THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM
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U.S. Environmental Protection Agency

Battelle
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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**PORTABLE EMISSION ANALYZER**
APPLICATION:	**DETERMINING NITROGEN OXIDES EMISSIONS**
TECHNOLOGY NAME:	**PG-250 Portable Gas Analyzer**
COMPANY:	**Horiba Instruments, Inc.**
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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; stakeholder groups which 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) program, one of 12 technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. AMS has recently evaluated the performance of portable nitrogen oxides monitors used to determine emissions from combustion sources. This verification statement provides a summary of the test results for the Horiba PG-250 Portable Emission Analyzer.

VERIFICATION TEST DESCRIPTION

The verification test described in this report was one of a series of tests conducted in early 1999 on commercial portable nitrogen oxides analyzers at Battelle's facilities in Columbus, Ohio. Verification testing of the analyzers

involved (1) a series of laboratory tests in which certified NO and NO_2 standards were used to challenge the analyzers over a wide concentration range and (2) tests using realistic combustion sources, in which data from the portable analyzers undergoing testing were compared to simultaneous NO and NO_x measurements obtained with two chemiluminescent analyzers.

Verification testing lasted three to four days, of which two days were required for laboratory testing and the remainder for source emissions testing. To assess inter-unit variability, two identical analyzers were tested simultaneously in all tests, and results from the two analyzers were kept separate. The analyzers were operated at all times by a representative of Horiba and supervised at all times by Battelle staff.

Verification testing focused on measurement of NO and NO_2, the sum of which is denoted as NO_x. Laboratory testing included a linearity test over the entire nominal ranges of the analyzers for both NO and NO_2; estimation of detection limits and response times; interference testing; assessment of sample pressure and ambient temperature effects on analyzer response; and evaluation of zero and span drift during the various laboratory tests. Tests with combustion sources assessed the accuracy of NO, NO_2, and NO_x measurements, relative to the chemiluminescent NO/NO_x approach that is the basis of EPA Method 7E. Sources used in the testing were a gas-fired rangetop burner, a gas-fired water heater, and a diesel-powered electrical generator operated at both idle and at high RPM. These sources produced NO_x emissions ranging from less than 10 to over 400 ppm. Zero and span drift resulting from exposure to source emissions were assessed, and analyzer stability was monitored during one hour of uninterrupted sampling of diesel emissions.

Quality assurance (QA) oversight of verification testing was provided by both Battelle and U.S. EPA. Battelle QA staff conducted a technical systems audit, a performance evaluation audit, and a data quality audit of 10 percent of the test data. EPA QA staff conducted an independent on-site technical system audit.

TECHNOLOGY DESCRIPTION

The Horiba Model PG-250 multi-gas portable analyzer is 10.2 inches high, 10.2 inches wide, and 20.1 inches deep and weighs 37 pounds. The PG-250 provides the user with simultaneous analyses of CO, CO_2, O_2, NO_x, and SO_2 in flue gas samples. Each gas constituent can be monitored over multiple ranges. The PG-250 employs non-dispersive infrared detection of SO_2, CO, and CO_2; chemiluminescence detection of NO and NO_x; and an electrochemical cell for O_2 measurement. Only the NO/NO_x measurement capabilities were verified in this test. Measurements of NO_x are achieved with a low temperature converter that reduces NO_2 to NO for detection. Although the PG-250 offers NO/NO_x measurement ranges up to 2,500 ppm, the applicability of the NO_2 converter is limited to concentrations below 6 ppm. Converter lifetime is shortened by sampling NO_2 above 6 ppm. The PG-250 incorporates a built-in sample conditioner consisting of a dual-stage moisture removal system that includes a gravity drain separator and thermal-electric cooler. Other sample conditioning components can include acid mist eliminators, filters, sample pump, condensate drain pump, and a sample flow monitor. Sampling is accomplished with a 316 stainless steel unheated sample probe equipped with an external primary filter. Data may be output from the instrument via 4 to 20 mA analog signals or from the instrument's RS-232C serial communication port. A large liquid crystal display screen also displays in real time the gas parameters being measured, in addition to the selected measurement ranges for each gas and the sample flow through the analyzer.

VERIFICATION OF PERFORMANCE

Linearity: The Horiba PG-250 analyzers provided linear response to NO over the full 0 to 2,500 ppm range tested. Response to NO_2 over a range of 0 to 500 ppm was approximately linear, but exhibited a slope much less than one (i.e., about 0.7) on both analyzers. This behavior is attributed to the limited capacity of the NO_2 converters in the analyzers.

Detection Limit: For analyzers A and B, respectively, detection limits determined from the linearity test data were 6 and 7 ppm on the 0 to 2,500 ppm range for NO, and 16 and 9 ppm on the 0 to 500 ppm range for NO_2. Lower detection limits can be achieved using lower measurement ranges, as is indicated by the relative accuracy results obtained with a range of emission sources.

Response Time: Response times of both analyzers for NO were 40 seconds; for NO_2, analyzer A had a response time of about 90 seconds, and analyzer B had a response time of 130 seconds.

Zero/Span Drift: Zero drift during laboratory tests was 6 ppm or less. Span drift in those tests was equivalent to about 1 to 3 percent of the corresponding span concentration. Shutting the analyzers down overnight produced no additional effect on zero or span drift.

Interferences: No interference was found from elevated concentrations of SO_2, CO, CO_2, NH_3, or hydrocarbons, but a reduction of about 13 percent in response to 381 ppm NO was seen when SO_2 was also present at about 450 ppm.

Pressure Sensitivity: Over the range of +10 to -10 inches of water (relative to the ambient pressure), the sample gas pressure had no significant effect on zero or span response to NO or NO_2.

Ambient Temperature: Ambient temperature over the range of 45° to 105°F had a significant effect only on response to NO. The effect was about a 5 percent increase in NO response at reduced temperature, and about a 6 percent decrease in response to NO at elevated temperature, relative to response at room temperature.

Relative Accuracy: Accuracy for NO ranged from 1.9 to 8.5 percent relative to the reference method, in emission measurements on a range of sources. Accuracy for NO_2 from those same sources ranged from about 35 to 50 percent, because of the limited capacity of the NO_2 converters. The sources tested emitted predominantly NO, so the overall accuracy for NO_x determination ranged from 5 to 19 percent at NO_x levels from less than 10 to over 400 ppm.

Inter-Unit Repeatability: Comparison of results from the two PG-250 analyzers shows that they performed essentially identically in the verification tests. Unit-to-unit agreement of the two Horiba analyzers was within 4.8 percent, on combustion sources emitting from 8 ppm to 400 ppm NO_x, and was usually better than the unit-to-unit agreement of the reference analyzers.

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