THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**MULTI-PARAMETER WATER QUALITY PROBE**
APPLICATION:	**MEASURING WATER QUALITY**
TECHNOLOGY NAME:	**RCM Mk II with Optode 3830**
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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 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 AANDERAA Instruments, Inc. RCM Mk II with Optode 3830.

VERIFICATION TEST DESCRIPTION

The Mk II with Optode 3830 was evaluated by determining calibration check accuracy and by comparing Mk II with Optode 3830 measurements with standard reference measurements and measurements from handheld calibrated probes. Two Mk II with Optode 3830s 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 Mk II with Optode 3830s 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), temperature, and turbidity.

The saltwater phase lasted for 28 days, during which time the Mk II with Optode 3830 monitored the naturally occurring range of the target parameters, collecting data every 10 minutes, 24 hours a day. For the duration of the test, the Mk II with Optode 3830 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 phase, 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 phase, 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. Variations in temperature were driven by natural forces. 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/liter (mg/L)	6 mg/L	6.8 mg/L	11.2 mg/L	9.3 mg/L	12.1 mg/L
Temperature	20°C	28°C	11°C	27°C	9°C	16°C
Turbidity	8 nephelometric turbidity units (NTU)	37 NTU	1.7 NTU	3.6 NTU	0.4 NTU	15 NTU

During this verification test approximately 12,000 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 Mk II with Optode 3830 was provided by the vendor and does not represent verified information.

The Optode 3830 uses a platinum porphyrin complex as a dynamic fluorescence quencher to monitor oxygen in water. The porphyrin complex is embedded in a gas-permeable foil that is exposed to the surrounding water. A black optical isolation coating protects the complex from sunlight and fluorescent particles in the water. This sensing foil is attached to a sapphire window, providing optical access for the measuring system from inside a watertight titanium housing. The foil is excited by modulated blue light, and the phase of a returned red light is measured. By linearizing and temperature compensating with an incorporated temperature sensor, the absolute oxygen concentration can be determined. The diameter of the Optode 3830 is 36 millimeters (mm) (1.42 inches). It is 86 mm (3.39 inches) long and weighs 0.23 kilograms (8.11 ounces). Pricing information is available from the vendor. The range, resolution, and accuracy, as indicated by the vendor, are listed below.

Vendor-Provided Range, Resolution, and Accuracy

Parameter	Range	Resolution	Accuracy
Air saturation	0 to 120%	<0.4%	<5%
Oxygen concentration	0 to 500 µMolar (µM)	<1 µM	<8 µM or 5%, whichever is greater
Temperature	-2.7 to 36.66°C	0.1% of range	±0.05°C
Turbidity	0 to 20 NTU	0.1% of full scale	2% of full scale

VERIFICATION OF PERFORMANCE

The table below summarizes the performance of the Mk II with Optode 3830. The two Mk II with Optode 3830s collected data without interruption at 10-minute intervals from October 1, 2003, until January 5, 2004, and 100% of the required data was collected.

Performance Results

Statistical Measure	Parameter	1103			1104		
		Saltwater	Freshwater	Mesocosm	Saltwater	Freshwater	Mesocosm
Calibration check accuracy[a]	DO (%)	98.9	98.9	99.7	97.3	95.6	83.9
	Turbidity (%)	30	1,500	NA[b]	18	800	520
Average relative bias[c]	DO (%)	-19.7	–[d]	-6.79	-13.8	–[d]	6.61
	Temperature (%)	-0.99	–[d]	-1.76	-1.76	–[d]	-1.51
	Turbidity (%)	54.2	–[d]	-521	69.0	–[d]	-452

		1103	1104
Average precision	DO (%RSD)	1.32	0.73
	Temperature (%RSD)	2.20	2.80
	Turbidity (%RSD)	26.8	24.4

Linearity	Best agreement between readings and reference values was for temperature. During the saltwater deployment, the DO measurements resulted in slopes between 0.70 and 0.74 and regression coefficients between 0.76 and 0.79 over a range of 3 to 6 mg/L. During the mesocosm deployment, slopes and regression coefficients both decreased. Finally, when the Mk II was within its range, the turbidity measurements resulted in a slope of 0.99 and a regression coefficient of 0.93 over a range of 0.4 to 15 NTU.

		Average Difference Between 1103 and 1104 Readings		
		Saltwater	Freshwater	Mesocosm
Inter-unit reproducibility	DO (mg/L)	1.02	1.42	1.78
	Temperature (°C)	0.16	0.04	0.03
	Turbidity (NTU)	3.12	10.9	7.26

[a] The closer the percentage is to 100, the better.
[b] Saturated; no data reported.
[c] The closer the percentage is to zero, the better.
[d] Stratification; no data reported.

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