

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION  
PROGRAM



## ETV Joint Verification Statement

**TECHNOLOGY TYPE:** Dioxin Emission Monitoring System

**APPLICATION:** Monitoring Incinerator Emissions

**TECHNOLOGY  
NAME:** Jet-REMPI

**COMPANY:** SRI International

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The U.S. Environmental Protection Agency (EPA) has established 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](http://www.epa.gov/etv).

ETV works in partnership with recognized standards and testing organizations, with stakeholder groups (consisting of buyers, vendor organizations, and permittees), 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 six technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center evaluated the performance of the SRI Jet-REMPI (resonance enhanced multi-photon ionization) in monitoring emissions of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF). This verification statement provides a summary of the test results.

## **VERIFICATION TEST DESCRIPTION**

The performance of the Jet-REMPI was evaluated in terms of relative accuracy (RA), range, data completeness, and operational factors (ease of use, maintenance, and consumables/waste generated). RA and range were determined by comparing Jet-REMPI results to those from reference samples collected simultaneously using Method 23 sampling trains. Range was determined from measurements over a variety of defined operating conditions that produced differing levels of PCDD/PCDFs. Data completeness was assessed as the percentage of maximum data return achieved by the Jet-REMPI over the test period. Operational factors were evaluated by means of operator observations and records of needed maintenance, vendor activities, and expendables used.

A 2.94 thousand British thermal unit per hour, 3-Pass Wetback Scotch Marine Package Boiler (SMPB), manufactured by Superior Boiler Works, Inc., and located at the EPA Research Triangle Park facility, was used for the verification test. During this verification test, the SMPB was fully instrumented with continuous emission monitors for a variety of species including oxygen, carbon monoxide, carbon dioxide, water, and hydrogen chloride. Reference samples were collected and analyzed for PCDD/PCDFs using Method 23 with several documented modifications.

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](http://www.epa.gov/etv/centers/center1.html).

## **TECHNOLOGY DESCRIPTION**

The following description of the Jet-REMPI is based on information provided by the vendor. This technology description was not verified in this test.

Jet-REMPI is an analytical technique that is designed to selectively identify and quantify vapor-phase constituents present at part-per-trillion levels in incinerator emissions without preconcentration or sample collection. Ions produced by REMPI are typically detected using a time-of-flight mass spectrometer (TOF-MS) that takes advantage of the pulsed nature and well-defined temporal character of laser ionization. Simultaneous detection by mass and wavelength yields the extremely high chemical selectivity crucial to identifying one trace compound in the midst of many other similar ones.

The laser system used in the verification test consists of a Nd:YAG pumped OPOTEK Vibrant OPO with frequency doubling unit with a nominal tuning range between 250 and 340 nanometers, a 5-nanosecond pulse width, and a repetition rate of 10 hertz. The optical line width of the system is approximately 2 centimeters ( $\text{cm}^{-1}$ ). The pulsed valve is an unmodified General Valve Series 9 unit, with an orifice diameter of 0.5 millimeter. The nominal opening time was 150 microseconds, with a 2.5-cm separation between the exit of the valve and the ionization region. With the sample reservoir at atmospheric pressure, the two 250-liters-per-second turbomolecular pumps (Varian Turbo V-250) maintain pressures in the ionization chamber and mass spectrometer regions of  $10^{-5}$  Torr, and  $5 \times 10^{-7}$  Torr, respectively. The mass spectrometric capabilities of the reflectron-type TOF mass analyzer used in this verification test include an upper mass range typically up to 500 atomic mass units and mass resolution ( $m/\Delta m$ ) greater than 500.

## VERIFICATION RESULTS

Parameter Evaluated	Method of Evaluation	Results	
		Relative accuracy	Comparison to Method 23 reference samples
		Intermethod RSD	61.5%
		Intramethod RSD	8.4%
Range	Comparison to Method 23 reference samples	<ul style="list-style-type: none"> <li>• Apparent dependence of accuracy on PCDD/F toxic equivalent (TEQ) over range of approximately 1 to 6 nanograms TEQ/dry standard cubic meters with better agreement at high concentration</li> <li>• Apparent dependence of accuracy on sample duration over range of 4 to 8 hours with better agreement for longer sampling duration</li> </ul>	
Data completeness	Ratio of number of samples successfully collected to number of potential samples that could have been collected	<ul style="list-style-type: none"> <li>• 100% completeness in number of samples collected</li> <li>• Approximately 7% downtime</li> </ul>	
Ease of use	Operator observations	<ul style="list-style-type: none"> <li>• Time required for installation of the Jet-REMPI system was not verified</li> <li>• Significant on-site support was needed during testing. During routine operation, a representative of ARCADIS was on-site and constantly monitoring instrument diagnostic and indicator signal</li> <li>• Extensive training and experience with advanced knowledge of mass spectrometry and laser spectroscopy techniques is required for operation of the Jet-REMPI and interpretation of the results</li> </ul>	
Maintenance	Verification test staff observations	Repair of a faulty pulsed valve on a parallel Jet-REMPI unit was required during the verification test. The maintenance activities resulted in approximately 4 hours of instrument downtime.	
Consumables/waste generated		Small amounts of compressed gas and calibration gas standards were used during the verification test.	

RSD = relative standard deviation

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