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:	**Thermo Electron Mercury Freedom System**	
COMPANY:	**Thermo Electron 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 Thermo Electron Mercury Freedom System (MFS) 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 MFS 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 MFS vapor-phase total mercury (Hg_T) results to simultaneous results from American Society for Testing and Materials D 6784-02, the "Ontario Hydro" (OH) method. Calibration error was evaluated by comparing MFS 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 MFS when switching from a zero gas or upscale elemental mercury (Hg^0) standard gas, supplied at the MFS probe inlet, to sampling of stack gas. Data completeness was assessed as the percentage of maximum data return achieved by the MFS 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 MFS was verified at Unit 17 of the R.M. Schahfer Generating Station, located near Wheatfield, Indiana, in part of a field test that took place 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. During the period of operation of the MFS, twelve successive OH method runs, each of 2 hours duration, were conducted on the Unit 17 stack using paired OH trains. Those reference samples were collected and analyzed to determine 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 MFS is based on information provided by the vendor. The information provided below was not verified in this test.

Designed to meet the provisions of 40 CFR Parts 60 and 75, the MFS can determine Hg^0, Hg_{OX}, and Hg_T in exhaust stacks of coal-fired boilers. The system uses a direct measurement atomic fluorescence method that precludes the use of argon tanks and gold amalgamation. The system extracts a small sample flow from the flue gas stream and immediately dilutes it inside the probe. Any Hg_{OX} in the diluted sample is then converted to Hg^0 in a dry heated converter to obtain an Hg_T measurement. This diluted, converted sample is continuously transported to the mercury analyzer in the MFS rack where it is analyzed using atomic fluorescence technology developed specifically for measuring mercury vapor concentrations on a continuous, real-time basis. In this test, the continuous readings of the MFS were averaged and reported at one-minute intervals. The MFS determined only Hg_T for the purposes of this test.

The MFS consists of a sampling probe with an integrated converter, a heated umbilical line, a probe controller, a saturated Hg^0 vapor calibrator, and an atomic fluorescence analyzer. The MFS can be audited by introduction of mercury calibration gas standards, which can be delivered directly to the probe inlet by the MFS umbilical. In its rack configuration, the system is 70 inches high by 36 inches deep by 24 inches wide. The probe box measures 34.5 inches long by 18.5 inches high by 10.5 inches wide and weighs 90 pounds. Onboard data storage capacity is 4 megabytes. Recording to a data acquisition system can be accomplished using analog output signals, digital (RS232/485), or modbus (via an industry standard Ethernet port).

VERIFICATION RESULTS

The RA of the Thermo Electron MFS was 16.4% for Hg_T, based on comparison to 11 OH reference results. The overall average value from that set of OH data was 1.008 micrograms per dry standard cubic meter (µg/dscm), respectively, whereas that from the MFS was 1.090 µg/dscm, a difference of 0.082 µg/dscm.

The linearity error of the MFS was 2.6 to 7.2% when tested over the range of 3 to 9 µg/dscm.

The seven-day calibration error of the MFS was evaluated with zero gas and with a calibration gas of 10 µg/dscm Hg^0. Error in zero readings ranged from 0.24 to 0.27% of span, and error in calibration gas readings from 0.0 to 1.3% of span, in both cases relative to an assumed 10 µg/dscm span value.

Cycle time of the MFS was estimated to be 5 to 6 minutes, based on readings during switching from zero gas to sampling of stack gas. The MFS recorded a mercury reading every minute, so the cycle time was estimated as a multiple of this integration time.

Data completeness for the MFS was 38.7%, based on its operation for 16.8 days over the approximately six-week field test. Considering only those 16.8 days on which the MFS was fully operational, 12.1 days of stack gas data were recovered, 1.2 days were spent in calibration/zeroing/other instrument checks, and 0.1 day was spent in conducting or recovering from filter blowback. Another 3.3 days of routine stack gas monitoring proceeded without apparent problems but produced no recorded mercury data.

The MFS required 120V AC power and connection to facility compressed air. The MFS is controlled by software that can be accessed locally or remotely and that provides rapid control of all instrument operations and information on mercury results and instrument functions. Zeroing, calibrations, and other operations were not clearly identified in the data files that resulted from this software. It was necessary to decipher the data files, by means of a separate code file provided by Thermo Electron, to identify such operations in the data. The MFS suffered from several problems that delayed its arrival in the field and limited its operational time once there. Problems included inadequate performance of the inertial probe material, failure of probe heating and control circuit boards, improperly installed valves, excessively high sample flow for the stack conditions, and failure of communication with the MFS on-board computer.

The cost of the Thermo Electron MFS as tested was approximately $124,790, excluding the umbilical line, installation, and training.

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