Turbidity control in food and beverage production

Overview, applications and selection criteria

Make your processes clear!

How you can optimize your production processes (even retrospectively) with turbidity measurement in order to:

· avoid product loss
· automate processes
· reduce production times
· monitor product quality
· control CIP efficiency

If you are still monitoring phase transitions using sight glass, time or volume measurement, you are losing money every day.

In many applications in the food and beverage industry, turbidity measurement is the most suitable in-line analysis technique for differentiating fluids in the process. The turbidity sensors of the ITM series enable highly precise monitoring and real-time control of processes. Two different measuring techniques offer a suitable solution for every degree of turbidity from 0...300 000 NTU (0...75 000 EBC).

Since fat particles behave the same as solid particles or other turbidity-causing substances during turbidity measurement, dairy products can also be differentiated with the utmost accuracy.

In this whitepaper, we discuss the advantages and possibilities of turbidity control for the following applications:

· **Product differentiation**
· **CIP phase transition**
· **Process control**
· **Quality monitoring**

and provide a variety of examples of how these have been successfully implemented by our customers.

Overview of applications and measuring systems

To meet the diverse requirements of our customers and provide the best solution for each application we offer different measuring techniques and configurations/options.

Relative turbidity measurement: The main advantages of this measurement technology, which is based on the backscattered light method, are the flush installation of the sensor in the process and the affordable price. With a wide selection of process adaptations, the ITM-51 can also be easily integrated into existing pipes from DN25 in compliance with internationally recognized hygiene guidelines such as 3-A and EHEDG.

Four-beam turbidity measurement: The ITM-4 and ITM-4DW (for drinking water) use the 4-beam alternating light method or the transmitted / scattered light method at 90° and 180° for turbidity control. With its measuring ranges starting from 0...5 NTU (0...1 EBC), even the smallest changes in turbidity are detected and output.

This table shows which measuring systems can be recommended for which applications.

On the following pages you will find further details on the various measurement technologies, a complete product overview with the most important technical specifications of the individual sensors as well as many practical examples of successful applications by our customers

Note: For many applications, the specific recommendation for a sensor type depends largely on the medium and process. For new setups, we recommend consulting with your local sales and application specialist.

	Relative Turbidity Control	4-Beam Turbidity Control	
	ITM-51	ITM-4	ITM-4DW
Separation / Centrifugal separator feed control	***	**	-
Separation / Centrifugal separator outlet control	**	***	-
Filtration / Monitoring the filtering function	***	***	-
Monitoring the product quality	***	***	-
Standardization / Monitoring the fat content	***	**	-
Cheesemaker / Control of the whey concentration	***	***	-
Butter oil production / Monitoring the product quality	***	***	-
Lauter tun / Automatic switching to the wort boiler	-	***	-
Yeast harvest / Separation of reusable yeast	***	***	-
Spent yeast / Blowdown monitoring	***	*	-
Filling / Product control	***	***	-
Cooling / Monitoring the cooling circuit for defects	**	***	*
CIP-Process / Monitoring the product purity	***	**	-
CIP- Process / Control of reusable media	***	**	-
Fresh water supply / Monitoring the water quality	*	-	***
Waste water monitoring / Minimization of wastewater treatment cost	***	**	***

*** very recommended ** very suitable * suitable - not suitable

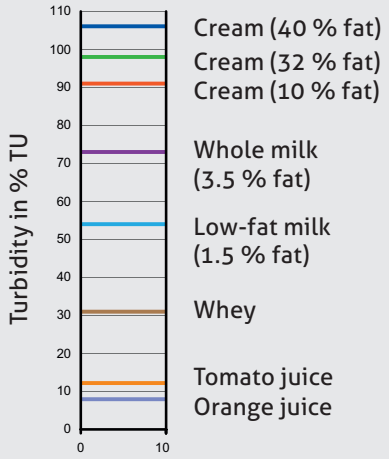
Examples of applications for turbidity control

Examples of applications for turbidity control in the production of dairy products, beer, wine, juices and other foods and beverages:

1. **Product differentiation**
   Monitoring the correct processing, storage or filling of products.
2. **CIP phase transition**
   Inline CIP control and monitoring of the cleaning quality with response times < 1 sec.
3. **Process control**
   Alarm signal, process correction or production stop when the measured turbidity exceeds or falls below the specified threshold. This helps to avoid damage to the system or product contamination.
4. **Quality monitoring**
   Monitoring consistent product quality, turbidity or concentration.

In this white paper, we present the possibilities and advantages of turbidity control for these applications and provide a variety of examples of how our customers have successfully implemented it.

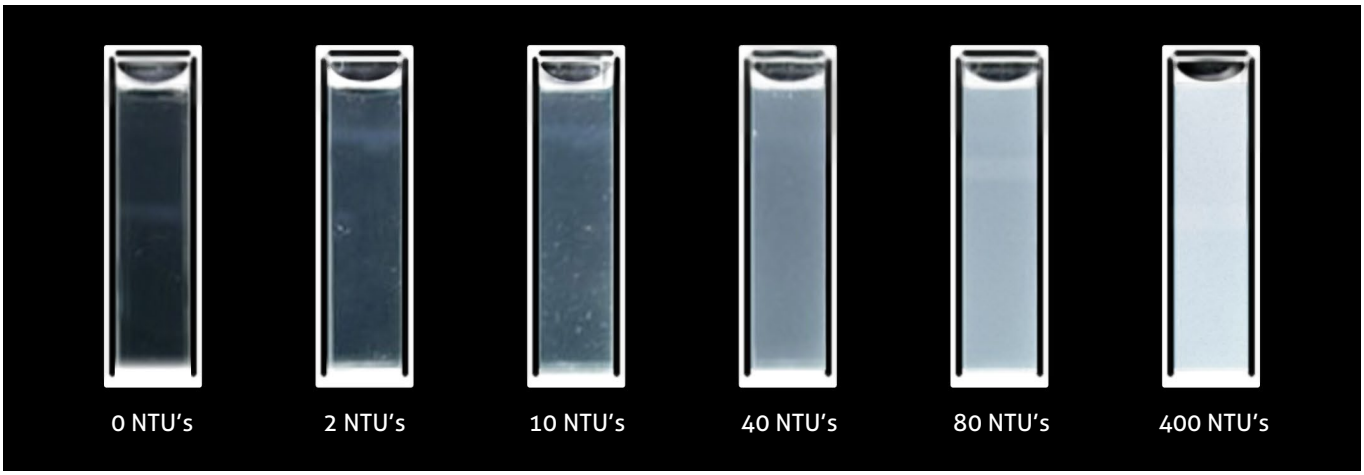
Exemplary values of different media



Average turbidity of typical food and beverage products at 100 % concentration.

Examples of turbidity values in NTU

The Formazin scale provides reference values that can be used as a basis for the measurement accuracy of turbidity sensors. However, for practical application with various products or media in the food and beverage industry, the values must be determined individually.



Further selection criteria

In addition to the application and the measurement technology itself, there are other parameters that must be considered when deciding on a system or product, such as:

- The **hygienic design** of the sensor and process connection
- The **lifespan** of the components
- The **ROI time** and possible **continuous cost reductions**
- **Resistance** to **chemical** or **mechanical stress**
- **Basic measurement accuracy**
- **Display requirement** on site / via remote display / PLC data transmission only
- **Data transfer** (analog / digital)
- Simple operation, etc.

Anderson-Negele offers not only a wide selection of sensor types with extensive configuration options, but also an in-depth consulting service, including on-site, with a wealth of experience from countless applications in the food and beverage industry worldwide.

Methods for monitoring phase transition

In a variety of production and cleaning-in-place (CIP) processes, an optimal phase transition can be crucial for the quality of the end product, the efficiency of the process and the costs of resource losses.

Common methods for phase transition:

Time-controlled phase change: This is the classic technique for certain applications such as CIP cleaning. However, a **safety buffer of several seconds** must be considered to ensure that the wrong product or cleaning agent does not enter the product tanks. As a result, many liters of valuable **product or cleaning agent are lost in the wastewater** with every phase change.

Visual inspection / laboratory samples: Manual sampling or **monitoring through a sight glass** are still frequently used. However, experience shows that both methods result in **high personnel costs** and **quality inconsistencies** between samples.

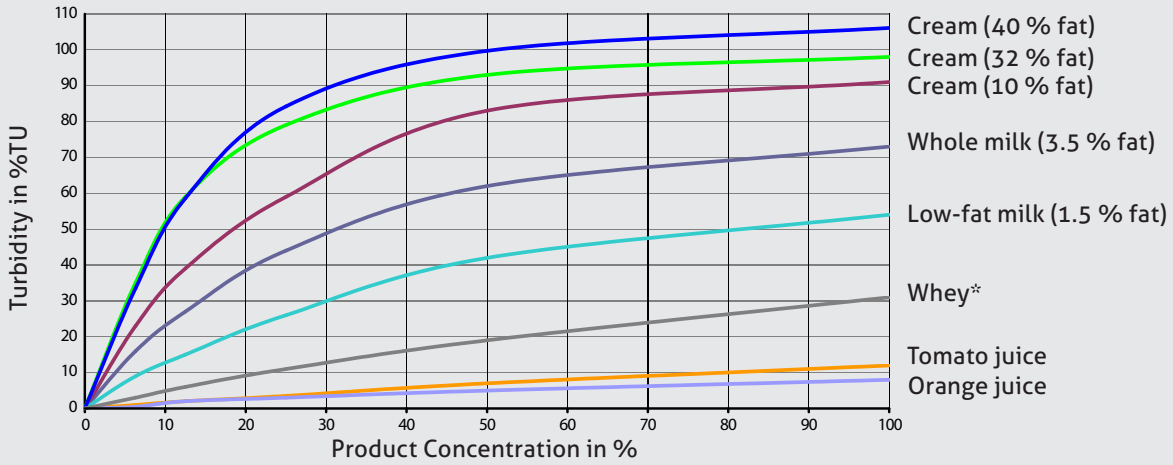
Advantages of turbidity control:

Turbidity meters can, as it were, act as an "eye in a tube" to monitor liquids for **qualitative criteria** in real time and with a very high degree of accuracy. This inline analysis makes it possible to automatically adjust the processes in many production plants and application areas in a matter of seconds. This **avoids the loss of resources** due to incorrect or delayed discharge of media, and also **reduces personnel costs** for visual or manual control, thus **saving money.** In many field applications, the use of an Anderson-Negele turbidity sensor has **paid for itself in a very short time.**

How inline turbidity control works:

Turbidity-causing substances such as solids, fat particles or gas bubbles in the flowing liquid reflect light beams. Using a light source and a light receiver in the sensor, the size, quantity and concentration of the turbidity-causing substances in the flowing liquid can be accurately detected.

Based on their turbidity values, products can also be differentiated depending on their concentration or fat content. The graph shows typical turbidity values for various milk and juice products. To program the settings for the turbidity meter for a particular process, it has proven useful to use an individual learning curve at the installed sensor. To do this, samples can be taken and compared with the sensor display, or a visual-manual comparison can be made with the sight glass.



* Average turbidity of customary products at different dilutions.

Examples for the use of turbidity control

Product Differentiation

Application: The correct processing, storage or filling of products can be controlled and ensured by differentiating between liquids. Phase transition monitoring, which is accurate to the second, enables processes to be optimized and can avoid product loss.

Result: Maximum resource utilization.

Examples:

- Distinguishing between milk with 3.5 % or 1.5 % fat, cream with 10 % or 30 % fat, or whey.
- Distinguishing between beer or wort or water, distinguishing between different yeast concentrations
- Distinguishing between different fruit juices

CIP Phase Transition

Application: Monitoring the cleaning quality according to hygiene guidelines, as well as checking the cleaning media and rinse water for reusability according to their degree of contamination by measuring them in the CIP return line. This is where the combination of turbidity and conductivity measurement (e.g. with the ILM-4) comes into play for optimal, real-time CIP control and reproducible cleaning quality.

Result: Maximum multiple use and thus savings on expensive CIP cleaning agents, reduction of water consumption and waste water volume, monitoring of the cleaning quality according to hygiene guidelines.

Examples:

- Real-time phase transition between water, caustic, acid and product (in combination with conductivity control) ensures a verifiable, safe, efficient and resource-saving phase transition and thus cleaning quality.
- The duration and quality of the CIP process can also be optimized. For example, the pre-rinsing with water can be automatically and precisely terminated when the turbidity of the pre-rinsing water reaches a certain value, and not after a predetermined time, which may be too short or too long.

Quality monitoring

Application: Turbidity control can be used to monitor compliance with a specification for turbidity, fat content or the concentration of certain products.

Result: Improved and more consistent product quality and avoidance of quality deviations

Examples:

- Monitoring the standardization of cream or milk to exactly the specified value
- In breweries, the turbidity of craft beer or other unfiltered or lightly filtered beers can be maintained within a specific target range for consistent product quality
- Juices and other blended drinks can also be maintained at a consistent, desired level of turbidity to ensure a consistent product experience for consumers.
- Fresh water and drinking water can be monitored before mixing with product

Process control

Application: If the turbidity level rises above or falls below a certain predefined value, a signal can be sent to the PLC process control system to trigger a process correction or a process stop.

Result: Avoiding extensive damage to production facilities or through contaminated products, avoiding additional costs for wastewater with excess pollution levels

Examples:

- Filter monitoring, in which, for example, the turbidity after a cross-flow filter is continuously checked
- Monitoring the cooling circuit by continuously checking the glycol for foreign matter caused by a leak and the penetration of other media.
- The separator control, in which the separator automatically "ejects" into a waste container when a predefined turbidity value is reached.
- The waste water control, to monitor compliance with specifications for the acceptable degree of contamination.

ROI calculator for the use of turbidity meters

Is it worth installing a turbidity meter financially? You can calculate this here with just a few clicks. By using inline turbidity analysis, you can save time and resources compared to time-based control or visual monitoring at each phase change. Our ROI calculator provides a rough estimate of how quickly the installation of a turbidity sensor will pay for itself through savings in product costs alone.
www.anderson-negele.com/us/roi

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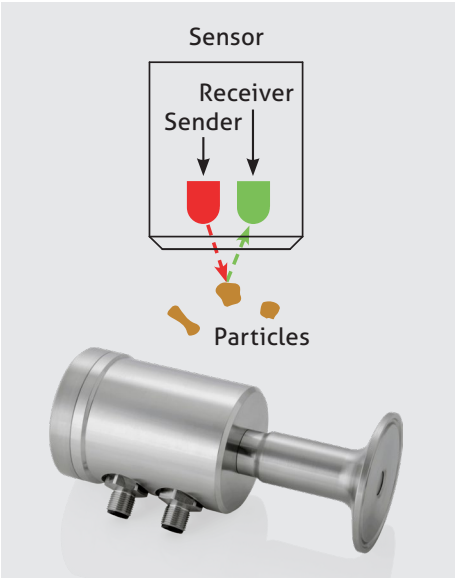
Relative turbidity control

Backscatter light method

A diode at the sensor tip uses an **LED light source** to radiate infrared light into the medium via an optical system made of **highly resistant and unbreakable sapphire.** Particles present in the medium reflect this radiation, which is then detected by the receiving diode in the sensor tip (so-called backscattered light method). The electronics calculate the relative turbidity of the medium from the received signal. This measuring method is ideal for measuring media with **medium to high turbidity** (200...300 000 NTU) and is used in the **ITM-51.**

The main advantages of this backscatter light method are the simple, **flush installation** of the sensor in the process and the **affordable price.**

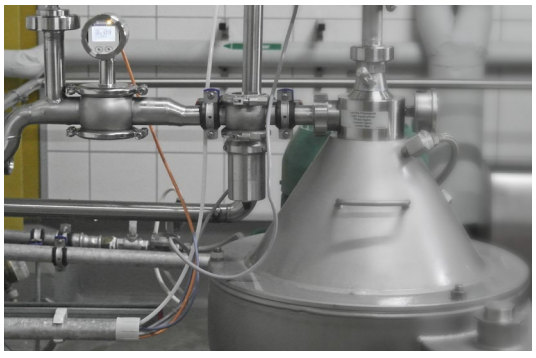
This sensor can also be easily retrofitted into existing pipes from DN25 in compliance with internationally recognized hygiene guidelines such as 3-A and EHEDG.

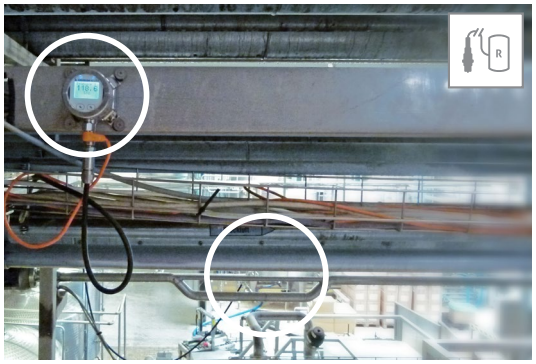


Measuring accuracy: Extract from the ITM-51 technical data

Resolution/measurement range	the resolution is dependent on the selected measurement range	range/NTU	resolution/NTU
		< 1 000	15
		1 000...10 000	30
		10 000...100 000	100
Accuracy	0...9 999 NTU 10 000...300 000 NTU	±3 % from measurement value; ±50 NTU offset ±5 % from measurement value	

Installation examples ITM-51

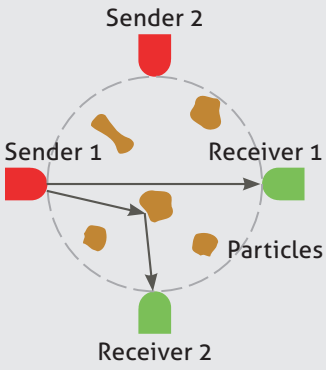




Four-beam turbidity control

Transmitted / Scattered light method

In the 4-beam alternating light method or the transmitted light/scattered light method, two infrared transmitters and two infrared receivers are arranged at 90° intervals in the ring-shaped measuring device. The transmitters are activated alternately to determine the turbidity value. When transmitter 1 is active, receiver 1 registers the transmitted light and receiver 2 registers the 90° scattered light. When transmitter 2 is active, the process is reversed. An exact turbidity value is determined from the four measured values of a measuring cycle.



Since a transmitted light reference value is available for each 90° scattered light measurement, **interfering factors are automatically compensated,** such as dirt on the optics or component aging. By evaluating several measurement cycles and using an adjustable filter, **interfering influences from occasionally occurring solids and air bubbles are also suppressed.**

The ITM-4 is integrated in a ring-shaped fitting that can be installed in pipes from DN25 to DN100 or DN1" to DN4" using a hygienic screw connection or clamp connection.

The main advantage of this measuring principle is the very high measuring sensitivity. With its **measuring ranges from 0...5 NTU (0...1 EBC)** to 0...5000 NTU (0...1250 EBC), even the slightest changes in turbidity are registered and output.

The same measuring method is used in the ITM-4DW. In this model, the material used for the measuring probe has been specially adapted for use with **drinking water** and approved for this application. This makes it less expensive than the ITM-4 option, which is approved for use with all food products.

The ITM-4 and ITM-4DW also feature an **LED light source** infrared light and optics made of **highly durable and break-resistant sapphire** for maximum service life and product uptime.

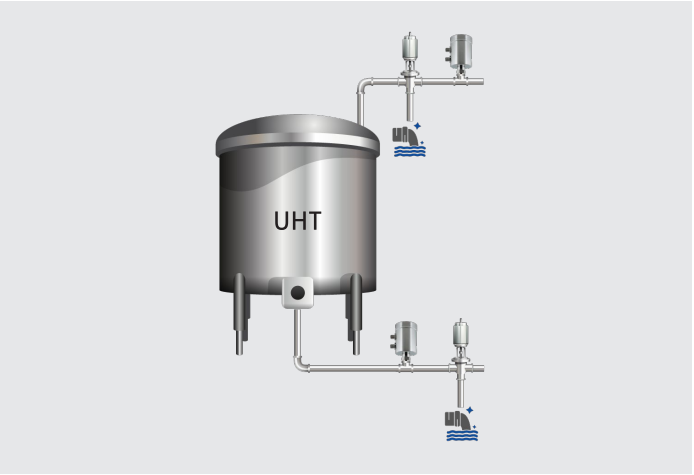
Measuring accuracy: Extract from the ITM-4 technical data

Measurement range	**0...5 NTU** **0...1.25 EBC**	**6...100 NTU** **1.5...25 EBC**	**101...1 000 NTU** **26...250 EBC**	**1 000...5 000 NTU** **251...1 250 EBC**	**Annotation**
Resolution	0.1 NTU	0.1 NTU	1 %	10 %	display
Reproducibility (with the same process conditions)	±0.3 NTU	±0.5 NTU	±3 %	±4 %	of measurement value ±1 resolution step
Absolute accuracy acc. to FNU-for-mazine-scale	±2 NTU ±0.5 EBC	±4 NTU ±1 EBC	±4 %	±6 %	of measurement value ±1 resolution step

Installation examples ITM-4




Real-life examples



1. 120 liters of milk saved with each UHT phase change

Application:

At the Söbbeke organic dairy, raw milk is processed into end products in the UHT plant. Each phase is individually pushed out by water. To avoid any hygiene risk in the end product, a **long buffer time** was programmed into **the time control,** so that the **product phase was discharged** into the drainage system well before the water arrived.

In order to reduce this product loss, an **ITM-51** was installed at the **inlet and outlet.**

According to measurements taken by the operator, **59 liters of product** per phase change no longer flow into the sewer system but into the UHT plant at both the inlet and outlet. In addition, the respective dairy products in the line can be precisely controlled for quality control by distinguishing the turbidity.

Results:

» Compared to the time control, 118 liters less product are lost **at each phase change** (proven by measurement) since the ITM-51 turbidity meters have been used.

» **Only two sensors** are required, one ITM-51 for controlling the UHT inlet and one ITM-51 for outlet control.

» The **remote version** simplifies on-site control at a location that is not easily accessible at the inlet.

2. Brewery automation

Application:

At the Leibinger Brewery, all suitable process steps **have been optimized and automated through turbidity control.** Depending on the sensitivity required for the measurement, either the ITM-51 or the ITM-4 turbidity sensor is used.

In the **lauter tun,** an ITM-4 turbidity meter ensures seamless monitoring of the turbid wort, and as soon as the desired turbidity value is reached, it switches over to the wort pan. Since the ITM-4 is equipped with an active switching output, the sensor itself can trigger the switchover.

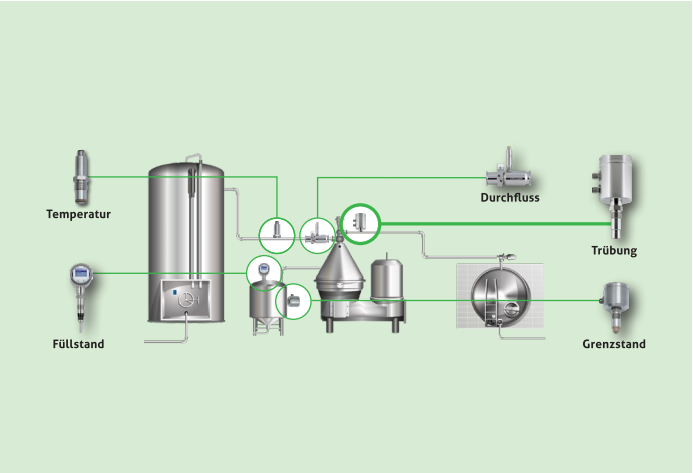
ITM-51 is used for **harvesting yeast** in fermentation tanks and for **clarifying spent yeast.** When a pre-set turbidity value is reached, the yeast is separated out at the fermentation tanks and can be reused for the next brew thanks to the high degree of accuracy of the measurement. After the positive experiences in the brewhouse, a turbidity sensor was also installed for the spent yeast blowdown.

Results:

» Automation saves **3-4 minutes in each clearing process**

» Due to the **high degree of purity of the harvested yeast,** it can be completely reused.

» In the past, an employee had to monitor the sight glass of each storage tank for approx. **15 minutes** while the spent yeast was being cleared. This time is now **completely eliminated.**



3. Butter Oil Separation

Application:

In the production, processing and packaging of butter, the processing systems in this dairy are regularly cleaned with pre-heated water to ensure reliably hygienic production. **High-purity butter oil can be separated from this mixture as a valuable raw material.** The ITM-51 is an important tool for its **automated, economical and high-quality refinement.**

Results:

» In a separator, the butter oil phase is concentrated to a **degree of refinement of 99.5 %.** An automated phase transition when the butter oil mixture reaches a turbidity level of 50%TU, measured with the ITM-51 turbidity sensor, ensures a **consistently high and verifiable product quality** in day-to-day operation.

4. Separator control and filtration monitoring in wine production

Application:

For the wine connoisseur, the first quality criterion is the visual appearance, followed by the bouquet and then the flavor. In addition to the color, the clarity of the wine is particularly essential. To ensure the highest quality, a winery in California has installed an ITM-4 turbidity sensor to monitor the **filtering process before bottling.** To maximize product exploitation, an ITM-4 was also added to the separator control. In both applications, the customer was able to **improve processes, increase production yields** and consistently monitor **product quality** specifications.

Results:

» If a separator drum is not rinsed in time, the solids pass through the centrifuge and into the bottling process. If the drum is rinsed too early, wine is also drained along with the solids, reducing production yields. In a centrifuge, wine turbidity increases at the outlet when the solids drum reaches its maximum fill level. This increase in turbidity is immediately and **precisely detected by the ITM-4 and signaled to the PLC in real time.** For this customer application, the ITM-4 was scaled for turbidity in the range of **30 to 40 NTU.**

» In cross-flow filtration, the filtrate and permeate are permanently separated, preventing the formation of a filter cake and reducing the need for filter cleaning. However, a thick, highly turbid wine can quickly clog the filters, requiring the filtration process to be stopped immediately to clean the filters. An ITM-4 **continuously monitors the wine filter retentate** prior to bottling and emits an alarm at < 1.0 NTU turbidity. The resulting process automation has replaced the traditional periodic filter inspection, **saving labor hours entirely.**

5. Quality control in the production of soy sauce

Application :

To ensure consistent quality of the soy sauces, the manufacturing process, which is based on natural fermentation, requires permanent monitoring and control. Only in this way can a balanced mixture of salts, starch, sugar and flavorings be achieved for a **consistent taste experience.** Due to the intense color of soy sauce, the ITM-4's **color-independent turbidity control** from 0 to 5000 NTU is an ideal measuring principle for enabling **continuous quality monitoring** in the process and for immediately triggering an alarm signal if there is a deviation from the desired values.

Results:

» **Reduction of downtime** and maintenance costs through the use of long-lasting sensor technology

» **Reduction of production costs,** as the service life of the filter membranes has increased significantly due to process monitoring with the ITM-4 turbidity meter

» Achieving a **higher level of quality** through high measurement accuracy and more precise process control

6. Glycol contamination protection in a dairy

Application :

Our customer, a dairy, uses plate heat exchangers in various process steps to cool the milk. To prevent **contamination from the coolant,** the dairy uses an ITM-51 turbidimeter directly after the heat exchanger in the tubing of the cooling circuit to monitor the purity of the glycol-based coolant. If a cooler plate is damaged, the fluids will always interchange, and milk will enter the coolant.

This monitoring system ensures that no milk contaminated by glycol can enter the market, **thus maximizing product safety** for customers.

Results:

» **Maximum product safety** and purity to protect consumers

» Real-time error reporting: In the event of glycol contamination, the turbidity sensor emits an alarm signal within **< 1 second,** so that the process can be stopped immediately.

Further case studies online

You can find many more application reports at
https://www.anderson-negele.com/us/turbidity-sensors/

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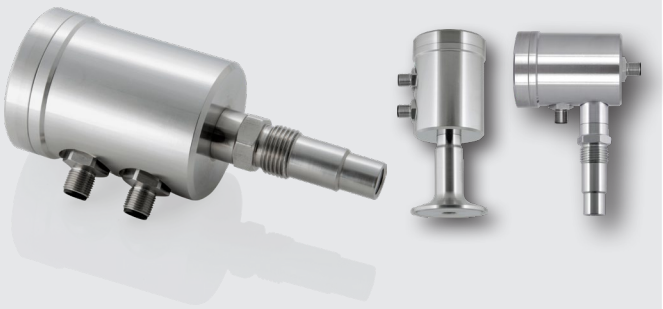
Product Overview

Turbidity sensor Backscatter light

ITM-51



- Compact, flush sensor, easy to clean (pigging)
- Measuring range 200...300 000 NTU (50...75 000 EBC)
- Very easy hygienic installation with clamp or screw connection (CLEANadapt)
- High reproducibility ≤ 1 % and short response time < 1 sec.
- High reliability and durability due to glass-free sapphire optics
- Extended temperature and pressure range (process temperature up to 130 °C, pressure -1...20 bar)
- No influence of reflections at small nominal tube widths or electropolished surfaces
- Flex-Hybrid technology with digital + analog interface (IO-Link + 4...20 mA)

ITM-51R

- Remote version with detached electronics
- Increased service life through protection against vibrations, high temperatures and mechanical stress
- Easy operation by placing the programming display in an accessible location

Turbidity sensor Four-beam light

ITM-4

- Four-beam alternating light technology (90° scattered light + 180° transmitted light) with 2 transmitters and 2 receivers
- Measuring range: 0...5 000 NTU (0...1 250 EBC)
- Response time < 1 sec.
- Many process connections from DN25 to DN100
- High safety and durability due to glass-free sapphire optics

ITM-4DW

- Affordable sensor with PPSU plastic optics block, optimized for process and drinking water applications
- Ideal for monitoring fresh and wastewater, cooling circuits, etc.
- A declaration of conformity is available for use in drinking water applications

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