THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**PORTABLE EMISSION ANALYZER**		
APPLICATION:	**DETERMINING NITROGEN OXIDES EMISSIONS**		
TECHNOLOGY NAME:	**Model 3000E Portable Emission Analyzer**		
COMPANY:	**Enerac Division of Energy Efficiency Systems, 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 Enerac 3000E 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 analyzers undergoing testing were compared to simultaneous chemiluminescent NO and NO_x measurements.

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 Enerac 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 Enerac 3000E analyzer combines electrochemical sensor technology for NO and NO_2 measurement with automatic quality control features. The Enerac 3000E measures 18" x 13" x 6" and weighs 22 pounds. The NO sensor is controlled to a constant temperature by means of a pair of thermoelectric coolers located below the aluminum plate on which the sensor is mounted. A temperature sensor monitors and controls the temperature of the NO sensor. This feature is designed to avoid over-reporting of NO emissions due to temperature effects on the sensor. The analyzer also has an autocalibration protocol that checks the performance of the electrochemical sensors and interference rejection filters during each calibration. Nominal ranges for NO of 0 to 300 ppm, 0 to 1,000 ppm, and 0 to 3,000 ppm are selectable using Enerac's precision control modules (PCMs). The nominal range for NO_2 is 0 to 500 ppm.

The Enerac 3000E uses a battery-operated permeation dryer to provide effective sample conditioning for low NO_x combustion systems which can emit a large fraction of the NO_x as NO_2. The Enerac 3000E also has advanced two-way communications via a modem. All performance parameters can be remotely checked by the factory.

VERIFICATION OF PERFORMANCE

Linearity: The Enerac 3000E analyzers provided linear response for NO over the basic 0 to 1,000 ppm range, and over extended (0 to 3,000 ppm) and reduced (0 to 300 ppm) ranges. NO_2 response was linear over the tested range of 0 to 400 ppm.

Detection Limit: In linearity tests to 400 ppm, the detection limit for NO_2 was about 6 ppm. Using a low-range PCM in a linearity test up to 300 ppm, an NO detection limit comparable to the l ppm measurement resolution of the analyzer was indicated. Using a mid-range PCM in linearity tests up to 3,000 ppm, detection limits for NO were 1.2 to 8.3 ppm.

Response Time: The response times of both analyzers for NO were about 60 seconds, and for NO_2 about 100 seconds.

Zero/Span Drift: Drift in zero readings was usually 4 ppm or less over the course of a variety of laboratory and combustion source tests, on both the NO and NO_2 sensors of both analyzers. Within a single day, span drift was less than 2 percent of the span concentration for NO, using span concentrations of 700 to 1,000 ppm NO, and also for NO_2, using span concentrations of 350 to 400 ppm NO_2. Shutting the analyzers off overnight did not increase either zero or span drift.

Interferences: No interference was found from any of the following: 496 ppm CO, 5.03 percent CO_2, 494 ppm NH_3, 590 ppm of total hydrocarbons, and 501 ppm SO_2. When sampling a mixture of 451 ppm SO_2 and 385 ppm NO, the NO sensors of the Enerac analyzers indicated 426 ppm and 422 ppm, respectively, suggesting a positive interference from the SO_2 equivalent to 8 to 9 percent of the SO_2 concentration.

Pressure Sensitivity: Over the range of –10 to +10 inches of water (relative to the ambient pressure), the sample gas pressure had no consistent effect on the zero or span readings of the analyzers.

Ambient Temperature: Ambient temperature over the range of 45 to 105°F had no consistent effect on NO or NO_2 span and zero responses. The small zero drifts observed (5 ppm or less) are of minimal practical importance.

Relative Accuracy: Relative accuracy was assessed using combustion sources having NO_x emissions in the low end of the Enerac 3000E's measurement range. The relative accuracy for NO_x measurements with the two analyzers ranged from 11 to about 20 percent.

Inter-Unit Repeatability: In source sampling, the NO_x unit-to-unit precision of the two Enerac analyzers ranged from 0.4 to 6.2 percent, and in some cases was better than that of the reference analyzers. The performance of the two Enerac analyzers was essentially identical in all verification tests.

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