Turbidity a "Quantum Leap in Technology"

PA Section AWWA
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Swan Analytical USA

Agenda

- Turbidity – What is it?
- History of Turbidity Measurement
- Measurement Principle
  - Units of Measure
  - Interferences
  - Calibration
  - Verification
- Types of Continuous Inline Instruments
  - Contact with Sample
  - Non Contact with Sample

Turbidity – What is it?

- Turbidity is a principal physical characteristic of water and is an expression of the optical property that causes light to be scattered and absorbed by particles and molecules rather than transmitted in straight lines through a water sample. It is caused by suspended matter or impurities that interfere with the clarity of the water.

History of Turbidity Measurement

- One of the early parameters tested was turbidity. The normal procedure in 1912 used the turbidity standard adopted by the U. S. Geological Survey: A rod with a platinum wire on the end was calibrated by placing graduation marks on the rod, at various distances from the end, and this was lowered into the water as far as the wire could be seen. The vanishing depth was compared to a table of known values to get the measured turbidity.

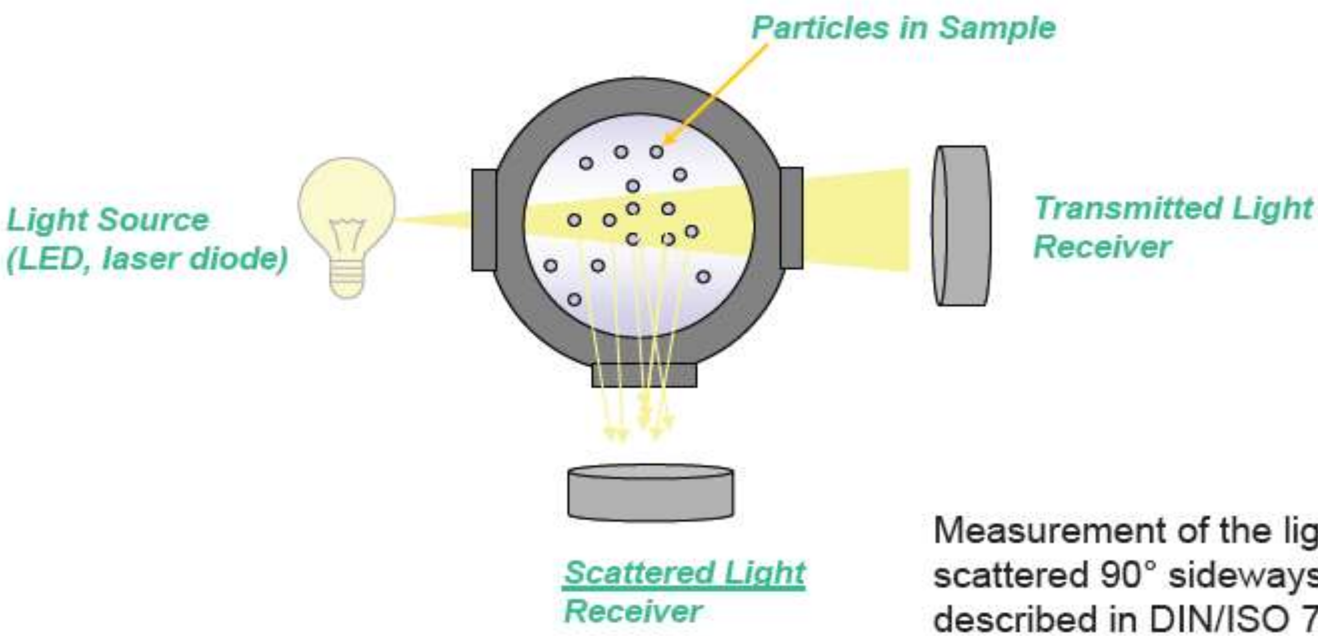
History of Turbidity Measurement

- By 1933 the Jackson candle turbidimeter became the standard.
- Expressed as JTU (Jackson Turbidity Units).
- A water sample was poured into the tube until the visual image of the candle flame viewed from the top of the tube, is diffused to a uniform glow. When the intensity of the scattered light equals that of the transmitted light, the image disappears The depth of the sample in the tube is read against the ppm-silica scale.
- The nephelometric turbidimeter was developed in the 1970's.

Measurement Principle

- Send light of an appropriate wavelength through the sample and detect the intensity at 90^o from the incident beam (scattered light).
- A 90^o detection angle is considered to be the least sensitive to variations in particle size.
- Readings are from a calibration curve established with Formazine. Results are expressed in FNU (Formazine Nephelometric Units) or NTU (Nephelometric Turbidity Units.)
- The result is a ratio.

Measurement Principle



Measurement of the light scattered 90° sideways described in DIN/ISO 7027

Interferences

- The measurement of turbidity is subject to a combination of different interferences.
- Some interferences are inherent with the sample itself and others are instrument-based.
- Turbidity interferences will either cause positive or negative bias.
- Negative is typically associated with measurements >1 NTU and can become more significant as the value increases.
- Positive turbidity interferences are typically associated with extremely low turbidity measurements, < 0.1 NTU, which are significant in filtered drinking water.

Typical Interferences

Absorbing particles (colored)	Negative bias (reported measurement is lower than actual turbidity)
Color in the matrix	Negative bias if the incident light wavelengths overlap the absorptive spectra within the sample matrix.
Particle Size	Either positive or negative bias (wavelength dependent)
	a) Large particles scatter long wavelengths of light more readily than will small particles.
	b) Small particles scatter short wavelengths of light more efficiently than long wavelengths
Particle Density	Negative bias (reported measurement is lower than the actual turbidity)

Instrument Based Interferences

Optical Variation	Degradation of instrument optical components is usually negative.
Sample cell variations	Either positive or negative bias. The impact of this interference is most severe at turbidity values below 0.1 turbidity units.
Particle Settling	Positive or negative bias can result from due to the rapid settling of particles.
Stray light	Positive bias. Stray light has the most significant impact at turbidity levels below 0.1 turbidity units.
Contamination	Positive bias. This is caused by dust contamination on optical surfaces that cannot be easily cleaned.

Contact Turbidimeters – Hach 1720E

Most continuous turbidimeters are contact design.

Contact Turbidimeters – US Filter & E+H

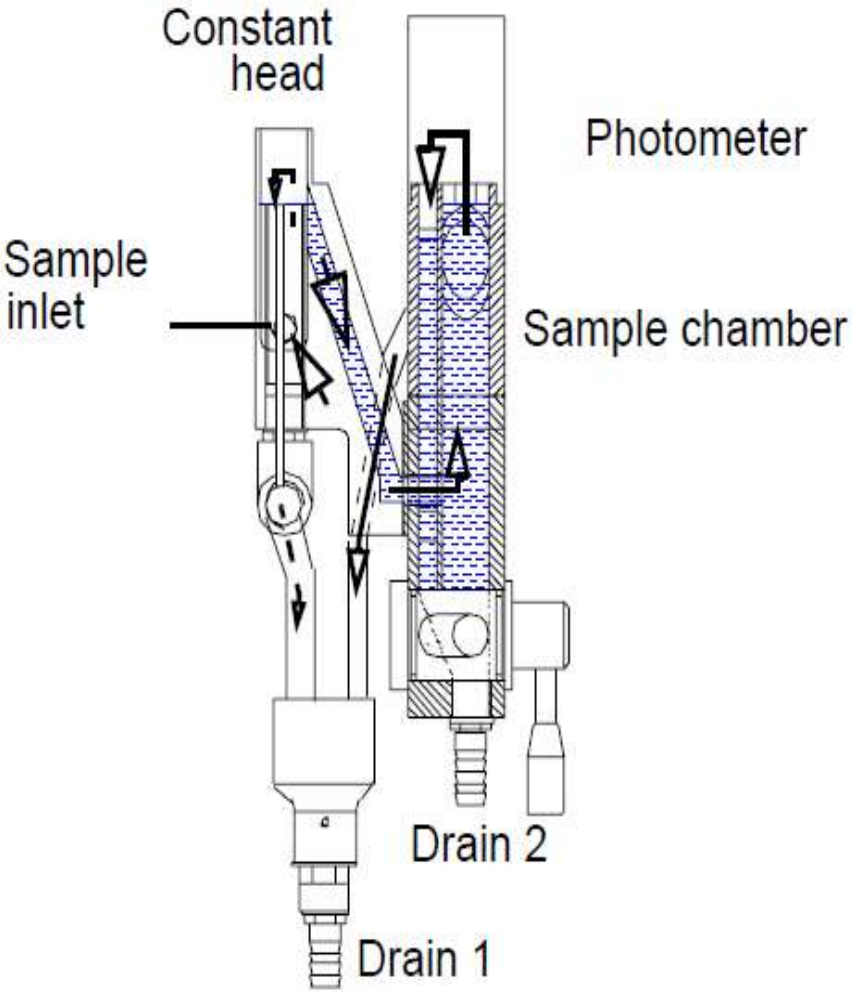
Non-Contact Turbidimeter - White LED

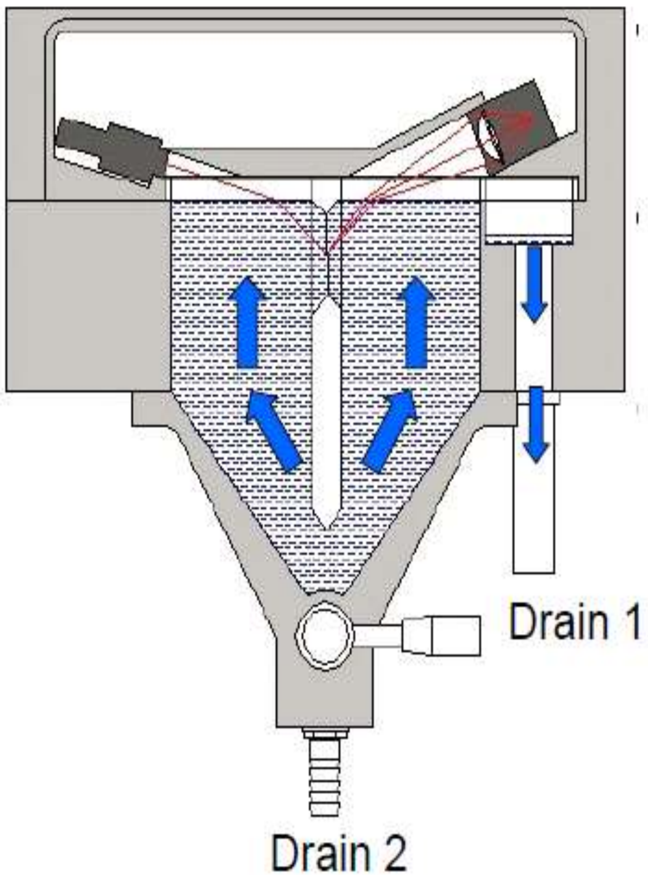
- Measuring range: 0.000 - 100 NTU
- Automatic range switching.
- Precision: ± 0.003 NTU or ± 1% of reading.
- Non-contact with sample avoids fouling
- Heated optics to avoid condensation
- Optional sample degasser to avoid bubble formation
- High quality long LED light source.
- Specially design chamber avoids measurement errors due to light reflection.
- LED emits light at a wavelength of 400 – 600 nm (white) due to EPA regulations.

Non-Contact Turbidimeter - Red LED

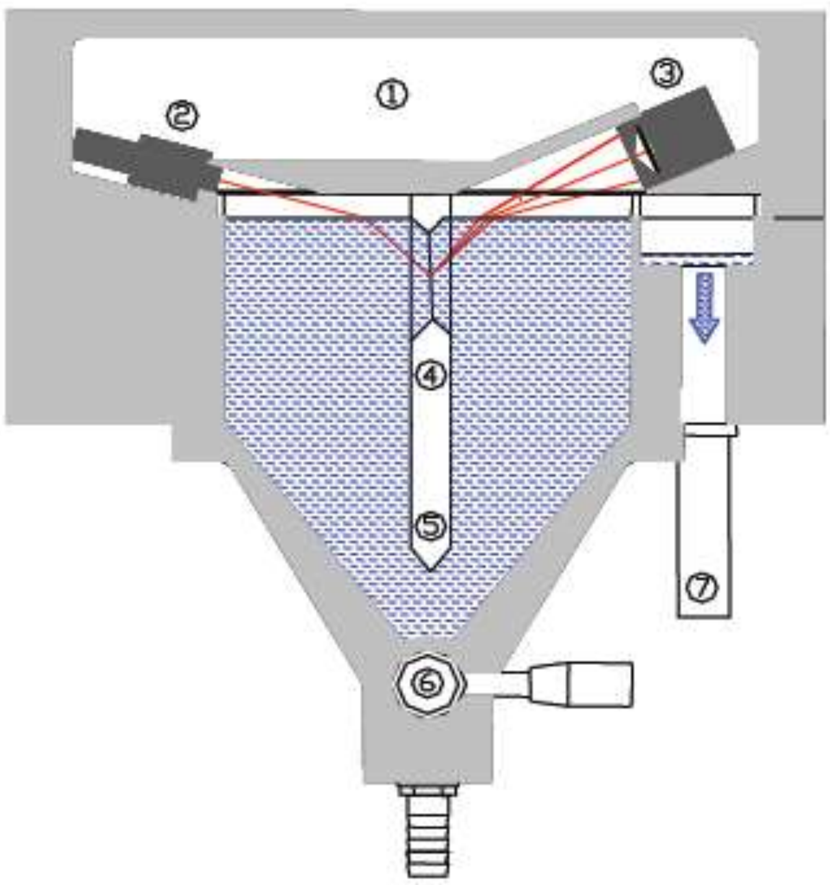
- Measuring range: 0.000 - 200 NTU
- Automatic range switching.
- Precision: ± 0.003 NTU or ± 1% of reading.
- Non-contact with sample avoids fouling
- Heated optics to avoid condensation
- Optional sample degasser to avoid bubble formation
- High quality long LED light source.
- Specially design chamber avoids measurement errors due to light reflection.
- LED emits light at a wavelength of 850 nm (red) because almost no substance absorbs light at this wavelength.

Non-Contact Measurement Principle



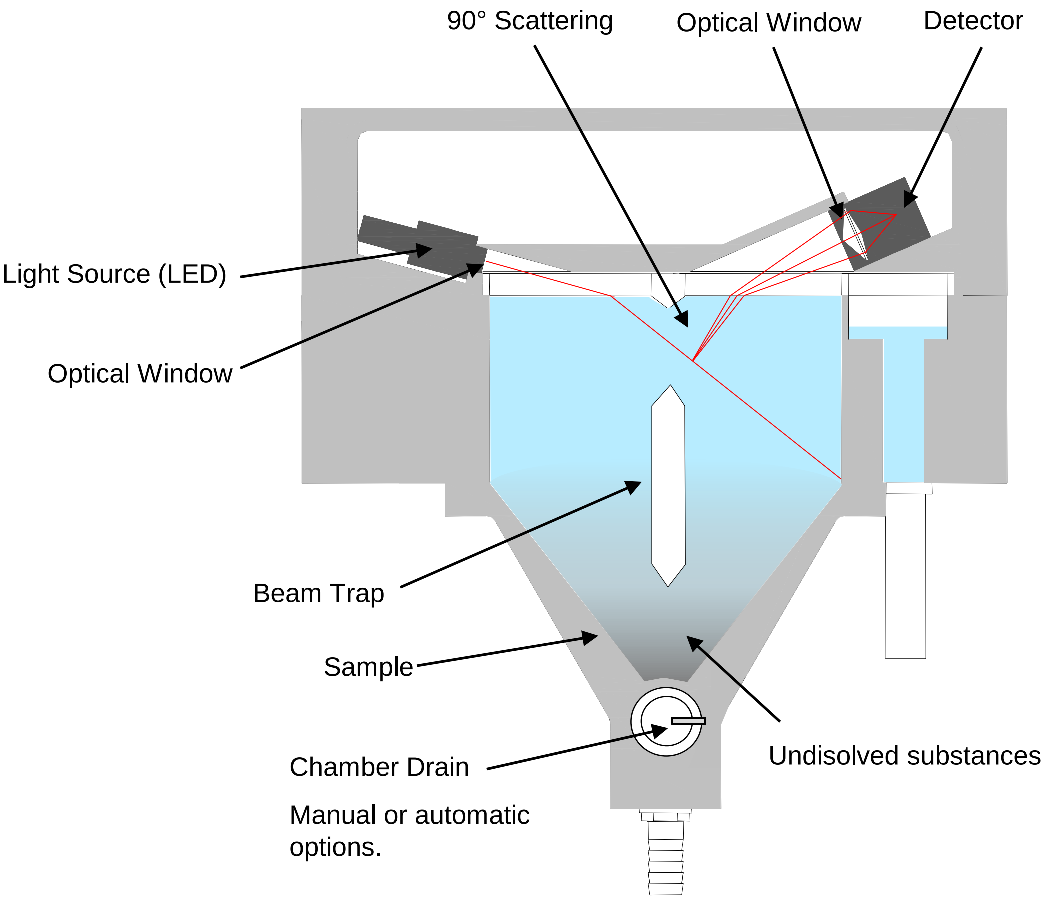


Non-Contact Turbidimeter Sensor



- Non-contact optical setup avoids bio fouling
- LED beam of emitter (2) impinges the water surface and is refracted.
- In an angle of 90°, the detector (3) measures the incoming, scattered light.

AMI Turbiwell



Light beam impinges the water surface and is refracted.

In angle of 90°: detector measures the incoming, scattered light.

Beam trap prevents light reflections thus avoids measurement errors.

Sedimentation of un-dissolved substances

Periodic cleaning of chamber by automatic drain

EPA Approval

- EPA approved the Swan AMI Turbiwell as an alternative method to 180.1
- For the measurement of turbidity following U.S. EPA regulations(e.g. EPA 180.1) an approved, alternative method is available at www.nemi.gov. Method Nr. SWAN AMI Turbiwell.
- LED light source, not a Tungsten light source
- The manufacturer recommends verification rather than calibration.

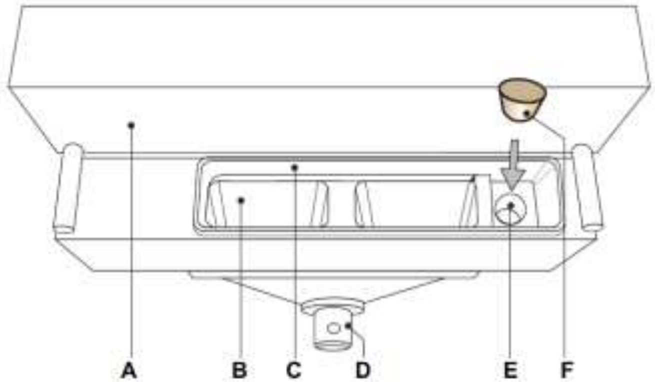
Calibration

- The readings indicated by turbidimeters are not scaled in light intensity but in the concentration of a reference suspension.
- Since the accuracy of the calibration solution determines the accuracy of the turbidity measurements, it is of crucial importance!
- The international turbidity standard is “formazine” which can be made using ISO 7027 or Standard Methods.

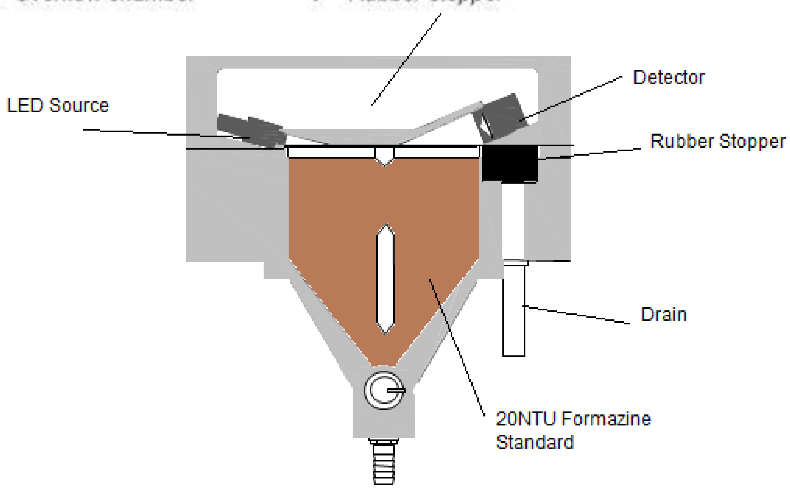
Calibration

- Electronic drift is one of the causes for the need to calibrate.
- The most significant drift results from minute contaminants fouling the optical elements.
- Zero calibration is essential for low level measurements.
- The slope of the calibration is predefined and stored in the instrument.

Calibration



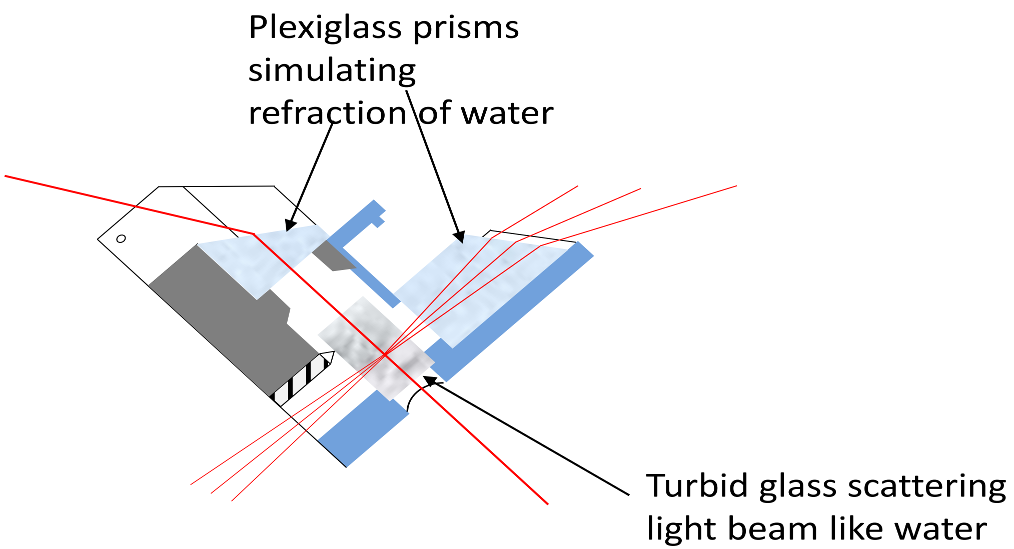
A *Cover*
B *Sample chamber*
C *Overflow chamber*
D *Drain valve*
E *Overflow (Drain 1)*
F *Rubber stopper*



Verification

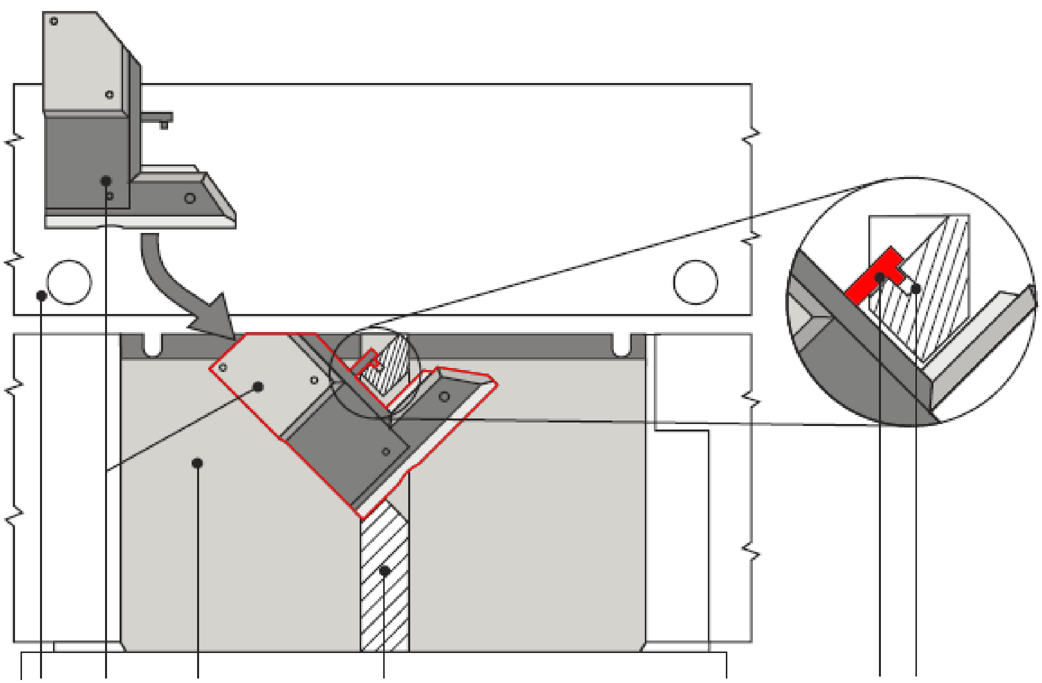
- To verify the instrument reading, a high precision secondary standard (solid material) can be used.
- Before the verification begins, the sample cell must be drained and opened.
- The verification test value is correct at 25°C.

AMI Turbiwell: Verification Kit

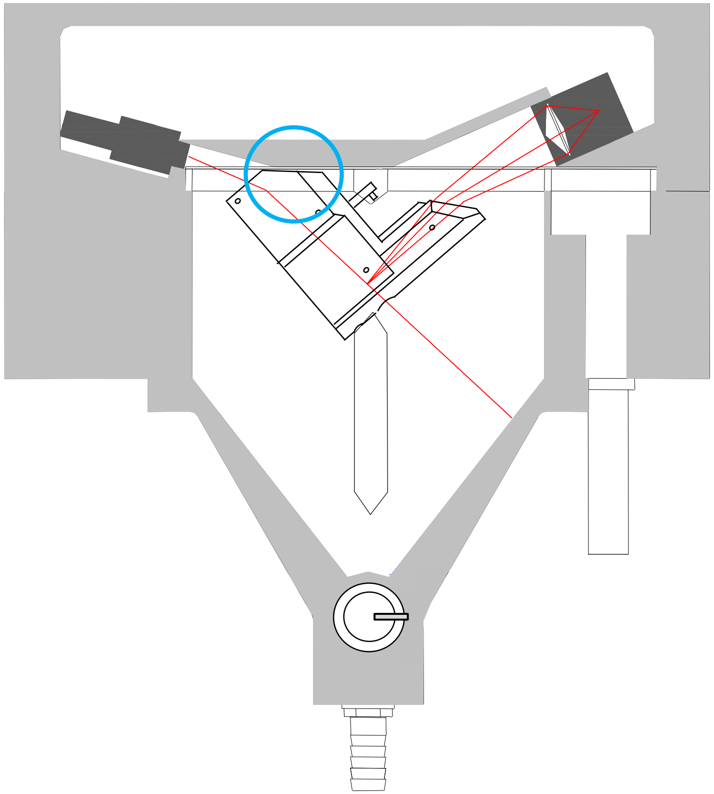


Verification

- Verification kit is placed in flow cell via attachment
- Mounted flush for integrity of the measurement



Non-Contact Turbidimeter Verification



Easy to use thanks to guidance

Questions

Thank You!

References

1. The Basics of Turbidity Measurement Technologies, Prepared for the Methods and Data Comparability Board QA/QC Sensors Group, Mike Sadar , Hach Company, July 16, 2009
2. Swan AMI Turbiwell Manual, 8/22/13