

Greenhouse Gas Monitoring Technologies

The U.S. EPA Environmental Technology Verification (ETV) Program's Advanced Monitoring Systems (AMS) Center, operated by Battelle under a cooperative agreement with EPA, has verified¹ 11 technologies that can be used to monitor greenhouse gas (GHG) precursors and GHGs such as carbon dioxide (CO₂), chlorofluorocarbons, methane, various nitrogen oxides (NO_x), ozone (O₃), and total hydrocarbons (THC). In 2009, the AMS Center also plans to verify CO₂ monitors at carbon sequestration sites.

Verification Testing Description

Between 1999-2008 the AMS Center verified 11 GHG monitoring technologies. These technologies were verified for measurement of the different GHGs listed. Other gaseous pollutants were also measured. **Table 1** provides a description of the technologies and the gases measured during testing. Range, detection limits, percent recovery, relative accuracy, bias, precision, and other factors were verified. Selected performance data are available in **Table 2**, and details are available in the verification reports for each technology at <http://www.epa.gov/nrmrl/std/etv/vt-ams.html>, under the Air category. Monitoring data were compared to results obtained from air samples analyzed using EPA Method 3A for CO₂, EPA Method 7E for NO_x, EPA methods from 40 CFR Part 86 for THC, and direct instrument comparison for O₃ (EPA, 1997, 2004).

GHG Pollution at a Glance

EPA estimates that, in 2002, the United States emitted almost 6.4 billion tons of CO₂ and nearly 22 million tons of NO_x. There is support for the position that human activities generate GHGs, thus increasing their concentration in the atmosphere. If GHGs continue to increase, climate models predict that the average temperature at the Earth's surface could increase from 3.2 to 7.2 °F above 1990 levels by the end of this century (EPA, 2009). Increasing global temperatures will cause sea level rise and changes in global precipitation patterns.

Table 1. Portable GHG Emission Monitoring Technologies and Descriptions

| Vendor/Technology (Verification Year) | Technology Description |
|--|--|
| JSC OPTEC Ltd., 3.02 P-A, Chemiluminescent Ozone Analyzer (2008) | Rack-mounted technology combines solid phase chemiluminescence with menu-driven software including diagnostic functions. Technology detects ambient O ₃ through a chemical reaction with a solid-phase reactant of proprietary composition. |
| Testo, Inc., Model 350 Portable Multi-Gas Emission Analyzer (2003) | Portable technology uses electrochemical sensors to measure oxygen (O ₂), carbon monoxide (CO), NO _x (NO and NO ₂), sulfur dioxide (SO ₂), hydrogen sulfide (H ₂ S), and THC from combustion sources. Technology was verified for CO, NO, NO ₂ , O ₂ , SO ₂ , measurements. |
| Clean Air Technologies International, Inc., REMOTE On-Board Emissions Monitor (2003) | Technology uses infrared and electrochemical techniques to measure CO, CO ₂ , THC, and NO _x . Technology is capable of measuring exhaust emissions from late-model (1996-present) passenger vehicles with on-board diagnostics ports. |
| Bacharach, Inc., Model ECA 450 (2000) | Analyzer uses electrochemical sensors. Can be fitted with up to seven gas sensors to measure O ₂ , CO (two ranges), NO, NO ₂ , SO ₂ , and THC. Only NO and NO ₂ measurements were verified in the test. |
| COSA Instruments Corp., 7000 Vario Plus (2000) | Analyzer uses electrochemical sensors. Measures oxygen, carbon monoxide, oxides of nitrogen (NO and NO ₂), and sulfur dioxide emissions from combustion sources. Calculates carbon dioxide concentrations, combustion efficiency, excess air, and flue gas losses. Only NO and NO ₂ measurements were verified in the test. |
| Land Combustion, LANCOM Series II (2000) | Analyzer uses electrochemical sensors. Can be fitted with up to seven gas sensors to measure O ₂ , CO (two ranges), NO _x (NO and NO ₂), SO ₂ , and THC. Only NO and NO ₂ measurements were verified in the test. |
| ECOM America, Ltd., A-Plus (1999) | Analyzer uses electrochemical sensors. Measures O ₂ , CO, NO _x (NO and NO ₂), and SO ₂ emissions. Only NO and NO ₂ measurements were verified in the test. |
| Enerac/Energy Efficiency Systems, Inc., Enerac 3000E (1999) | Analyzer combines sensor technology for NO _x (NO and NO ₂) measurement with automatic quality control features. Can be operated remotely through a two-way modem connection. Performance parameters can be remotely checked by the factory. |
| Horiba Instruments, Inc., Horiba PG-250 (1999) | Analyzer employs non-dispersive infrared detection for SO ₂ , CO, and CO ₂ ; chemiluminescence detection of NO _x ; and electrochemical cell for O ₂ . Only NO and NO ₂ measurements were verified in the test. |
| Testo, Inc., Model 350 (1999) | Analyzer uses electrochemical sensors to measure O ₂ , CO, NO _x (NO and NO ₂), SO ₂ , H ₂ S, and THC. Also captures data on pressure, temperature, and flow. Only NO and NO ₂ measurements were verified in the test. |
| TSI, Inc., Combustion Single Gas Monitor (1999) | Hand-held single gas monitor that uses interchangeable electrochemical sensors. Can measure O ₂ , CO, NO _x (NO and NO ₂), and SO ₂ . Only NO and NO ₂ measurements were verified in the test. |

¹ The ETV Program operates largely as a public-private partnership through competitive cooperative agreements with non-profit research institutes. The program provides objective quality-assured data on the performance of commercial-ready technologies. Verification does not imply product approval or effectiveness. ETV does not endorse the purchase or sale of any products and services mentioned in this document.

Selected Outcomes of Verified GHG Monitoring Technologies

In 2009, the U.S. EPA has undertaken a number of initiatives intended to monitor and reduce GHG emissions. In April, EPA announced proposed rulemaking for mandatory reporting of GHG emissions from all sectors of the economy (EPA, 2009b). Additionally, EPA has developed several Climate Leaders Offset Project Methodologies that use a standardized approach to determine GHG reduction projects, select and set baseline emissions, identify monitoring options, and quantify reductions (EPA, 2009c). A major component of these, and other new GHG initiatives, is monitoring technologies.

Real-time monitoring technologies like those verified by AMS can be used by EPA and others to help determine when GHG emissions occur, establish baseline emissions, quantify reductions, and determine compliance.

References

U.S. EPA, 1997. EPA Methods 3A and 7E. 40 CFR Part 60.

U.S. EPA, 2004. Control of Air Pollution from New and In-Use Motor Vehicles and New and In-Use Motor Vehicle Engines: Certification and Test Procedures. 40 CFR Part 86.

U.S. EPA, 2009. Climate Change, Basic Information. <http://www.epa.gov/climatechange/basicinfo.html>

U.S. EPA, 2009b. Mandatory Reporting of Greenhouse Gases; Proposed Rule. 74 Federal Register 68 (10 April 2009), pp. 16448-16731.

U.S. EPA, 2009c. EPA Strategic Plan. <http://www.epa.gov/ocfo/plan/plan.htm>

| Technology | Parameter | Range | Accuracy | Recovery |
|--|-----------------|----------------|-----------------|------------------------------------|
| JSC OPTEC Ltd., 3.02 P-A, Chemiluminescent Ozone Analyzer | O ₃ | 51-260 ppb | < 1 ppb | %R: 83.4-110 |
| Testo, Inc., Model 350 Portable Multi-Gas Emission Analyzer (low and high concentration sensors) | CO | 0-5000 ppm | 0.25-1.22 ppm | RA:1.52-16.1% |
| | NO | 0-2500 ppm | 0.25-1.66 ppm | RA:6.95-10.4% |
| | NO ₂ | 0-2500 ppm | 0.26-0.41 ppm | RA:21.8-25.6% |
| | O ₂ | 0-25% | ND ^b | RA:0.30-0.82% |
| | SO ₂ | 0-2000 ppm | 1.24 ppm | RA:4.70% |
| Clean Air Technologies International, Inc., REMOTE On-Board Emissions Monitor | CO | 0-13 g/mile | ND ^b | A: 2.54±1.12 |
| | CO ₂ | 300-620 g/mile | | A: 3.17±1.40 |
| | THC | 0-1 g/mile | | A: 6.04±2.66 |
| | NO _x | 0-1.4 g/mile | | A: 4.03±1.78 |
| Bacharach, Inc., Model ECA 450 (low and high concentration sensors) | NO | 0-1000 ppm | 8-11 ppm | RA:1-10.5% |
| | NO ₂ | 0-450 ppm | 3-4 ppm | RA:1-19.5% |
| COSA Instruments Corp., 7000 Vario Plus | NO | 0-2000 ppm | 3-4 ppm | RA for NO _x : 2.8-10.7% |
| | NO ₂ | 0-512 ppm | 2-4 ppm | |
| Land Combustion, LANCOM Series II | NO | 0-2000 ppm | 2.5 ppm | RA for NO _x : 1.8-17.5% |
| | NO ₂ | 0-512 ppm | 1.5-2.3 ppm | |
| ECOM America, Ltd., A-Plus | NO | 0-3500 ppm | 4 ppm | RA for NO _x : 1.5-12.1% |
| | NO ₂ | 0-450 ppm | 1.2 ppm | |
| Enerac/Energy Efficiency Systems, Inc., Enerac 3000E | NO | 0-3000 ppm | 1.2-8.3 ppm | RA for NO _x : 11-20% |
| | NO ₂ | 0-400 ppm | 6 ppm | |
| Horiba Instruments, Inc., Horiba PG-250 | NO | 0-2500 ppm | 6-7 ppm | A:2-8.5% |
| | NO ₂ | 0-500 ppm | 9-16 ppm | A:35-50% |
| Testo, Inc., Model 350 | NO | 0-3000 ppm | 6 ppm | RA for NO _x : 5.8-11.4% |
| | NO ₂ | 0-500 ppm | 1.9 ppm | |
| TSI, Inc., Combustion Single Gas Monitor | NO | 0-2000 ppm | 20-25 ppm | 8.6-40.4 ppm |
| | NO ₂ | 0-100 ppm | 1.5-3 ppm | |

^a %R = Percent recovery; RA = Relative accuracy; A = Accuracy (bias and precision)

^b ND = Not determined

ppb = parts per billion

ppm = parts per million

g/mile = grams per mile

ETV Advanced Monitoring Systems Center

ETV [Advanced Monitoring Systems Center \(AMS\)](http://www.epa.gov/etv) verifies the performance of technologies that detect contaminants and natural species in air, water, and soil. AMS is operated by Battelle, a non-profit technology research and development organization, under a cooperative agreement with EPA. To date, AMS has completed verification tests of over 125 technologies, including continuous emission monitors for mercury, dioxin, and ammonia; ambient monitors for fine particulate, ammonia, hydrogen sulfide and ozone; test kits for arsenic, cyanide, atrazine, and other water contaminants; and multi-parameter water probes. Nearly 20 additional technologies are currently in the verification testing process. For further information, please contact:

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