SensoTech

Sulfuric acid production

Inline analytical technology for:

- concentration
- density
- process control
- acid dilution

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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, corrosion-resistant, gasket-free sensor design with no moving parts
- maintenance-free
- use in temperatures up to 200 °C (392 °F)
- accurate, drift-free measurements within ± 0.03 wt%
- 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

1 Applications

1.1 Introduction

Sulfuric acid (H_2SO_4) is one of the most important basic chemicals totaling up to 200 million tons per year. Steady demand grows because H_2SO_4's favorable properties make it useful in preparing a variety of products. For example, H_2SO_4's hygroscopic nature is ideal for drying synthesis gases in the chemical and petrochemical industries.

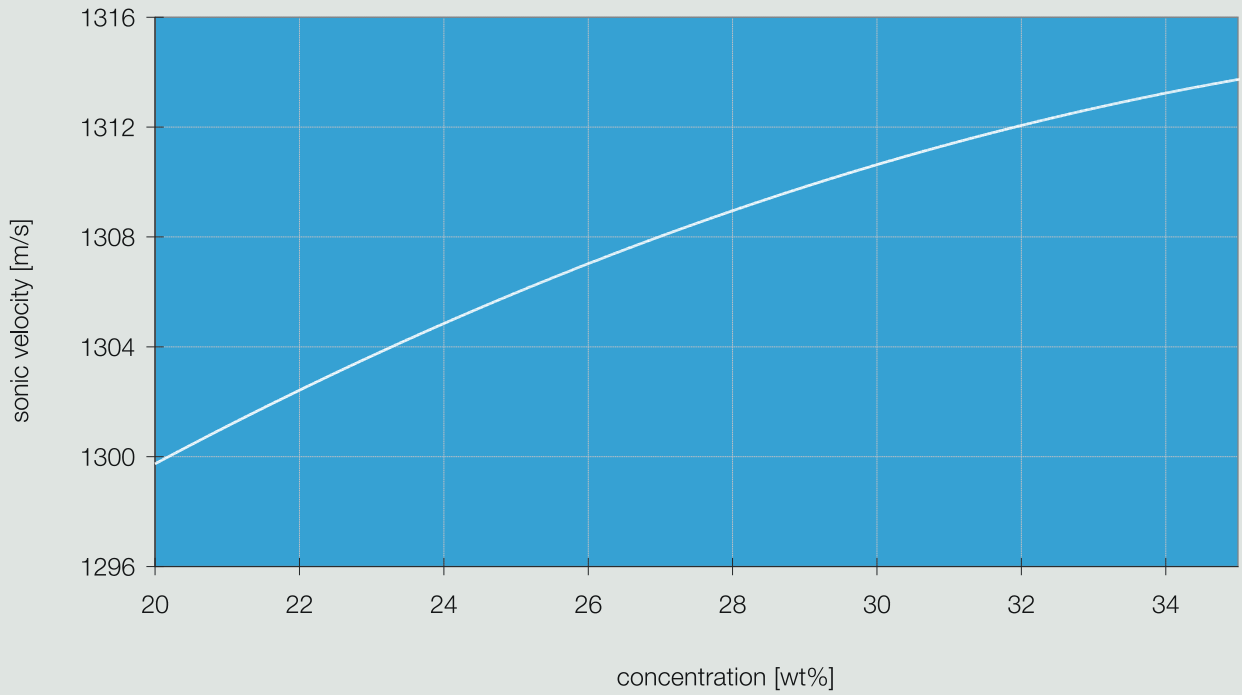
Several applications for LiquiSonic® analyzer measurements of sulfuric acid and oleum concentrations are::

- H_2SO_4 and oleum production
- fertilizer production
- synthesis gas drying
- etching and pickling baths
- mine-ore processing
- refinery catalysis
- production of various chemicals

Two main H_2SO_4 production processes include, first of all, "double contact double absorption" (DCDA) - a process featuring a vanadium pentoxide (V_2O_5) catalyst to produce highly concentrated H_2SO_4 and oleum. A second application developed in 1980 removes sulfur from various process gases in an approach known as "wet sulfuric acid" (WSA) process.

The LiquiSonic® analyzer can easily integrate into the process stages of both DCDA and WSA methods. LiquiSonic's® rapid, robust sensing technology improves asset utilization, process safety and product yield.

Relation of sonic velocity and oleum concentration in the range of 20 - 35 wt% of oleum



1.2 Double contact double absorption process (DCDA)

DCDA uses a variety of starting materials which synthesize into sulfur dioxide during different reactions. Initially, SO_2-containing gas enters a drying tower for removal of its water content. Next, the gas encounters three catalyst beds in the converter where SO_2 oxidizes into SO_3:

$$SO_2 + 0.5\ O_2 \rightarrow SO_3$$

SO_3 then enters the intermediate absorption tower (IAT). Although absorption of SO_3 in a water solution is possible, such a strong exothermal reaction could corrode and destroy the plant. Instead, SO_3 reacts with the water content of 98 wt% H_2SO_4 to form super-concentrated H_2SO_4:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

To avoid environmental pollution, SO_2-containing exhaust air leaving the IAT passes the converter again to prepare SO_3 for processing into concentrated H_2SO_4 in the final absorption tower (FAT).

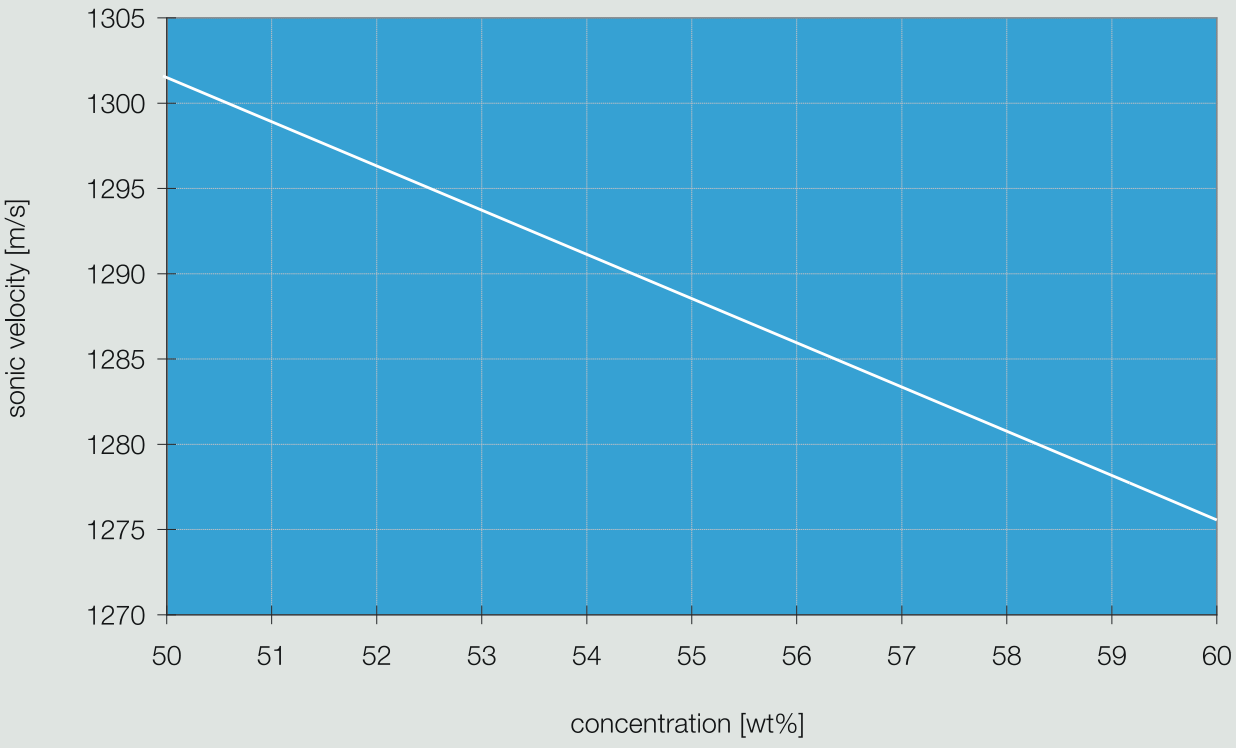
DCDA processing forms oleum as an intermediate product, consisting of 100 wt% H_2SO_4 enriched with SO_3 – also known as fuming sulfuric acid or disulfuric acid. Applications include:

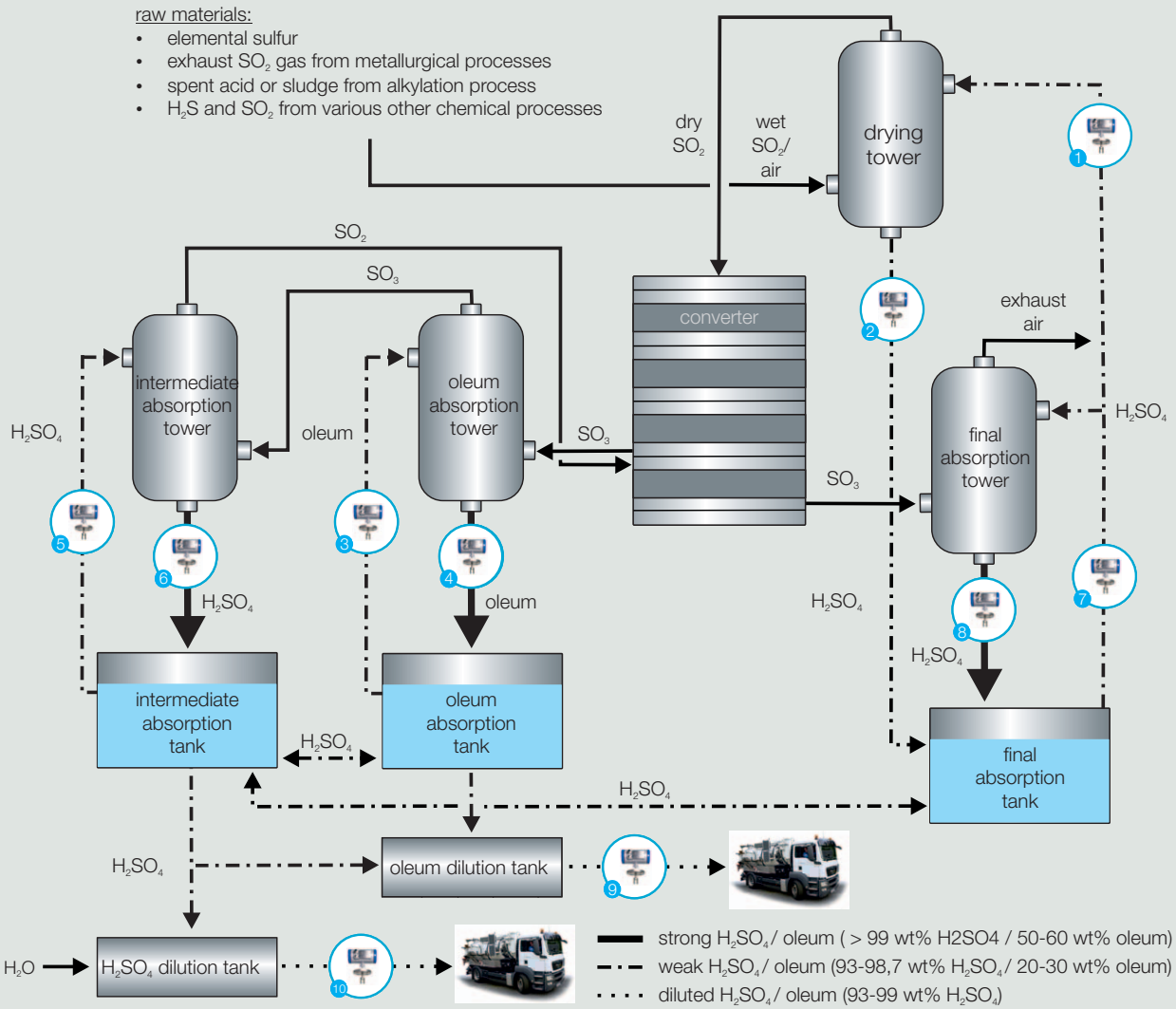
- production of highly concentrated H_2SO_4
- manufacturing of caprolactam and nylon
- nitration process in combination with nitric acid

Oleum is produced by the absorption of SO_3 in an oleum-absorption tower. LiquiSonic® sensors provide excellent process control in oleum concentration ranges of 20 - 30 wt% and 50 - 60 wt% as the graphs depicts.

LiquiSonic® sensors may be installed in feed and return lines of absorption towers and after the dilution unit.

Relation of sonic velocity and oleum concentration in the range of 50 - 60 wt% of oleum





Measuring point	Installation	Benefit
1, 2	feed and return line of drying tower	control of the desired concentration, optimization of the drying process, increase process safety
3, 4	feed and return line of oleum absorption tower	control of the desired concentration, optimization of the oleum absorption process, increase process safety
5, 6	feed and return line of intermediate absortion tower	control of the desired concentration, optimization of the intermediate absorption process, increase process safety
7, 8	feed and return line of final absorption tower	control of the desired concentration, optimization of the final absorption process, increase process safety
9, 10	line after the dilution unit	control of the desired final product concentration

LiquiSonic® measuring points in the DCDA process

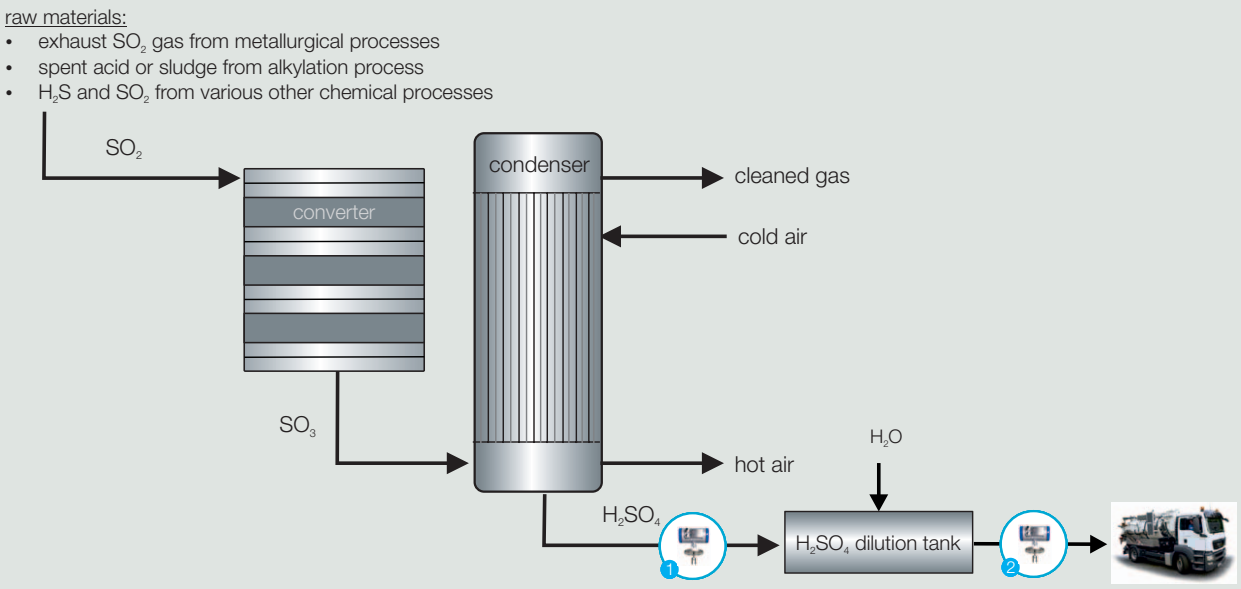
1.3 Wet sulfuric acid process (WSA)

Originally, the WSA process was developed to remove sulfur components from the exhaust gases of various industrial manufacturing processes with a wide spectrum of starting materials which can result in SO_2.

Unlike for DCDA, water vapor remains in the SO_2 gas. By virtue of a special vanadium-containing catalyst, the vapor has no negative impact on the cathalytical oxidation from SO_2 to SO_3 in the converter.

Finally, the SO_3 gas enters the WSA condenser, where water vapor condenses to change SO_3 into H_2SO_4.

Product concentrations of 98 wt% H_2SO_4 are typical. Measuring the concentration inline, the LiquiSonic® sensors are installed in the exit lines for both the WSA condenser and the dilution unit.



Measuring point	Installation	Benefit
1	line after the WSA condenser	control of the desired concentration, optimization of the condensation process, increase process safety
2	line after the dilution unit	control of the desired final product concentration

LiquiSonic® measuring points in the WSA process

1.4 Customer benefits

With the high sensitivity of sonic velocity to sulfuric acid concentration, the LiquiSonic® sensors can achieve an unmatched accuracy of ± 0.03 wt%.

LiquiSonic® overcomes the dual sensitivities of both conductivity and density by generating a clear signal in the concentration range of 80 - 100 wt% H_2SO_4 as graphed below to offer reliable, real-time process data.

In the event of acid degradation to a highly corrosive level under 95 wt%, LiquiSonic® detects that critical acid “runaway” to curb the probability of heat-exchanger or other component damage, enhancing process safety and control.

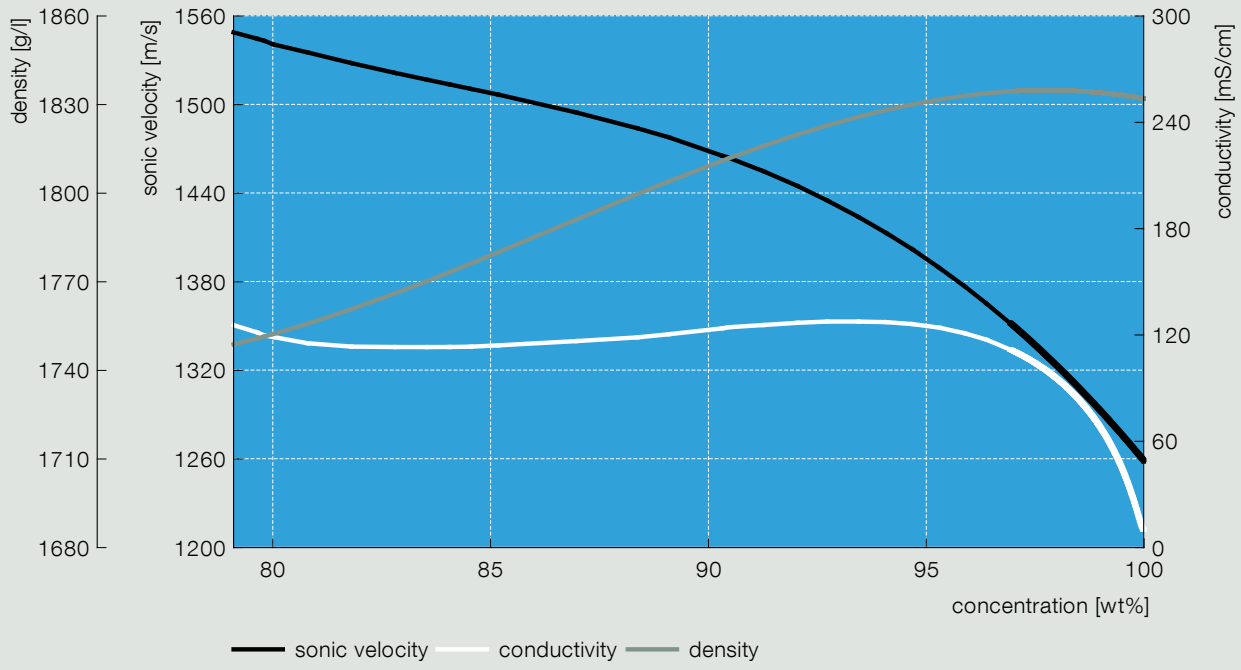
The inline LiquiSonic® analyzer reduces manual laboratory measurements, saving labor and material costs in a typical laboratory titration budget for sulfuric acid measurement:

- sampling time: 15 minutes
- sampling frequency: 6 times per day
- labor costs: 50 € per hour (69 $ per hour)
- investment: 18,000 €
- cost savings: 17,250 € per year (23,800 $ per year)
- investment payback within 13 months

Additional benefits of LiquiSonic® measuring systems include:

- easy, user-frinedly installation (plug&play)
- excellent long-term stability
- one sensor for all applications (reduced investmenst costs)
- comprehensive diagnostic capabilities
- suitability for all needed concentration ranges with high accuracy
- enhanced process control and safety

Advantage of sonic velocity over conductivity and density



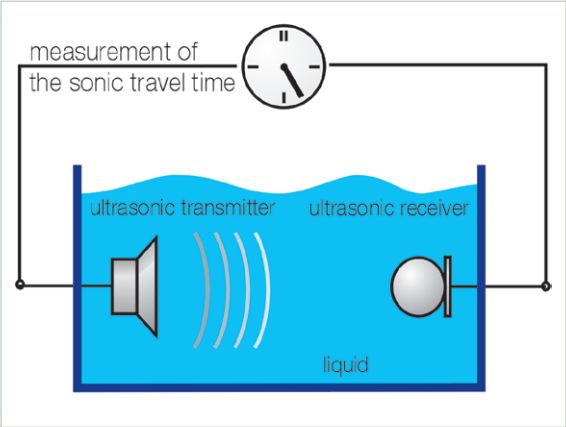
2 LiquiSonic® system

2.1 Measuring principle

The LiquiSonic® ultrasonic analyzer can determine liquid parameters such as concentration or density, as well as being useful for phase separation and reaction monitoring.

The measuring principle is based on the determination of sonic velocity in liquids. The sensor distance (d) between the sonic transmitter and receiver is known, so it is possible to determine sonic velocity (v) simply by clocking the travel time (t) of the sonic signal (v = d / t). Since sonic velocity depends on substance concentration, they form a direct relationship to compute and control concentration levels.

The ultrasonic measuring method is independent of a liquid's optical transparency and features high accuracy, repeatability and reliability. Complementing the sonic velocity measurement, the LiquiSonic® analyzer includes a fast, accurate temperature measurement for temperature compensation – offering great benefits for many applications where conventional measuring methods are limited.



Measuring principle of sonic velocity

2.2 Sensor

The liquid-wetted parts of the sensor are made of corrosion-resistant Hastelloy C-2000.

The rugged, completely enclosed design requires no gaskets or "window", making it totally maintenance-free.

Additional sensor features such as flow / stop, full / empty pipe monitoring greatly advance process control.

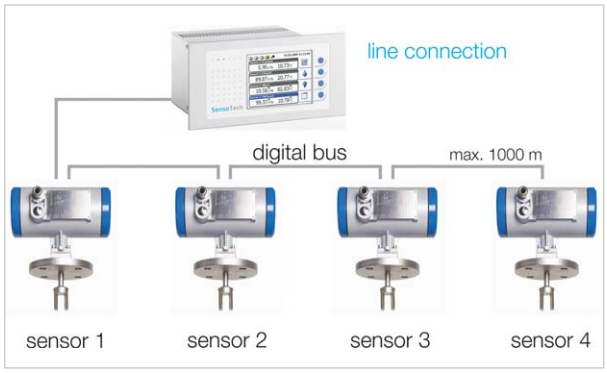
Special high-power technology stabilizes measuring results, even when facing gas-bubble accumulations or large-scale signal attenuation through the process flow.

Immersion sensor 40-14

2.3 Controller

LiquiSonic® sensing is available in three systems: LiquiSonic® 20, LiquiSonic® 30 and LiquiSonic® 40.

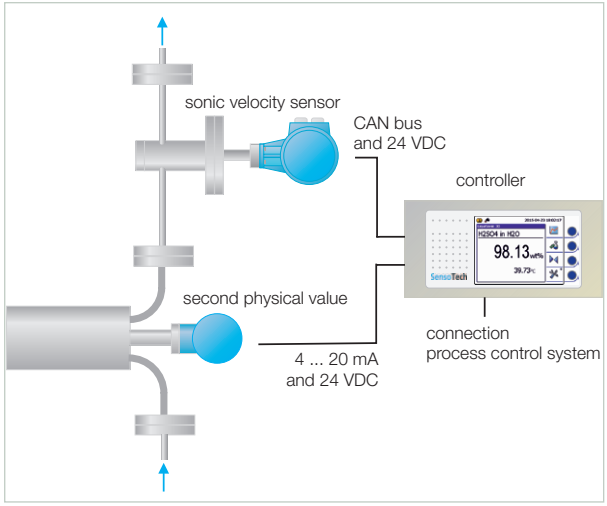
LiquiSonic® 30 is a highly efficient device that includes one controller with connection up to four sensors that can be installed in different locations.



Controller with connection of maximum four sensors

LiquiSonic® 20 is an economical single-channel solution.

LiquiSonic® 40 enables the simultaneous determination of two concentrations in one liquid mixture by tracking a second physical quantity in combination with the sonic velocity.



LiquiSonic® 40 application

LiquiSonic® continuously senses both concentration and temperature in pre-defined ranges for updating all process-related information every second.

Measuring data can be transmitted in several defined analog-digital forms or through different field-bus interfaces to communicate with process control systems or computers. It is possible to create user-configured thresholds to regulate the process to avoid undesirable process states, including acid "runaway."

The controller features an integrated data logger which can store up to 4 GB of process information with up to 256 datasets for different process liquids, such as H_2S0_4 or oleum.

The event log records states and configurations such as manual product switches, changes to date and time, alarm messages or system states.

The software SonicWork facilitates data-log display for easy-to-create, user-defined process reports.

Accessories include:

- fieldbus
- modem
- network integration
- web server
- rack-mounted housing (anodized aluminium)
- wall-mounted housing (plastic or stainless steel)

Controller integrated in the wall-mount plastic housing

2.4 Technical specifications

controller type	controller 20 controller 30 controller 40
sensor type	immersion sensor
sensor material	Hastelloy C-2000
sensor length	customized
minimum process temperature	20 °C (-4 °F)
maximum process temperature	120 °C (248 °F) optional 200 °C (392 °F)
maximum process pressure	250 bar (3626 psi)
process fitting	DIN ANSI others on request
interface	analog outputs: 4 x 4-20 mA MODBUS RTU Profibus DP digital outputs: 6 x electronical relays
concentration range H_2SO_4:	70 wt% to 100 wt%
concentration range oleum:	20 wt% to 35 wt% 50 wt% to 60 wt%
Ex approvals	ATEX IECEx on request: FM, CRN
protection degree	IP65 IP76 IP68 NEMA 4X
ambient temperature range	- 20 °C to 60 °C (-4 °F to 140 °F)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ndards **for process analysis.**

n, that **creates new solutions.**

osolute **spirit of development.**

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 and density 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.

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In liquids, we set the measure.

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