THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

Illinois Clean Coal Institute

Battelle
The Business of Innovation

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**Mercury Emissions Monitor**	
APPLICATION:	**Monitoring of Flue Gas Mercury**	
TECHNOLOGY NAME:	**Series 3300 Mercury Continuous Emissions Monitoring System**	
COMPANY:	**Tekran Instruments Corporation**	
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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 or 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 Advanced Monitoring Systems (AMS) Center, one of six technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. In collaboration with the Illinois Clean Coal Institute, and with assistance from the Northern Indiana Public Service Company, the AMS Center

evaluated the performance of the Tekran Instruments Corporation Series 3300 Mercury Continuous Emissions Monitoring (CEM) System for determining mercury in stack gas at a coal-fired power plant. This verification statement provides a summary of the test results.

VERIFICATION TEST DESCRIPTION

The performance of the Series 3300 CEM was evaluated in terms of relative accuracy (RA), linearity, seven-day calibration error, cycle time, data completeness, and operational factors (ease of use, maintenance and data output needs, power and other consumables use, reliability, and operational costs). RA was determined according to Equation A-10 of Chapter 40 of the Code of Federal Regulations Part 75 (40 CFR Part 75) Appendix A, by comparing CEM vapor-phase mercury results to simultaneous results from American Society for Testing and Materials D 6784-02, the "Ontario Hydro" (OH) method. RA of the Series 3300 was determined for total mercury (Hg_T) and elemental mercury (Hg^0). Linearity was determined based on Series 3300 responses to Hg^0 standards. Calibration error was evaluated by comparing Series 3300 readings on mercury standard and zero gases performed once each day over a consecutive seven-day period. Cycle time was evaluated in terms of the response of the Series 3300 when switching from a zero gas or upscale Hg^0 standard gas, supplied at the Series 3300 inlet, to sampling of stack gas. Data completeness was assessed as the percentage of maximum data return achieved by the Series 3300 over the test period. Operational factors were evaluated by means of observations during testing and records of needed maintenance, vendor activities, and expendables use.

The Series 3300 was verified at Unit 17 of the R.M. Schahfer Generating Station, located near Wheatfield, Indiana, between June 12 and July 25, 2006. Unit 17 burns pulverized Illinois sub-bituminous coal and has an electrostatic precipitator and a wet flue gas desulfurization unit. Twelve successive OH method runs, each of 2 hours duration, were conducted on the Unit 17 stack in each of two separate reference sampling periods using paired OH trains. Those reference samples were collected and analyzed for Hg^0 and oxidized mercury (Hg_{OX}), the sum of which is Hg_T.

QA oversight of verification testing was provided by Battelle and EPA. Battelle QA staff conducted a technical systems audit, a performance evaluation audit, and a data quality audit of 10% of the test data.

This verification statement, the full report on which it is based, and the test/QA plan for this verification test are all available at www.epa.gov/etv/centers/center1.html.

TECHNOLOGY DESCRIPTION

The following description of the Series 3300 CEM is based on information provided by the vendor. The information provided below was not verified in this test.

The Series 3300 measures Hg_T, Hg^0, and Hg_{OX} in combustion sources. It is designed to be insensitive to the presence of sulfur dioxide, nitrogen oxides, carbon monoxide, hydrogen chloride (HCl), and other common combustion by-products and to operate unattended for extended periods. In this verification the Series 3300 was programmed to report a reading of mercury concentration every 2.5 minutes. The CEM alternated measurements of Hg_T and Hg^0, providing two successive readings of Hg_T, followed by two of Hg^0, two of Hg_T, etc.

The Series 3300 consists of a sampling probe, a heated umbilical line, a dual channel sample conditioner, a mercury analyzer, a saturated Hg^0 vapor calibration source, and a control system. It uses a stack-mounted inertial probe to minimize mercury measurement artifacts due to filtering. The probe can perform automated filter blowback, multi-point calibrations, and standard additions of mercury into the sample matrix. The sample flow from the probe is diluted and sent at a high rate through the heated umbilical line to the sample conditioning module, which speciates the mercury into elemental and oxidized forms without using chemical

reagents or solid sorbents. In one channel, a thermal conditioner unit converts all mercury forms into Hg^0, and is designed to avoid recombination by the quantitative removal of HCl and other gases. The second channel removes Hg_{OX}, leaving only the Hg^0 to pass through to the converter. This stream is then subjected to additional conditioning to remove acid gases and excess humidity from the sample. The two conditioned streams are analyzed by a Tekran Model 2537A mercury vapor analyzer using gold preconcentration combined with atomic fluorescence detection.

All temperatures, flows, and pressures are displayed by the control system and may be set by authorized users. The system features remote operation and problem diagnosis. The Series 3300 can be audited by introduction of mercury calibration gas standards, which can be delivered directly to the probe inlet by the umbilical line.

The Series 3300 component rack system is approximately 67 inches high by 31.5 inches deep by 23 inches wide. The associated air purification system occupies a wall-mountable panel 24 inches by 24 inches in size.

VERIFICATION RESULTS

The RA of the Tekran Series 3300 CEM was 18.5% for Hg_T and 15.4% for Hg^0, based on comparison to 12 OH reference results obtained at the start of the six-week field test. The overall average Hg_T, Hg^0, and Hg_{OX} values from that first set of OH data were 0.815, 0.768, and 0.047 microgram per dry standard cubic meter (μg/dscm), whereas those from the Series 3300 were 0.923, 0.849, and 0.074 μg/dscm, with resulting differences of 0.108, 0.081, and 0.027 μg/dscm, respectively. The RA of the Series 3300 was 28.7% for Hg_T and 27.8% for Hg^0, based on comparison to nine OH reference results obtained at the end of the six-week field test. The overall average Hg_T, Hg^0, and Hg_{OX} values from that set of OH data were 1.011, 0.948, and 0.060 μg/dscm, whereas those from the Series 3300 were 0.805, 0.735, and 0.098 μg/dscm, with resulting differences of 0.206, 0.213, and 0.038 μg/dscm, respectively.

The linearity error of the Series 3300 was 4.7 to 6.9% when tested over the range of about 1 to 4.5 μg/dscm and 1.6 to 5.7% when tested over a range of about 4 to 16 μg/dscm.

The seven-day calibration error of the Series 3300 was evaluated with zero gas and with a calibration gas of about 4.5 μg/dscm Hg^0. Error in zero readings ranged from 5.75 to 14.6% of span, and error in calibration gas readings from 0.66 to 3.14% of span, in both cases relative to an assumed 10 μg/dscm span value.

Cycle time of the Series 3300 was estimated to be 7.5 to 10 minutes, in switching from either zero gas or span gas to sampling of stack gas. The Series 3300 provided a mercury reading every 2.5 minutes, so the cycle time was estimated as a multiple of this integration time.

Data completeness of the Series 3300 was 99.9% over the six-week field test, in the sense that the CEM operated with minimal down time and provided readings at 2.5-minute intervals throughout the test. However, not all readings were valid measurements of stack gas mercury. Frequent erroneous readings of 0 μg/dscm were reported by the Series 3300 in a portion of the field period, amounting to 8.1 days of such readings (18.6% of the field test duration).

The Series 3300 used one standard cylinder of argon (about 200 cubic feet of gas) in about one month of continuous operation. The Series 3300 also used deionized water at a rate of about 3 liters per day; required both 240 and 120V AC power, with connections for the latter both at the ground and aloft at the stack sampling port; and required connection to facility compressed air. The Series 3300 is controlled by software that can be accessed locally or remotely and provides rapid control of all instrument operations and detailed information on mercury results and instrument functions. The only recurring problem with the Series 3300 was the frequent reporting of 0 μg/dscm for stack gas mercury over approximately two weeks of the field period. This problem apparently was related to the ultraviolet lamp in the mercury analyzer of the Series 3300 and was ultimately solved by replacement of the lamp and proper adjustment of lamp voltage.

The cost of the Tekran Series 3300 Mercury CEM as tested was approximately $125,000, excluding the umbilical line, installation, and training.

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