Flow measurement in hygienic applications

Overview, Technologies and Selection Criteria

Every drop counts:

How can reliable, precise, and demand-driven flow control in the food, beverage, and pharmaceutical industries help you optimize processes, ensure product quality, and save costs and resources?

Precise flow measurement is the basis for safe and efficient processes in almost all applications in the food, beverage, and pharmaceutical industries. But when is which measurement technology suitable: flow meter, flow switch, magnetic-inductive, Coriolis/density measurement, turbine, PMO-approved, ultrasonic, calorimetric?

In this white paper, we show you various measurement technologies and give you tips on how to find the best solution for your application.

Flow meters for the precise detection of the quantity or volume of media flowing in your systems are the basis for the automation, control, and monitoring of many processes.

Typical applications are

- **Precise dosing** when blending beverages or dairy products
- **Recipe monitoring** for soft drinks, in food production, or in pharmaceutical manufacturing
- Monitoring **manufacturing processes** in breweries or CIP systems
- High-precision control of **filling systems** for kegs, vessels or transport vehicles
- Precise quantity measurement for **customs declarations or billing.**

Flow switches are used in almost all production facilities to monitor the **technical safety** of the systems and the **correct operation** of the processes. They immediately trigger an alarm if the flow is interrupted and are ideal for monitoring pump systems, filters, cooling circuits, CIP return flows, or for detecting misdirected media.

40+ years of magnetic-inductive expertise meets 90+ years of hygiene competence

Following the integration of GEA Diessel's magnetic-inductive flow meter business, Anderson-Negele is now your **specialist for hygienic applications with the special “flow-how.”**

Overview of applications and measuring systems

	Flow Sensor					Flow Switch	
	Electro-Magnetic			Coriolis	Turbine	Ultrasonic	Calorimetric
	FMQ	FMI	IZMSA	Micro Motion	HM-E / HMP-E	FWS / FWA	FTS
Product receiving	**	**	***	**	**	*	-
Separation / Centrifuge	***	**	*		*	*	-
Homogenization	***	***	*	**	*	*	-
Standardization	***	***	*	**	*	*	*
Short Time Heating HTST	**	**	*	*	*	***	***
Pasteurization / UHT	**	**	*	*	*	***	***
Cooling	**	*	*	*	*	***	***
Membrane Filtration	**	*	*	*	*	***	***
Fermentation / Culture	***	***	*	*	*	*	*
Mixing / Dosing of product	***	***	*	**	*	*	*
In-Line Blending	**	***	*	***	**	-	-
Measurement of highly viscous media or those containing chunks (e.g. fruit yoghurt)	***	***	*	-	-	-	-
Quality control (e.g. density / Brix / alcohol)	-	-	-	***	-	-	-
Cheese production	***	**	*	**	*	*	*
Spray Drying / Pulverization	***	**	*	**	*	*	*
Mash Tun	***	**	*	**	*	-	-
Lauter Tun	***	***	*	**	*	-	-
Brew Kettle / Copper	***	***	*	**	*	-	-
Whirlpool	***	***	*	**	*	-	-
Maturing Tank / Fermentation Tank	***	***	*	**	*	-	-
Storage Tank / Batch Tank	***	***	*	**	**	-	-
Juice Press / Extractor	*	*	*	*	*	***	*
Concentration / Evaporator	**	**	*	**	**	***	*
Carbonization	*	*	*	*	*	-	*
Filling (Kegs / Tanks / Transport vehicles)	**	**	*	**	*	*	-
CIP	***	**	*	*	*	**	***
Fresh Water Supply	***	**	*	*	*	-	-
Ultra-Pure / De-ionized water / WFI	-	-	-	***	***	-	**
Waste Water Control	***	**	*	*	*	*	-

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

Additional factors / media properties for selecting measurement systems

	FMQ	FMI	IZMSA	Micro Motion	HM-E / HMP-E	FWS/ FWA	FTS
Measurement Accuracy	±0.5 % ± 2 mm/s	±0.2 % ± 1 mm/s	±0.5 % ± 2 mm/s	±0.05 %	±0.5 % of full scale	±10 % of full scale	±10 % of full scale
Repeatability	± 0.2 %	± 0.1 %	± 0.2 %	0.025 %	± 0.10 %		
Conductivity / turbidity of the liquid	Conductivity >5 µS/cm	Conductivity >5 µS/cm	Conductivity >5 µS/cm	Nothing required	Nothing required	Turbidity ≥ 1 NTU	Nothing required
Process temperature	0…165 °C	0…165 °C	0…165 °C	100…204 °C	0…120 °C	0…100 °C	0…100 °C
Measuring range (Volume)	30…280,000 l/h	30…280,000 l/h	30…280,000 l/h	1,336… 238,499 kg/h	1,600…56,750 l/h	2.9…1,178 l/min	0.1…3 m/s
Nominal width	DN 10…100	DN 10…100	DN 10…100	DN 6…100	DN 25…50	DN 25…100	DN 25…100
Operating pressure max. (absolute)	17 bar	17 bar	17 bar	100 bar	10 bar	10 bar	60 bar
Suitability for official measuring systems	-	-	2014/32/EU, TC7520	NTEP	-	-	-
Surface roughness up to	R_a ≤ 0.4 µm	R_a ≤ 0.4 µm	R_a ≤ 0.4 µm	R_a ≤ 0.4 µm	R_a ≤ 0.5 µm	R_a ≤ 0.8 µm	R_a ≤ 0.8 µm
Data transmission	4…20 mA, IO-Link, Pulse	4…20 mA, Ethernet/IP, HART, Pulse	4…20 mA, 4x Oktocoupler	4…20 mA, Ethernet/IP HART, …	4…20 mA, Pulse	4…20 mA, PNP	PNP

Selection criteria for flow measurement systems

The suitability of flow measurement methods for hygienic processing depends on a variety of factors. The most important are:

Measurement accuracy: Depending on the application, the required measurement accuracy for the flow rate can vary significantly. For example, mixing or dosing products may require a measurement accuracy of ±0.2 %, while ±0.5 % may be sufficient for filling storage tanks, and a value of ±10 % may be adequate for measuring wastewater quantities. Since this significantly influences the purchase price of the devices, it should be determined in advance what measurement accuracy is actually required in the process.

Media consistency: Electro-magnetic or Magnetic-Inductive Devices (MID) require a conductivity >5 µS/cm. If the medium is not conductive, e.g. demineralized water, water for injection (WFI) or oils, Turbine or Coriolis sensors can be used.

Viscosity (e.g., in dough or paste) or the proportion of chunks (e.g., pieces of fruit in yogurt) are also important. MIDs do not impose any restrictions here, whereas Turbine and Coriolis Meters and Flow Switches are not or less suitable due to their mechanical components in the tubing or reduction of the nominal diameter.

Quantity preselection: For kegs or transport containers, precise quantity preselection can facilitate automation of the filling process.

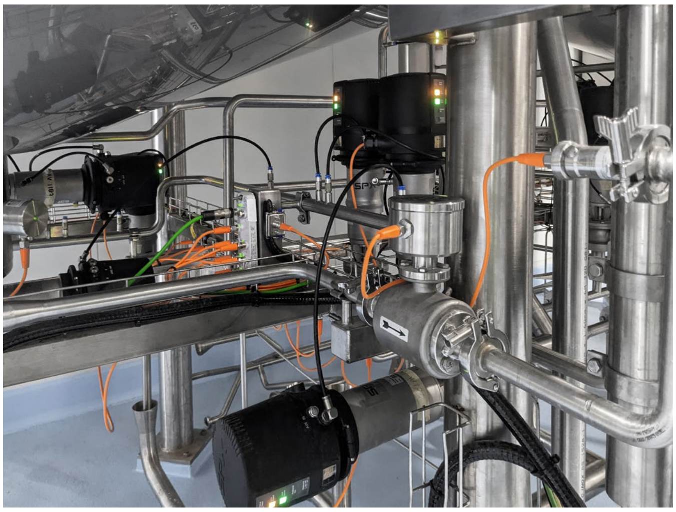
Official measurement protocol: For certain applications, such as customs declarations, customer orders, or transfer of ownership, proof is required by calibration authorities or customers. This can be fulfilled by appropriate systems with calibration capability for official measuring systems. However, since calibration authorities have different requirements, these must be clarified with the responsible authority in each individual case before selecting the measuring system.

Aggressive media/acids: Measuring systems are exposed to high mechanical or chemical stress due to media or CIP/SIP cleaning processes. All parts that come into contact with media, such as measuring tubes, coatings, electrodes, or process connections, must be checked for resistance to these influences.

Installation conditions: The different measuring systems have different process connections, installation dimensions, inlet and outlet lengths, electrical connections, and maximum operating pressures. For processes with **high vibrations or high media temperatures,** remote devices can be beneficial, as the sensitive electronic components can be mounted at several meters distance. **Mobile sensor units** can be a cost-saving option for applications where, for example, several storage or maturation tanks are filled or emptied one at a time.

Pig cleaning: Only Electro-magnetic devices are suitable for this purpose, as they have the same pipe diameter as the process lines and do not have any components inside the tubing.

Density measurement: If density (e.g., concentration, Brix, Plato, proof, or Baume value) is required in addition to volume, Coriolis meters that combine flow and density measurement in a single device are recommended.



What are the measuring principles for flow control?

The most important product category for hygienic applications is **Electromagnetic / Magnetic-Inductive Flow Meters (Mag Meters).** This product line includes a wide range of different sensor types with a big diversity of variants and technical specifications.

For non-conductive media that cannot be measured with Mag Meters, **Turbine Flow Meters** are the suitable alternative.

Another system works with the **Ultrasonic measuring principle** and achieves a measuring accuracy of ±10 %. It can be used as a flow meter with sufficient accuracy for many applications or as a flow switch.

Finally, there are **Calorimetric devices** that, being pure flow switches, only transmit an I/0 signal.

Anderson-Negele offers devices developed and manufactured in-house for all these areas. These are supplemented by Micro Motion brand **Coriolis devices** for flow and density measurement. These were added to the Anderson-Negele product portfolio as part of a distribution partnership with Emerson, one of the world's leading suppliers of such systems.

Due to the wide range of requirements, these devices are available in many configurations and with additional options. This enables the best solution for almost every purpose and application.

Electromagnetic Flow Measurement

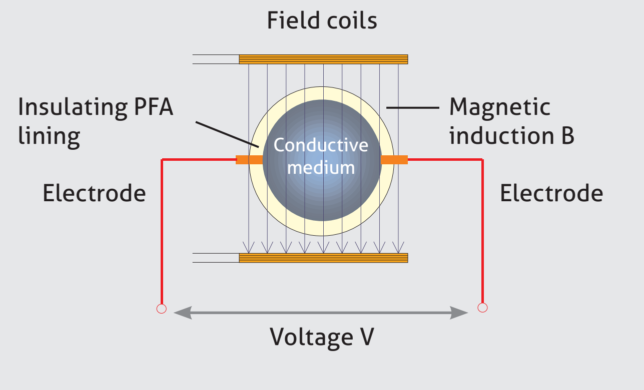
This measurement principle is based on Faraday's law of induction. Two field coils generate a constant magnetic field and the induced voltage is measured via two stainless steel electrodes. This voltage is generated, i.e. induced, by the flowing, conductive medium. It is directly proportional to the flow velocity and can be converted into flow volume based on the nominal width. The measured values are available as a counting pulse, as a 4...20 mA standard signal, and, for IO-Link devices, also in digital form.

For which products is the electromagnetic measuring principle suitable?

A minimum conductivity of > 5 μS/cm is required for measurement, so that an evaluable voltage can be induced. This technology is suitable for media such as **milk, cream, beer, ketchup, sauces, creams, porridge, molasses, yogurt, concentrates, cleaning media, and many more.**

Since the diameter of the flow meter can be precisely adapted to the nominal pipe diameter of the process from DN 10 to 100, the pressure loss is reduced to a minimum. This also makes the measuring principle ideal for lumpy or highly viscous products such as fruit yogurt, molasses, honey, or dough.

Magnetic-inductive measurement



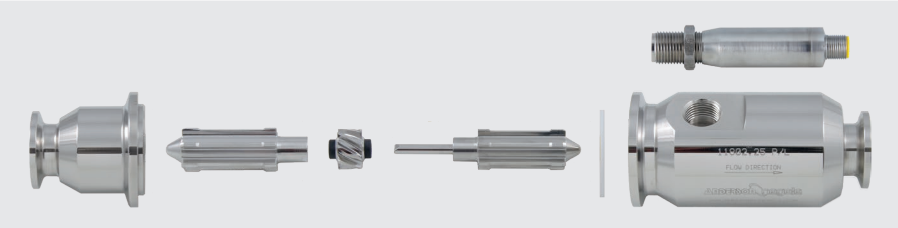
For applications with very high process temperatures up to 165 °C or for processes with high vibrations that could affect the measurement and service life of the measuring devices, remote sensors are recommended, in which the transmitter unit is mechanically separated from the measuring unit.

Turbine Flow Measurement

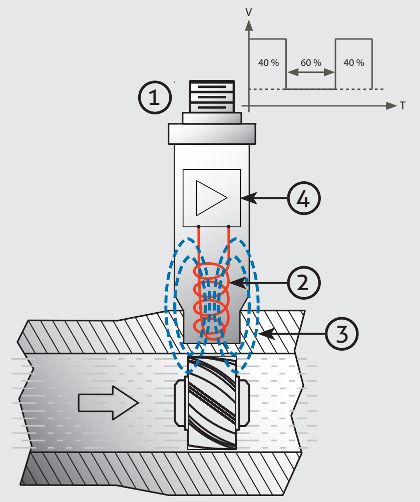
This measuring principle works with contactless pulse measurement. A turbine is located directly in the liquid flow and is set in rotation by the flow movement via its rotor blades. A signal probe generates an electromagnetic field via an oscillating circuit. The rotating rotor interacts with this to generate an induction current, which can be precisely measured and output by the sensor.

For which products is the turbine measuring principle suitable?

Turbine sensors with contactless pulse measurement are the reliable, precise, and economical alternative to mass sensors or electromagnetic devices. This technology is also suitable **for non-conductive, aqueous media such as filtered fruit juice or beer, alcohols, light oils, salt solutions, cleaning media, and acids, as well as process water, demineralized water, and WFI.**



Non-contact pulse measurement



Coriolis Flow Measurement

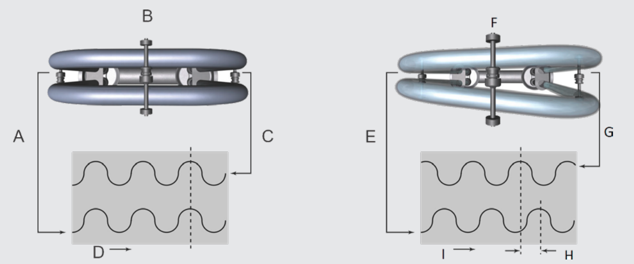
In Emerson's Coriolis measuring system, the medium is guided through two parallel measuring tubes in the sensor. The measuring tubes are set into vibration. At zero flow, the two tubes vibrate in phase. When flow begins, the Coriolis forces cause the tubes to twist, resulting in a phase shift of the vibration. The time difference between the waves is measured and is directly proportional to the mass flow.

Mass and volume measurement: The volume flow is calculated based on the mass flow and density.

Density measurement: Since the measuring tubes vibrate at their natural frequency, a change in the mass of the process medium contained in the tubes causes a corresponding change in the natural frequency of the tube. This change in frequency of the tube is used to calculate the density.

For which products is the Coriolis measuring principle suitable?

This measurement technology is suitable for almost all production processes in the food and beverage industry. It is particularly advantageous in applications where the density (or concentration, Brix, Plato, proof, or Baume value) must be determined simultaneously with the flow.



A. Inlet pickoff displacement
B. No flow
C. Outlet pickoff displacement
D. Time
E. Inlet pickoff displacement
F. With flow
G. Outlet pickoff displacement
H. Time difference
I. Time

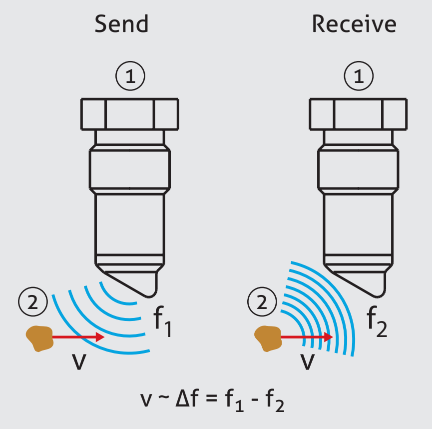
Ultrasonic flow measurement / flow monitoring

A transmitter sends ultrasonic waves into the flowing medium. These ultrasonic waves hit particles, e.g., sediments, contaminants, or air bubbles, which are moving in the direction of flow and are reflected. The receiver now sees the reflected frequency slightly shifted because the wavelength changes due to the forward movement of the reflecting particle (ultrasonic Doppler principle). The frequency difference between the transmitted and received frequencies is a measure of the speed of movement of the particles and thus also a measure of the flow velocity.

For which products is the Ultrasonic measuring principle suitable?

Many flow monitors are limited to aqueous media. In contrast, the ultrasonic Doppler measuring principle is ideal for all media with slight turbidity or air bubbles. This technology can be used when other systems do not work, e.g., with **dough, glycol, oils and oil-based media, adhesive or viscous media, creams, but also drinking water, milk, juice (unfiltered), and CIP media.**

Schematic drawing



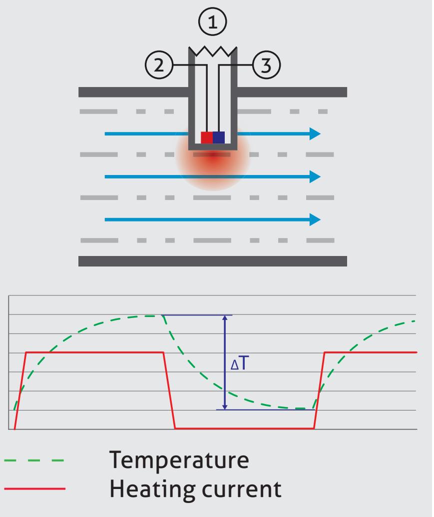
Calorimetric flow monitoring

The operating principle of the FTS calorimetric flow switch is based on a temperature sensor attached to the sensor tip, which is periodically heated by a heating element. When the medium is stationary, a constant temperature difference ΔT between the heated and unheated states is established. When flow occurs, heat energy is extracted from the heated temperature sensor and the temperature difference changes depending on the flow velocity. In contrast to designs based on two separate temperature sensors, one of which is constantly heated, the measuring principle of the FTS with only one sensor and periodic heating enables a shorter response time thanks to optimized heat transfer and lower heat capacity.

For which products is the Calorimetric measuring principle suitable?

This measuring principle is ideal for all aqueous products: even for demineralized and highly filtered media such as **cola and other soft drinks, filtered beer, demineralized water, and media in pressure lines.**

Schematic drawing



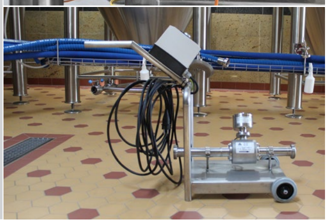
Product Overview

Electromagnetic Flow Sensors (Mag Meters)

FMQ

- Compact, robust, reliable: The affordable all-rounder for almost all applications
- Technology with digital + analog interface (IO-Link + 4...20 mA)
- Measuring range from 30 l/h to 280,000 l/h (8 gal/hr to 80,000 gal/hr)
- Measuring accuracy: ±0.5 % ±2 mm/s
- All components made of stainless steel, the magnetic field coils of the measuring system are encapsulated
- For liquids, slurries, and pastes with a minimum conductivity of > 5 µS/cm
- Process temperature up to 165 °C (329 °F), CIP / SIP up to 130 °C (266 °F), max. 30 min
- Aseptic flange, suitable for many common process connections





FMI

- The benchmark for accuracy, reliability, and durability
- Powerful electronics with 4...20 mA or serial interface: RS485 (CS3 bus)
- Measuring range from 30 l/h to 280,000 l/h (8 gal/hr to 80,000 gal/hr)
- Measuring accuracy: ±0.2% ±1 mm/s
- All components made of stainless steel, the magnetic field coils of the measuring system are encapsulated
- For liquids, slurries, and pastes with a minimum conductivity of > 5 µS/cm
- Process temperature up to 165 °C (329 °F)
- Aseptic flange, suitable for many common process connections



IZMSA

- The specialist for dosing and filling applications
- Integration in official measuing systems possible (acc. to 2014/32/EU with Certificate TC 7520)
- Measuring accuracy: ±0.5 % ±2 mm/s
- All components made of stainless steel, the magnetic field coils of the measuring system are encapsulated
- For liquids, slurries, and pastes with a minimum conductivity of > 5 µS/cm
- Process temperature up to 165 °C (329 °F)
- Aseptic flange, suitable for many common process connections

Turbine Flow Sensors

HM-E / HMP-E

- The solution for non-conductive media
- High media resistance thanks to AISI 316L stainless steel and Rulon™ bearings
- Nominal sizes according to ASME BPE and DIN 11850
- Measuring range 1,600…56,750 l/h (7…250 GPM)
- Measuring accuracy: ±0.5 %
- Process temperature up to 120 °C (250 °F), CIP/SIP/Autoclave 149°C (300°F)
- Extremely fast response time <50 ms
- Two-piece stainless steel housing for easy cleaning and vibration resistance

Coriolis Flow and Density Sensors

Micro Motion*

- One device for various applications: mass and flow measurement, density measurement of liquids and slurries
- Measurement accuracy ±0.05% (flow) and ±0.0005 g/cm3 (density)
- The Micro Motion G series is the affordable and compact all-rounder for the most common applications
- The Micro Motion H series offers improved values for measurement accuracy, turndown, pressure and temperature stability

* Emerson's Micro Motion series offer a comprehensive range of sensors, transmitter, and options. Please contact us for further details on the possible configurations for your application.

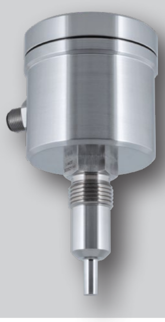
Flow Switches

FWS / FWA

- Ultrasonic flow switch and flow meter with measuring accuracy ±10%
- Thanks to the ultrasonic Doppler measuring principle, ideal for all media with turbidity >1 NTU, e.g., drinking water, fruit juice (unfiltered), milk, emulsions, CIP media
- Measuring range 0.1…2.5 m/s
- Process temperature 0…100 °C (32…212 °F)

FTS

- Calorimetric flow switch with pulse measurement method
- Also suitable for demineralized and highly filtered media such as cola and other soft drinks, filtered beer, demineralized water, and for media in pressure lines
- Insensitive to temperature shocks
- Measuring range 0.1…3 m/s
- Process temperature 0…100 °C (32…212 °F), CIP/SIP up to 140 °C (284 °F)



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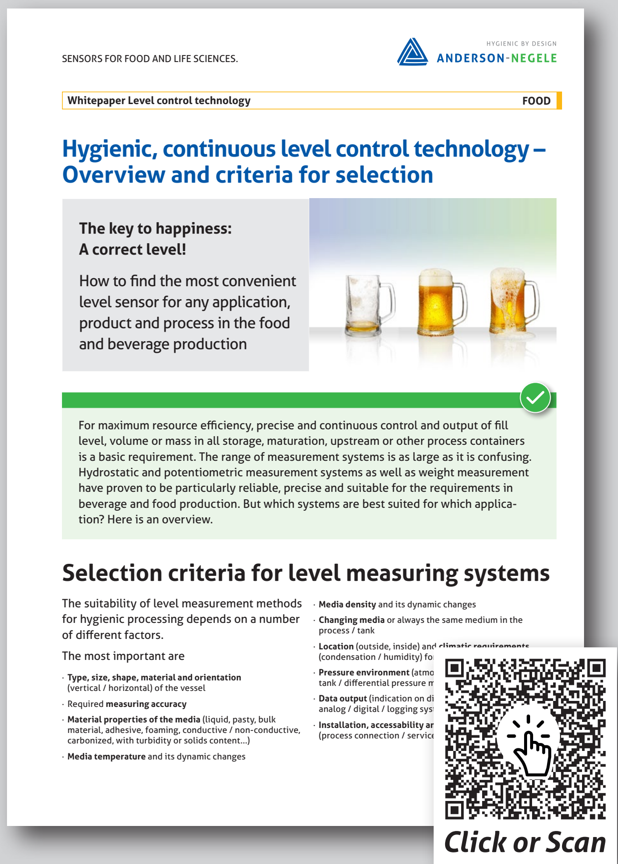

SENSORS FOR FOOD AND LIFE SCIENCES. HYGIENIC BY DESIGN ANDERSON-NEGELE

Whitepaper Level control technology FOOD

Hygienic, continuous level control technology – Overview and criteria for selection

The key to happiness: A correct level!

How to find the most convenient level sensor for any application, product and process in the food and beverage production

For maximum resource efficiency, precise and continuous control and output of fill level, volume or mass in all storage, maturation, upstream or other process containers is a basic requirement. The range of measurement systems is as large as it is confusing. Hydrostatic and potentiometric measurement systems as well as weight measurement have proven to be particularly reliable, precise and suitable for the requirements in beverage and food production. But which systems are best suited for which application? Here is an overview.

Selection criteria for level measuring systems

The suitability of level measurement methods for hygienic processing depends on a number of different factors.

The most important are

- **Type, size, shape, material and orientation** (vertical / horizontal) of the vessel
- Required **measuring accuracy**
- **Material properties of the media** (liquid, pasty, bulk material, adhesive, foaming, conductive / non-conductive, carbonized, with turbidity or solids content...)
- **Media temperature** and its dynamic changes
- **Media density** and its dynamic changes
- **Changing media** or always the same medium in the process / tank
- **Location** (outside, inside) and climatic requirements (condensation / humidity) fo
- **Pressure environment** (atmo tank / differential pressure m
- **Data output** (indication on di analog / digital / logging sys
- **Installation, accessability ar** (process connection / service

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SENSORS FOR FOOD AND LIFE SCIENCES. HYGIENIC BY DESIGN ANDERSON-NEGELE

Whitepaper Turbidity control technology FOOD

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 our customers.

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