THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

Battelle
The Business of Innovation

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**MULTI-PARAMETER WATER QUALITY PROBE**	
APPLICATION:	**MEASURING WATER QUALITY**	
TECHNOLOGY NAME:	**6600 Extended Deployment System**	
COMPANY:	**YSI Incorporated**	
ADDRESS:	**15 Brannum Lane** **Yellow Springs, OH 45387**	**PHONE: 937-767-7241** **FAX: 937-767-1058**
WEB SITE:	**http://www.ysi.com**	
E-MAIL:	**environmental@ysi.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 seven technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. The AMS Center has recently evaluated the performance of multi-parameter water quality probes. This verification statement provides a summary of the test results for the YSI Incorporated 6600 Extended Deployment System (EDS).

VERIFICATION TEST DESCRIPTION

The 6600 EDS was evaluated by determining calibration check accuracy and by comparing 6600 EDS measurements with standard reference measurements and measurements from handheld calibrated probes. Two 6600 EDSs were deployed in saltwater, freshwater, and laboratory environments near Charleston, South Carolina, during a 3 ½-month verification test. The saltwater site was in a tributary of Charleston Harbor, the freshwater site was a wetlands on the campus of the National Oceanic and Atmospheric Administration Center for Coastal Environmental Health and Biomolecular Research (CCEHBR), and the laboratory site was the CCEHBR mesocosm facility. Water quality parameters were measured both by the 6600 EDSs and by reference methods consisting of collocated field-portable instrumentation and analyses of collected water samples. During each phase, performance was assessed in terms of calibration check accuracy, relative bias, precision, linearity, and inter-unit reproducibility. Test parameters included dissolved oxygen (DO), conductivity, temperature, pH, turbidity, and chlorophyll.

The saltwater test lasted for 28 days, during which time the 6600 EDS monitored the naturally occurring range of the target parameters, collecting data every 15 minutes, 24 hours a day. For the duration of the test, the 6600 EDS was deployed at depths between approximately one and 10 feet, varying according to the tide. Samples were collected at intervals throughout the test. Freshwater testing was conducted at the wetlands on the CCEHBR campus. Because the salinity and stratification of the wetlands increased during this portion of the deployment, an extended freshwater period was added to the end of the mesocosm deployment to provide data from a freshwater deployment. For the mesocosm tests, the mesocosm tanks were filled with saltwater/freshwater and drained daily, simulating a tide. Water samples were collected during each test day throughout the normal operating hours of the facility (nominally 6 a.m. to 6 p.m.). During this period, the mesocosm was manipulated to introduce variations in the measured parameters. The turbidity of the system was varied by operating a pump near the sediment trays to suspend additional solids in the water. Conductivity was varied by adding freshwater to the saltwater during the last three weeks of testing. Variations in temperature, pH, DO, and chlorophyll were driven by natural forces and the changes in the other test parameters. The table below provides a summary of the water conditions at the test sites.

Test Site Water Conditions

	Saltwater		Freshwater		Mesocosm	
Parameter	**Low**	**High**	**Low**	**High**	**Low**	**High**
DO	3 milligrams (mg)/liter (L)	6 mg/L	6.8 mg/L	11.2 mg/L	9.3 mg/L	12.1 mg/L
Specific conductivity	31 mS/ centimeter (cm)	41 mS/cm	0.27 mS/cm	29.3 mS/cm	0.5 mS/cm	28 mS/cm
Temperature	20°C	28°C	11°C	27°C	9°C	16°C
pH	7.2	7.8	6.9	7.5	7.1	8.5
Turbidity	8 nephelometric turbidity units (NTU)	37 NTU	1.7 NTU	3.6 NTU	0.4 NTU	15 NTU
Chlorophyll (total fluorescence)	2 micrograms (µg)/L	5 µg/L	0.0 µg/L	16 µg/L	0.2 µg/L	1.4 µg/L

During this verification test approximately 8,000 data points were collected for each of the three parameters tested, and 127 sets of reference measurements were made.

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 are all available at www.epa.gov/etv/centers/center1.html.

TECHNOLOGY DESCRIPTION

The following description of the 6600 EDS was provided by the vendor and does not represent verified information.

The 6600 EDS is a multi-parameter water probe/sonde capable of measuring dissolved oxygen (DO), conductivity, temperature, pH, turbidity, and chlorophyll. The 6600 EDS is maintained free of fouling by the Clean Sweep™ universal wiper assembly, as well as by individual optical wipers. 6600 EDS sensors are field-replaceable and integrate with data collection platforms. Flash memory prevents data loss, and C-cell battery power allows long-term deployment. The tested 6600 EDS was coated with YSI's optional anti-fouling paint. The outer diameter of the 6600 EDS is 8.9 cm (3.5 inches). It is 52 cm (20.4 inches) long and weighs 2.7 kilograms (six pounds). The 6600 EDS sells for approximately $10,000. The range, resolution, and accuracy of the 6600 EDS, as indicated by the vendor, are listed below for the parameters tested.

Vendor-Provided Range, Resolution, and Accuracy

Parameter	Range	Resolution	Accuracy
DO % Saturation	0 to 500%	0.1%	0 to 200% ±2%; 200 to 500% ±6% of reading
DO	0 to 50 mg/L	0.01 mg/L	0 to 20 mg/L ±0.2 mg/L; 20 to 50 mg/L ±0.6 mg/L
Conductivity	0 to 100 millisiemen (mS)/cm	0.001 to 0.1 mS/cm	±0.5% of reading +0.001 mS/cm
Temperature	-5 to +45˚C	0.01˚C	±0.15˚C
pH	0 to 14	0.01	±0.2
Turbidity	0 to 1,000 NTU	0.1 NTU	±5% of reading or 2 NTU, whichever is greater
Chlorophyll	0 to 400 µg/L 0 to 100% fluorescence	0.1 µg/L chlorophyll 0.1% fluorescence	NA

NA = not applicable (measures total fluorescence)

VERIFICATION OF PERFORMANCE

The table below summarizes the performance of the 6600 EDS. The two 6600 EDSs collected data without interruption at 15-minute intervals from October 1, 2003, until January 5, 2004, and 100% of required data was collected.

Performance Results

Statistical Measure	Parameter	YSI AA			YSI AB		
		Saltwater	Freshwater	Mesocosm	Saltwater	Freshwater	Mesocosm
Calibration check accuracy [a]	DO (%)	99.6	87.0	97.0	101	105	99.1
	Specific conductivity (%)	100	101	96.8	99.5	102	98.1
	pH (%)	100-101	98.3-101	102-101	101-102	100-101	100-101
	Turbidity at 120 NTU (%)	100	99	99	98	100	101
	Turbidity at 0 NTU (NTU)	0.3	-0.2	0.2	0.2	-0.2	0.2
	Chlorophyll (total *in vivo*)	-0.5	0.9	0.8	-0.3	-0.1	-0.1
Average relative bias [b]	DO (%)	-7.4	–[c]	0.3	-5.7	–[c]	1.7
	Specific conductivity (%)	-8.7	–[c]	12.8	-7.6	–[c]	10.2
	Temperature (%)	-0.1	–[c]	-0.2	-0.1	–[c]	-0.2
	pH (%)	7.5	–[c]	0.39	8.1	–[c]	0.35
	Turbidity (%)	-33.6	–[c]	-17.4	-184	–[c]	-30.1
	Chlorophyll (%)	-98.0	–[c]	-72.1	-133	–[c]	-131
		YSI AA			YSI AB		
Average Precision	DO (%RSD)	0.44			0.46		
	Specific conductivity (%RSD)	0.14			0.53		
	Temperature (%RSD)	0.74			0.75		
	pH (%RSD)	0.62			0.76		
	Turbidity (%RSD)	29.6			19.4		
	Chlorophyll (%RSD)	19.8			24.6		
Linearity		Linearity and regression coefficients indicated better agreement between the 6600 EDS readings and reference values for the parameters that do not use optical measurements, such as DO, conductivity, temperature, and pH.					
		Average Difference Between YSI AA and AB Readings					
		Saltwater	Freshwater	Mesocosm			
Inter-unit reproducibility	DO (mg/L)	0.14	0.48	0.19			
	Specific conductivity (mS/cm)	0.42	0.38	0.05			
	Temperature (°C)	0.03	0.02	0.02			
	pH	0.01	0.08	0.03			
	Turbidity (NTU)	10.5	0.29	0.27			
	Chlorophyll (total)	0.78	1.95	0.48			

RSD = relative standard deviation

[a] The closer the percentage is to 100, the better.

[b] The closer the percentage is to zero, the better.

[c] Stratificaion; no data reported.

Original signed by Gabor J. Kovacs 7/27/04
Gabor J. Kovacs Date
Vice President
Energy and Environment Division
Battelle

Original signed by Gary J. Foley 9/13/04
Gary J. Foley Date
Director
National Exposure Research Laboratory
Office of Research and Development
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.