Designation: D7937 – 15

Standard Test Method for In-situ Determination of Turbidity Above 1 Turbidity Unit (TU) in Surface Water[1]

This standard is issued under the fixed designation D7937; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the in-situ field measurements of turbidity in surface water. The measurement range is greater than 1 TU and the lesser of 10 000 TU or the maximum measurable TU value specified by the turbidimeter manufacturer.

1.1.1 Precision data was conducted on both real world and surrogate turbidity samples up to about 1000 TU. Many of the technologies listed in this test method are capable of measuring above that provided in the precision section (see Section 16).

1.2 "In-situ measurement" refers in this test method to applications where the turbidimeter sensor is placed directly in the surface water in the field and does not require transport of a sample to or from the sensor. Surface water refers to springs, lakes, reservoirs, settling ponds, streams and rivers, estuaries, and the ocean.

1.3 Many of the turbidity units and instrument designs covered in this test method are numerically equivalent in calibration when a common calibration standard is applied across those designs listed in Table 1. Measurement of a common calibration standard of a defined value will also produce equivalent results across these technologies. This test method prescribes the assignment of a determined turbidity values to the technology used to determine those values. Numerical equivalence to turbidity standards is observed between different technologies but is not expected across a common sample. Improved traceability beyond the scope of this test method may be practiced and would include the listing of the make and model number of the instrument used to determine the turbidity values.

1.4 In this test method, calibration standards are often defined in NTU values, but the other assigned turbidity units, such as those in Table 1 are equivalent. For example, a 1 NTU formazin standard is also a 1 FNU, a 1 FAU, a 1 BU, and so forth.

1.5 This test method was tested on different natural waters and with standards that served as surrogates for samples. It is recommended to validate the method response for waters of untested matrices.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1129 Terminology Relating to Water
D1193 Specification for Reagent Water
D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water
D3864 Guide for On-Line Monitoring Systems for Water Analysis
D4411 Guide for Sampling Fluvial Sediment in Motion
D7315 Test Method for Determination of Turbidity Above 1 Turbidity Unit (TU) in Static Mode
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

[1] This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.07 on Sediments, Geomorphology, and Open-Channel Flow.

Current edition approved Jan. 1, 2015. Published February 2015. DOI: 10.1520/D7937-15.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Summary of Known in-situ Instrument Designs, Applications, Ranges, and Reporting Units

Design and Reporting Unit	Prominent Application	Key Design Features	Typical Instrument Range	Suggested Application Ranges
Nephelometric Non-Ratio (NTU)	White light turbidimeters Comply with EPA 180.1 for low level turbidity monitoring.	Detector centered at 90° relative to the incident light beam. Uses a white light spectral source.	0.0–40	0.0–40 Regulatory
Ratio White Light Turbidimeters (NTRU)	Complies with U.S. EPA regulations and EPA 2130B. Can be used for both low and high level measurement.	Used a white light spectral source. Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.	0–10 000	0–40 Regulatory 0–10 000 other
Nephelometric, Near-IR Turbidimeters, Non- Ratiometric (FNU)	Complies with ISO 7027. The wavelength is less susceptible to color interferences. Applicable for samples with color and good for low level monitoring.	Detector centered at 90° relative to the incident light beam. Uses a near-IR (780-900 nm) monochromatic light source.	0–1 000	0–40 Regulatory (non-US) 0–1 000 other
Nephelometric Near-IR Turbidimeters, Ratio Metric (FNRU)	Complies with ISO 7027. Applicable for samples with high levels of color and for monitoring to high turbidity levels.	Uses a near-IR monochromatic light source (780–900 nm). Primary detector centered at 90°. Other detectors located at other angles. An instrument algorithm uses a combination of detector readings to generate the turbidity reading.	0–10 000	0–40 Regulatory 0–10 000 other
Formazin Back Scatter (FBU)	Not applicable for regulatory purposes. Best applied to high turbidity samples. Backscatter is common probe technology and is best applied in higher turbidity samples.	Uses a near-IR monochromatic light source in the 780–900 nm range. Detector geometry is 30 ± 15° relative to the incident light beam.	100–10 000+	100–10 000
Backscatter Unit (BU)	Not applicable for regulatory purposes. Best applied for samples with high level turbidity.	Uses a white light spectral source (400–680 nm range). Detector geometry is 30 ± 15° relative to the incident light beam.	10–10 000+	100–10 000+
Formazin Attenuation Unit (FAU)	May be applicable for some regulatory purposes. This is commonly applied with spectrophotometers. Best applied for samples with high level turbidity.	Detector is geometrically centered at 180° relative to incident beam (attenuation) Wavelength is 780–900 nm.	20–1 000	20–1 000 Regulatory
Light Attenuation Unit (AU)	Not applicable for some regulatory purposes. This is commonly applied with spectrophotometers.	Detector is geometrically centered at 180° relative to incident beam (attenuation). Wavelength is 400–680 nm.	20–1 000	20–1 000
Nephelometric Turbidity Multi-beam Unit (FNMU)	Is applicable to EPA regulatory method GLI Method 2. Applicable to drinking water and wastewater monitoring applications.	Detectors are geometrically centered at 90° and 180°. An instrument algorithm uses a combination of detector readings, which may differ for turbidities varying magnitude.	0.02–4000	0–40 Regulatory 0–4 000 other
Forward Scatter Ratio Unit (FSRU)	The technology encompasses a single, light source and two detectors. Light sources can vary from single wavelength to polychromatic sources. The detection angle for the forward scatter detector is between 0 and 90° relative to the centerline of the incident light beam.	The technology is sensitive to turbidities as low as 1 TU. The ratio technology helps to compensate for color interference and fouling.	1-800 FSRU The measurement of ambient waters such as streams, lakes, rivers.	Forward Scatter Ratio Unit (FSRU)
Forward Scatter Unit (FSU)	The technology encompasses a single, light source and one detector between 0 and 90° relative to the centerline of the incident light beam.	The technology is sensitive to turbidities as low as 1 TU. The ratio technology helps to compensate for color interference and fouling.	1-1000 FSU The measurement of ambient waters such as streams, lakes, rivers and process waters.	Forward Scatter Unit (FSU)

2.2 *Other Referenced Standards:*
EPA 180.1 Determination of Turbidity by Nephelometry[3]
EPA 2130B Analytical Method For Turbidity Measurement[3]
ISO 7027 (International Organization for Standardization) Water Quality for the Determination of Turbidity[4]
GLI Method 2 Turbidity[3]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard*—Unless otherwise noted, the term 'light' means visible light or near-infrared (NIR) radiation or both.

3.2.1 *ambient light, n*—light or optical path or both that does not originate from the light source of a turbidimeter.

3.2.2 *attenuation, n*—the amount of incident light that is scattered and absorbed before reaching a detector, which is geometrically centered at 180° relative to the centerline of the incident light beam.

3.2.2.1 *Discussion*—Attenuation is inversely proportional to transmitted signal.

Attenuated Turbidity = Absorbed Light + Scattered Light

3.2.2.2 *Discussion*—The application of attenuation in this test method is as a distinct means of measuring turbidity. When measured in the FAU or AU mode, the turbidity value is a combination of scattered (attenuated) light plus absorbed light. The scattered light is affected by particle size and is a positive response. The absorption due to color is a negative response. The sum of these two responses results in the turbidity value in the appropriate unit.

3.2.3 *automatic power control (APC), n*—the regulation of light power from a source such that illumination of the sample remains constant with time and temperature.

3.2.4 *broadband, white-light source, n*—a visible-light source that has a full bandwidth at half of the source's maximum intensity (FWHM) located at wavelengths greater than 200 nm.

3.2.4.1 *Discussion*—Tungsten-filament lamps (TFLs) and white LEDs are examples of broadband sources.

3.2.5 *calibration turbidity standard, n*—a turbidity standard that is traceable and equivalent to the reference turbidity standard to within defined accuracy; commercially prepared 4000 NTU Formazin, stabilized formazin, and styrenedivinylbenzene (SDVB) are calibration turbidity standards.

3.2.5.1 *Discussion*—These standards may be used to calibrate the instrument. All meters should read equivalent values for formazin standards. SDVB-standard readings are instrument specific and should not be used on meters that do not have defined values specified for that instrument. Calibration standards that exceed 10 000 turbidity units are commercially available.

3.2.6 *calibration-verification standards, n*—defined standards used to verify the instrument performance in the measurement range of interest.

3.2.6.1 *Discussion*—Calibration-verification standards may not be used to adjust instrument calibration, but only to check that the instrument measurements are in the expected range. Examples of calibration-verification standards are opto-mechanical light-scatter devices, gel-like standards, or any other type of stable liquid standard. Calibration-verification standards may be instrument-design specific.

3.2.7 *color, n*—the hue (red, yellow, blue, etc.) of a water sample produced by the combination of: the selective absorption of visible light, the spectral reflectivity, and the degree of darkness or blackness of suspended matter.

3.2.7.1 *Discussion*—The combination above is defined by the Munsell (**1**)[5] color-classification scheme.

3.2.8 *detector, n*—a solid-state device that converts light into electrical current or voltage.

3.2.9 *detector angle, n*—the angle between the axis of the detector acceptance cone and the axis of the source light or NIR beam.

3.2.9.1 *Discussion*—The detector angle equals 180° – θ (θ is the scattering angle).

3.2.10 *narrow-band source, n*—a light source with a full bandwidth (at half of the source's maximum intensity) (FWHM) located at wavelengths less than 5 nm.

3.2.11 *operating spectrum, n*—the wavelength-by-wavelength products of source intensity, filter transmittance, and detector sensitivity.

3.2.11.1 *Discussion*—The operating spectrum determines the relative contributions of wavelengths in the light-to-current conversions made by a turbidimeter.

3.2.12 *ratio turbidity measurement, n*—the measurement derived through the use of a primary detector and one or more other detectors to compensate for variation in incident-light intensity, stray light, sample color, window transmittance, and dissolved NIR-absorbing matter.

3.2.13 *reference turbidity standard, n*—a standard that is synthesized reproducibly from traceable raw materials by a skilled analyst.

3.2.13.1 *Discussion*—All other standards are traced back to this standard. The reference standard for turbidity is formazin.

3.2.14 *sample volume, n*—the water-sample volume wherein light from a turbidimeter source interacts with suspended particles and is subsequently detected.

3.2.15 *scattering (also referred to as scatter), n*—light interaction that alters the direction of light transport through a sample without changing the wavelength.

3.2.15.1 *Discussion*—The light interaction can be with suspended particles, water molecules, and variations in the sample's refractive index.

3.2.16 *scattering angle (θ), n*—the angle between a source light or NIR beam, and the scattered beam.

[3] Available from United States Environmental Protection Agency (EPA), William Jefferson Clinton Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20004, http://www.epa.gov.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] The boldface numbers in parentheses refer to the list of references at the end of this standard.