 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 ELPI™ measures particle sizes (from 0.03 to 10 micrometers in diameter) and particle concentrations in real time. The ELPI™ sensor measures the electrical current carried by charged particles at 12 impactor stages, using a highly sensitive, multichannel electrometer as the particle impacts the collection plate. Aerosol is sampled through a unipolar corona charger, and the charged particles pass into a low pressure impactor with electrically isolated collection stages. Particle collection into each impactor stage is dependent on the aerodynamic size of the particles. Measured current signals are converted to (aerodynamic) size distribution using particle-size dependent relations describing the properties of the charger and the impactor stages. Particles can be collected on substrates for microscopic analysis or additional measurements of mass or composition. The ELPI™ charger calibration is based on aerosol particle number distribution measurement. Particulate mass is calculated assuming a spherical shape and known density for the particles. $PM_{2.5}$ mass is calculated by integrating the particle mass from ELPI™ stages 1 to 8 from the particle size distribution. The ELPI™ software features a graphical user interface and permits monitoring each stage during loading. Total concentration and particle-size data are updated continuously. Data can be displayed either on a number, volume, area, or mass basis. ELPI™ components are housed in a single unit with a standard RS-232 port for communication with a laptop or PC. The ELPI™ is 570 mm high x 420 mm wide x 260 mm deep.

VERIFICATION OF PERFORMANCE

Inter-Unit Precision: During Phase I, regression analysis showed r^2 values of 0.958 and 0.963, respectively, for the 10-minute data and the 24-hour averages from the duplicate ELPI™ monitors. The slopes of the regression lines were 0.922 (0.006) and 0.958 (0.073), respectively, for the 10-minute data and 24-hour averages, and no statistically significant intercept was observed in either case at the 95% confidence level. The calculated coefficient of variation (CV) for the 10-minute data was 9.2%; and, for the 24-hour data, the CV was 8.8%. During Phase II, regression analysis showed r^2 values of 0.910 and 0.896, respectively, for the 10-minute data and the 24-hour averages. The slopes of the regression lines were 1.237 (0.012) and 1.240 (0.167), respectively, for the 10-minute data and 24-hour averages, indicating a bias between the two monitors. The calculated CV for the 10-minute data was 18.2%; and, for the 24-hour data, the CV was 18.5%.

Comparability/Predictability: During Phase I, comparisons of the 24-hour averages with $PM_{2.5}$ FRM results showed intercepts that were not significantly different from zero and slopes of the regression lines of 1.81 (0.29) and 1.85 (0.31), respectively, for Monitor 1 and Monitor 2. The regression results show r^2 values of 0.871 and 0.862 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 2.13 (0.30) and 2.60 (0.44), respectively. The regression results show r^2 values of 0.897 and 0.843 for Monitor 1 and Monitor 2, respectively.

Meteorological Effects: The multivariable analysis model of the 24-hour average data during Phase I ascribed to horizontal and vertical wind speed, wind direction, total precipitation, and temperature a statistically significant influence on the ELPI™ readings relative to the FRM values, at the 90% confidence level. Multivariable analysis of the 24-hour average data during Phase II ascribed only to barometric pressure a statistically significant influence on the readings of Monitor 1 relative to the FRM values, at 90% confidence. 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 that none of the precursor gases measured had a statistically significant influence on either of the ELPI™ monitors. During Phase II, the multivariable model of the 24-hour average data ascribed to the concentration of carbon monoxide a statistically significant but negligible effect on the readings of Monitor 1 relative to the FRM. None of the measured gases had an effect on Monitor 2.

Short-Term Monitoring: In addition to 24-hour FRM samples, short-term monitoring was performed on a five-sample-per-day basis during Phase II. The ELPI™ results were averaged for each of the short-term sampling periods and compared with the gravimetric reference method results. Considering all short-term results together, linear regression showed slopes of 2.06 and 2.55, respectively, for Monitor 1 and Monitor 2, consistent with the bias found relative to the 24-hour FRM data. The intercept was not significantly different from zero for either regression line, and the r^2 values were 0.882 and 0.850, respectively.

Other Parameters: With the exception of short periods during which impactor plates were replaced and brief power outages, 100% data recovery was achieved by each of the ELPI™ monitors from the time of installation to the end of Phase I sampling. No operating problems arose during Phase I of testing. The only maintenance that was performed on the ELPI™ monitors involved changing the impactor plates. This process took approximately 30 minutes per week for each monitor. During Phase II of the verification test, approximately three days of data were lost for one monitor when its internal memory buffer reached its capacity. As in Phase I, the only maintenance that was performed on the ELPI™ monitors was changing the impactor plates weekly.

Gabor J. Kovacs	Date	Gary J. Foley	Date
Vice President		Director	
Environmental Sector		National Exposure Research Laboratory	
Battelle		Office of Research and Development	
		U.S. Environmental Protection Agency	