ARTICLE

Drinking Water Turbidity Monitoring: 7 Key Considerations

Turbidity, as a measure of cloudiness or haze in water, has many useful applications for industrial processes, pharmaceutical manufacturing, environmental monitoring, and utility applications. Unlike general commercial applications, however, the use of turbidity readings in municipal drinking water treatment comes with unique demands and considerations related to regulatory compliance.

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For the purposes of this article devoted to water treatment plant (WTP) applications, the primary focus is on meeting U.S. EPA drinking water standards based on the EPA turbidity provisions guidance document. Many of the following application considerations, principles of operation, and selection criteria, however, can also be relevant to other turbidimeter applications in and beyond WTP operations.

It is important to note that the EPA does not approve equipment, only methods, and some of those are for measuring turbidity. Since 1993, subsequent alternative methods submitted by manufacturers have been approved as being compatible with the original Method 180.1 and providing equal or better performance. Instruments approved as compatible to standards other than those set by Method 180.1 might produce slightly different results.

1. Application-Specific Designs

While all **turbidimeters** operate on a similar concept of measuring light interactions with a fluid, different designs are suited to different applications. Different designs are required for different applications because variations in the size, number, shape, and color of particles suspended in that fluid can affect the readings provided.

In 1926, Kingsbury, Clark, Williams, and Post developed a new standard reference solution (formazin polymer) that was easier to formulate. It provided greaterconsistency than Jackson's diatomaceous earth reference standard, which could vary according to the material source. Formazin also does a good job of replicating the particulates and turbidity typically experienced in drinking water applications. One advantage of formazin is that, even though not all of the polymer chains are of an identical size, it produces a very regular response every time it is synthesized. The formazin standard was a major step toward standardizing turbidity testing. It is still in use today, while other turbidimetry components — such as light sources and light detectors — have been refined to eliminate the variables of candle light and human eyesight.

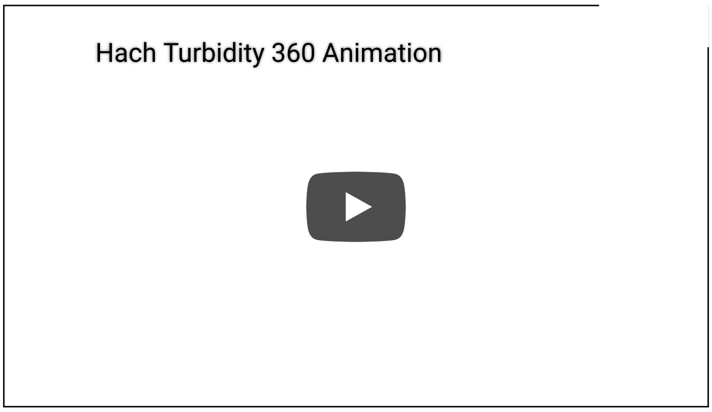
- **Transmitted-Light Turbidimetry**
  The earliest turbidimeters worked on the principle of attenuation — a measure of how light passing through a fluid is blocked or absorbed by particles in that fluid. This style of turbidimeter is not applicable for EPA drinking water compliance applications.
- **Scattered-Light Turbidimetry**
  Many turbidimeters measure the amount of light reflected off the particles. This reflected light can be measured at a specific angle (i.e., 90 degrees for drinking water compliance) or at a combination of angles. Each version has its benefits based on the application and the fluid being measured.
- **Nephelometry**
  A nephelometer is a particular type of turbidity-sensing device that measures the amount of reflected light detected at a 90-degree angle from a collimated light source. It is the specific design mandated by EPA Method 180.1 for drinking water standards regarding post-filtration turbidity monitoring compliance in WTPs. In practice, it is primarily used to indicate the potential presence of microscopic pathogens — such as Giardia lamblia and Cryptosporidium parvum — in water with relatively low particulate levels.
- **Ratio Turbidimetry**
  Colored fluids, or fluids with large particles or a diverse mix of particle sizes — as are often typically found in industrial processes or other commercial applications — benefit from the comparison of multiple-angle readings (i.e., 180 degrees, 90 degrees, 70 degrees, and 130 degrees) provided by a ratio turbidimeter.
- **Non-Contact Turbidimetry**
  A non-contact turbidimeter is useful for very turbid waters, where immersion of the sensor in fluids with high loads of suspended solids could cause frequent fouling and sensitivity loss, which may disrupt accuracy. This design is a good choice for evaluating surface water sources entering a WTP application. It can identify deteriorating inflow conditions in time to adjust flocculation and coagulation treatments to improve the chances of meeting post- filtration turbidity compliance requirements. Although this type of turbidimeter can be subject to condensation issues in high- humidity air, its anti-fouling properties make it a good choice for wastewater treatment and other highly turbid applications — up to 9,999 nephelometric turbidity units (NTUs).

2. On-Line Vs. Laboratory Instruments

TOn-line instruments are the favored choice for EPA compliance monitoring of post-filtration water flow, because they provide continuous readings in real time to offer the quickest notification of changing trends or process upsets. Lab devices can be used for occasional grab samples and emergency backup.

Historically, WTP personnel have considered laboratory instrument readings to be more accurate than process equipment readings when they saw differences between the two units. In actuality, there are multiple factors about sample handling that can affect differences in laboratory instrument readings — settling of particles or introduction of air bubbles in the time it takes to transfer samples, other human- induced errors, the introduction of a glass vial, or simply differences in calibration, etc.

New nephelometers that standardize sensing technology to provide identical readings (Video) from both on-line and laboratory units and use the same exact calibrant can eliminate that confusion and instill greater confidence in all readings.



3. Accuracy

One of the most important advancements in the accuracy of turbidity measurement since publication of the original EPA Method 180.1 document in 1993 relates to light sources. Today, LED and laser diode light sources capable of providing far better performance have been approved as acceptable alternatives to the original tungsten light bulb specified by the original method. In fact, they provide a stable, more controllable light that avoids the changes in the power and geometry experienced with tungsten bulbs over their lifetime of operation. The enhanced performance made possible by these light sources has led to immense improvements in the stability, accuracy, and repeatability of turbidimeter readings. Instrumentation with built-in software that complements quality assurance and quality control requirements can improve operating integrity and boost end user confidence in turbidity readings.

4. Speed Of Response

Newer turbidimeter designs can detect changes in rising turbidity values in a matter of seconds, not minutes — going from zero to full-scale reading in as little as 5 seconds. In WTPs using membrane filtration, that speed of response can be critical to indicating potential membrane deterioration or catching actual breakthroughs immediately after they occur, allowing enough time to prevent the process from going out of compliance. Slow-response devices can mask short- duration turbidity events by averaging out skewed readings over a longer period. Speed of response also helps minimize backwash cycle times by detecting when the backwashed flow from filter media starts running clean.

5. Digital Vs. Analog

While any nephelometer that satisfies the EPA 180.1 Method requirements should provide satisfactory results, the advantages of digital nephelometers lend themselves to applications where data is automatically captured and managed by digital information systems. First, there is no danger of skewed data readings due to analog interference. Second, instant data access across a range of devices, made practical through cloud connectivity, provides an added degree of convenience and comfort for end users. Digital monitoring and recording also makes it easier to identify process upset conditions and then pinpoint and analyze the cause of problems in the process. Analog loops require additional periodic electronic verification and calibration verification not required by digital connections.

6. Ease Of Maintenance

Maintenance efforts mandated by the EPA or necessitated by frequent sensor cleaning due to surface fouling can vary drastically from one nephelometer design to another. Consider all aspects of routine calibration/verification and ancillary maintenance costs along with spare-part and contract-service availability.

- **Convenience**
  Modern nephelometer designs that reduce the surface area needing to be cleaned by 98 percent can cut overall cleaning time from 10 minutes to just 1 minute or less and may be carried out automatically. Those same designs can cut verification time in half and reduce operator involvement for calibration from 15 minutes to just 1 minute per quarter.
- **Consistent Standard Operating Procedures**
  In WTPs with multiple turbidimeters/ nephelometers, standardizing on one method/style of unit with common interface, maintenance, calibration, and validation requirements can reduce time and complexity for maintenance personnel. Simplifying the process reduces chances for missed or incorrectly performed maintenance and minimizes the time and effort needed to comply with conflicting methods or equipment designs. Maintenance for backup units should be the same as that for regulatory reporting instruments.
- **Cuvette Or Not Cuvette?**
  When considering a tur- bidimeter/nephelometer with a glass or plastic sample cell (cuvette), be sure to calculate the added time needed to maintain it properly, so as not to compromise readings. This can be an important consideration in application environments subject to manganese and iron deposits, biofouling, or chemical fouling.

7. Total Cost Of Ownership

The best instrument choice is the one that can provide the overall best results at the most efficient total cost — including unit purchase price; cost of consumables; labor and material costs for operation, calibration, and maintenance, etc. Take into account how much calibration standard will be required every three months — a liter, 100 ml, or 10 ml. Units that minimize and/or simplify maintenance, calibration, and verification procedures will be more cost-effective in providing consistently reliable results over the long run.