THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**AMBIENT AMMONIA MONITOR**		
APPLICATION:	**MEASURING AMMONIA EMISSIONS AT ANIMAL FEEDING OPERATIONS**		
TECHNOLOGY NAME:	**AiRRmonia**		
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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 Mechatronics Instruments BV AiRRmonia NH_3 analyzer.

VERIFICATION TEST DESCRIPTION

The objective of this verification test was to evaluate the AiRRmonia's performance in measuring 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 AiRRmonia 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 AiRRmonia response time, the time to reach 95% of the change in the stable signal, was also assessed during the delivery of the gas standards. Interference effects were quantified from the AiRRmonia 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 AiRRmonia response to ambient air also was evaluated during both phases as the comparability to simultaneous determinations by an 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 AiRRmonia was provided by the vendor and does not represent verified information.

The AiRRmonia is a stand-alone single-point monitor that measures NH_3 concentrations continuously in ambient air. The AiRRmonia draws an air sample through a folded channel system in the sampling block. This channel system is positioned on a Teflon, gas-permeable membrane with an aqueous absorption solution counter-flow on the opposite side of the membrane. The NH_3 in the air sample permeates the membrane at an air flow rate of one liter per minute and forms ammonium ions in the absorption solution. Almost all aerosols bypass the sampling channel, without penetration of the membrane, thereby limiting interference effects from ammonium-laden aerosol. After dissolution of the NH_3 in the absorption solution, the sample solution flows into the detector block though a de-bubbling chamber. In the detector block, a sodium hydroxide solution mixes with the sample solution, and the sample solution passes along a second Teflon membrane. At this step in the process, gaseous NH_3 penetrates the membrane and is dissolved in purified water flowing on the opposite side of the membrane. A conductivity cell monitors the initial water conductivity, and a second conductivity cell measures the amount of ammonium and hydroxide after the membrane exchange. The difference in conductivity, corrected for temperature drifts, is the measure of the original NH_3 content in the sampled air. Monitoring process parameters and an automated check by a blank and a standard ammonium solution control the performance of the AiRRmonia.

The AiRRmonia is housed in a weatherproof box and contains a membrane diffusion sampler, a detector block with a diffusion membrane, and two conductivity cells. An air pump and mass flow controller are used for the air sampling. A three-channel syringe pump is used to deliver the aqueous solutions at fixed flow rates.

The AiRRmonia also includes bottles for water, standard solution, diluted sodium hydroxide, and waste. A processor and a display with key entries are used for programming, and an internal data logger stores monitoring and diagnostic data.

The AiRRmonia power requirements are 115 to 230 volts, 50 to 60 Hertz, and 10 Watts (120 Watts including heater). It is 62 centimeters (cm) wide, 40 cm deep, and 50 cm high and weighs 23 kilograms. An optional extension box for a two-month solution supply has the same dimensions. Data are recorded at a default interval of two minutes, which can be changed. Average values of the measured parameters (time, date, air flow, detector temperature, conductivity of purified water, and conductivity of the sample after diffusion) are logged, as well as the calculated NH_3 concentrations. Results of the calibration check also are logged. The cost of the AiRRmonia is $27,000 U.S., plus $2,500 U.S. for optional accessories.

VERIFICATION OF PERFORMANCE

The performance of the AiRRmonia was evaluated in two phases in this verification test. During Phase I, the AiRRmonia was installed outside on a scaffold at a height of approximately 2 meters. During Phase II, the AiRRmonia was installed inside a temperature-regulated instrument trailer, with a stainless steel tube used to draw the outside air into the AiRRmonia inlet. An auxiliary pump was used to flush the inlet tube continuously at approximately 10 liters per minute. The following presents a summary of the performance of the AiRRmonia during this verification test. The values presented in this table are based on 2-minute average readings recorded by the AiRRmonia. Values in parentheses are 95% confidence intervals.

Performance Summary of the AiRRmonia

Parameter	Results	
	Phase I	**Phase II**
Relative accuracy[a]	Average RA = 34% Percent difference (%D) range = 26% to 44%	Average RA = 2.4% %D range = 1.0% to 4.0%
Linearity	Range = 0 to 10,000 ppb Slope = 1.28 (± 0.08) Intercept = 136 ppb (± 344) r^2 = 0.9957	Range = 0 to 2,000 ppb Slope = 1.02 (± 0.01) Intercept = -2.4 ppb (± 15.3) r^2 = 0.9999
Precision	Average relative standard deviation (RSD) = 2.1% Range = 0.8% to 3.0%	Average RSD = 0.7% Range = 0.5% to 1.0%
Response time	Rise time = 480 to 1,200 seconds (8 to 20 minutes) Fall time = 1,439 seconds (24 minutes)	Rise time = 721 to 1,200 seconds (12 to 20 minutes) Fall time = 1,080 to 1,200 seconds (18 to 20 minutes)
Calibration/ zero drift	• No response to zero air or the NH_3 gas standards apparent in the AiRRmonia data; supply of gas standards was unsuccessful.	• No apparent drift in response to zero air or a 1,000-ppb NH_3 gas standard during Week 1. No results available from Week 4.[c]
Interference effects[b]	Interference check conducted during Phase II	• Hydrogen sulfide (285 ppb): no apparent effect • Nitrogen dioxide (95 ppb): no apparent effect • 1,3-Butadiene (95 ppb): no apparent effect • Diethylamine (95 ppb): no apparent effect in 500 ppb NH_3, 25% change observed in zero air[d]
Comparability	Slope = 1.18 (± 0.06) Intercept = -1.38 ppb (± 20.9) r^2 = 0.9755	Slope = 0.41 (± 0.15)[e] Intercept = 58 ppb (± 16) r^2 = 0.538
Ease of use	• Daily checks were simple and quick • Lack of plotted display increased uncertainty in success of testing activities • Little skill required to operate • No data download necessary	• Daily checks were simple and quick • Little skill required to operate • No data download necessary • Interface to laptop computer allowed on-site verification of testing activities • Syringe pump malfunction resulted in ~40% data loss
Data completeness	99%	59%

[a] Relative accuracy is expressed as an average absolute value of the percent difference from NH_3 gas standards.

[b] Calculated as the change in signal divided by the interferent gas concentration, expressed as a percentage.

[c] Data were not available due to malfunction of the AiRRmonia.

[d] The presence of an NH_3 impurity in the diethylamine gas standard or the release of NH_3 from the sample lines during delivery could not be ruled out.

[e] An extended stainless steel sampling line and auxiliary pump were used during normal operation in Phase II, including the comparability checks. However, these were bypassed for all Phase II RA/linearity checks, calibration, zero checks, and interference testing.

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