



AMBIENT AMMONIA MONITORING TECHNOLOGIES



Ann Louise Sumner, Ken Cowen, Amy Dindal, and Karen Riggs
Battelle, Measurement and Data Analysis Sciences, Columbus, Ohio

Jerry Hatfield
U.S. Department of Agriculture, National Soil Tilth Laboratory, Ames, Iowa

Robert Fuerst
U.S. Environmental Protection Agency, National Exposure Research Laboratory, Research Triangle Park, North Carolina

ABSTRACT

The performance of seven ambient ammonia monitoring technologies was recently verified by the U.S. Environmental Protection Agency (EPA) Environmental Technology Verification (ETV) Program's Advanced Monitoring Systems (AMS) Center. The technologies were tested under an EPA cooperative agreement with Battelle Memorial Institute in collaboration with the United States Department of Agriculture National Soil Tilth Laboratory in Ames, Iowa.

Ambient emissions from animal feeding operations (AFOs), account for approximately 65% of the national ammonia emissions, based on 2002 emission data. Decision-makers within the environmental industry need high quality, credible performance data to evaluate ammonia monitoring technologies under the conditions at and near AFOs. The seven technologies verified by the AMS Center (see below) could be used to enhance the scientific understanding of the environmental effects ammonia concentrations have on the emissions at AFOs. The ammonia monitors were

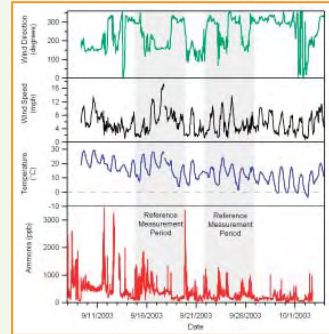
evaluated on a number of performance parameters, including relative accuracy, linearity, precision, response time, calibration and baseline drift, interference effects, comparability to a reference method, ease of use, and data completeness. The verification test was conducted in two phases, each at separate animal feeding operations. Phase I was conducted at a swine finishing farm and Phase II was conducted at a cattle feedlot. All tests were performed in accordance with the *Test/QA Plan for the Verification of Ambient Ammonia Monitors at Animal Feeding Operations* (http://www.epa.gov/etv/pdfs/testplan/01_tp_ammonia.pdf). The results of this performance verification can be found at <http://www.epa.gov/etv/verifications/vcenter1-30.html>. These performance data will assist users of ammonia monitoring technologies, such as farm owners, researchers, permittees, and regulatory agencies, to better control ammonia emissions through better monitoring. Real-time monitoring data will enable users of this type of technology to evaluate the efficacy of control technologies and management plans intended to reduce ammonia emissions at AFOs.

VERIFICATION TEST RESULTS

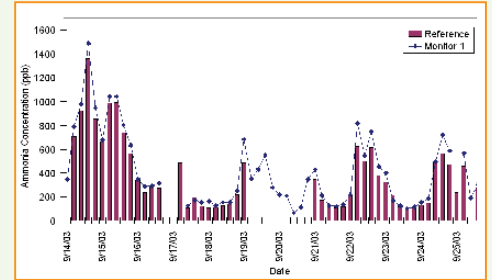
A selection of verification test data is shown here: The complete verification reports and summary statements are available on the ETV website at:

<http://www.epa.gov/etv/verifications/verification-index.htm>

Phase I - Example Ambient Measurement Data



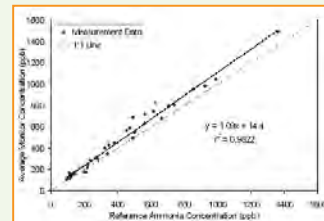
Phase I - Example Ambient Data and Reference Method Measurements



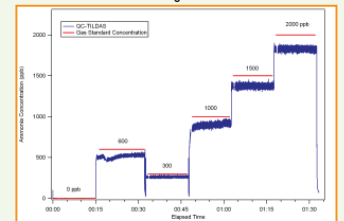
Summary of Comparability Results

Monitor	Phase I			Phase II		
	Slope	Intercept (ppb)	r ²	Slope	Intercept (ppb)	r ²
1	1.09	14.4	0.982	0.984	-9.5	0.994
2	Did not participate			1.15	-4.1	0.994
3	1.46	-6.7	0.984	1.10	21.6	0.979
4	1.18	-1.7	0.976	0.41	58	0.538
5	1.2	16	0.984	0.86	-0.5	0.990
6	Did not participate.			Insufficient data		
7	Did not participate			1.56	-15.4	0.994

Phase I - Example Comparability Analysis



Phase II - Example Analyzer Response to NH₃ Gas Standards



Summary of Linearity Results

Monitor	Phase I				Phase II			
	Range (ppb)	Slope	Intercept (ppb)	r ²	Range (ppb)	Slope	Intercept (ppb)	r ²
1	0 - 3,030 0 - 2,326	0.840 0.962	35 1.5	0.999 1.000	0 - 2,000	0.919	-8.8	1.000
2	Did not participate				0 - 2,000	0.966	15.9	1.000
3	0 - 5,000 0 - 5,000	1.25 0.924	13.2 -12.8	1.000 0.999	0 - 2,000 0 - 2,000	0.586 0.716	-12.2 -58.5	0.999 0.985
4	0 - 10,000	1.28	136	0.996	0 - 2,000	1.02	-2.4	1.000
5	0 - 10,000	1.03	-24	1.000	0 - 2,000	0.90	-0.6	1.000
6	Did not participate				0 - 1,152	0.583	24.9	0.914
7	Did not participate				0 - 1,000	0.815	1.1	1.000

VERIFIED TECHNOLOGIES

QC-TILDAS
Company: Aerodyne Research, Inc.
Address: 45 Manning Rd.
Billerica, MA 01821
Phone: 978-663-9500
Fax: 978-663-4918
Web Site: www.aerodyne.com
E-Mail: shorter@aerodyne.com



TGA310 Ammonia Analyzer
Company: Omnisens SA
Address: Parc Scientifique d'Ecublens
1015 Lausanne, Switzerland
Phone: +41 216938486
Fax: +41 12742031
Web Site: www.omnisens.ch/
E-Mail: info@omnisens.ch



OPAG 22 Open-Path Gas Analyzer
Company: Bruker Daltonics, Inc.
Address: 40 Manning Rd.
Billerica, MA 01821
Phone: 978-663-3660
Fax: 978-667-5993
Web Site: www.bdal.com
E-Mail: fnt@bdal.com



NitroluxTM 1000 Ammonia Analyzer
Company: Pranalytica, Inc.
Address: 1101 Colorado Ave.
Santa Monica, CA 90401
Phone: 310-458-3345
Fax: 310-458-0171
Web Site: www.pranalytica.com
E-Mail: patel@pranalytica.com



IonPro-IMS Ammonia Analyzer
Company: Molecular Analytics,
Division of Particle Measuring Systems
Address: 8475 Airport Blvd.
Boulder, Colorado 80301
Phone: 800-238-1801
Fax: 303-546-7331
Web Site: www.ionpro.com
E-Mail: kwebber@pmeasuring.com



AiRRmonia Ammonia Analyzer
Company: Mechatronics Instruments BV
Address: P.O. Box 225
1620 AE Hoorn
The Netherlands
Phone: +31 229 291129
Fax: +31 229 241534
Web Site: www.mechatronics.nl
E-Mail: rob@mechatronics.nl



Model 17C Ammonia Analyzer
Company: Thermo Electron Corp.
Address: 72 Forge Parkway
Franklin, MA 02038
Phone: 508-553-6850
Fax: 508-520-0430
Web Site: www.thermo.com/
E-Mail: michael.nemergut@thermo.com



TEST DESCRIPTION

Phase I: AFO Test Site
Large swine finishing farm
(up to 20,000 swine)
Ames, Iowa
September 8 - October 3, 2003



Phase II: AFO Test Site
Cattle feed lot
(2,000-3,000 head)
Carroll, Iowa
October 20 - November 14, 2003



The performance of commercially-available ammonia analyzers was evaluated based on the following test parameters:

- Relative Accuracy**.....Percent difference of analyzer response compared with NH₃ gas standard concentrations
- Linearity**.....Linear regression analysis of analyzer response compared with NH₃ gas standard concentrations
- Precision**.....Relative standard deviation of analyzer response while sampling NH₃ gas standards
- Response Time**.....Time to reach 95% of the change in stable reading during delivery of NH₃ gas standards
- Calibration/zero Drift**.....Response to zero air and 1,000 ppb NH₃ standards delivered up to 6 times during each phase of testing
- Interference effects**.....Analyzer response to potentially interfering gases (hydrogen sulfide, nitrogen dioxide, 1,3-butadiene, and diethylamine)
- Comparability**.....Linear regression of average analyzer response to ambient air compared to reference method measurements
- Ease of Use**.....Qualitative evaluation made by test staff of the maintenance and skill needed to operate analyzer
- Data Completeness**.....Percentage of possible data collected by analyzer

FUTURE WORK

Verification test of Hydrogen Sulfide monitors

- Swine finishing farm
- In collaboration with USDA National Soil Tilth Laboratory and Applied Measurement Science
- Tentative test start date in April, 2005 for five weeks

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support of all those who helped plan and conduct the verification test, analyze the data, and prepare the reports. We would like to thank Ernie Bouffard, Connecticut Department of Environmental Protection; Rudy Eden, South Coast Air Quality Management District; Roy Owens, Owens Corning; Jim Homolya, U.S. Environmental Protection Agency;

Bruce Harris, U.S. Environmental Protection Agency; and Lowry A. Harper, U.S. Department of Agriculture, for their careful review of the verification test/QA plan and verification reports. We also thank Richard Pfeiffer, Kenwood Scoggin, Amy Morrow, and Diane Farris of the U.S. Department of Agriculture National Soil Tilth Laboratory for their assistance with the verification test.

Disclaimer: The ETV verifications are based on evaluation of technology performance under specific predetermined criteria and the appropriate quality assurance procedures. The EPA and Battelle make no expressed or implied warranties as to the performance of the technology and do not certify that a technology will always operate as verified. The end user is solely responsible for complying with any and all applicable federal, state, and local requirements. Mention of commercial product names does not imply endorsement.



epascienceforum
Collaborative Science
for Environmental Solutions



2005
epa.gov/scienceforum