THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

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Massachusetts Department of Environmental Protection

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Continuous Emission Monitor**
APPLICATION:	**MEASURING ELEMENTAL MERCURY**
TECHNOLOGY NAME:	**Model AM-2**
COMPANY:	**Nippon Instruments Corporation**
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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 emission monitors used to measure mercury in flue gases. This verification statement provides a summary of the test results for the Nippon Instruments Corporation Model AM-2 elemental mercury continuous emission monitor (CEM).

VERIFICATION TEST DESCRIPTION

The verification test was conducted over a three-week period in January 2001 at the Rotary Kiln Incinerator Simulator (RKIS) facility at EPA's Environmental Research Center, in Research Triangle Park, North Carolina. This mercury CEM verification test was conducted jointly by Battelle's AMS Center, EPA's Office of Research and Development, and the Massachusetts Department of Environmental Protection. A week of setup and trial runs was followed by two weeks of verification testing under different flue gas conditions. The daily test activities provided data for verification of the following performance parameters of the AM-2 monitor: relative accuracy in comparison to reference method results, correlation with the reference method, precision in sampling at stable flue gas conditions, calibration/zero drift from day to day, sampling system bias in transfer of mercury to the CEM's analyzer, interference effects of flue gas constituents on CEM response, response time to rising and falling mercury levels, response to low levels of mercury, data completeness over the course of the test, and setup and maintenance needs of the CEM. The Ontario Hydro (OH) draft American Society for Testing and Materials mercury speciation method was used as the reference method in this verification test. Paired OH trains were sampled at two locations in the RKIS duct to establish the precision of the OH method.

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, a series of performance evaluation audits on several measurements at the RKIS, and both an internal and an external technical systems audit of the procedures used in this verification. EPA QA staff also conducted an independent technical systems audit at the RKIS.

TECHNOLOGY DESCRIPTION

The AM-2 mercury CEM is a sampling, preconcentration, and detection system for elemental mercury. The unit draws a sample flow rate of 0.5 L/min through a distilled water scrubbing trap, for removal of any oxidized mercury species, and then through a dehumidifier, for removal of water vapor. The sample flow then passes through a gold amalgamation trap, which collects and concentrates the elemental mercury from the sample stream. Rapid heating of the gold trap drives the collected mercury into the absorption cell of the detector of the AM-2. Operating the unit with a fixed sample flow rate, collection time, and detection conditions allows the AM-2 response to be related to the $\mu g/m^3$ of mercury in the original sample stream. The sampling, desorption, and detection steps are conducted in a fully automated sequential fashion, so the AM-2 provides one measurement of elemental mercury with each complete cycle. In this verification test, the AM-2 operated with a 5-minute sample collection step, and a 13-minute overall cycle time. The AM-2 uses cold vapor atomic absorption to detect elemental mercury. The AM-2 requires no chemical reagents or gases other than a purified air supply, and operates on 100-110 V AC power. The unit is 44.5 cm wide x 28.7 cm deep x 28.5 cm high (17.5 in. W x 11.3 in. D x 11.2 in H), and weighs 20 kg (44 lbs). A front panel keyboard allows programming of the AM-2 cycle parameters, and an LCD display provides a readout for mercury concentrations, date, time, self diagnostic functions, and error messages. A thermal dot matrix printer and RS-232C port for output of measurement data are built into the AM-2.

VERIFICATION OF PERFORMANCE

Relative accuracy: During the first week of verification testing, the Nippon AM-2 provided relative accuracy for elemental mercury of about 14% relative to OH results, at elemental mercury levels of approximately 6 to 7 $\mu g/m^3$. In the second week of verification, the AM-2 provided relative accuracy of about 23%, with elemental mercury levels ranging from about 5 to 25 $\mu g/m^3$. Excluding two of the nine OH runs in the second week, the AM-2 gave a relative accuracy of 12.3% in the second week of verification.

Correlation with the reference method: The coefficient of determination (r^2) of the AM-2 and OH results was 0.878, based on the combined data from both weeks of verification.

Precision at stable flue gas conditions: The precision (as percent relative standard deviation) of the AM-2 response was within 10% in 11 of the 15 OH periods and within 15% in 13 of the periods. This measured variability includes both variability in the test facility and in the AM-2 monitor.

Calibration/zero drift: Analysis of elemental mercury standard gases gave a 4.1% relative standard deviation (RSD) in AM-2 response during the first week of testing and a 3.4% RSD in AM-2 response during the second week.

Sampling system bias: The bias in transport of elemental mercury through the Nippon inlet system was approximately -7%.

Interference effects of flue gas constituents: When added to the duct along with mercury, chlorine (and to a lesser extent hydrogen chloride) sharply reduced the elemental mercury response of the AM-2. However, elevated levels of sulfur dioxide, nitrogen oxides, and carbon monoxide had a minimal effect on AM-2 response, and when these gases were all present along with chlorine and hydrogen chloride, no reduction in AM-2 response was observed, relative to that with mercury alone.

Response time to changing mercury levels: The AM-2 achieved 90 to 100% response to increases and decreases in mercury concentrations within one 13-minute measurement cycle. Thus, the 95% response time is essentially one measurement cycle.

Response to low levels of mercury: The AM-2 elemental mercury response increased with as little as 0.57 $\mu g/m^3$ of total mercury added to the flue gas. The actual elemental mercury concentrations were not determined independently for comparison to the AM-2 results. However, the AM-2 elemental mercury readings were highly correlated with the nominal total mercury level ($r^2 = 0.997$).

Data completeness: Data completeness for the AM-2 was 100%.

Setup and maintenance needs: The AM-2 was set up and ready to sample flue gas within about four hours after it was placed at the sampling port. The monitor required no gas supplies or other consumables and produced no waste. No scheduled maintenance was required over the two-week period of the verification test.

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