THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

ETV

U.S. Environmental Protection Agency

ESTCP Environmental Security Technology Certification Program

ornl Oak Ridge National Laboratory

Joint Verification Statement

TECHNOLOGY TYPE:	**EXPLOSIVES DETECTION**	
APPLICATION:	**MEASUREMENT OF EXPLOSIVES IN CONTAMINATED WATER**	
TECHNOLOGY NAME:	**FAST 2000™**	
COMPANY:	**Research International, Inc.**	
ADDRESS:	**18706 142nd Avenue NE Woodinville, WA 98072-8523**	**PHONE: (425) 486-7831 FAX: (425) 485-9137**
WEB SITE:	**www.resrchintl.com**	

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification Program (ETV) 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 substantially 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.

ETV works in partnership with recognized standards and testing organizations and stakeholder groups consisting of regulators, buyers, and vendor organizations, with the full participation of 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 protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Department of Defense (DoD) has a similar verification program known as the Environmental Security Technology Certification Program (ESTCP). The purpose of ESTCP is to demonstrate and validate the most promising innovative technologies that target DoD's most urgent environmental needs and are projected to pay back the investment within 5 years through cost savings and improved efficiencies. ESTCP demonstrations are typically conducted under operational field conditions at DoD facilities. The demonstrations are intended to generate supporting cost and performance data for acceptance or validation of the technology. The goal is to transition mature environmental science and technology projects through the demonstration/ validation phase, enabling promising technologies to receive regulatory and end user acceptance in order to be fielded and commercialized more rapidly.

The Oak Ridge National Laboratory (ORNL) is one of the verification organizations operating under the Site Characterization and Monitoring Technologies (SCMT) program. SCMT, which is administered by EPA's National Exposure Research Laboratory, is one of 12 technology areas under ETV. In this demonstration, ORNL evaluated the performance of explosives detection technologies. This verification statement provides a summary of the test results for Research International's (RI's) FAST 2000™. This verification was conducted jointly with the Department of Defense's (DoD's) Environmental Security Technology Certification Program (ESTCP).

DEMONSTRATION DESCRIPTION

This demonstration was designed to evaluate technologies that detect and measure explosives in soil and water. RI elected to analyze only water samples with the FAST 2000. The demonstration was conducted at ORNL in Oak Ridge, Tennessee, from August 23 through September 1, 1999. Spiked samples of known concentration were used to assess the accuracy of the technology. Explosives-contaminated water samples from Tennessee, Oregon, and Louisiana with concentrations ranging from 0 to 25,000 μg/L were analyzed. The primary constituents in the samples were 2,4,6-trinitrotoluene (TNT); isomeric dinitrotoluene (DNT), including both 2,4-dinitrotoluene and 2,6-dinitrotoluene; hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX). The results of the water analyses conducted under field conditions by the FAST 2000 were compared with results from reference laboratory analyses of homogenous replicate samples determined using EPA SW-846 Method 8330. Details of the demonstration, including a data summary and discussion of results, may be found in the report entitled *Environmental Technology Verification Report: Explosives Detection Technology—Research International, Inc., FAST 2000™*, EPA/600-R-00/045.

TECHNOLOGY DESCRIPTION

The FAST 2000 is based on a displacement assay that uses antibodies and fluorescence as a means of detection. The unit (weighing 2.8 lb, with dimensions of 6 × 15.5 × 16 cm) can be easily carried into the field and plugged directly into a portable PC for on-site data acquisition and analysis. The key elements of the sensor are (1) antibodies specific for the analyte; (2) signal molecules that are similar to the analyte but are labeled with a fluorophore (a cyanine-based fluorescent dye, Cy5) to enable fluorescence detection; and (3) a fluorescence detector. For analysis, the analyte-specific antibodies are immobilized onto a solid support and then saturated with the fluorescently labeled signal molecule, creating an antibody/signal molecule complex. Monoclonal antibodies (the Naval Research Laboratory's 11B3 TNT and Strategic Diagnostics RDX) are immobilized onto porous membrane supports and saturated with the fluorescent tag. The membrane is inserted into a disposable coupon and placed in the FAST 2000, and the buffer flow is started by a computer command. Once the fluorescence background signal due to unbound Cy5 has stabilized (generally 15–20 minutes), the biosensor is ready for sample injection. If the sample contains the target analyte, a proportional amount of the labeled signal molecule is displaced from the antibody and detected by the fluorimeter downstream. The coupon and membrane can be used for repeated assays. The life of the membrane is dependent upon the number and concentration of positive assays that are run. The reporting limit for both TNT and RDX was 20 μg/L.

VERIFICATION OF PERFORMANCE

The following performance characteristics of the FAST 2000 were observed:

Precision: For the water samples, the mean relative standard deviations (RSDs) for RDX and TNT were 52% and 76%, respectively.

Accuracy: The mean recoveries for RDX and TNT were 192% and 316%, respectively.

False positive/false negative results: Of the 20 blank water samples, RI reported RDX in 4 samples (24% false positives) and TNT in 16 samples (80% false positives). Three of the RDX results were reported as "ME," which indicated that the sample had "matrix effects" and the result could not be reported by the FAST 2000. False positive and false negative results were also determined by comparing the FAST 2000 result to the reference laboratory result on environmental and spiked samples (e.g., whether the FAST 2000 reports a result as a nondetect that the reference laboratory reported as a detect, and vice versa). For RDX, 2% of the results were false positives relative to the reference laboratory result, while 16% of the TNT results were reported as false positives. RI reported a small fraction of the samples (3% for each analyte) as nondetects (i.e., false negatives) when the laboratory reported a detect.

Completeness: Approximately 80% of the water analyses were complete. Approximately 18% of the RDX results and 21% of the TNT results were reported as "matrix effects," where a result could not be obtained.

Comparability: A one-to-one sample comparison of the FAST 2000 results and the reference laboratory results was performed for all samples (spiked and environmental) that were reported above the reporting limits. The correlation coefficient (r) for the comparison of the entire water data set for TNT was 0.23, and the slope (m) of the linear regression line was 1.81. When comparability was assessed for specific concentration ranges, the r value did not change dramatically for TNT, ranging from 0.14 to 0.21 depending on the concentration ranges selected. RDX correlation with the reference laboratory for water was higher ® = 0.63, m = 1.60). Examination of the data indicated that the RDX results were usually higher than those of the reference laboratory. However, for specific environmental sample matrices (such as the samples from the Louisiana Army Ammunition Plant), the FAST 2000 results were generally lower than those of the reference laboratory. This indicated the possibility of a matrix-dependent effect.

Sample Throughput: Operating under the outdoor conditions, the RI team, usually consisting of three operators, accomplished a sample throughput rate of approximately three samples per hour for the water analyses. Separate instruments were used for the TNT and RDX analyses. Typically, two operators analyzed samples while one operator performed data analysis, but the technology can be run by a single trained operator.

Overall Evaluation: The verification team found that the FAST 2000 was relatively simple for the trained analyst to operate in the field, requiring less than an hour for initial setup. The overall performance of the FAST 2000 for the analysis of water samples was characterized as imprecise and biased high for TNT, and imprecise and biased high (but matrix-dependent) for RDX. As with any technology selection, the user must determine if this technology is appropriate for the application and the project data quality objectives. For more information on this and other verified technologies, visit the ETV web site at *http://www.epa.gov/etv*.

Gary J. Foley, Ph.D.
Director
National Exposure Research Laboratory
Office of Research and Development

David E. Reichle, Ph.D.
Associate Laboratory Director
Life Sciences and Environmental Technologies
Oak Ridge National Laboratory

Jeffrey Marqusee, Ph.D.
Director
Environmental Security Technology Certification Program
U.S. Department of Defense

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