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:	**WTM500 On-Line Turbidimeter**
COMPANY:	**Sigrist-Photometer AG**

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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 Sigrist WTM500 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, which other studies have shown can be as low as 0.01 NTU.

In the off-line phase of testing, the linearity, accuracy, and precision of the Sigrist WTM500 turbidimeter were determined by comparing turbidity measurements on formazin 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 Sigrist WTM500 turbidimeter was determined. In the on-line phase, a sample stream from a municipal water plant was continuously monitored by the WTM500 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 WTM500. 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 Sigrist WTM500 turbidimeter is designed to conform to ISO 7027 requirements, and thus comparison of WTM500 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 WTM500 (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 one of the required methods for drinking water compliance measurements. Consequently, comparisons of the WTM500 results to Method 180.1 results were also made, and are presented as a secondary illustration of performance.

TECHNOLOGY DESCRIPTION

The Sigrist WTM500 is an on-line turbidimeter, manufactured by Sigrist-Photometer AG, that provides non-contact measurement of the 90° scattered light in a free-falling water stream. Automatic adjustment using a fixed internal reference standard enhances measurement reliability and minimizes the need for cleaning and calibration. The WTM500 has a nominal range of 0 to 500 formazin nephelometric units (FNUs) in eight selectable scale ranges, with a maximum resolution of 0.001 FNU. The control unit has a two-line liquid-crystal display. Because the WTM500 has no flow cell and no windows, the optics of the turbidimeter do not need to be cleaned regularly. The turbidimeter is adjusted using a solid internal reference standard. The formazin calibration is checked at regular intervals against a built-in solid reference, and any deviations are corrected automatically. The WTM500 turbidimeter’s measuring wavelength is 880 nm. The turbidimeter is designed to meet ISO 7027 requirements and measures samples between 0 and 40°C at a flow rate of between 0.84 and 1.06 gpm.

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 Sigrist WTM500 turbidimeter provided linear response over the tested range of <0.1 to 5 NTU. The slope of the response curve for the WTM500 relative to the ISO 7027 reference turbidimeter was 1.013, with an r^2 value of >0.999, and an intercept of 0.001 NTU.

Accuracy: In measuring standard formazin solutions, the Sigrist WTM500 turbidimeter agreed within 5% with the ISO 7027 reference turbidimeter throughout the range of turbidity from 0.3 to 5 NTU. This accuracy tolerance was comparable to the fluctuations of the daily reference turbidimeter calibration checks.

Precision: The precision of the Sigrist WTM500 as relative standard deviation was within 4.1% or less in the turbidity range of 0.3 to 5 NTU, and was approximately the same as for the ISO 7027 reference turbidimeter in this range of turbidity.

Water Temperature Effect: Water temperature in the range of 15 to 30°C had no effect on the response of the Sigrist WTM500 relative to the ISO 7027 reference turbidimeter.

Flow Rate: There was no effect of sample flow rate on the turbidity readings of the WTM500 turbidimeter in the range from 0.85 to 0.95 gpm.

Color: Color had no effect on turbidity readings at low turbidity (~0.1 NTU). At 5 NTU, the addition of color to the sample stream resulted in a decrease in the observed turbidity of about 0.1% per color unit relative to the ISO 7027 reference turbidimeter.

On-Line Testing

Accuracy: In reading the turbidity of treated, unfiltered water from a municipal drinking water plant, the Sigrist WTM500 turbidimeter showed a general positive bias relative to the ISO 7027 reference turbidimeter. In the turbidity range from 0.1 to 0.6 NTU, as measured by the reference turbidimeter, the WTM500 typically read approximately 0.05 to 0.2 NTU higher than the reference turbidimeter. (A similar offset was observed with other turbidimeters tested.) In contrast, calibration checks of the Sigrist WTM500 turbidimeter performed throughout the four weeks of on-line testing showed only a slight negative bias (-4% to -7% 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 of 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 Sigrist readings.

Drift: Comparison of results from linearity checks at the beginning and end of the verification test showed no significant drift, i.e., changes were within the combined experimental uncertainty of the reference measurements.

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