THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

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ETV Joint Verification Statement

TECHNOLOGY TYPE:	**ON-LINE TURBIDIMETER**		
APPLICATION:	**MEASURING LOW TURBIDITY LEVELS**		
TECHNOLOGY NAME:	**TST-SC On-Line Turbidimeter**		
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The U.S. Environmental Protection Agency (EPA) has created 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 substantially 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.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups which consist of buyers, vendor organizations, and permitters; and with the full participation of 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 protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Advanced Monitoring Systems (AMS) program, one of 12 technology areas under ETV, is operated by Battelle in cooperation with EPA's National Exposure Research Laboratory. AMS has recently evaluated the performance of on-line turbidimeters for use in water treatment facilities. This verification statement provides a summary of the test results for the Monitek TST-SC on-line turbidimeter.

VERIFICATION TEST DESCRIPTION

The verification test described in this report was conducted by Battelle in the fall of 1999 on commercial on-line turbidimeters at the City of Columbus Water Division's Dublin Road Water Plant in Columbus, Ohio. The

verification test was conducted in two phases. An off-line phase challenged the turbidimeters with a series of prepared standards and other test solutions under controlled conditions, whereas an on-line phase assessed long-term performance under realistic conditions by monitoring a sample stream in a municipal water treatment plant. The on-line phase was intended to evaluate performance in continuous unattended monitoring over a low range of turbidity [i.e., 0.1 to 1 nephelometric turbidity unit (NTU)]. No attempt was made to determine the ultimate detection limits of the turbidimeters tested.

In the off-line phase of testing, the linearity, accuracy, precision, and detection limit of the Monitek TST-SC turbidimeter were determined by comparing turbidity measurements on standard solutions to reference measurements of the same solutions. By intentionally varying the water temperature, flow rate, and color of the sample solution, the effect of these parameters on the response of the Monitek TST-SC turbidimeter was determined. In the on-line phase, a sample stream from a municipal water plant was continuously monitored by the TST-SC turbidimeter for approximately 4 weeks. Results from this phase of testing were used to determine the accuracy in measuring real-world samples and the drift characteristics of the TST-SC. Quality assurance (QA) oversight of verification testing was provided by independent Battelle QA staff, who conducted a technical systems audit, and a data audit on 10 percent of the test data.

The verification test relied upon two reference methods: ISO 7027, "Water Quality—Determination of Turbidity" and EPA Method 180.1, "Determination of Turbidity by Nephelometry." The Monitek TST-SC turbidimeter is designed to conform to ISO 7027 requirements, and thus comparison of TST-SC results to those from the ISO 7027 reference method was the primary means of verification. EPA Method 180.1 uses a different wavelength of light than the TST-SC (i.e., visible rather than infrared), and thus is not a directly equivalent method. However, the EPA Method 180.1 method is widely recognized in the U.S. by virtue of its status as the required method for drinking water compliance measurements. Consequently, comparisons of the TST-SC results to Method 180.1 results were also made and are presented as a secondary illustration of performance.

TECHNOLOGY DESCRIPTION

The Monitek Technologies Monilog Model TST-SC uses on-line turbidimeter alternating four-beam technology to measure turbidity and suspended solids. This method uses an array of two light-emitting diodes (LEDs) and two detectors. The LEDs are oriented 90 degrees from each other and are pulsed alternately. This causes the two detectors (located across the process stream and 90 degrees apart) to alternate between their functions as the scatter and direct beam detectors. Since each detector element alternates between functions as the measurement and reference channel, the system compensates for variations in the LED output, window coatings, and other effects. The turbidimeter meets ISO 7027 requirements. The TST-SC has a lower limit of response of 0.1 NTU.

VERIFICATION OF PERFORMANCE

The following are summaries of key performance characteristics as verified by comparison to the ISO 7027 reference method. Secondary illustrations of performance relative to the EPA 180.1 method are also shown in the body of the report, and generally showed similar performance to that found in the verification comparisons.

Off-Line Testing

Linearity: The Monitek TST-SC turbidimeter responded linearly to turbidity in the tested range from 0.3 to 5 NTU. The slope of the response curve was 0.935, relative to the ISO 7027 reference turbidimeter, with an r^2 value of > 0.9995, and had a negative intercept of approximately 0.1 NTU.

Accuracy: In measuring standard formazin solutions, the Monitek TST-SC turbidimeter showed a negative bias in turbidity throughout the range from 0.3 to 5 NTU. This bias ranged from -0.1 NTU at 0.3 NTU (25 to 30%) to -0.3 NTU at 5 NTU (6 to 8%). A large portion of this bias can be attributed to the intercept (- 0.1 NTU)

calculated from the linearity plots. A shift in the calibration curve to eliminate the offset would result in a dramatic reduction in the observed bias throughout the measured range of turbidity.

Precision: The Monitek TST-SC turbidimeter had approximately the same precision as the bench-top reference turbidimeters in the range of 0.3 to 5 NTU measured in this verification test. The precision ranged from ~ 3.3% RSD at 0.3 NTU to ~ 0.35% RSD at 5 NTU.

Water Temperature Effect: At 0.3 NTU this effect amounts to a decrease in relative turbidity of ~ 0.4% per degree C. At 5 NTU, there was no statistically significant correlation between turbidity readings and water temperature.

Flow Rate: There was no effect of the sample flow rate on the response of the Monitek turbidimeter in the flow range from 0.1 to 1.0 gpm.

Color: At 5 NTU, color had no significant effect on the response of the Monitek TST-SC turbidimeter. At the 0.1 NTU turbidity level, color appeared to have an effect; however, it is unclear whether the effect is the result of an actual response to color or if it was an artifact of measurements taken at the lower limit of the turbidimeter's measuring range.

On-Line Testing

Accuracy: In reading the turbidity of treated, unfiltered water from a municipal drinking water plant, the Monitek TST-SC showed a general positive bias with respect to the ISO 7027 reference turbidimeter. In the turbidity range from 0.1 to 0.6 NTU, as measured by the reference turbidimeter, the TST-SC typically read within 0.1 NTU of the reference turbidimeter. Calibration checks of the Monitek TST-SC turbidimeter performed throughout the four weeks of on-line testing showed a negative bias (~ 11% to ~ 14% average) with respect to the reference turbidimeter in reading a 0.5 NTU formazin solution. These data show a clear difference in results between sampling formazin solutions and water from the plant. A systematic negative bias in the reference readings on the stream samples, perhaps as the result of large particle settling, is a possible contributor to the apparent positive biases in the Monitek readings.

Drift: No long-term drift in the calibration of the Monitek TST-SC turbidimeter was observed during the 7-week verification test.

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