Fertilizer production

Inline analytical technology for:

- ammonia
- ammonium nitrate
- nitric acid
- phosphoric acid
- sulfuric acid
- urea
- urea ammonium nitrate

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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

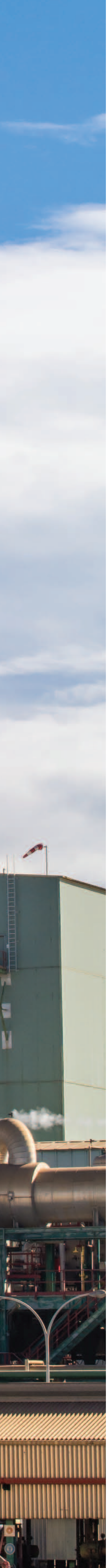
LiquiSonic's® ‚state-of-the-art' digital signal processing technology guarantees highly accurate, fail-safe measuring of absolute sonic velocities and liquid concentrations.

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:

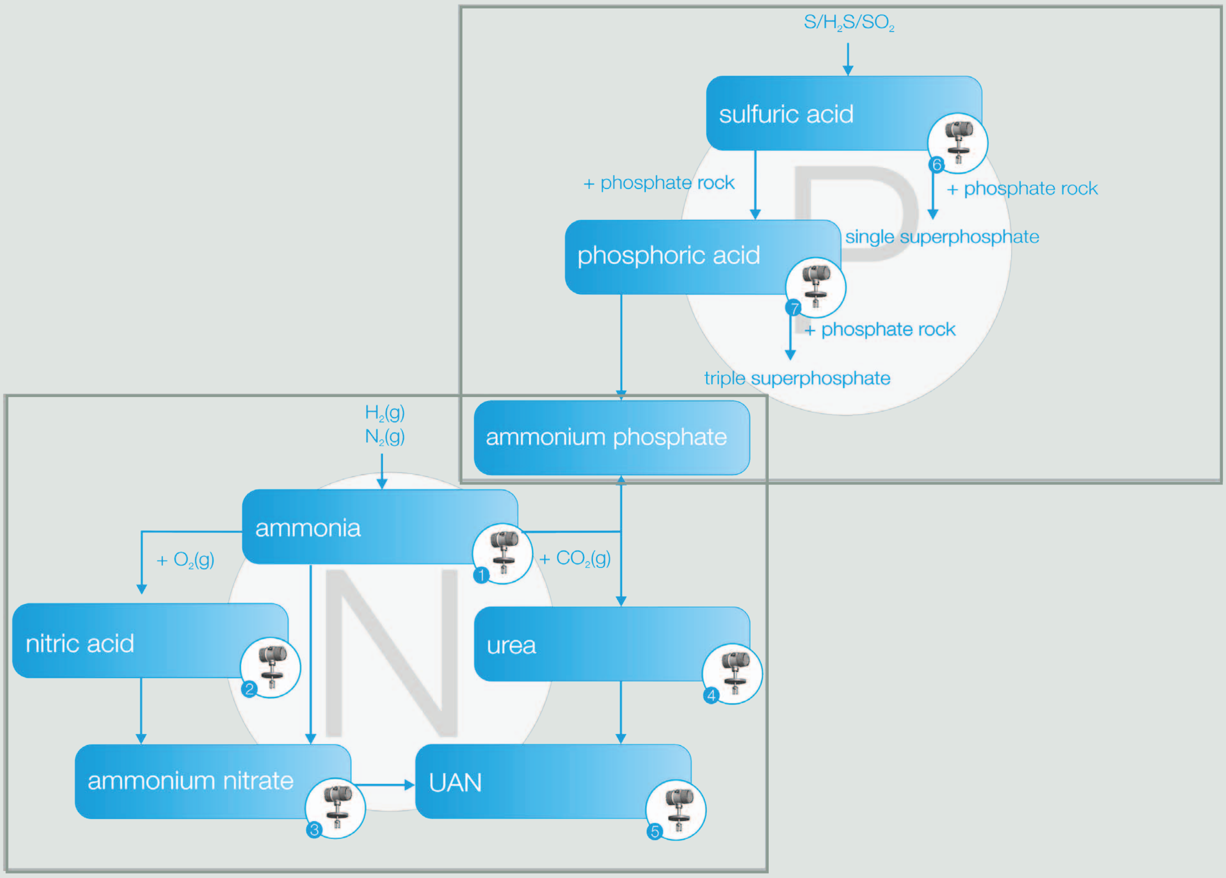
- absolute sonic velocity as a well-defined and retraceable physical quantity
- independence from conductivity, color or optical transparency of the process liquid
- installation directly into pipes, tanks or vessels
- robust, all-metal, gasket-free sensor design with no moving parts
- corrosion-resistant 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 Processes


S/H2S/SO2
sulfuric acid
+ phosphate rock
+ phosphate rock
phosphoric acid
single superphosphate
+ phosphate rock
triple superphosphate
ammonium phosphate
H2(g)
N2(g)
ammonia
+ O2(g)
+ CO2(g)
nitric acid
urea
ammonium nitrate
UAN
1
2
3
4
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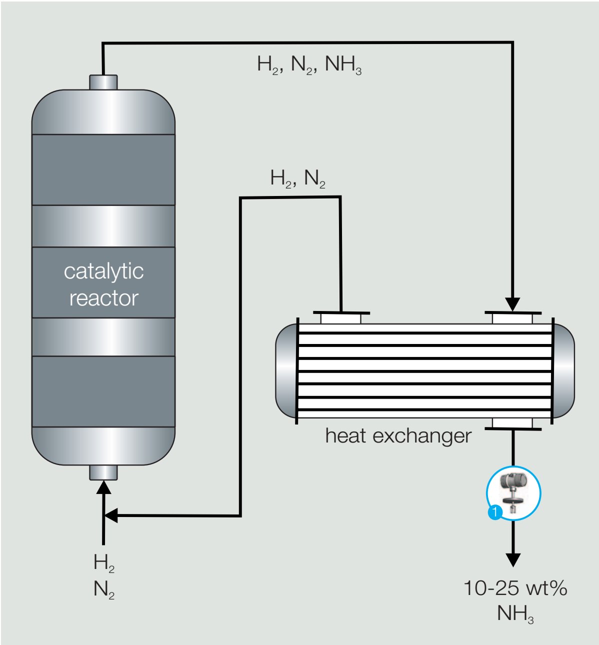
7
P
N

1.1 Ammonia synthesis

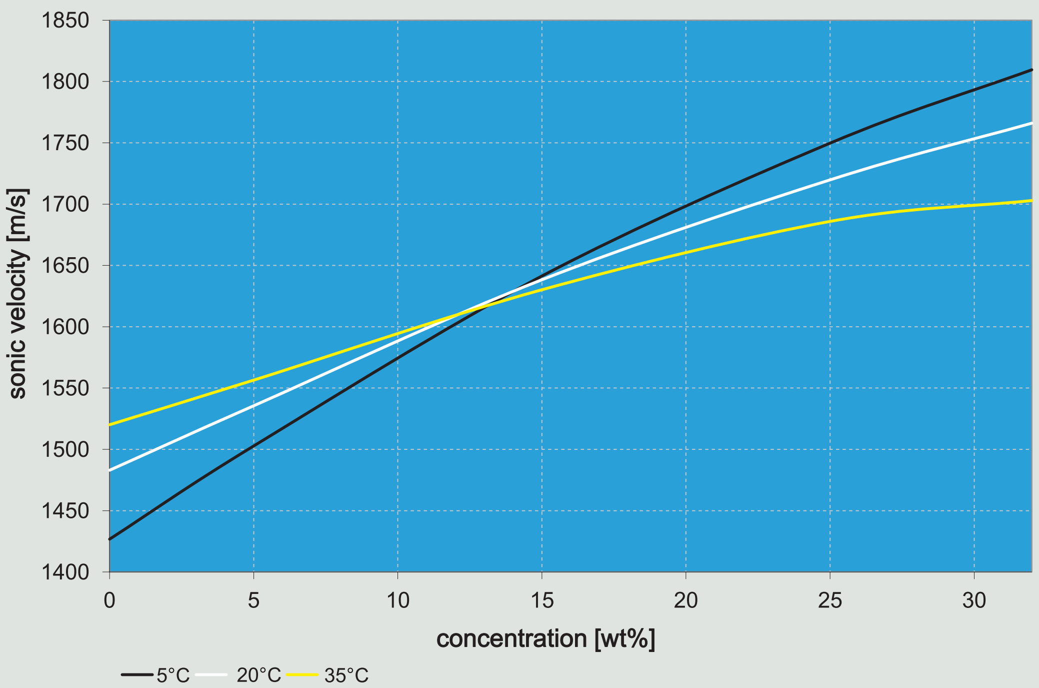
Ammonia (NH_3) is a key ingredient in nitrogen fertilizer production. Ammonia also serves as activation material for synthesizing nitric acid and urea for further processing into fertilizers. On an industrial scale, the Haber-Bosch process develops ammonia from the elements nitrogen (N_2) and hydrogen (H_2) using three production stages: gas production, gas purification and synthesis.

Ammonia formation ($N_2 + 3H_2 \rightarrow 2NH_3$) is catalyzed using iron or ruthenium within the catalytic reactor. Cooling finally condenses ammonia in water solution. In ambient temperatures, the concentration of NH_3 typically ranges from 10 wt% to 25 wt%. This can be precisely monitored by the LiquiSonic® analyzer as seen in the graph below.



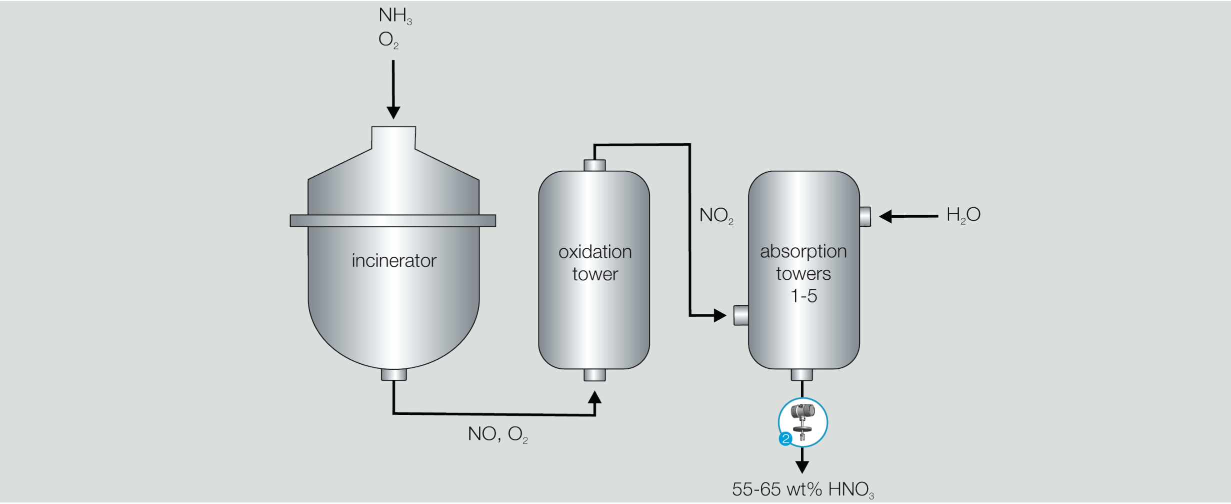
LiquiSonic® in the ammonia synthesis process

Relationship between sonic velocity and concentration of ammonia in water



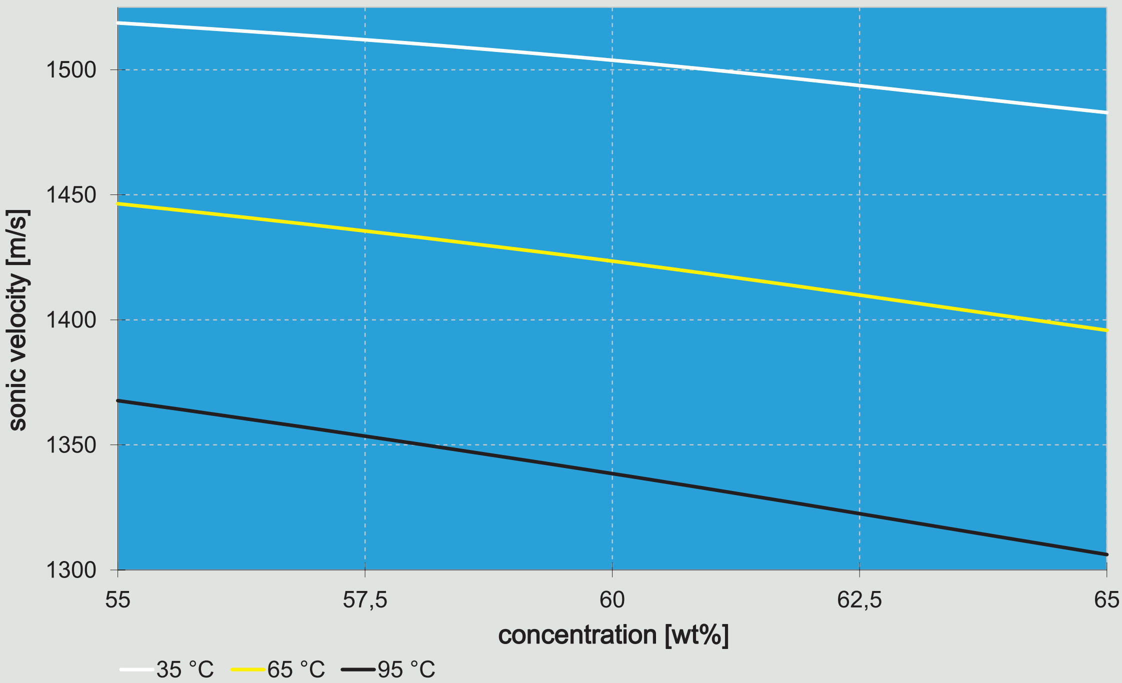
1.2 Nitric acid synthesis

Nearly 70 % of nitric acid (HNO_3) production goes toward developing crop fertilizer ammonium nitrate (AN), with the rest used in producing explosives and for the pickling of stainless steel. Nitric acid is formed by the Ostwald process in three stages. First, a gas mixture of NH_3 and air is incinerated where NH_3 reacts on a platinum-rhodium catalytic surface to form nitric oxide (NO). Next, NO gas cools to naturally react with secondary air to prepare nitrogen dioxide (NO_2). Lastly, NO_2 feeds an absorption tower to engage counter-flowing water (H_2O) to yield nitric acid in typical concentrations of 55 wt% to 65 wt% HNO_3. This production range can be measured by the LiquiSonic® analyzer as shown in the following exhibit.



LiquiSonic® in the nitric acid sythesis process

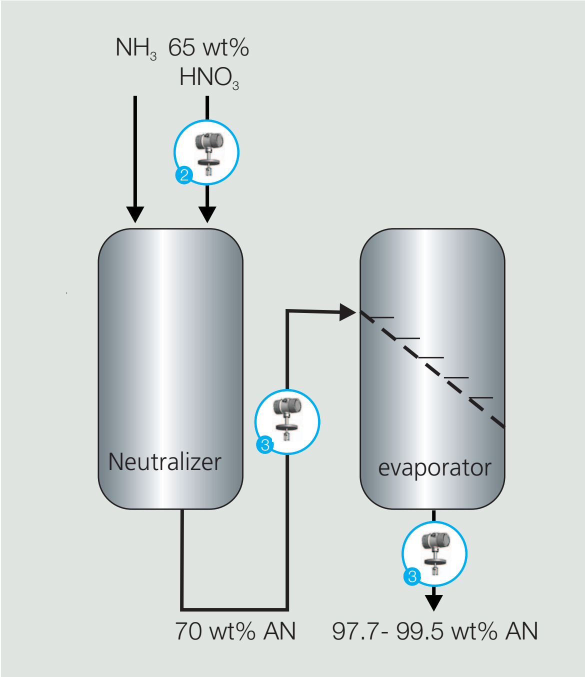
Relationship between sonic velocity and concentration of nitric acid in water



1.3 Ammonium nitrate production

Ammonium nitrate (NH_4NO_3) or “AN” is one of the most important nitrogenous fertilizers comprising 12.4 % of the world‘s total nitrogen consumption. Beyond agriculture, AN is useful in the production of explosives.

Industrial ammonium nitrate is produced almost exclusively by neutralizing NH_3 with HNO_3 (55 wt% to 65 wt%) to form AN with concentrations of about 70 wt% that can be enhanced to 99.5 wt% by an evaporation process.

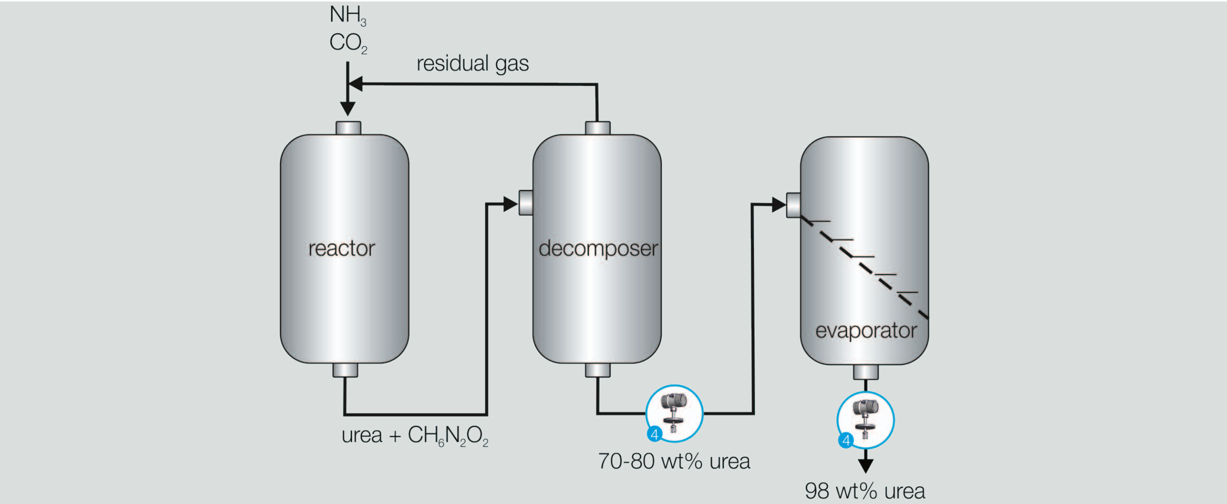


LiquiSonic® in the ammonium nitrate production process

1.4 Urea production

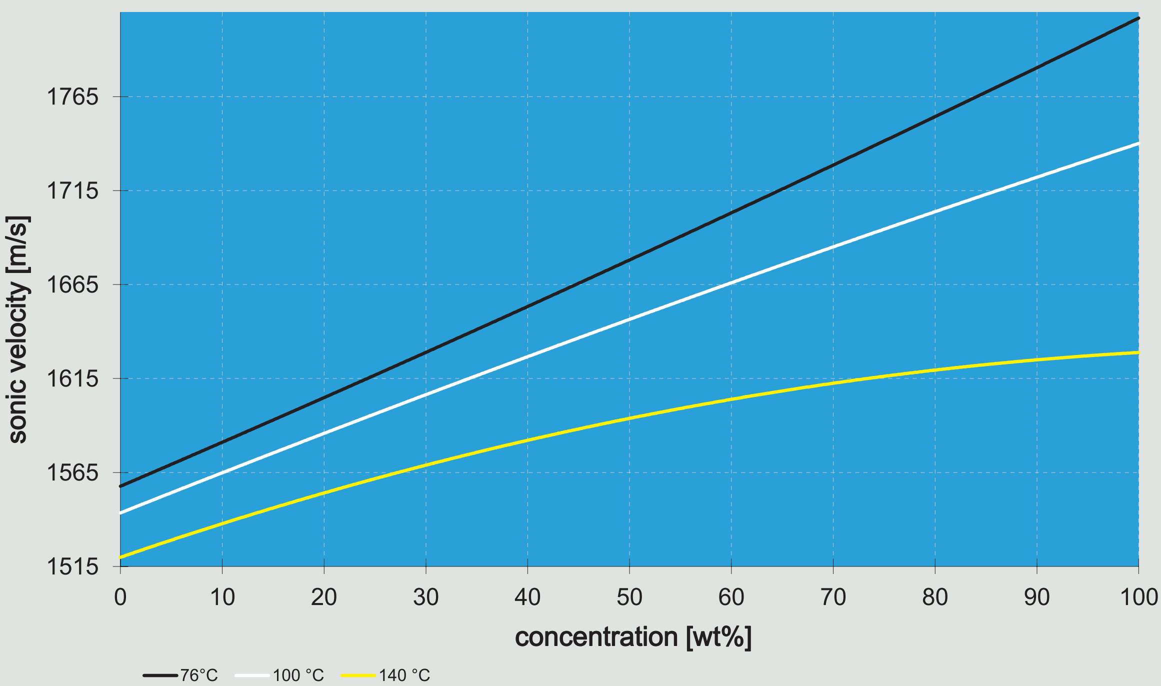
Urea's (CH_4N_2O) high nitrogen content makes it ideal as an agricultural fertilizer and for key roles in pharmacy (e.g. skin care) and chemistry (e.g. melamine). Urea production follows NH_3 formation since Haber-Bosch products – ammonia (NH_3) and carbon dioxide (CO_2) – are the required building blocks for urea synthesis.

Urea production occurs in two stages. First, NH_3 and CO_2 are heated under pressure to develop ammonium carbamate ($CH_6N_2O_2$). Second, dehydration removes H_2O to yield concentrations of 70 wt% to 80 wt% urea – recoverable up to 98 wt% by evaporation. The graph below depicts the LiquiSonic® measurement range for this yield level with high accuracy.



LiquiSonic® in the urea production process

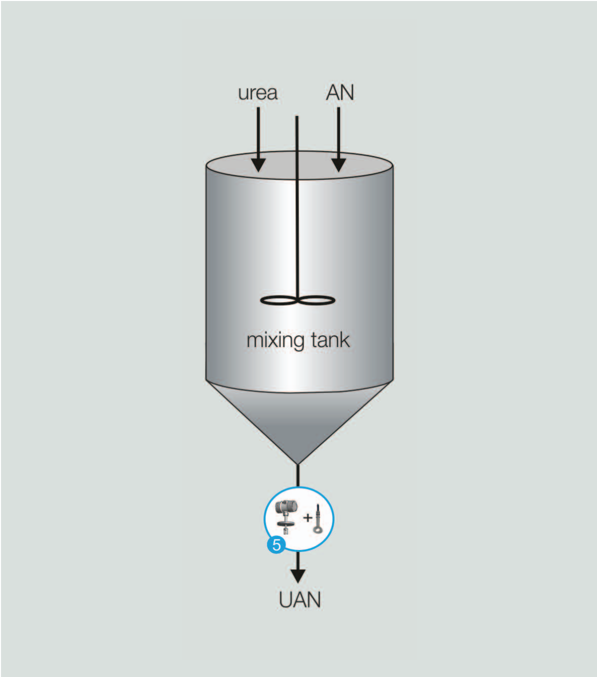
Relationship between sonic velocity and concentration of urea in water



1.5 UAN production

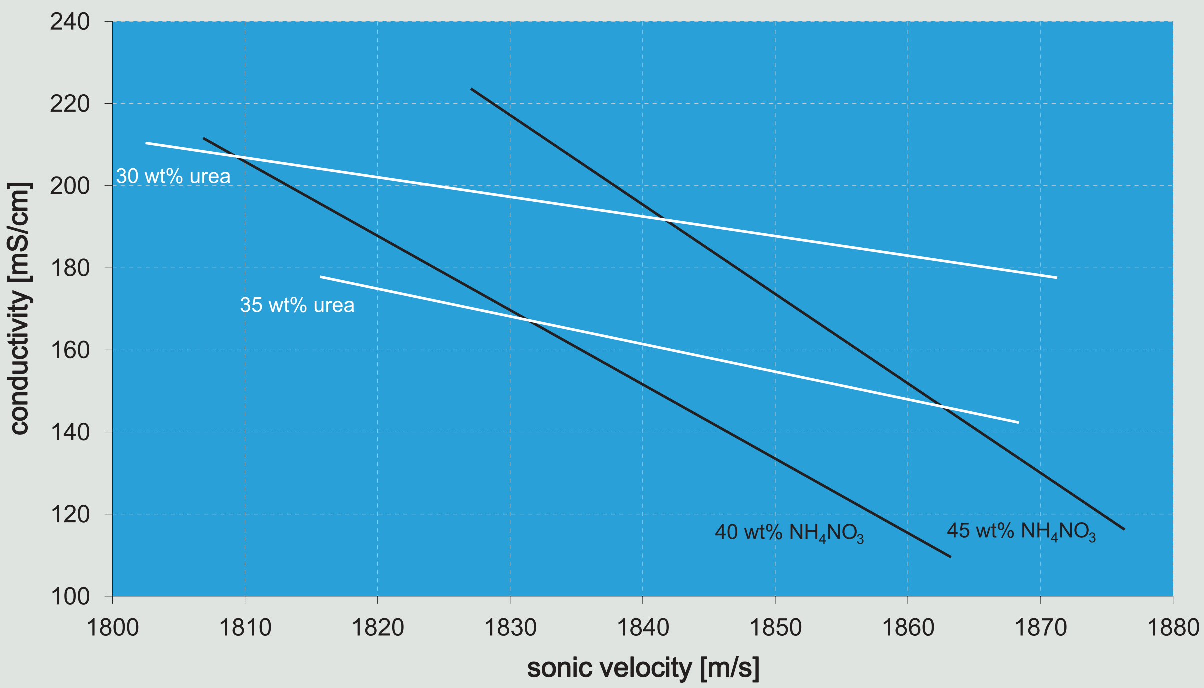
Industrial plants that prepare urea ammonium nitrate solutions (UAN) usually incorporate urea and AN production lines upstream. Typical recipes merge 40 % AN, 30 % urea and water together in a mixing tank.

The LiquiSonic® analyzer measures the concentrations of reactants and products using a combination of sonic velocity and conductivity.



LiquiSonic® in the UAN production process

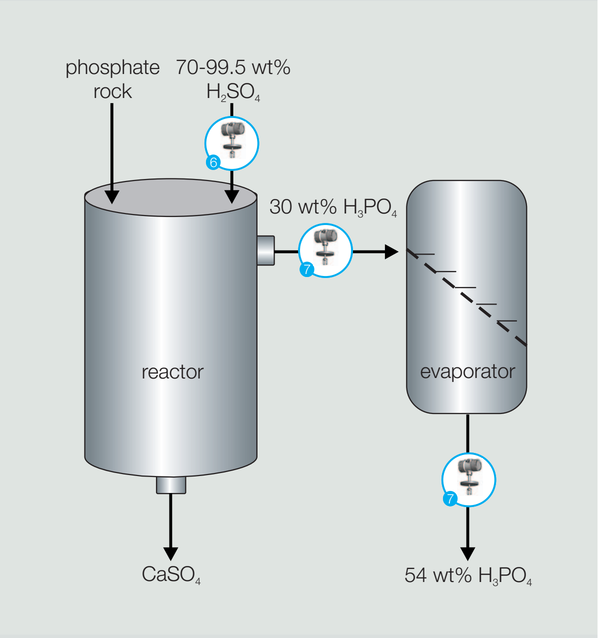
Relationships among sonic velocity, conductivity and concentration of UAN in water



1.6 Phosphoric acid production

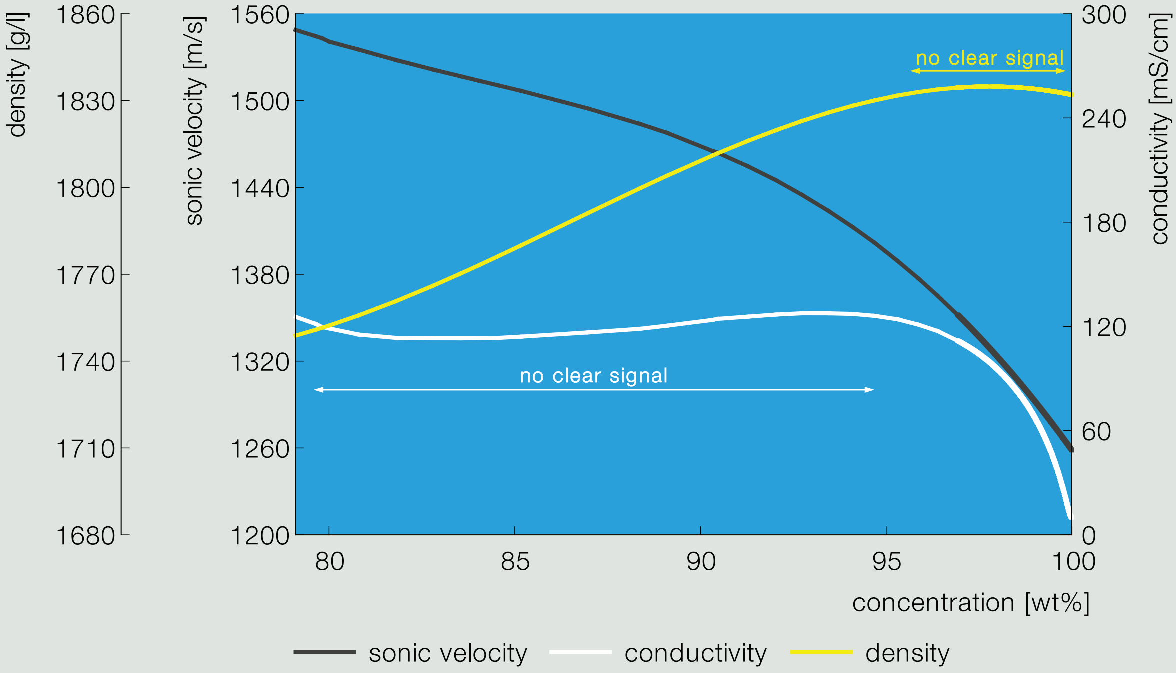
Phosphoric acid (H_3PO_4) is a most important inorganic acid formed by combining phosphate rock (calcium-laden “apatite”) with concentrated sulfuric acid (98 wt% H_2SO_4). These two components react to yield about 30 wt% phosphoric acid alongside the byproduct calcium sulfate ($CaSO_4$).

Evaporators can further concentrate phosphoric acid to 54 wt%. As seen below, concentration monitoring of H_2SO_4 and H_3PO_4 within this process is favored using the LiquiSonic® analyzer.



LiquiSonic® in the phosphoric acid production process

Advantage of sonic velocity over conductivity and density in sulphuric acid



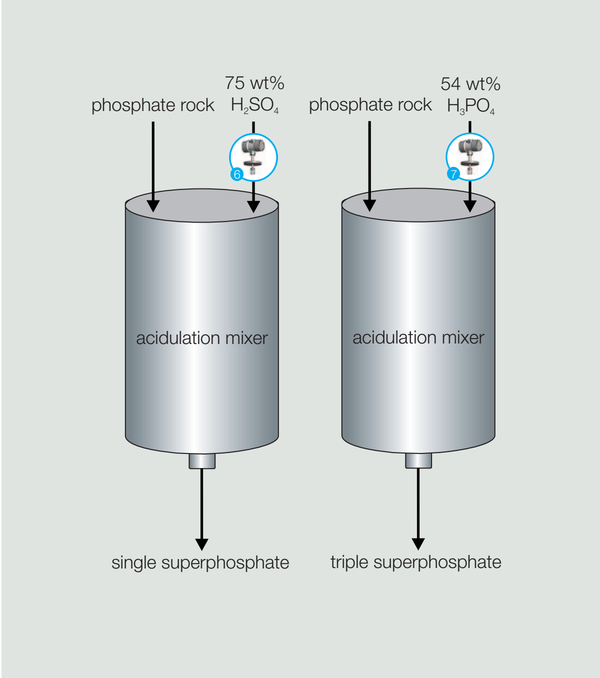
1.7 Superphosphate production

Superphosphates are fertilizers that vary both in phosphate wt% and in secondary water-insoluble contents.

Single superphosphate forms by mixing pulverized phosphate rock with 70 wt% to 75 wt% of H_2SO_4. Post-reaction solutions solidify a finished product containing 16 wt% to 20 wt% of phosphorus pentoxide (P_2O_5).

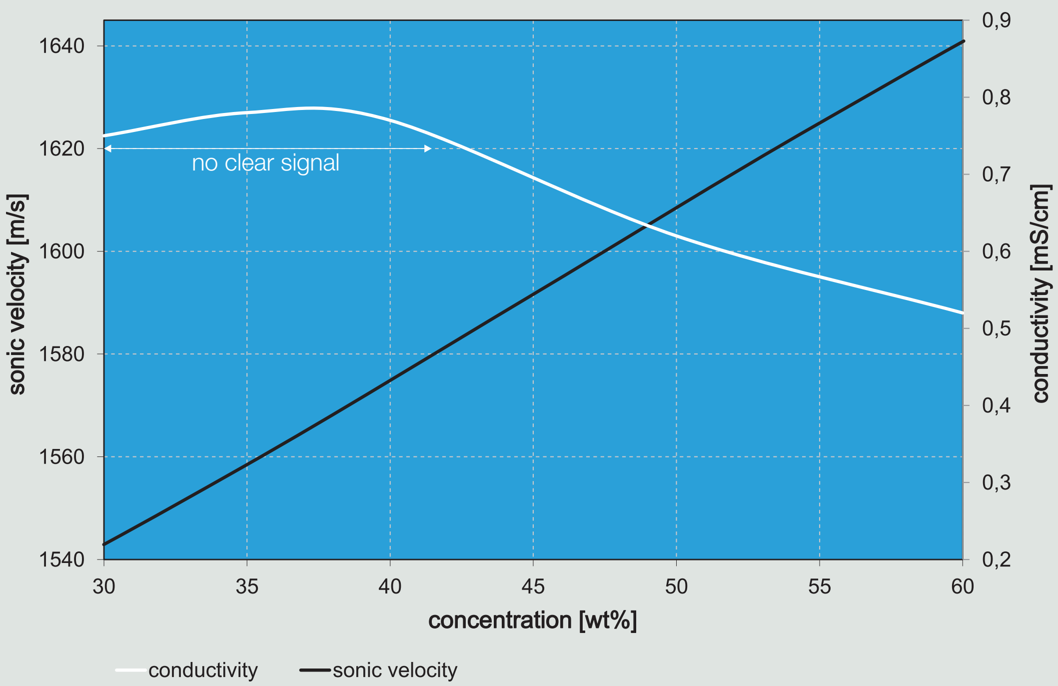
Triple superphosphate is prepared with phosphate rock that reacts with phosphoric acid (50 wt% to 54 wt% P_2O_5). A solid fertilizer with more than double the phosphate content is thus produced (45 wt% to 46 wt% P_2O_5).

The LiquiSonic® analyzer facilitates safe control of critical ranges for sulfuric-phosphoric acid concentrations.



LiquiSonic® in the production of superphosphates

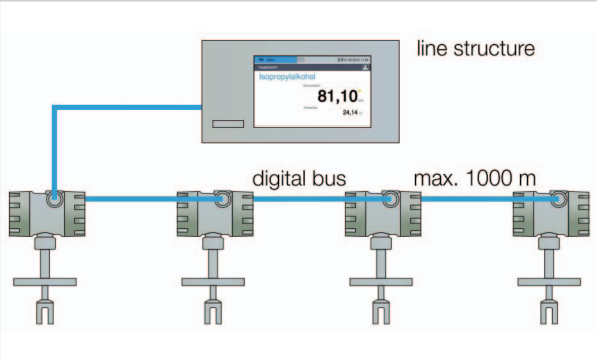
Advantage of sonic velocity over conductivity in phosphoric acid



2 LiquiSonic® system

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

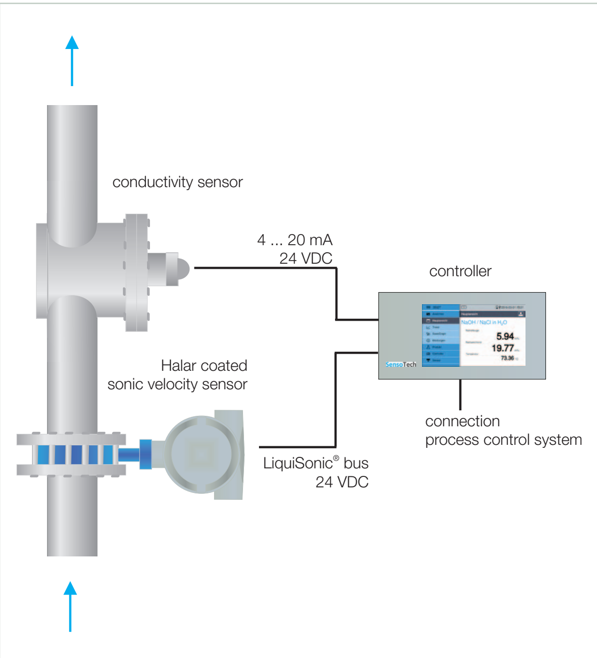
LiquiSonic® 30 is a highly efficient device that includes one controller with connection up to four sensors that can be installed in different locations.



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 sonic velocity. In fertilizer production processes, the LiquiSonic® 40 system includes a conductivity probe as second physical value.



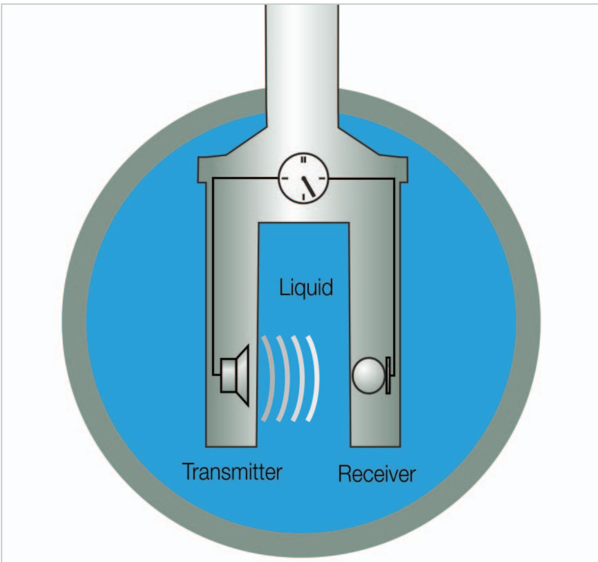
LiquiSonic® 40 application

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 Customer benefits

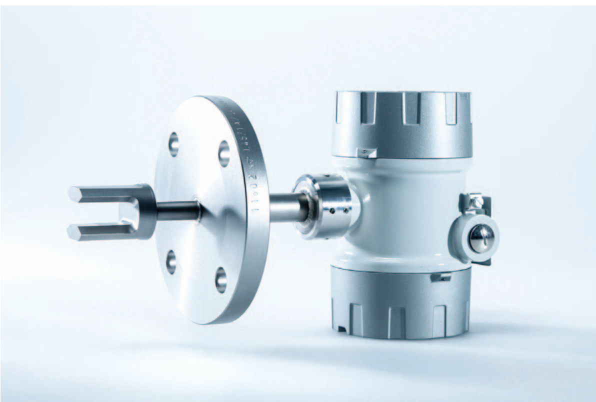
- improved process control
- long-term stability and maintenance-free operation with no measurement drift
- accelerated return on investment (ROI) through low operating expenses
- integrated high-precision temperature measurement with accuracy of ± 0.025 K
- concentration accuracy of ± 0.05 wt%
- ultra-fast measurement response times
- comprehensive diagnostic capabilities
- no bypass required
- no moving parts, gaskets or seals
- measurement unaffected by solid or gas particles
- measurement sensitivity independent of flow velocity, vibrations, fouling and abrasions
- applicable in any facility
- available in customer-specified materials
- same price regardless of pipe diameter

2.3 Sensor

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

The liquid-wetted parts of the sensor are made of stainless steel or corrosion-resistant material such as Hastelloy C-2000, Halar or PFA. The rugged, completely enclosed design requires no gaskets or "window", making it totally maintenance-free.

Additional sensor features such as flow / stop or 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

2.4 Controller

The controller processes and displays the measuring results. The operation via the high resolution touch screen is easy and intuitive. Secure network integration including web server allow operating the controller alternatively via browser with a PC or tablet.

The data can be transmitted in several defined analog-digital forms or through different fieldbus 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 2 GB of process information with up to 32 (optional 99) data sets for different process liquids. For processing on the PC, the data can be transferred via network or USB port. In addition, the controller enables creating easily process reports for documentation purposes.

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

Accessories include:
- fieldbus
- UMTS router
- network integration & web server
- rack-mounted housing (anodized aluminium)
- wall-mounted housing (plastic or stainless steel)

Controller integrated in the wall-mount plastic housing

2.5 Technical specifications

controller type	controller 20 controller 30 controller 40
sensor type	immersion sensor
sensor material	Stainless steel Hastelloy C-2000 on request: Halar, PFA, ETFE.Titan, Tantalum, Monel
sensor length	customized
minimum process temperature	-20 °C (-5 °F)
maximum process temperature	120 °C (250 °F) optional 200 °C (390 °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
Ex approval	ATEX IECEx FM
protection degree	IP65 IP67 IP68 NEMA 4X NEMA 6P
ambient temperature range	-20 °C to 60 °C (-5 °F to 140 °F)
accuracy	sonic velocity: up to ± 0.1 m/s concentration: up to ± 0.05 wt%

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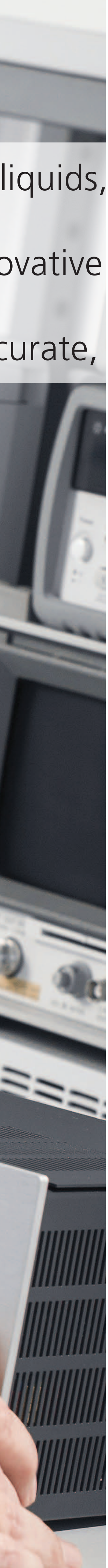

liquids, **we set the measure.**

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.

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In liquids, we set the measure.

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