THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**AMBIENT AMMONIA MONITOR**	
APPLICATION:	**MEASURING AMMONIA EMISSIONS AT ANIMAL FEEDING OPERATIONS**	
TECHNOLOGY NAME:	**Model 17C Ammonia Analyzer**	
COMPANY:	**Thermo Electron Corporation**	
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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 seven technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. In collaboration with the U.S. Department of Agriculture, the AMS Center has recently evaluated the performance of ambient ammonia (NH_3) monitors to measure NH_3 emissions. This verification statement provides a summary of the test results for the Thermo Electron Corporation Model 17C NH_3 analyzer.

VERIFICATION TEST DESCRIPTION

The objective of this verification test was to evaluate the Model 17C's performance in measuring gaseous NH_3 in ambient air at two animal feeding operations. The verification test was conducted in two phases, each at separate animal feeding operations. The first phase of testing was conducted between September 8 and October 3, 2003, at a swine finishing farm near Ames, Iowa. The second phase was conducted between October 20 and November 14, 2003, at a cattle feedlot in Carroll, Iowa. These sites were selected to provide realistic testing conditions and were expected to exhibit a wide range of NH_3 concentrations during the test periods. The verification test was designed to evaluate relative accuracy (RA), linearity, precision, response time, calibration and zero drift, interference effects, comparability, ease of use, and data completeness.

During each phase of the verification test, the Model 17C response to a series of NH_3 gas standards of known concentration was used to quantify RA, linearity, precision, and calibration/zero drift. Ammonia gas standards ranging from 0 to 10,000 parts per billion (ppb) NH_3 and 0 to 2,000 ppb NH_3 were delivered during Phases I and II, respectively. The Model 17C response time, the time to reach 95% of the change in the stable signal, was also assessed during the delivery of the gas standards. During the second phase, interference effects were quantified from the Model 17C response to various chemical species that may be present at animal feeding operations; the potential interferent gases were delivered both in the presence and absence of NH_3. The Model 17C continuous response to ambient air also was evaluated during both phases as the comparability to simultaneous determinations by a time-integrated ambient NH_3 reference method (acid-coated denuders). Comparisons were made with reference samples that were collected on a five-per-day schedule for periods of between 2 to 12 hours for approximately 10 days during each phase, based on procedures in EPA Method IO-4.2.

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 Model 17C was provided by the vendor and does not represent verified information.

The Model 17C is a chemiluminescence analyzer that uses the reaction of nitric oxide (NO) with ozone (O_3) to measure NH_3 concentrations in the atmosphere. A sample is drawn into the Model 17C by an external pump. After the sample reaches the reaction chamber, it mixes with O_3, which is generated internally. The reaction of NO with O_3 produces a characteristic luminescence with an intensity proportional to the concentration of NO. Light is emitted when electronically excited nitrogen dioxide (NO_2) molecules decay to lower energy states. The light emission is detected by a photomultiplier tube, which in turn generates an electronic signal. The signal is processed by the microcomputer into a NO concentration reading. To measure the NO, NO_2, and NH_3 concentrations, NO_2 and NH_3 are transformed to NO in a stainless steel converter heated to approximately 775°C before reaching the reaction chamber. Upon reaching the reaction chamber, the converted molecules, along with the original NO molecules, react with O_3. The resulting signal represents the total NO, NO_2, and NH_3 reading (N_t). Separately, NO_2 is transformed into NO in a molybdenum converter heated to approximately 340°C. The NO, plus converted NO_2 concentrations are measured as NO_x. The NO_2 concentration is determined by subtracting the signal obtained in the NO mode from the signal obtained in the NO_x (the sum of NO and NO_2) mode. The NH_3 concentration is determined by subtracting the signal obtained in the N_t mode from the signal obtained in the NO_x mode. NO, NO_2, and NH_3 concentrations are displayed on the front panel of the Model 17C as analog output. The Model 17C has a 1-ppb detection limit and operates manually or automatically, with a sample flow rate of 0.6 liters per minute. The Model 17C requires 500 Watts of power from 90 to 110, 105 to 125, or 210 to 250 volts alternating current. The Model 17C consists of two components: the analyzer and the converter. The analyzer dimensions are 426 millimeters (mm) by 219 mm by 584 mm, and the converter dimensions are 426 mm by

175 mm by 389 mm. The analyzer weighs 27 kilograms (kg), and the converter weighs 9 kg. The Model 17C costs about $17,000.

VERIFICATION OF PERFORMANCE

The performance of the Model 17C was evaluated in two phases in this verification test. During both phases of the verification test, the Model 17C was installed inside a climate-controlled instrument trailer, with a Teflon tube used to draw the outside air into the Model 17C inlet. The following presents a summary of the performance of the Model 17C during this verification test. The Model 17C stored NH_3 measurement data as both 1- and 5-minute averages. When available, 1-minute averaged data were used for the RA, linearity, precision, calibration/zero drift, response time, and interference tests. The comparability tests utilized 5-minute averaged data. Values in parentheses are 95% confidence intervals.

Performance Summary of the Model 17C

Parameter	Results	
	Phase I	**Phase II**
Relative accuracy[(a)]	Average RA = 3.7% Percent difference (%D) Range = −10.2% to 2.8%	Average RA = 10.5% %D Range = −11.5% to -8.9%
Linearity	Range = 0 to 10,000 ppb Slope = 1.03 (± 0.01) Intercept = −24 ppb (± 23) r^2 = 1.000	Range = 0 to 2,000 ppb Slope = 0.90 (± 0.02) Intercept = −0.6 ppb (± 20.3) r^2 = 1.000
Precision	Average relative standard deviation (RSD) = 0.3% Range = 0.2% to 0.5%	Average RSD = 0.3% Range = 0.2% to 0.6%
Response time	Rise time = 180 to 4,560 seconds[(b)] Fall time = 120 to 180 seconds[(b)]	Rise time = 600 to 900 seconds[(c)] Fall time = 1,200 seconds[(c)]
Calibration/ zero drift	No apparent drift in response to zero air or a 1,000-ppb NH_3 gas standard during Phase I.	No apparent drift in response to zero air or a 1,000-ppb NH_3 gas standard during Phase II.
Interference effects[(d)]	Interference check conducted during Phase II.	• Hydrogen sulfide (285 ppb): no apparent effect • Nitrogen dioxide (95 ppb): a small negative response in zero air and 500 ppb NH_3 • 1,3-Butadiene (95 ppb): no apparent effect • Diethylamine (96 ppb): ~50% response in both zero air and 500 ppb NH_3
Comparability	Slope = 1.20 (± 0.05) Intercept = 16 ppb (± 29) r^2 = 0.984	Slope = 0.86 (± 0.03) Intercept = −0.5 ppb (± 3.8) r^2 = 0.990
Ease of use	• Daily checks were simple and quick • Little skill required to operate • Minimal maintenance required • Regular data download necessary • Data download software unreliable	• Daily checks were simple and quick • Little skill required to operate • Minimal maintenance required • Regular data download necessary • Data download software unreliable
Data completeness	99% data collected, 66% data recovered[(e)]	99% data collected, 86% data recovered[(e)]

[(a)] Relative accuracy is expressed as an average absolute value of the percent difference from NH_3 gas standards.
[(b)] Only 1-minute averaged data available for this test. Standards for rise time calculation were delivered for three hours.
[(c)] Only 5-minute averaged data available for this test.
[(d)] Calculated as the change in signal divided by the interferent gas concentration, expressed as a percentage.
[(e)] Data loss due to incomplete or failed data downloads.

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