chemtronic
Waltemode GmbH

Optical or Acoustic
Process measurement of liquids

- **Oil in Water**
- **UV- / VIS- / NIR- Photometry**
- **Ultrasonic Turbidimetry**
- **Optical Turbidimetry**

Model MoniTurb-C-FS

12° & 90° scattered light Turbidity Measurement

What does turbidity mean?

Turbidity is an optical impression, which describes the characteristic of a transparent product, to scatter light. A focused light beam will be attenuated and scattered in hazy products, so that this product can become practically opaque in bigger layers.

What causes turbidity?

Turbidity is caused by particles in transparent products. A particle is defined as something with a different
refractive index as the carrier product. Some examples of particles are minerals, yeast cells, metals, oil drops in water, milk in water, gas bubbles and aerosols.

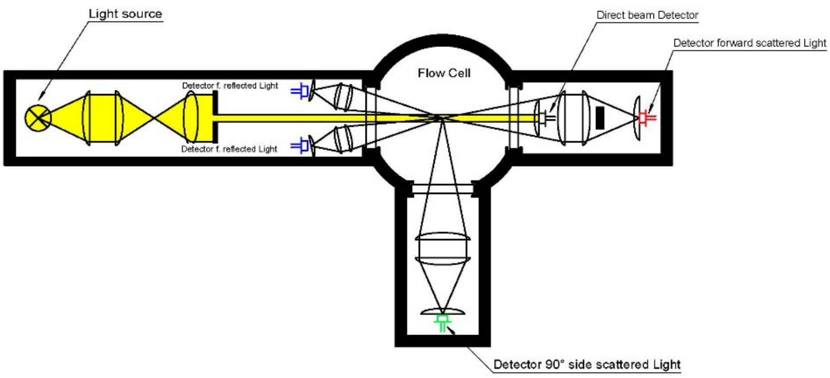
Measurement of turbidity

Turbidity is not a clearly defined magnitude like e.g. temperature or pressure.
Turbidity is a subjective impression. For this reason, turbidity measurement systems will be typically calibrated by using a comparison's standard such as Formazin or Diatomatious Earth.

Measuring methods

The most common scattered light turbidity measuring methods are:

- Side scattering (90°) The detector is positioned in a right angle (90°) to the light beam
- Forward scattering (12°) The position of the detector is 12° shifted to the axis of light beam



An intense collimated beam of light is projected through a sample contained within the sensor.
The intensity of this light beam is measured by the direct beam detector, located opposite to the light source.
The light, scattered by particles inside the sample is measured by a scatter light detector
Depending by sensor specification, this detector is located 12° and/or 90°, displaced from the beam axis.

The ratio of scattered and direct light signals, compensate for changes in product color, lamp ageing and window coatings. The signals will be processed as followed:

$$\frac{\text{Scattered light signal}}{\text{Direct light signal}} = \text{Turbidity value}$$

The particles inside the liquid flow decrease the intensity of direct light, and increase the intensity of the
scattered light, that means the turbidity rises.
Product color, lamp ageing and window coatings decrease the intensity of direct **and** scattered light in same ratio that means the turbidity value stays constant.

Comparison of the different measuring methods

The two different measurement methods (12° forward scattering / 90° side scattering) are not comparable.
The deviations of the measuring results are caused by the different particle size distributions in the measured liquid. Both measurement methods respond different, depending by particle size distribution in the sample.

Please take notice:
Make sure that your turbidity meters operate according to the same principle of measurement,
if you compare measurement results.

You can compare 90° vs. 90° scattered light turbidity meters, or 12° vs. 12° scattered light turbidity meters.
Never compare turbidity meters with different methods of measurement!

Context between particle size, measurement methods and measurement results

The most common Calibration standard for turbidity is based on Formazin liquid.
When using Formazin as calibration standard, defined Formazin suspensions have to show identical measurement results with all different measurement methods. 12° scattered light turbidity meter, 90° scattered light turbidity meter or absorption turbidity meter have to show equal readings if measuring Formazin suspensions.

During observation of a real sample, such as a filtrated liquid, the different methods will show different measurement results. The measurement results of the 90° side scattered method are typically by factor 3 to 10 above the measurement results of the 12° forward scatter method.
The reason is, that filtrate typically contains a higher number of small particles compared to the number of large particles.
The small particles will be overvalued with the 90° method, due to the fact that this method is more affected by the quantity of the particles as by the particle size.
The 12° forward scatter method is more mass related because a small particle creates low scattered light intensity and a large particle creates a high scattered light intensity.

90° method:
small particles and large particles will cause comparable scattered light intensities.
12° method:
small particles create low scattered light intensities;
large particles create high scattered light intensities;

At a particle size of approx. 0.3 µm (Formazin) both methods will create about equal scatter light intensities.
The combination of both measurement results informs about the tendency of the particle size distribution.
If the 90° measuring results are higher compared to the 12° measuring results means that the average particle size is smaller than 0,3 µm.
If the 90° measuring results are lower compared to the 12° measuring results means that average particle size larger as 0,3 µm.

particle size	result 90° scatter light	result 12° scatter
larger 0,3 µm	lower value	higher value
smaller 0,3 µm	higher value	lower value

Typical Measurement units

ppm: **P**arts **p**er **m**illion
FTU: **F**ormazin **T**urbidity **U**nit
TEF: **T**rübungs**e**inheiten **F**ormazin (German for FTU)
EBC: **E**uropean **b**rewery **c**onvention
NTU[1]: **N**ephelometric **t**urbidity **u**nit
FNU[1]: **F**ormazin **n**ephelometric **u**nit
mg/l: Milligram per liter
gr/l: Gram per liter
% TS: Percent total solids

The dependencies on the different measurement units

1 FTU = 1 TEF = 1 NTU[1] = 1 FNU[1] = 0,25 EBC

[1] Nephelometry describes the method of side scatter turbidity measurements, these units are used at 90° side scatter turbidimeters only.

Based on comparisons measurements, by using a 12° forward measurement system we have found the following dependencies.
1 FTU = 1 TEF = 0,25 EBC = 2,05ppm = 2,05 mg/l = 0,00205 g/l = 0,00000205 % TS

* At a specific particle weight of 1 kg/dm, 1mg/l particles in 1 kg of water will correspond to 1 ppm.

Typical ranges

The original design of scatter light turbidimeter was used for the detection of low turbidities. The resolution of these instruments is suited easily in ranges lower than 0.1ppm (approx. 0.05 TEF / FTU / FNU / NTU or approx. 0.01 EBC) and better. The maximum range is in ideal case lower as 200ppm, but there are as well systems available with a range of more as 8000ppm.