THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

The Business of Innovation

Revised
ETV Joint Verification Statement

TECHNOLOGY TYPE:	**CONTINUOUS EMISSION MONITOR**		
APPLICATION:	**MEASURING AMMONIA EMISSIONS**		
TECHNOLOGY NAME:	**LD500**		
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The U.S. Environmental Protection Agency (EPA) supports 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 verification 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 (CEMs) to measure ammonia emissions. This verification statement provides a summary of the test results for the Opsis AB LD500 ammonia CEM.

VERIFICATION TEST DESCRIPTION

The purpose of this verification test was to evaluate the ability of ammonia CEMs to determine gaseous ammonia in flue gas, under normal operating conditions, in a full-scale coal-fired power plant equipped with selective catalytic reduction nitrogen oxide control technology. This verification test was conducted at American Electric

Power's Mountaineer Plant in New Haven, West Virginia, from July 15 to August 15, 2003. The performance parameters to be addressed included agreement with standards, relative accuracy, linearity, precision, calibration and zero drift, response time, ease of use, and data completeness. Agreement with standards was assessed for the LD500 based on the differences between LD500 readings and known concentrations of ammonia prepared from ammonia compressed gas standards. Relative accuracy refers to the degree of agreement of LD500 readings with flue gas ammonia measurements made by a reference method. Precision was assessed in terms of the repeatability of the LD500 ammonia measurements with stable ammonia concentrations. Linearity, calibration drift, zero drift, and response time were assessed using commercial compressed gas standards of ammonia and high purity nitrogen zero gas. (Due to the nature of the test procedure, the response times recorded were limited by the gas changeover time in the test cell and not by the instrument response time of the LD500.) The effort spent in installing and maintaining the LD500 was documented and used to assess ease of use. The amount of time the LD500 was operational and the maintenance activities performed were recorded to assess data completeness.

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

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

TECHNOLOGY DESCRIPTION

The following description of the LD500 was provided by the vendor and does not represent verified information.

The LD500 is an optical open-path monitoring system designed to measure ammonia, water vapor, hydrochloric acid, hydrogen fluoride, oxygen, and temperature. The LD500 allows multiplexing of monitoring paths and can be configured with up to eight individual paths. The LD500 housed in a 19-inch rack cabinet, is the central unit of a laser diode gas monitoring system. Up to four laser diode heads can be installed, each one a complete laser control and data sampling system monitoring a specific gas. The LD500's laser module emits near-infrared light, operates continuously, and is tunable. The laser is scanned rapidly (in kilohertz frequency range) over the absorption line of the gas to be measured for 10 to 30 seconds. An internal reference beam maintains the wavelength stability of the laser diode. At the end of the measurement interval, the averaged spectrum is evaluated. The results are compared through a least-squares fitting procedure with the known absorbance cross section of the gas. The Beer-Lambert absorption law is used to determine the gas concentration from the absorption measured in the monitoring path, using the known monitoring path length.

The LD500 includes an emitter and a receiver to be mounted on ports on the flue gas duct. The laser signal is sent through a fiber optic cable to the receiver where it is divided into two fiber optic cables, one providing the signal to the emitter and the second providing the light signal for calibration. The emitter projects the infrared energy across the stack or duct. The receiver focuses the projected infrared energy to a solid-state detector. The raw signal is converted to a digital communication signal and transmitted through a communications optic fiber back to the LD500. The LD500 processes the final signal and presents a concentration. The receiver is equipped with a calibration/audit cell. The calibration cell is 5.11 inches (130.0 millimeters) long and heated to a constant temperature of 150°F. A solenoid valve unit is connected to the LD500, providing daily automatic zero and span calibration. In calibration mode, the gas is flushed at a low flow rate through the cell and vented through a ¼-inch tube at a secure point.

For absolute zero and span calibrations, a flat mirror is folded in to deflect the calibration laser beam through the calibration cell. At the beginning of the calibration cycle, the mirror is automatically folded in; it is folded out upon completion of the calibration cycle. The same laser source is used both for measurements and for calibration checks. An add-on spiking run is performed with the mirror folded out, i.e., the measurement light beam is measured on the detector. In this mode, a concentration entered in the calibration cell is added to the measured stack concentration. A signal input and output unit is connected to the LD500. Signals include stack temperature entering the system and analog output signals being delivered to an outside data system. The LD500 stores all raw data, measurements, and logged data from the signal system on its internal hard drive. For data presentation, a personal computer provides real-time graphics of monitored results.

VERIFICATION OF PERFORMANCE

Below is a summary of the results for each of the LD500 performance parameters. Note that all test results originate from discrete 10-second readings reported by the LD500 without smoothing or averaging.

Parameter	Performance Results	Comments
Agreement with Standards	10.4% at 2.14 parts per million, weight volume basis (ppmwv) 7.9% at 5.22 ppmwv 14.3% at 8.15 ppmwv	Results of three concentration levels with 12 data points each; nine data points used in each calculation; median difference from expected value = 0.43 ppmwv
Relative Accuracy	Not calculated	Reference sampling location unrepresentative of duct ammonia concentrations[a]
Linearity	Regression line = 1.198 (± 0.036)x - 0.521 (± 0.209) ppmwv, $r^2 = 0.970$	Calculated over range of 2.14 to 8.15 ppmwv, 36 total data points
Precision	48.6% relative standard deviation (RSD) at 2.82 ppmwv 24.1% RSD at 6.26 ppmwv 15.8% RSD at 10.12 ppmwv	Discrete 10-second data, no smoothing; variability due partly to the variability of background ammonia concentration in the duct
Calibration and Zero Drift	Zero drift averaged 1.86 ppmwv Span RSD values = 0.96 to 2.43%	Minimal span drift over the five-week test
Response Time	Rise times average 53 seconds Fall times average 57 seconds	Observed response times largely due to concentration changeover in the test cell
Ease of Use	Generally easy to use	
Completeness	70% data capture	Missing data due to data system lock up and hard drive failure

[a] Reference sampling port was improperly located and did not allow sampling across width of duct. Mapping of ammonia concentrations at points along the CEM light path confirmed that sampling at reference port could not adequately determine duct ammonia concentrations.

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