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Optical or Acoustic

Process measurement of liquids

- **Turbidity**
- **Colour**
- **Oil in Water**
- **Water in Oil**
- **Oil on Water**

Scatter 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 aerosoles.

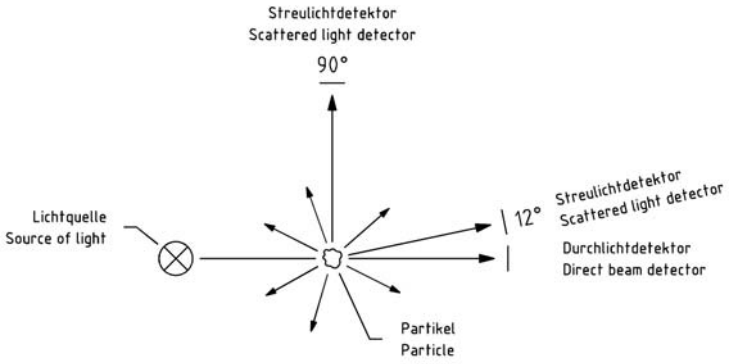
Measurement of turbidity

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 and Diatomatious Earth.

Measuring methods

The most common scattered light turbidity measuring methods are:

- Side scattering (90°) The detector is located 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



As shown in the figure above, 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 on sensor specification, this detector can be located 12° or 90°, displaced from the direct light axis.

The signals caused by scattered and direct light will be amplified and processed by the electronics. The results displayed, is the turbidity value.

$$\frac{\textbf{Scatterd light signal}}{\textbf{Direct light signal}} = \textbf{Turbidity}$$

The particles inside the liquid flow decrease the intensity of direct light, and increase the intensity of the scattered light, i. e. the turbidity rises.
Colour decreases the intensity of direct and scattered light in same ratio I. e. the turbidity value is constant. Lamp ageing and window coatings are compensated as well by this ratio.

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Comparison the different measurement methods

The two different measurement methods (12° forward scattering / 90° side scattering) are not comparable.
Even in if you use the same calibration standard to calibrate the systems, different samples will show you different measurement results.
This deviations of the results, is caused by the different particle size distribution inside different samples. The measurement methods will respond different, depending on current particle distribution inside the actual sample.

Very Important:

When comparing measurement results. The same methods must be compared to one another. For example, 90° vs. 90°, 12° vs. 12°. Never 90° vs. 12°.

Context between particle size, measurement method 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 methods 12° and 90°.
During observation of a real sample, such as filtrated beer, the different methods will show different measurement results. The measurement results of the 90° side scatter method are typically by factor 3 to 10 above the measurement results of the 12° forward scatter method.
There are typically a lot of small particles left inside the filtrated beer, such as proteins, etc. This colloidale turbidity 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 particle size. The 12° forward scatter method is affected more by particle size.

90° method: small particles and large particles will cause comparable scatter light intensities.
12° method: small particles / low scatter light intensity; large particles / high scatter light intensity.

At a particle size of approx. 0.3 µm (Formazin) both methods will show approx. equal scatter light intensities.
The combination of both measurement results informs about the tendency of the particle size distribution.
Measurement value 90°, above the measurement value 12°, average particle size smaller as 0,3 µm.
Measurement value 90°, below the measurement value 12°, 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

Application Example

Example filtration control:

90° side scatter:

Small particles (e.g. proteins, colloides, etc.) within the filtrated beer will be monitored perfectly by the using the 90° instrument. A filter breakthrough will be monitored delayed with this technology due to the fact that this is typically a slow process at witch you will see first just a few large particles within the filtrate. The total amount of particles will be raised minimally; therefore the measurement value will be raised minimal as well.

12° forward scatter:

Small particles (e.g. proteins, colloides, etc.) within the filtrated beer can be monitored well by the using the 12° instrument. The beginning of a filter breakthrough will be monitored immediately due to the large particles (e.g. DE, yeast cells, etc.) within the filtrate. The few large particles will be monitored immediately and the measurement value will rise sharply. This is also a mass related measurement principle which will allow calibration in mg/l if necessary.

Typical Measuring units

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

The dependencies on the different measuring 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 turbidimeter 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 1ppm.

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 as 0.1ppm (approx. 0.05 TEF / FTU / FNU / NTU or approx. 0.01EBC) 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.

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Select your measuring method

The 12° forward scatter method:
The forward scatter method is typically used at low turbidities and produces nearly mass related measurement results. Main applications are quality control, filtration control, oil in water, etc.

The 90° side scatter method:
The side scatter method is typically as well used at low turbidities. This principle of measurement will produce measurement results related to the number of particles inside the product.
The main application is the observation of small, well distributed particles e.g. beyond a filter. The second typical application is the monitoring of potable water as well as waste water according ISO7027 or according to the US- FDA requirements.
The measurement results of a 90° scatter light system has to be handled with care, due to the fact, that a turbidity caused by many large particles can show a similar measurement result as a turbidity caused by the same quantity of small particles.

The combined 12°/ 90° forward- / side- scatter method:

The 12° measurement method shows higher sensitivity with large particles. The 90° measurement method shows higher sensitivity with small particles. The most common application for the combined systems is filtration control. A filter break through is recognized early, with the 12° forward scattered instrument. Some particles inside the filtrate will raise the 12° measurement value significant.

The 90° side scattered method shows only a small increase of the measurement values in case some big particles pass the filter. A filter break through would be shown very late, due to the fact that the number of particles will not raise significant in case the filter starts to break.

Please note:
The combination of forward- and side- scatter turbidity measurement does not replace a particle size analysis, but it can provide a tendency of the particle size distribution.

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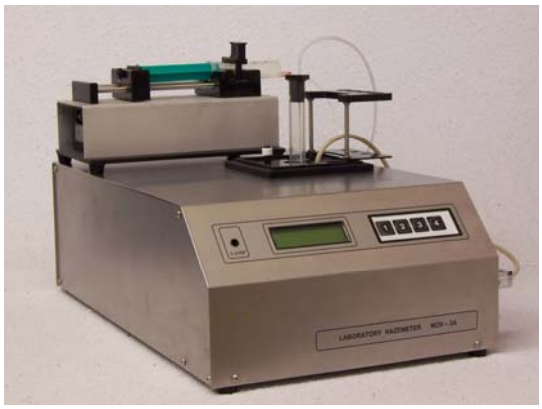
Model Turbilab-FS (TBL-FS)



- **Calibration Interval 24 Month**
- **Water Bath**
- **Direct Measuring in Bottles**
- **Bottle Revolving**
- **Optional Software Package**
- **Optional Temperature controlled measuring Chamber**
- **Optional Titration Pump**

Description:

The turbidimeter model TurbiLab-FS works on the principles of measurement of 12° forward and 90° side scattered measurement. The measurement can performed directly in bottles or in a cuvette. The instrument detects the turbidity only. Product- or bottle colorations will be compensated. The instrument does 200 individual measurements per bottle rotation. This automatic bottle revolving in the water bath of the measuring chamber compensates for scratches and unevenness of the bottle. The evaluation of the quotient scattered light / transmitted light ensures long-term stability and reproducibility of the device. The comparison of the two measurements (12 ° / 90 °) allows the user to draw conclusions on the particle size distribution in the product. The measured values are displayed in EBC units or alternatively in FTU, NTU or ppm. The measuring units can be selected from the keyboard. The optional software package, titration pump, magnetic stirrer and the temperature-controlled sample chamber makes the device to a full-titrator. The Windows software controls the measurement cycles, the reagent pump for and allows the evaluation, archiving and presentation of the measuring results.

Applicatiom Examples:

- Forcier Test
- Tannoid Content Test (Polyphenol reaction)
- Sensitive Protein Content
- SASPL (saturated ammonium Sulphate precipitation limit)
- Monitoring and recording of the sedimentation of yeast
- Monitoring and recording of the yeast activity
- Monitoring and recording of the sedimentation of diatomite
- Monitoring and recording of the sedimentation behaviour of PVPP...

Technical Data:

Measuring Range (90 °):
0-250EBC, 0-1000NTU, 0-2000ppm (auto ranging)
Measuring Range (12 °):
0-80EBC, 0-250FTU, 0-500ppm (auto ranging)
Measuring Units:
EBC,NTU, FTU, ppm (Based on Formazin standard)
Resolution in EBC:
0.01 at 0-10EBC / 0.1EBC at 10-100EBC / 1EBC at 100-250EBC
Accuracy
better 2%
Display:
Backlit LC-Display (2 rows, 16 caracters)

Light Source:
650nm Mebak conform (alternative 860nm conform to ISO7027 / EN27027)
Measuring Chamber:
Standard Cuvettes Ø 40mm / Bottles maximum Ø 100mm (1,5L PET, NRW, Euro, etc) / Test tubes / Cuvettes Ø 25mm (min. sample volume 20 ml)
Interface: RS-232 (alternative RS-485, Blue tooth or USB)
Supply Voltage: 115VAC / 230V (50-60 Hz)
Power consumption: max. 12 W
Dimensions: 450 x 300 x 500mm
Weight:10 kg

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Model MoniTurb-F (MTF)

Process- Turbidimeter, Monitek Product Line of Galvanic Applied Sciences Inc.

- **Low maintenance**
- **Extended calibration interval: Typical 24 month**
- **Sight glass material: Sapphire**
- **Sight glass cleaning: Via cleaning jet probe**
- **Cleaning in place (CIP)**
- **Process connection: DIN, ANSI, SMS, NPT, APV, TH, …**
- **Optional air purge connection: 4mm**

Description:

The turbidity sensor Model MoniTurb-F uses the principle of 12° forward scattered light to detect suspended particles in liquids. The transmitter model Messenger is required to use this sensor. The system has been designed for continuous operation with long life time. A ratio measurement of direct- / scatter light assure highly reliable and repeatable measurement results. Inaccuracies caused by product colour, lamp ageing or window coating will be compensated. The forward scatter measuring results are nearly independent of particle size and will correlate to product concentration. Calibration can be done in multiple ranges and measurement units like EBC, ppm, mg/l, etc. The sensors can be installed into almost any type of pipe. Process connection, pressure, temperature, gasket material, etc will be application specific. Optional cleaning jets will allow a cleaning of the sapphire windows in determined intervals.

Applications:

- Filtration control
- Product quality
- Water in fuel
- Oil in water / Water in oil

Operational areas:

- Chemical industry
- Petrochemical industry
- Power plants
- Brew & Beverage

Technical Data:

Line size:	DN 25 – DN 125 / ½“ - 5“
Process pressure:	PN16 / ANSI class 150
Process temperature:	maximum 140°C
Sensor material:	1.4404 / 316L
Sight glass material:	Sapphire
Gasket material:	application specific
Protection class:	IP65 / NEMA 4X

Measurement range:	typical 0–1ppm, 0–500ppm
Reproducibility:	± 1 %
Detector system:	Silica diodes
Cleaning:	optional cleaning jet probe
Sterilization:	CIP (cleaning in place)
optional hazardous area:	ATEX Zone I or Zone II

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Model MoniTurb-FS (MTFS)

Process- Turbidimeter, Monitek Product Line of Galvanic Applied Sciences Inc.

- **Low maintenance**
- **Calibration interval: typical 24 month**
- **Sight glass material: Sapphire**
- **Sight glass cleaning: Via cleaning jet probe**
- **Cleaning in place (CIP)**
- **Process connection: DIN, ANSI, SMS, NPT, APV, TH, …**
- **Optional air purge connection: 4mm**

Description:

The turbidity sensor model MoniTurb-FS uses the principles of 12° forward- and 90° side scattered light to detect particles in liquids. The transmitter model Messenger is required to use this sensor. The system has been designed for continuous operation with long life time. The measuring results of the 12° system are not affected by particle size. The 90° system shows a high sensitivity for small particles (< 0.3 µm). Comparing both measurement values will allow conclusion of particle size distribution inside the liquid. The sensors can be installed into almost any type of pipe. Process connection, gasket material, etc. will be application specific. A ratio measurement of direct- / scatter light assure highly reliable and repeatable measurement results. Inaccuracies caused by product colour, lamp ageing or window coating will be compensated. Calibration can be done in multiple ranges and measurement units like EBC, ppm, mg/l, etc. Optional cleaning jets will allow a cleaning of the sapphire windows in determined intervals.

Applications:

- Filtration control
- Product quality
- Water / Waste water

Operational areas:

- Chemical industry
- Petrochemical industry
- Power plants
- Brew & Beverage

Technical Data:

Line size:	DN 25 – DN 125 / ½“ - 5“
Process pressure:	PN16 / ANSI class 150
Process temperature:	maximum 140°C
Sensor material:	1.4404 / 316L
Sight glass material:	Sapphire
Gasket material:	application specific
Protection class:	IP65 / NEMA 4X

Measurement range:	typical 0–1ppm, 0–500ppm
Reproducibility:	± 1 %
Detector system:	Silica diodes
Cleaning:	optional cleaning jet probe
Sterilization:	CIP (cleaning in place)
optional hazardous area:	ATEX Zone I or Zone II

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Model Monitek Messenger

Universal Transmitter, Monitek Product Line of Galvanic Applied Sciences Inc.

- **Configuration via PC, Laptop or Netbook**
- **Optional with implemented Panel PC**
- **Menu - based, intuitive User Interface**
- **Instruction Manual available via Help Function**
- **Serial Interface RS 232C / RS 485 (Modbus RTU Protocol)**
- **Simultaneous Use of up to 4 Sensors**
- **Sensors for Turbidity, Colour or Absorption measurement**
- **Fully Programmable Units (ppm, EBC, FTU, g/l, % TS...)**
- **Two Independent, fully programmable Cleaning Cycles**
- **Linearization of Measurement Values**
- **Integrated Data Logger for up to 8000 measurement Values**
- **Recovery via Back-up File**

Description:

The universal transmitter model Messenger can be used with all optical sensors of the Monitek series. The Messenger allows the simultaneous use of multiple sensors. Hereby you can use up to four single channel sensors. Even different sensors can be used with one transmitter. The measurement results can be linked together using almost any mathematical equation. This ensures an easy setup of e.g. dosage systems. The programming / calibration of the system will be done via a PC, Ntbook or Laptop using the menu-based software. Only one PC or Panel- PC is required to configure an instrument in a network of up to 255 Messengers. Using the Messenger with an integrated Panel- PC allows the paperless recording or displaying of the measurement results as bar- or line graph's.

Applications:

- Scatter light turbidity measurement
- Absorption turbidity measurement
- Single channel colour measurement
- Dual channel colour measurement

Operational areas:

- Chemical industry
- Petrochemical industry
- Pulp & Paper
- Beer and beverages

Technical Data:

Supply voltage:	90-260 VAC, 50-60 Hz optional: 24 V AC/ DC	optional digital inputs:	4x 5V High
Power consumption:	maximum 50 VA	Reproducibility:	± 1 %
Relay capacity:	4 Relays fully programmable (48V / 2A)	Temperature:	-10°C to 50°C
Analogue output:	Up to 4x 0/4 - 20mA (isolated)	Enclosure / Protection:	1.4301 / IP65 (NEMA 4X)
Interfaces:	RS 232C / RS 485 Modbus RTU	optional hazardous area:	ATEX Zone I / Zone II

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