Measuring concentration of liquids

Comparison of measuring methods

Increasing c

With high

Robust, ac

LiquiSonic®

quality, **saving resources: LiquiSonic®.**

-value, **innovative sensor technology.**

curate, **user-friendly.**

LiquiSonic® is an inline analytical system for determining the concentration in liquids directly in the production process. The analyzer is also used for phase separation and reaction monitoring. Sensor installation within the product stream means an extremely fast measurement that responds immediately to process changes.

User benefits include:

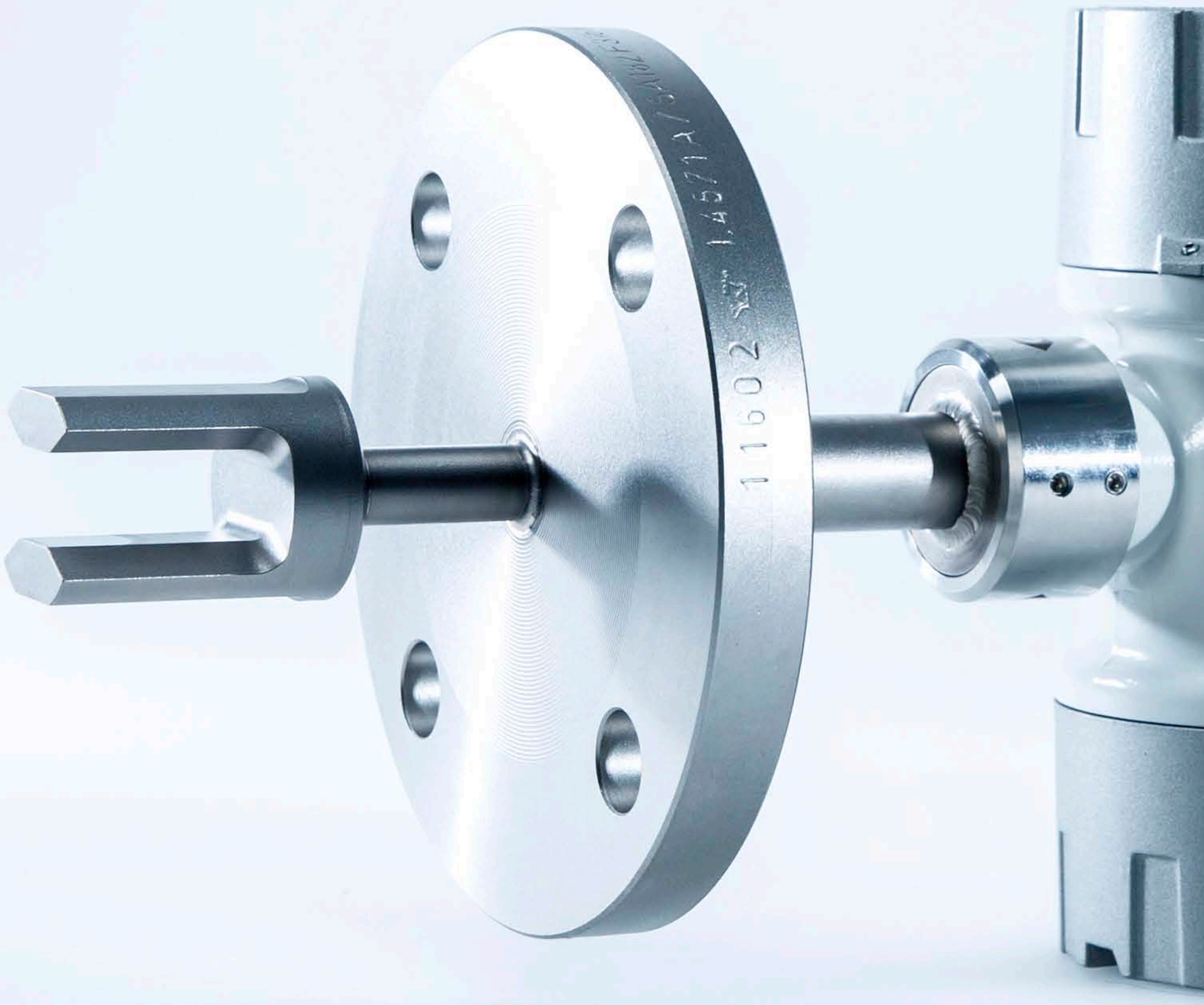
- optimal plant control through online and real-time information about process states
- maximized process efficiency
- increased product quality
- reduced lab costs
- immediate detection of process changes
- energy and material savings
- instant warning of irruptions in the process water or process liquid
- repeatable measuring results

LiquiSonic's® 'state-of-the-art' digital signal processing technology guarantees highly accurate, fail-safe measuring of absolute sonic velocities and liquid concentrations.

Integrated temperature detection, sophisticated sensor design, and know-how from SensoTech's extensive measurement history in numerous applications promises users a highly reliable, long-lived system.

Advantages of the measuring method are:

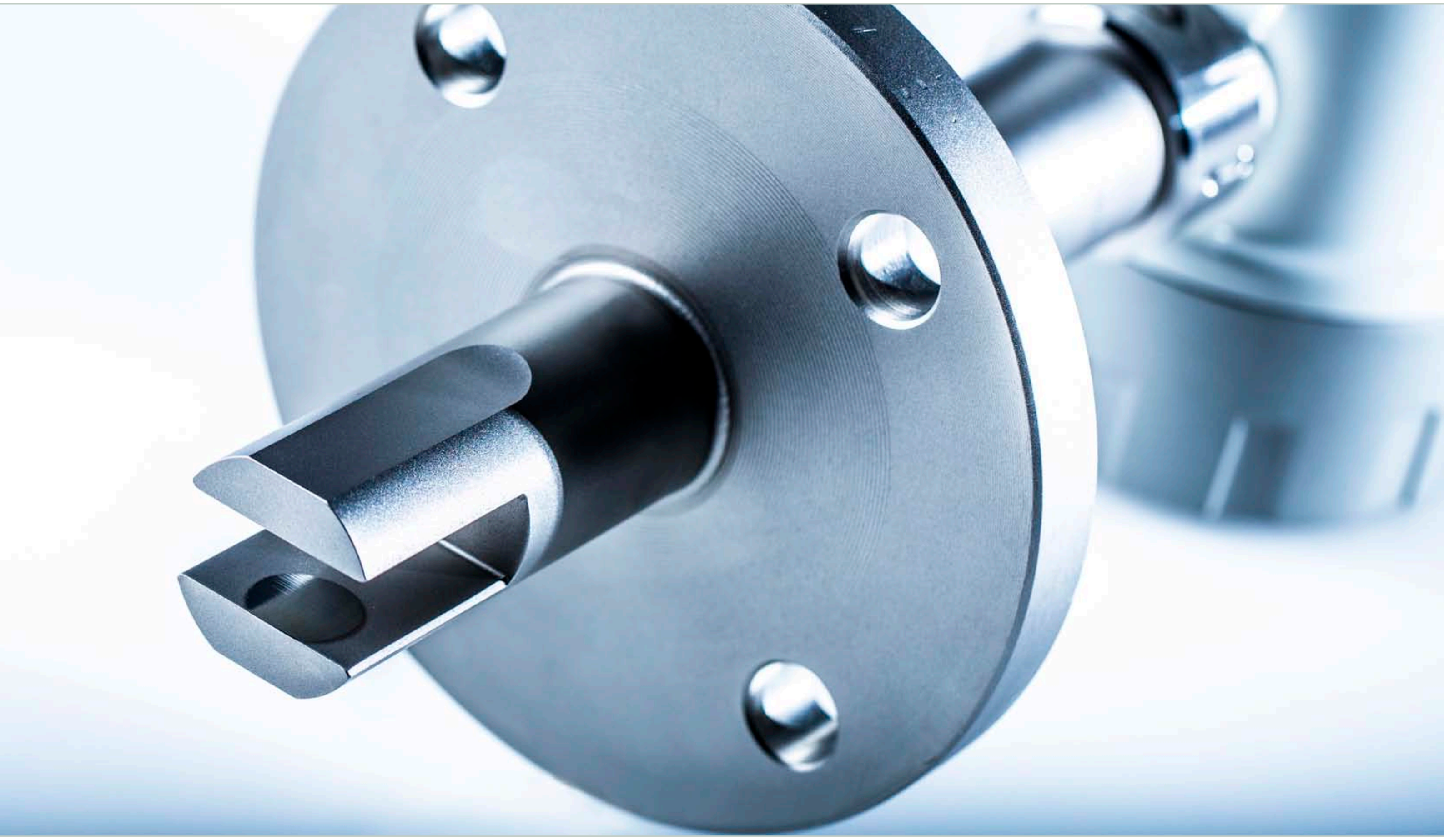
- absolute sonic velocity as a well-defined and retraceable physical quantity
- independence from conductivity, color or optical transparency of the process liquid
- installation directly into pipes, tanks or vessels
- robust, all-metal, gasket-free sensor design with no moving parts
- corrosion-resistant by using special material
- maintenance-free
- use in temperatures up to 200 °C (390 °F)
- accurate, drift-free measurements
- stable measurements even amid gas bubbles
- controller connection capacity reaching up to four sensors
- data transmission via fieldbus (Profibus DP, Modbus), analog outputs, serial interface or Ethernet



Inline process analysis

Contents

1 Sonic velocity



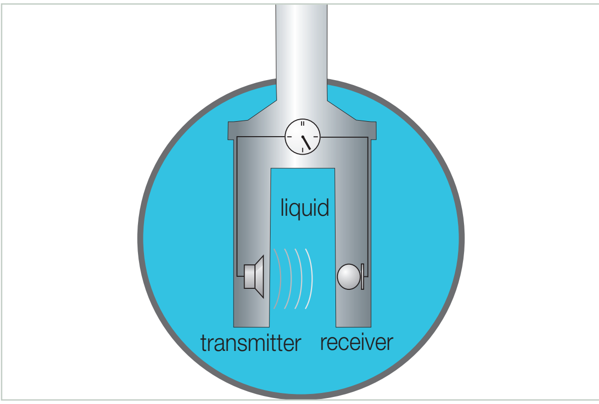
Measuring the sonic velocity relies on the measurement of running time. An ultrasonic signal is sent through the liquid from a sender to a receiver. The speed of the signal is calculated by measuring the time the signal needs to travel from the sender to the receiver.

Because the distance between the sender and receiver is constant, the sonic velocity can be determined.

$$\mathbf{v} = \frac{\mathbf{s}}{\mathbf{t}}$$

v: sonic velocity
s: distance between sender and receiver
t: signal delay

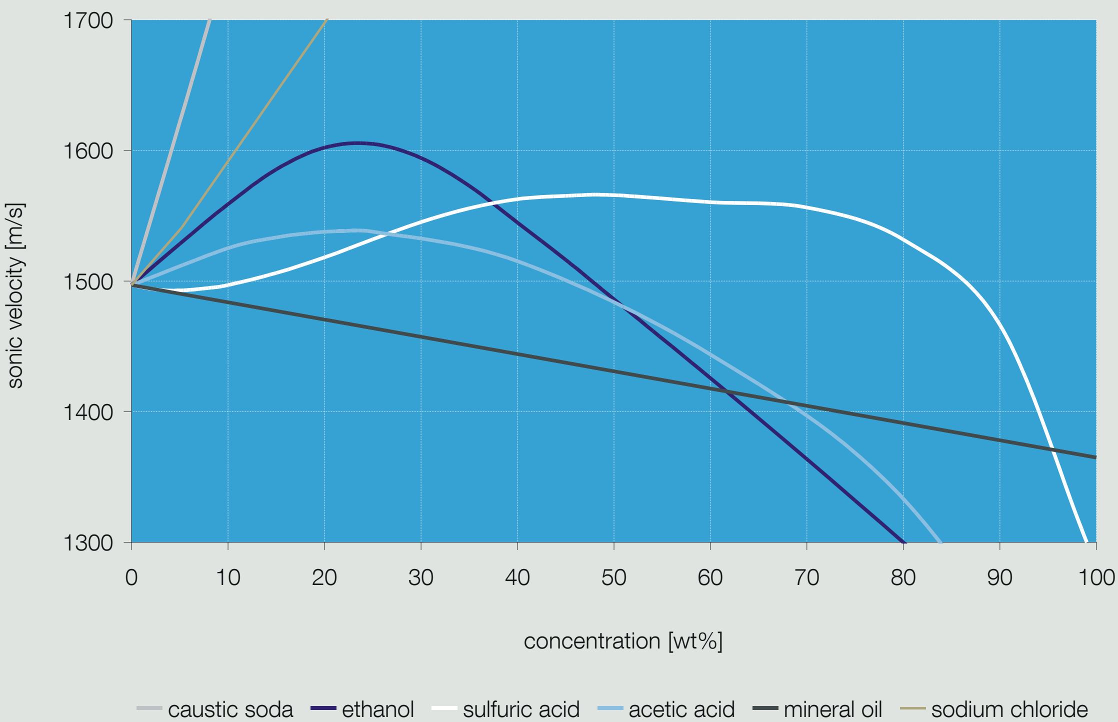
For example, at 20 °C the sonic velocity of water is 1.483 m/s. Depending on the liquid, the sonic velocity is between 200 m/s and 2.500 m/s.



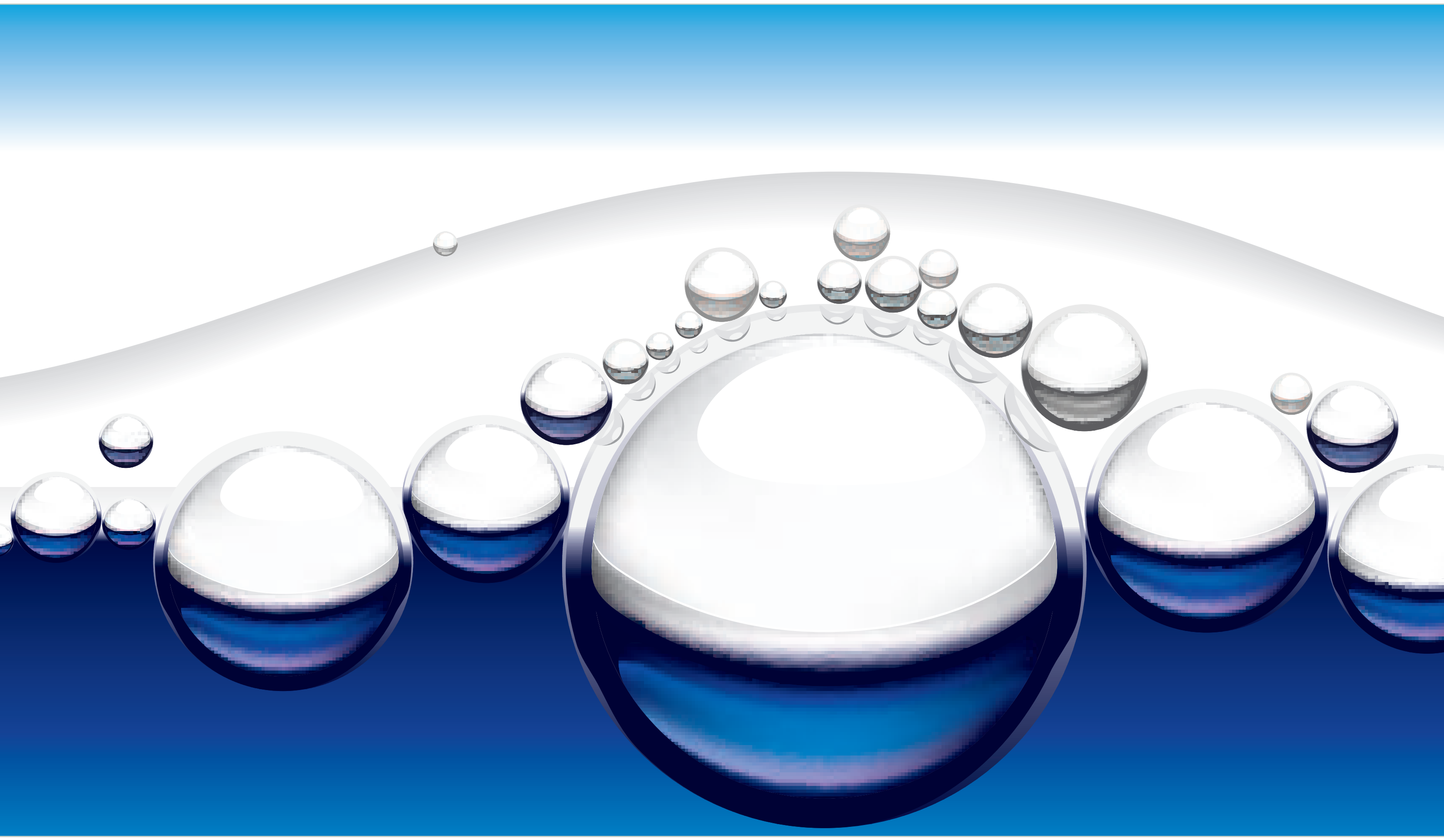
Measuring principle of sonic velocity

The relationship between sonic velocity and concentration is usually not linear. The following graphic illustrates the impact of changes in concentration on the sonic velocity

Correlation between sonic velocity and concentration of binary liquids



2 Alternative measuring methods

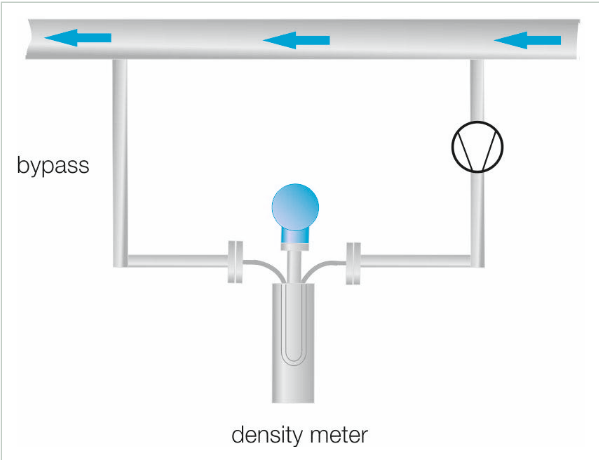


2.1 Density

Density measurement is based on a spring-mass system in which a tube is made to oscillate mechanically. The frequency of oscillation is dependent on the spring constant and on the mass of the tube, including its content.

Assuming the mass and volume of the tube remain constant, the density of liquid contained in the tube can be determined by measuring the frequency.

The spring rigidity of a tube is dependent on temperature. Generally, the temperature is measured in the device to compensate for its dependency.



Measuring principle of density

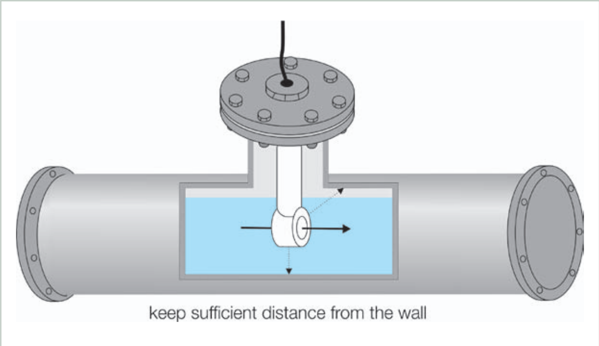
	Sonic velocity	Density	
	Ultrasonic sensor	Oscillating U-tube	Mass flow sensors (Coriolis)
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	sufficient documentation of specific density for many liquids	indirect density calculation by measurement of Coriolis force
calibration liquid	water	reference liquid (reference density)	reference liquid (reference density)
operating temperature	-90 to 200 °C	-50 to 200 °C	-40 to 200 °C
typical accuracy	±0.05 wt%	±0.05 wt%	±0.1 wt%
installation	no conditions	bypass	inline, fixed support structures
installation in vessel	direct, no dead space	only through external bypass	only through external bypass
maintenance	not required	not required	not required
execution	inline, relatively easy, robust	bypass NPS 6..25	inline, large, difficult
stilling pipe	not required	not required	required
gas bubbles, sediment	marginal impact on measuring accuracy, alarm signal	results in false measurements	results in false measurements
deposits	impact only with large deposits	small and large deposits influence oscillation properties	small and large deposits influence oscillation properties
vibrations	no impact (operating frequency > 1 MHz)	sensitive (operating frequency several hundred Hz)	sensitive (operating frequency several hundred Hz)
pressure surge	does not influence measuring accuracy	can influence measuring accuracy	can influence measuring accuracy
special materials	numerous available	with high nominal diameter very expensive	with high nominal diameter very expensive
pressure loss	minor	minor, because of bypass	high
weight	4 to 6 kg	2 to 4 kg	10 to 300 kg

2.2 Conductivity

Electrolytic conductivity measures the ability of a solution to transport ionic charges. It is dependent on the type and concentration of ions in the solution, in addition to temperature (up to 3 % per °C).

With the help of a coil, inductive conductivity sensors trigger a current in the liquid. This current is then measured and analyzed by a second coil.

The accuracy of the conductivity measurement amounts to 0.5 % of the measuring range, though accuracy decreases in cases of temperature fluctuations and when inadequate installation conditions are present.



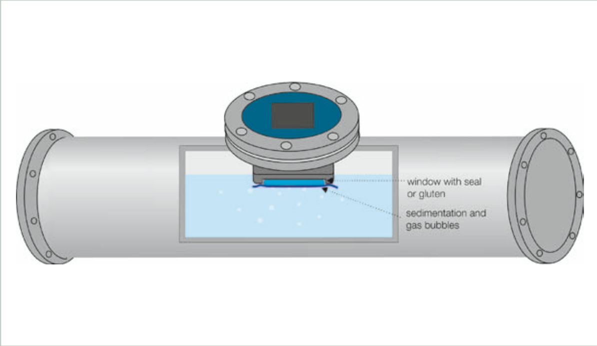
Measuring principle of conductivity

	Sonic velocity sensor	Conductivity sensor
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	sufficient documentation of specific conductivity for many liquids
calibration liquid	water	reference liquid (NaCl solution)
operating temperature	-90 to 200 °C	-20 to 180 °C
typical accuracy	±0.05 wt%	±0.25 wt%
installation	no conditions	no conditions
installation in piping	from DN 10	adapter/suspension for DN 80 / NPS 3 “ required because a gap from the pipe wall is necessary
maintenance	not required	not required
process liquid	inorganic and organic liquids	only inorganic liquids
number of product data sets	up to 256	up to 10
special materials	stainless steel (DIN 1.4404, DIN 1.4571, DIN 1.4335), Halar, PFA, Tantalum, Hastelloy, Titan, Zirconium, Monel, Incolloy, Inconel, ETFE	Peek, PFA
measuring cycle	32 measurements per second	1 measurement per second
weight	4 to 6 kg	2 kg
diganostic capabilities	powerful	limited

2.3 Refractometry

The refractometer determines the refractive index of liquids and solids. Calculating the refractive index depends on refraction of light, which is reflected or scattered by a liquid. Light scatters differently depending on the type and concentration of dissolved solid. Therefore, the refractive index is determined by the concentration of the dissolved solid.

An optimal sensor (window) measures the reflection of a light beam from an LED light source upon reaching the sample.

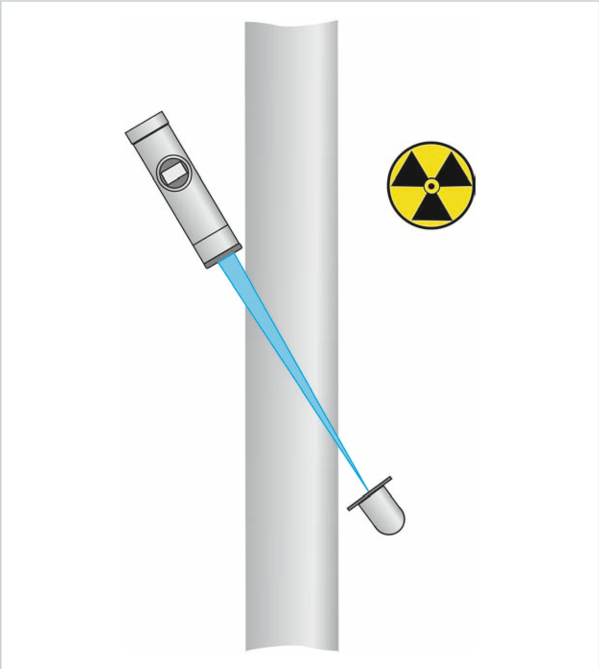


Measuring principle of refractometry

	Sonic velocity sensor	Refractometer
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	no account of the refractive index value from literature, first-hand sources or laboratory refractometers on the process device possible
calibration liquid	water	certified reference liquids
operating temperature	-90 to 200 °C	-20 to 150 °C
typical accuracy	±0.05 wt%	±0.3 wt%
installation	no conditions	no conditions
maintenance	not required	not required
calibration/adjustment	plug & play	extensive, time-consuming
vibrations	no impact	very sensitive
concentration	calculation of concentration from sonic velocity	no direct concentration calculation possible
process liquid	measurement undependent from color and transparency	measurement dependent from color and transparency
evaluation unit	external controller	temperature and shock-prone evaluation electronic directly on sensor head
robustness	very robust construction and materials	attack of gasket and glue on optical window through corrosive liquids, deposits on the window
pressure surge	up to 250 bar	up to 10 bar
weight	4 to 6 kg	3 to 5 kg
diganostic capabilities	powerful	limited

2.4 Radiometry

A radioactive source sends its rays through the material that is received by the detector. A scintillator uses light flashes to convert and determine the number of radioactive rays. Because the penetration of gamma rays is dependent on the type of matter, density is determined by the intensity of the incoming rays.



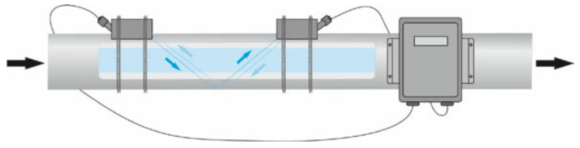
Measuring principle of radiometry

	Sonic velocity sensor	Radiometer
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	density can be calculated from intensity of incoming radiation; sufficient documentation
calibration liquid	water	very complex
operating temperature	-90 to 200 °C	-20 to 200 °C
typical accuracy	±0.05 wt%	±0.1 wt%
installation	no conditions	contactless measurement, installation outside on the pipe/vessel walls
maintenance	not required	required
delivery	standard delivery	delivery in special vehicle
review through external people	not required	twice per year
user training	not required	mandatory
approval by regulatory authority	not required	required
security officer	not required	required (radiation control officer)
authorizations	not required	required
pressure	up to 250 bar	optional
disposal costs	minor	very high
weight	4 to 6 kg	2 kg
service efford	minimal	complex

2.5 Clamp-on

The clamp-on method is based on measuring the ultrasonic transit-time differential. To this end, the two ultrasonic sensors are installed to the pipe from the outside. An ultrasonic signal is sent from one sensor and received by another. Ultrasonic signals are emitted alternately in the flow direction and against it.

The duration of sonic signals is shorter in the flow direction than in the one against it. Sonic velocity is the ratio of the ultrasonic signals in the liquid and the duration. Duration functions as an average of the duration of both sensor signals in the liquid, adjusted to the duration in the sensor and tube.



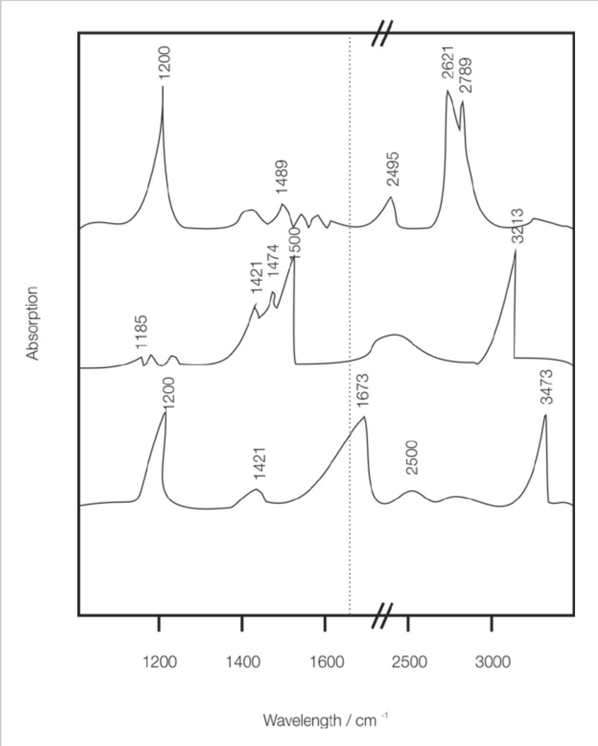
Measuring principle of clamp-on

	Sonic velocity sensor	Clamp-on sensor
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	scarce documentation of specific sonic velocity; therefore, preliminary laboratory testing or media databases
operating temperature	-90 to 200 °C	-30 to 200 °C
accuracy	±0.05 wt%	±0.5 wt%
installation	no conditions, stable connection	contactless measurement, installation outside on the pipe/vessel walls, unstable connection
switch to another measuring point	easy to realize	extense adjustment and calibration
maintenance	not required	not required
pipe materials	freely selectable	all acoustically conductive materials
pressure surge	up to 250 bar	optional
temperature measurement	highly exact (±0,05 °C)	inexact because temperature measurement is from the outside
stability of measuring device	stable, direct installation in pipelines and vessels	mechanically unstable, risk of measurement slippage and alteration of compound paste
weight	4 to 6 kg	2 kg
diganostic capabilities	powerful	limited

2.6 Spectroscopy

Spectroscopic examination methods facilitate the characterization of atoms, ions and molecules through specific wavelengths that can be measured using emission, absorption, distribution, etc.

In atomic spectroscopy, the type of spectroscopic procedure used to analyze the chemical elements of atoms is differentiated based on emission, absorption or fluorescence processes (for example, gamma-ray spectroscopy, atomic spectroscopy AFS). Molecular spectroscopy is based on the excitation and evaluation of rotation, oscillation and electronic states in molecules. In the process, so-called band spectrums are observed. Examples include infrared spectroscopy, UV/VIS spectroscopy and resonance spectroscopy.



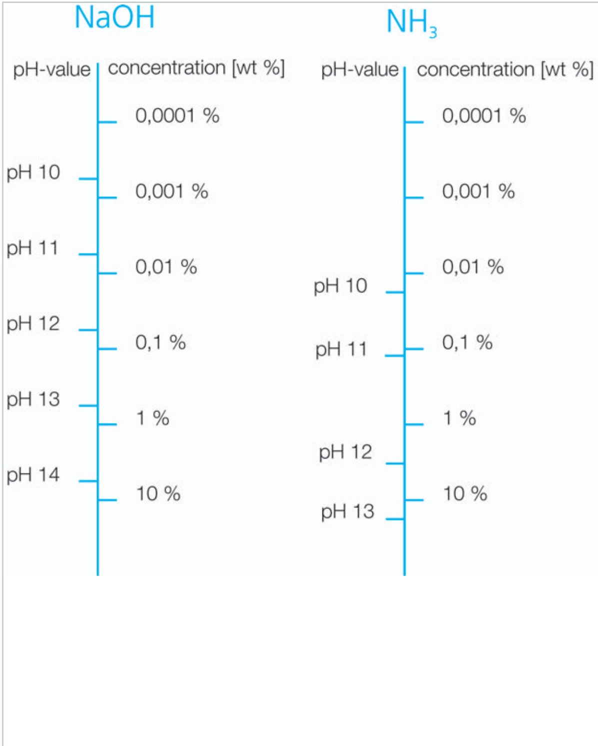
	Sonic velocity sensor	Spectroscopy
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	measurement of absolute remission in dependence from wavelength, extensive spectra databases available
calibration liquid	water	special calibration liquid
calibration efford	plug & play	very high
operating temperature	-90 to 200 °C	-10 to 80 °C
accuracy	±0.05 wt%	≥ ±0,05 wt%
installation	no conditions, no sample	external analysis through samples, sample preparation required
measuring task	concentration and temperature measurement	characterization of atoms, ions and molecules (complex analysis)
time expenditure	low expenditure of time, no sample and analysis necessary, second-by-second documentation of measuring values in internal data storage	high time expenditure for sample, analysis and evaluation of measuring values
operation	simple and understandable, concentration value evident immediately in controller	complex evaluation, specialized personnel with chemical knowledge required
investment costs	middle	high
weight	4 to 6 kg	2 kg

2.7 pH-value

One of the oldest chemical parameters in laboratory and industry is the pH-value. It is a measure for the alkalinity or basicity of a solution and is defined as the negative decadic logarithm of the hydrogen ion activity.

In laboratories pH-sensors are common practice, whereby inline sensors can be in use directly in the process too. Thereby, it is necessary to pay attention to operation site, material resistance and durability, because pH-sensors are well known as very susceptible measuring technology.

Offline, rarely inline pH-titrators can be found in the industrial environment, in particular for ion analysis in wet-chemical processing. For this special sample preparation techniques, cleaning and calibrating systems and subsequent documentation units are necessary.



	Sonic velocity sensor	pH probe
concentration determination	specific sonic velocity is required; (laboratory testing or media databases)	data available for common process liquids
calibration liquid	water	special calibration liquid
operating temperature	-90 to 200 °C	-10 to 80 °C
typical accuracy	±0.05 wt%	±0.5 wt%
installation	no conditions, no sample	expensive inline installation, max. flow: 2 m/s, installation angle important
maintenance	maintenance-free	permanent change of expandable parts, risk of breakage, fragile
consumable	not required	buffering solution, sensor must not run dry
operation	simple and understandable, concentration value evident immediately in controller	complex evaluation, specialized personnel with chemical knowledge required
inline cleaning	not required	automated cleaning system required
agressive process and CIP liquids	easy to handle because of special materials like Hastelloy or titan	corrosion, reduced runtime, breakage and defect
robustness	very robust construction and materials, no moving parts	attack through corrosive liquids, deposits and complex cleaning
calibration	plug & play	extensive
time expenditure	low expenditure of time, no sample and analysis necessary, second-by-second docu-mentation of measuring values in internal data storage	high time expenditure for sample, analysis and evaluation of measuring values

3 Quality and support

Enthusiasm for technical progress is the driving force behind our company as we seek to shape the market of tomorrow. As our customer you are at the centre of all our efforts and we are committed to serving you with maximum efficiency.

We work closely with you to develop innovative solutions for your measurement challenges and individual system requirements. The growing complexity of application-specific requirements means it is essential to have an understanding of the relationships and interactions involved.

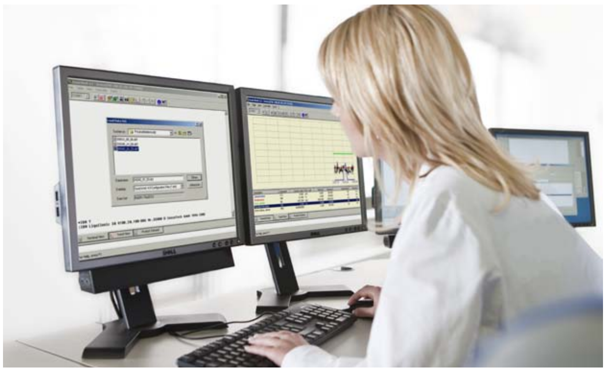
Creative research is another pillar of our company. The specialists in our research and development team provide valuable new ways to optimize product attributes, such as testing new types of sensor designs and materials or the sophisticated functionality of electronics, hardware and software components.

Our SensoTech quality management also only accepts the best production performance. We have been certified according to ISO 9001 since 1995. All device components pass various tests in different stages of production. The systems have all gone through an internal burn-in procedure. Our maxim: maximum functionality, resilience and safety.

This is only possible due to our employee`s efforts and quality awareness. Their expert knowledge and motivation form the basis of our success. Together we strive to reach a level of excellence that is second to none, with a passion and conviction in our work.

Customer care is very important to us and is based on partnerships and trust built up over time.
As our systems are maintenance free, we can concentrate on providing a good service to you and support you with professional advice, in-house installation and customer training.

Within the concept stage we analyse the conditions of your situation on site and carry out test measurements where required. Our measuring systems are able to achieve high levels of precision and reliability even under the most difficult conditions. We remain at your service even after installation and can quickly respond to any queries thanks to remote access options adapted to your needs.



In the course of our international collaboration we have built up a globally networked team for our customers in order to provide advice and support in different countries. We value effective knowledge and qualification management. Our numerous international representatives in the important geographical markets of the world are able to refer to the expert knowledge within the company and constantly update their own knowledge by taking part in application and practice-oriented advanced training programs.

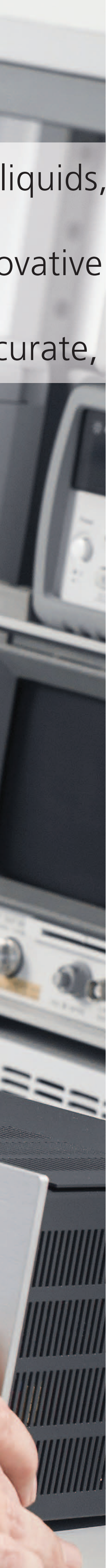
Customer proximity around the globe: an important element of our success worldwide, along with our broad industry experience.

In

With inno

Tough, acc

SensoTech



liquids, **we set the measure.**

ovative **sensor technology.**

curate, **user-friendly.**

SensoTech is a provider of systems for the analysis and optimization of process liquids. Since our establishment in 1990, we have developed into a leading supplier of process analyzers for the inline measurement of liquid concentration and density. Our analytical systems set benchmarks that are used globally.

Manufactured in Germany, the main principle of our innovative systems is to measure ultrasonic velocity in continuous processes.
We have perfected this method into an extremely precise and remarkably user-friendly sensor technology. Beyond the measurement of concentration and density, typical applications include phase interface detection or the monitoring of complex reactions such as polymerization and crystallization.

Our LiquiSonic® measuring and analysis systems ensure optimal product quality and maximum plant safety. Thanks to their enhancing of efficient use of resources they also help to reduce costs and are deployed in a wide variety of industries such as chemical and pharmaceutical, steel, food technology, machinery and plant engineering, car manufacturing and more.

It is our goal to ensure that you maximize the potential of your manufacturing facilities at all times. SensoTech systems provide highly accurate and repeatable measuring results even under difficult process conditions. Inline analysis eliminates safety-critical manual sampling, offering real-time input to your automated system. Multi-parameter adjustment with high-performance configuration tools helps you react quickly and easily to process fluctuations.

We provide excellent and proven technology to help improve your production processes, and we take a sophisticated and often novel approach to finding solutions. In your industry, for your applications – no matter how specific the requirements are. When it comes to process analysis, we set the standards.

SensoTech GmbH
Steinfeldstr. 1
39179 Magdeburg-Barleben
Germany

T +49 39203 514 100
F +49 39203 514 109
info@sensotech.com
www.sensotech.com

SensoTech Inc.
1341 Hamburg Tpk.
Wayne, NJ 07470
USA

T +1 973 832 4575
F +1 973 832 4576
sales-usa@sensotech.com
www.sensotech.com

In liquids, we set the measure.

LSM019_01_12_R 08/2018