THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

TECHNOLOGY TYPE:	**PARTICULATE METALS MONITOR**
APPLICATION:	**MONITORING OF METALS IN AEROSOL PARTICLES IN AMBIENT AIR**
TECHNOLOGY NAME:	**Xact 625**
COMPANY:	**Cooper Environmental Services LLC†**
ADDRESS:	**10180 SW Nimbus Ave. Suite J6 PHONE: (503) 670-8127 Portland, OR 97223**
WEB SITE:	**http://cooperenvironmental.com/**
E-MAIL:	**info@cooperenvironmental.com**

ETV Joint Verification Statement

The U.S. Environmental Protection Agency (EPA) has established 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 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. Information and ETV documents are available at www.epa.gov/etv.

ETV works in partnership with recognized standards and testing organizations, with stakeholder groups (consisting of buyers, vendor organizations, and permitters), and with 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 and laboratory tests (as appropriate), collecting and analyzing data, and preparing peer-reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance (QA) protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

† The license for the Xact 625 technology was given by Pall Corporation to Cooper Environmental Services LLC after completion of this verification. The box above was revised on April 15, 2013 to reflect this change. The product name remains the same. The remainder of this verification statement refers to the company name which was applicable when the technology was originally verified.

The Advanced Monitoring Systems (AMS) Center, one of six verification centers under ETV, is operated by Battelle in cooperation with EPA's National Risk Management Research Laboratory. The AMS Center evaluated the performance of a field deployable X-ray fluorescence (XRF) analyzer for determining metals in particulate matter in ambient air. This verification statement provides a summary of the test results for Pall Corporation's† Xact 625 Particulate Metals Monitor.

VERIFICATION TEST DESCRIPTION

This verification evaluated the ability of the Xact 625 to provide reliable quantitative measurements of metals in particulate matter having aerodynamic diameter less than 10 micrometers (i.e., PM_{10}), during continuous unattended operation. The verification was conducted over several weeks in the winter of 2011-2012 and involved continuous operation of an Xact 625 unit at an existing ambient air monitoring site in Marietta, Ohio. The verification was supported by EPA's Region 5 and Office of Air Quality Planning and Standards and was carried out with the help of the Ohio Environmental Protection Agency. A total of 23 metals were reported hourly by the Xact 625 over a field period of approximately 80 days. Daily averages of Xact 625 metals readings that exceeded the daily quantitation limits (QLs) of the analyzer were compared to corresponding results determined by EPA reference sampling and analysis by inductively coupled plasma mass spectrometry (ICP/MS). Quantitative comparisons of Xact 625 results to reference results could be made for six metals [calcium (Ca), copper (Cu), manganese (Mn), lead (Pb), selenium (Se), and zinc (Zn)], using reference measurements obtained over approximately 65 days within the 80-day period of continuous Xact 625 operation.

The following are the parameters on which Xact 625 performance was evaluated:

Comparability – The comparability of Xact 625 results to reference results was determined for each metal by examination of the slope and intercept of a linear regression of the data using the ICP/MS results as the independent variable and the Xact 625 daily averages as the dependent variable.

Correlation – The degree of correlation between the Xact 625 results and the reference method results was determined for each metal by the coefficient of determination (r^2) of the linear regression between the reference method results and the corresponding Xact 625 daily averages.

Bias – The bias of the Xact 625 readings was calculated as the percent difference of each daily average Xact 625 reading relative to the corresponding daily average reference method result.

Data Completeness – The completeness of Xact 625 data was calculated as the percentage of the field period for which valid hourly data were reported, and as the percentage of all daily reference measurement periods during which the Xact 625 reported at least 12 hours of monitoring data (i.e., produced data for at least half of the reference monitoring period).

Operational Factors – Performance factors such as maintenance requirements, ease of use, and effectiveness of data acquisition were assessed from observations by EPA and Ohio EPA staff.

Battelle and EPA QA staff conducted separate technical systems audits (TSAs) of the field operations, and Battelle QA staff conducted a TSA of the reference analysis laboratory and a data quality audit of the test data. This verification statement, the full report on which it is based, and the test/QA plan for this verification are available at www.epa.gov/etv/centers/center1.html.

TECHNOLOGY DESCRIPTION

The following description of the Xact 625 is based on information provided by the vendor and was not verified in this evaluation: The Xact 625 determines metals in airborne PM_{10} by XRF, in which X-rays from a source cause ejection of an electron from an inner electronic shell of a metal atom in a sample. The vacancy in the inner shell is filled by an electron from an outer shell, with resulting emission of an X-ray of wavelength longer than that of the original excitation and characteristic of the metal in question. The Xact 625 uses energy-dispersive XRF (EDXRF) and a low power X-ray source. EDXRF provides rapid acquisition of the entire X-ray spectrum so that

many elements can be detected within a few seconds. To monitor metals in atmospheric PM_{10}, the Xact 625 uses an automated moveable filter tape, in which sample air is drawn through a small spot on the tape, collecting and concentrating PM_{10} onto that spot. The tape then advances, placing the collected sample spot in the X-ray excitation and analysis section of the monitor and initiating particulate sampling onto a previously unexposed spot on the tape. The sequence of sampling and analysis can continue automatically, limited only by the supply of filter tape. The duration of sample collection at each spot can be set at a constant interval, or varied to maintain detection performance when atmospheric PM_{10} levels vary. The Xact 625 samples ambient air at a constant flow rate of 16.7 L/min (i.e., 1 m^3/hr). The Xact 625's sample inlet is designed to provide uniform sample deposition, and the instrument analyzes approximately 90% of the sample spot area to minimize effects of sample inhomogeneity. The Xact 625 incorporates sensors for temperature and atmospheric pressure, and uses those data to maintain a constant volumetric sample flow and consequently an accurate PM_{10} inlet size cut. For this verification the vendor of the Xact 625 programmed the monitor to perform the following automatic internal quality control (QC) checks on a daily basis to assure data quality:

- Internal energy alignment check, by XRF analysis of a Cu rod, conducted over a 15-minute period starting at midnight each day,
- Upscale rod check, by XRF analysis of a metal rod containing chromium (Cr), Pb, and cadmium (Cd), conducted once per day over a 15-minute period,
- Flow check, conducted at the same time as the upscale rod check, to determine the Xact 625 sample air flow by insertion of a second mass flow meter into the flow path,
- Palladium rod stability check by XRF analysis of a palladium rod in every ambient sample analysis.

VERIFICATION RESULTS

Of the 23 ambient PM_{10} metals determined by the Xact 625 in this verification, 19 were also determined by the ICP/MS analysis of reference samples. Of those 19 metals, Xact 625 results for 12 metals were almost always below the respective QLs of the Xact 625, and consequently no comparisons could be made to the reference results. Also the Xact 625 reported a nearly constant and unrealistic ambient concentration of molybdenum due to an incorrect energy window for that metal in the XRF analysis. The vendor of the Xact 625 indicates that this problem can be avoided in the future by narrowing the energy window. Table VS-1 presents a summary of the quantitative performance results of the Xact 625 for the remaining six metals, showing the performance parameters and resulting performance metrics.

Table VS-1 indicates that the daily average Xact 625 results were highly correlated and in close quantitative agreement with ICP/MS analysis results for most of the six metals, and that the Xact 625 achieved data completeness of over 95%. The regression results for Cu reflect the fact that the ambient Cu concentrations were often near the detection limit of the ICP/MS analysis and the QL of the Xact 625. In addition, investigations conducted after the verification test suggest that the regression results for Cu and the relatively high bias results for Pb may both have been affected by the background levels of these metals in the Xact 625's blank filter tape.

The Xact 625 required minimal operator attention during testing, with routine maintenance consisting of changing the sampling tape approximately every 2 weeks. The analyzer conducted several automated internal QC checks on a daily basis, and provided readily understandable data files that distinguished QC from ambient monitoring results and included analyzer flow and internal readings. The internal QC check results of the Xact 625 showed that the relative standard deviation of the palladium internal standard readings determined in every Xact 625 analysis was 2.0%, and the instrument's average flow error was -0.69% (± 0.004%) where the number in parentheses is the standard deviation of the daily flow check results. The average accuracy relative to upscale rod check standards analyzed daily was 100.2% (± 0.004%) for Cr, 100.6% (± 0.013%) for Cd, and 99.8% (± 0.007%) for Pb, where accuracy of 100% indicates perfect agreement with the upscale rod check standard. However, the test results for Cu and Pb strongly indicate that analysis of blank portions of the filter tape should be a component of the Xact 625's automated internal QC checks.

Table VS-1. Quantitative Performance Results for the Xact 625

Performance Parameter	Metal	Metric	
Comparability		**Slope (± 95% CI)**	**Intercept (± 95% CI) (ng/m^3)**
	Ca	0.82 (± 0.04)	-30.6 (± 11.9)
	Cu	0.30 (± 0.17)	2.1 (± 0.65)
	Mn	1.0 (± 0.01)	-0.09 (± 2.13)
	Pb	1.1 (± 0.07)	1.6 (± 0.30)
	Se	0.99 (± 0.11)	0.01 (± 0.22)
	Zn	0.97 (± 0.03)	-3.0 (± 0.98)
Correlation		**Coefficient of Determination (r^2)**	
	Ca	0.979	
	Cu	0.341	
	Mn	0.999	
	Pb	0.943	
	Se	0.926	
	Zn	0.988	
Bias		**Mean (± SD) (%)**	**Median (%)**
	Ca	-31.3 (± 9.5)	-31.0
	Cu	-5.6 (± 22.1)	1.2
	Mn	1.1 (± 21.8)	-0.60
	Pb	74.8 (± 54.3)	61.9
	Se	-0.70 (± 8.1)	-1.3
	Zn	-20.5 (± 15.4)	-17.9
Data Completeness		**Hourly Data (%)**	**Daily Averages with ≥ 12 Hours (%)**
	All	95.4 to 96.0	96.9

CI = Confidence interval; SD = Standard deviation

Signed by October 10, 2012

Tracy Stenner Date
Manager
Environmental Solutions Product Line
Energy, Environment, and Materials Sciences
Battelle

Signed by October 31, 2012

Cynthia Sonich-Mullin Date
Director
National Risk Management Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency