THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**MULTI-PARAMETER WATER MONITORS FOR DISTRIBUTION SYSTEMS**
APPLICATION:	**MONITORING DRINKING WATER QUALITY**
TECHNOLOGY NAME:	**Q45WQ Series**
COMPANY:	**Analytical Technology, Inc.**
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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 Analytical Technology, Inc., (ATI) Q45WQ Series water quality monitor in continuously measuring free chlorine, turbidity, 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 Q45WQ 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 Q45WQ. 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 Q45WQ units was evaluated during eight, 4-hour periods of stable water quality conditions by comparing each Q45WQ 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 Q45WQ 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 Q45WQ 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 Q45WQ performance to determine whether this length of operation would negatively impact the results from the Q45WQ. 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 Q45WQ could be evaluated. Second, to evaluate the response of the Q45WQ 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 Q45WQ unit was provided by the vendor and does not represent verified information.

The Q45WQ unit can be customized based on users' needs to include various monitoring devices. The unit verified during this test included sensors for pH, conductivity, free chlorine, ORP, temperature, and turbidity. The purpose of the unit is to provide an integrated package of monitors that can be deployed throughout water distribution systems to collect general water quality data and transmit it to remote locations, giving water companies access to real-time data from throughout their systems.

In this verification test, pH was measured using a differential pH sensor containing two glass pH electrodes, one for sensing and another in buffer to serve as a reference electrode. ATI informed Battelle that, during the same time period as this verification test, several users of its pH sensors reported a drift in the pH measurement similar to that observed during testing. ATI stated that it determined that a problem with the salt bridge assembly was causing the downward drift, which impacted not only the accuracy of the pH measurement, but also of the chlorine measurement. According to ATI, the problem was subsequently corrected. Conductivity was measured with a four-electrode conductivity sensor that measures the current-carrying capacity of the water. ORP was measured in millivolts with a differential ORP sensor containing a platinum sensing electrode and separate glass electrode in buffer to serve as a reference electrode. A membrane-covered amperometric (polarographic) sensor provided direct chlorine response without the need for chemical reagents. The conductivity sensor provided the output for both the conductivity and temperature measurements. Turbidity was measured with a 90-degree scatter nephelometer, using an infrared light source for stability and a sealed flow chamber to reduce bubble formation.

The Q45WQ unit that was tested was 24 inches wide by 47 inches high. The units normally provide 4-20 mA outputs for each parameter and can be connected to virtually any type of user-specified data acquisition system. During this verification test, ATI provided HOBO® data loggers from Onset Computer Corp. (Bourne, Massachusetts) to collect the data. Data points were collected every 30 seconds. The data logger generated a file with a .dtf suffix that required conversion to a delimited text file using software from Onset. This file was then imported into Microsoft Excel prior to further data analysis. These data loggers were downloaded daily using a serial port on a personal computer and Onset's Boxcar® software. The cost of the unit as configured for the verification test is $11,500. In addition, ATI estimates that the total cost of replacement parts is approximately $150 per year. This includes replacement membranes, electrolytes, O-rings on the chlorine sensor, and the salt bridge on the pH and ORP electrodes. Total labor required for preventive maintenance is approximately one hour per month.

VERIFICATION OF PERFORMANCE

Evaluation Parameter			Free Chlorine	Turbidity	Tem-perature	Conduc-tivity	pH	ORP
Stage 1—Accuracy	Units 1 and 2, range of %D (median)		-41.5 to 54.3 (-15.7)	-47.2 to -16.9 (-24.9)	-5.5 to 1.3 (-1.4)	-19.7 to -2.6 (-12.7)	-11.8 to -0.9 (-5.0)	(a)
Stage 2—Response to Injected Contaminants	Nicotine	Reference	–	(b)	NC	NC	NC	–
		Q45WQ	–	+	NC	NC	NC	–
	Arsenic trioxide	Reference	–	(b)	NC	+	+	–
		Q45WQ	–	+	NC	+	+	–
	Aldi-carb	Reference	–	(b)	NC	NC	NC	–
		Q45WQ	–	+	NC	NC	NC	–
Stage 3—Accuracy During Extended Deployment	Units 1 and 2, range of %D (median)		-33.7 to 29.7 (-7.3)	-88.0 to 18.2 (-42.3)	-4.9 to 1.5 (-1.4)	-19.4 to -5.3 (-13.6)	-8.3 to 1.5 (-3.5)	(a)
Stage 3—Accuracy After Extended Deployment	Unit 1, %D		1.1	-5.9	0.0	-14.0	0.1	(a)
	Unit 2, %D		-1.1	11.8	-0.9	-7.9	-2.2	(a)
Stage 3—Response to Injected Contaminants	*E. coli*	Reference	–	+	NC	+(c)	–	–
		Q45WQ	–	+	NC	NC	–	–
	Aldi-carb	Reference	–	+	NC	NC	–	–
		Q45WQ	–	+	NC	NC	(c)	–
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)		0.88 (0.10)	0.97 (0.028)	0.97 (0.31)	1.09 (-1.1)	0.71 (2.4)	0.89 (40)
	r^2		0.77	0.99	1.00	0.97	0.85	0.96
	p-value		0.59	0.76	0.41	0.00020	0.48	0.0093
	The ORP and conductivity sensor generated results that were significantly different from one another. Each unit's results were highly correlated with one another; but, because of the small degree of variability in each sensor's results, they were significantly different.							
Ease of Use and Data Acquisition	Based on the performance of the free chlorine and pH sensors, the pH sensor may have to be adjusted periodically to maintain the accuracy of both measurements. No other maintenance was necessary during the test.							

(a) ORP was not included in the accuracy evaluation because of the lack of an appropriate reference method.
(b) Relatively large uncertainty in the reference measurements made it difficult to determine a significant change.
(c) Results from duplicate injections did not agree.
+/− = Parameter measurement was increased/decreased upon injection.
NC = No obvious change was noted through a visual inspection of the data.

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