UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
Washington, D.C. 20460

ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM VERIFICATION STATEMENT

TECHNOLOGY TYPE:	**PHOTOACOUSTIC INFRARED MONITOR**
APPLICATION:	**MEASUREMENT OF CHLORINATED VOLATILE ORGANIC COMPOUNDS IN WATER**
TECHNOLOGY NAME:	**Type 1312 Multi-gas Monitor**
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PROGRAM DESCRIPTION

The U.S. Environmental Protection Agency (EPA) created the Environmental Technology Verification Program (ETV) to facilitate the deployment of innovative environmental technologies through verification of performance 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. The ETV Program is intended to assist and inform those involved in the design, distribution, permitting, and purchase of environmental technologies.

Under this program, in partnership with recognized testing organizations, and with the full participation of the technology developer, the EPA evaluates the performance of innovative technologies by developing demonstration plans, conducting field tests, collecting and analyzing the demonstration results, and preparing reports. The testing is 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 EPA's National Exposure Research Laboratory, in cooperation with Sandia National Laboratories, the testing organization, evaluated field-portable systems for monitoring chlorinated volatile organic compounds (VOCs) in water. This verification statement provides a summary of the demonstration and results for the Innova AirTech Instruments Type 1312 Multi-gas Monitor.

DEMONSTRATION DESCRIPTION

The field demonstration of the Type 1312 photoacoustic infrared monitor was held in September 1997. The demonstration was designed to assess the instrument's ability to detect and measure chlorinated volatile organic compounds in groundwater at two contaminated sites: the Department of Energy's Savannah River Site, near Aiken, South Carolina, and the McClellan Air Force Base, near Sacramento, California. Groundwater samples from each site were supplemented with performance evaluation (PE) samples of known composition. Both sample types were used to assess instrument accuracy, precision, sample throughput, and comparability to reference laboratory results. The primary target compounds at the Savannah River Site were trichloroethene and tetrachloroethene. At the McClellan Air Force Base, the target compounds were trichloroethene, tetrachloroethene, 1,2-dichloroethane, 1,1,2-

trichloroethane, 1,2-dichloropropane, and *trans*-1,2-dichloropropene. These sites were chosen because they contain varied concentrations of chlorinated VOCs and exhibit different climatic and geological conditions. The conditions at these sites are typical, but not inclusive, of those conditions under which this technology would be expected to operate. A complete description of the demonstration, including a data summary and discussion of results, may be found in the report entitled *Environmental Technology Verification Report, Photoacoustic Spectrophotometer, Innova AirTech Instruments, Type 1312 Multi-gas Monitor*. (EPA/600/R-98/143).

TECHNOLOGY DESCRIPTION

The Type 1312 utilizes photoacoustic spectroscopy for the detection of chlorinated VOCs in the headspace of a water sample. The vapors from the equilibrium headspace of a stirred water sample are circulated through the instrument's measurement cell. When a gas in the cell is irradiated with electomagnetic energy at frequencies that correspond to resonant vibration frequencies of VOC compounds in the gas, a portion of the incident energy is absorbed, causing some of the molecules of the gas to be excited to a higher vibrational energy state. These molecules subsequently relax back to the lower-energy, vibrational state through a combination of radiative and kinetic processes. The kinetic energy decay process results in increased heat energy of the gas molecules and a corresponding temperature and pressure increase in the gas. The incident infrared source is modulated and the resulting pressure is also modulated. The varying pressure in the cell produces an acoustic wave that is detected with a high-sensitivity microphone. Compound specificity is achieved by using bandpass filters tuned to the energy absorption bands of target compounds, and quantification is done by measuring the intensity of the resulting acoustic signal.

The Type 1312 is a commercially available measurement system that provides groundwater analysis capabilities in a field-portable package. The instrument weighs 30 pounds with accessories and is encapsulated in a weather-resistant case. Required accessories include a motorized stir plate, a 2-L flask, and assorted connecting tubing. The system can be easily transported and operated in the rear compartment of a minivan. Instrument detection limits for TCE and PCE in water are in the vicinity of 5 µg/L. Sample composition must be known since the measurement technique is susceptible to interference from unknown VOCs in the sample. Sample processing and analysis can be accomplished by a technician; however, method development and periodic instrument calibration require a higher level of operator experience and training. About 1 day of training is recommended for a technician to be able to perform routine sample processing. At the time of the demonstration, the baseline cost of the Type 1312 was $28,000. Maintenance costs are less than $100 per year. And with the exception of a disposable inlet air filter, the instrument uses no consumable items, such as carrier gases or calibration standards.

VERIFICATION OF PERFORMANCE

The following performance characteristics of the Type 1312 were observed:

Sample Throughput: Throughput was approximately one to two water samples per hour.

Completeness: The Type 1312 reported results for all but one of the 141 PE and groundwater samples provided for analysis at the two demonstration sites. One PE sample was dropped by the Innova team during preparation and handling.

Analytical Versatility: The Type 1312 was calibrated for and reported results for TCE and PCE. The Type 1312 reported results for 29 of 31 detects of TCE and PCE in groundwater samples from both sites that were reported by the reference laboratory. The instrument also reported results for carbon tetrachloride, chloroform, and *cis*-1,2-dichloroethene under appropriate circumstances. The instrument can report results for up to five compounds from a single analysis; however, sample composition must be known to account for possible spectral interferences from all sample components.

Precision: Instrument precision was determined by analysis of sets of four replicate samples from a variety of PE mixtures containing known concentrations of TCE and PCE. The range of relative standard deviations (RSDs) for TCE was 4 to 22%, and 5 to 46% for PCE. The distribution of RSD values for combined TCE and PCE

measurements from both sites had a median value of 15% and a 95th percentile value of 34%. By comparison, the compiled RSDs for TCE and PCE from the reference laboratory had a median value of 9% and a 95th percentile value of 18%.

Accuracy: Instrument accuracy was evaluated by comparing Type 1312 results with the known concentrations of TCE and PCE in PE mixtures. The range of absolute percent differences (APD) for TCE was 4 to 48%, and 2 to 48% for PCE. The distribution of APD values for combined TCE and PCE measurements at both sites had a median value of 29% and a 95th percentile value of 47%. By comparison, the compiled APDs for TCE and PCE from the reference laboratory had a median value of 10% and a 95th percentile value of 25%.

Comparability: A comparison of Type 1312 and reference laboratory data was based upon 33 groundwater samples analyzed at each site. The correlation coefficient (*r*) for TCE and PCE detected by both the Type 1312 and the reference laboratory below the 300 µg/L concentration level was 0.984 at Savannah River and 0.892 at McClellan. The number of data pairs above the 300 µg/L concentration level was insufficient for a meaningful correlation analysis. The observed correlation coefficients reveal a linear relationship between the Type 1312 and laboratory data at both sites. The median absolute percent difference between mutually detected TCE and PCE by the Type 1312 and the reference laboratory was 29% with a 95th percentile value in excess of 2000%.

Deployment: The system was ready to analyze samples within 30 minutes of arrival at the site. At both sites, the instrument was transported in a rental vehicle and was powered by line or generator ac power. During this demonstration, the system was set up and operated on a table. It can also be set up and operated in the rear luggage compartment of a minivan or station wagon.

The results of the demonstration show that the Innova AirTech Instruments Type 1312 Multi-gas Monitor can provide useful, cost-effective data for routine groundwater monitoring when the composition of the samples is known. Since the composition of the sample must be known to avoid spectral interference, the instrument is not well suited for site characterization applications where the VOC content of the samples is unknown. In the selection of a technology for deployment at a site, the user must determine what is appropriate through consideration of instrument performance and the project's data quality objectives.

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