THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**MULTI-PARAMETER WATER MONITORS FOR DISTRIBUTION SYSTEMS**
APPLICATION:	**MONITORING DRINKING WATER QUALITY**
TECHNOLOGY NAME:	**Model WQS**
COMPANY:	**Rosemount Analytical**
ADDRESS:	**2400 Barranca Parkway Irvine, CA 92606** — **PHONE: 949-757-8500 FAX: 949-863-9159**
WEB SITE:	**www.emersonprocess.com**
E-MAIL:	**Richard.Baril@EmersonProcess.com**

The U.S. Environmental Protection Agency (EPA) supports 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.

ETV works in partnership with recognized standards and testing organizations, with stakeholder groups (consisting of buyers, vendor organizations, and permitters), 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 Rosemount Analytical Multi-Parameter/Optical Water Quality System (Model WQS) in continuously measuring free chlorine, temperature, conductivity, pH, and oxidation-reduction potential (ORP) in drinking water. This verification statement provides a summary of the test results.

VERIFICATION TEST DESCRIPTION

The performance of the WQS unit was assessed in terms of its accuracy, response to injected contaminants, inter-unit reproducibility, ease of use, and data acquisition. The verification test was conducted between August 9 and October 28, 2004, and consisted of three stages, each designed to evaluate a particular performance characteristic of the WQS unit. All three stages of the test were conducted using a recirculating pipe loop at the U.S. EPA's Test and Evaluation Facility in Cincinnati, Ohio.

In the first stage of this verification test, the accuracy of the measurements made by the WQS units was evaluated during nine, 4-hour periods of stable water quality conditions by comparing each WQS unit measurement to a grab sample result generated each hour using a standard laboratory reference method and then calculating the percent difference (%D). The second stage of the verification test involved evaluating the response of the WQS units to changes in water quality parameters by injecting contaminants (nicotine, arsenic trioxide, and aldicarb) into the pipe loop. Two injections of three contaminants were made into the recirculating pipe loop containing finished Cincinnati drinking water. The response of each water quality parameter, whether it was an increase, decrease, or no change, was documented and is reported here. In the first phase of Stage 3 of the verification test, the performance of the WQS units was evaluated during 52 days of continuous operation, throughout which references samples were collected once daily. The final phase of Stage 3 (which immediately followed the first phase of Stage 3 and lasted approximately one week) consisted of a two-step evaluation of the WQS performance to determine whether this length of operation would negatively impact the results from the WQS. First, as during Stage 1, a reference grab sample was collected every hour during a 4-hour analysis period and analyzed using the standard reference methods. Again, this was done to define a formal time period of stable water quality conditions over which the accuracy of the WQS could be evaluated. Second, to evaluate the response of the WQS unit to contaminant injection after the extended deployment, the duplicate injection of aldicarb, which was also included in the Stage 2 testing, was repeated. In addition, a pure *E. coli* culture, including the *E. coli* and the growth medium, was included as a second injected contaminant during Stage 3. Inter-unit reproducibility was assessed by comparing the results of two identical units operating simultaneously. Ease of use was documented by technicians who operated and maintained the units, as well as the Battelle Verification Test Coordinator.

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.

TECHNOLOGY DESCRIPTION

The following description of the WQS unit was provided by the vendor and does not represent verified information.

The WQS unit measures pH, ORP, conductivity, temperature, and free chlorine in drinking water. The system combines user-specified instruments and sensors to create a customized system for monitoring water quality. The WQS unit does not need added reagents and uses minimum process flows of less than 183 milliliters per minute. The WQS unit uses three basic electrochemical principles of operation: millivolt measurements for pH and ORP, conductance/resistance measurements for conductivity, and amperometric/polarographic measurements for chlorine residuals. The WQS unit continuously monitors each parameter to provide constant surveillance of water quality events to ensure that acceptable water quality conditions are maintained. The WQS unit includes a sensor, cables, and instruments to measure water quality parameters. The verified WQS unit was 26 inches high and 32 inches wide. The width varies by system from 26 inches to 50 inches wide. The data output from the system is available as 4/20 mA analog, highway addressable remote transducer (HART®) or Foundation fieldbus® (H1), RS-485, Ethernet, or Modbus RTU digital outputs. It uses 115/230-volt alternating current or 24-volt direct current.

During this verification test, a Fluke (Everette, Washington) data logger was configured to the WQS unit to record the data every 30 seconds. The data logger was connected to a laptop computer that stored the data onto its hard drive as a delimited text file that was easily imported into a spreadsheet. The costs of the units as configured for the verification test ranged from $12,000 to $15,000. In addition, calibration reagents cost approximately $200 annually.

VERIFICATION OF PERFORMANCE

Evaluation Parameter			Free Chlorine	Tem-perature	Conductivity	pH	ORP
Stage 1—Accuracy	Units 1 and 2, range of %D (median)		-11.1 to 96.7 (14.5)	-5.9 to 1.5 (-1.7)	2.9 to 5.3 (4.2)	-7.4 to -1.1 (-3.0)	[a]
Stage 2— Response to Injected Contaminants	Nicotine	Reference	–	NC	NC	NC	–
		WQS	–	NC	NC	NC	–
	Arsenic trioxide	Reference	–	NC	+	+	–
		WQS	[b]	NC	+	+	–
	Aldicarb	Reference	–	NC	NC	NC	–
		WQS	–	NC	NC	NC	–
Stage 3—Accuracy During Extended Deployment	Units 1 and 2, range of %D (median)		-36.2 to 68.3 (1.6)	-4.1 to 2.4 (-0.2)	3.4 to 6.7 (5.2)	-2.8 to 1.8 (-1.2)	[a]
Stage 3—Accuracy After Extended Deployment	Unit 1, %D		-1.1	0.6	5.1	-0.6	[a]
	Unit 2, %D		-2.2	0.2	5.3	-0.9	[a]
Stage 3— Response to Injected Contaminants	*E. coli*	Reference	–	NC	+	–	–
		WQS	–	NC	NC	–	–
	Aldicarb	Reference	–	NC	NC	–	–
		WQS	[b]	NC	NC	NC	–
Injection Summary	For a reason that is not clear, aldicarb altered the pH, as measured by the reference method, during the Stage 3 injections, but not during the Stage 2 injections.						
Inter-unit Reproducibility (Unit 2 vs. Unit 1)	Slope (intercept)		0.48 (0.45)	1.01 (-0.19)	1.00 (0.26)	0.97 (0.25)	0.97 (-4.38)
	r^2		0.271	0.999	1.00	0.958	0.950
	p-value		0.367	0.882	0.787	0.832	0.011[c]
	With the exception of ORP, the t-test indicated that the sensors on each unit were performing similarly. For ORP, the linear correlation between the two units was very high, but the extremely small variability in the signal caused the difference between the two units to be statistically significant. Although the free chlorine sensors were not highly correlated with one another, the large variability in their measurements prevented the t-test from determining a significant difference between the units.						
Ease of Use and Data Acquisition	Based on the performance of the free chlorine sensors, calibration and membrane replacement may have to occur periodically to maintain accurate measurements, especially those involving response to injected contaminants. Also, the regular variability in free chlorine and pH measurements may prevent observing small changes in those water quality parameters.						

[a] Because a laboratory reference measurement equivalent to the on-line continuous measurement was not available, ORP was not included in the accuracy evaluation.
[b] Results from duplicate injections did not agree.
[c] The difference between the results from the two sensors was statistically significant.
+/− = Parameter measurement increased/decreased upon injection.
NC = No obvious change was noted through a visual inspection of the data.

Original signed by Gregory A. Mack 10/17/05
Gregory A. Mack Date
Assistant Division Manager
Energy, Transportation, and Environment Division
Battelle

Original signed by Andrew P. Avel 1/17/06
Andrew P. Avel Date
Acting Director
National Homeland Security Research Center
U.S. Environmental Protection Agency

NOTICE: ETV verifications are based on an evaluation of technology performance under specific, predetermined criteria and the appropriate quality assurance procedures. 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.