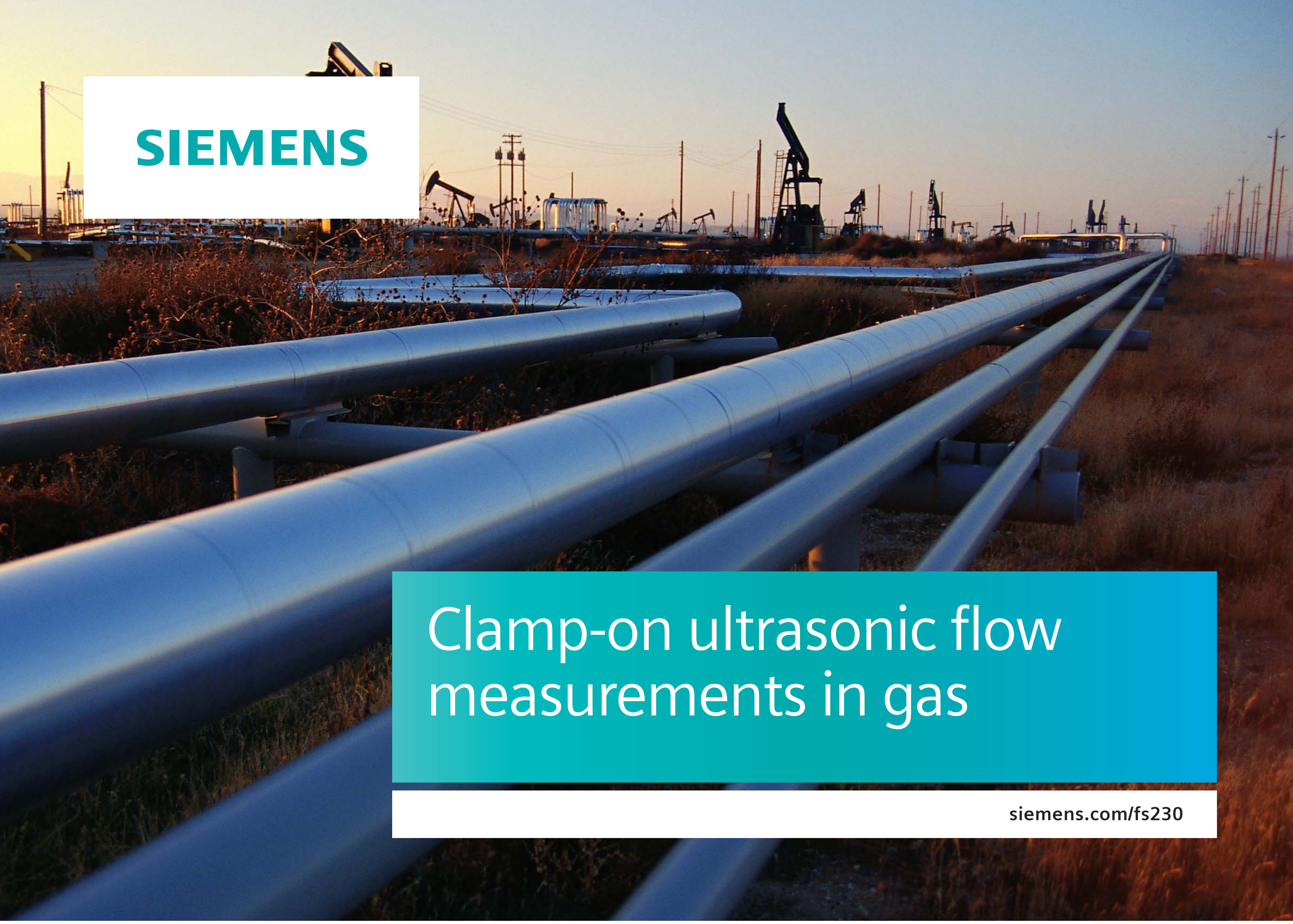


SIEMENS

Clamp-on ultrasonic flow measurements in gas

siemens.com/fs230

Clamp-on technology for flow measurements

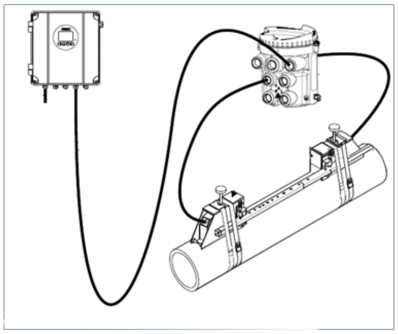
Non-intrusive flow measurements with the clamp-on technique use acoustic sonic waves to measure flow. Clamp-on sensors measure without contacting the medium by alternatingly sending/receiving ultrasonic signals. The emitted signals are being accelerated in the direction of flow, and slowed down when travelling against the direction of flow. The time difference between the emission of the signal and its reflection is the basis to calculate the transit-time difference and deriving the velocity of the flow going throuh the pipe. With non-intrusive flow measurements, operators profit from a flexible and cost-effective solution for measuring liquids and gases - independent of the conductivity of the medium to e measured, its pressure, temperature or viscosity and with guaranteed accuracy. For over 40 years, Siemens has been advancing clamp-on technology to further optimize the interplay of sensors, pipe charactersitcs and medium. Lambwave sensors for instance have a designated range of frequencies suitable for specific pipe wall thicknesses. The sensors broadcast frequencies within their available range through the pipe to identify the frequency most closely matching that of the pipe wall. Working "in sync" with the pipe produces a stronger, more stable signal independent of flow velocity.

For the majority of applications, Lamb-wave sensors ensure better performance over a wider array of medium conditions. They are designed primarily for steel pipes and are the preferred choice for hydrocarbon and gas applications . Independent of the technology and sensor variant used, clamp-on supports pipe sizes from DN 50 to DN 1500.

Gas- measurements with the SITRANS FS230 flow system

A gas measurement with the SITRANS FS230 flow system consists of the following components:

- one pair of SITRANS FSS200 clamp-on sensors
- a SITRANS FS-DSL digital sensor link
- a SITRANS FST030 transmitter



SITRANS FS230 for gas measurements:

- Suitable for new systems as well as for retrofitting
- Robust sensor assembly and device construction for years of operation, immersion-proof
- Measurement technology without media contact
- Fast measured value acquisition, real 100 Hz signal update
- Very high basic accuracy, easily expandable up to 4-path measurement
- Reynolds compensation including gas quality, pressure and temperature (gas table AGA8)
- State-of-the-art diagnosis, data backup and data output
- Designed according to NAMUR requirements and Industry 4.0, with a wide range of diagnostic options

Sensor Spotlight: SITRANS FSS200 sensors

As mentioned in the beginning, the type of sensors used is a decisive factor for the measurement quality of the flow system.
Due to the low density of gaseous media, ultrasound signals do not propagate as well as in liquids, which affects the signal-to-noise ratio. Hence, High Precision sensors are the device of choice for gas applications, offering maximum transmission power and optimal signal evaluation. To make this possible, the Wide Beam technology tests the entire frequency range of the sensors upon startup to determine the ideal measuring frequency. This enables optimum use of the sensors also in changing measuring conditions.
The SITRANS FSS200 sensor line is available with 10 different frequency ranges, withstanding process temperatures up to 120 °C.

Spotlight Internal / External Digital Sensor Link

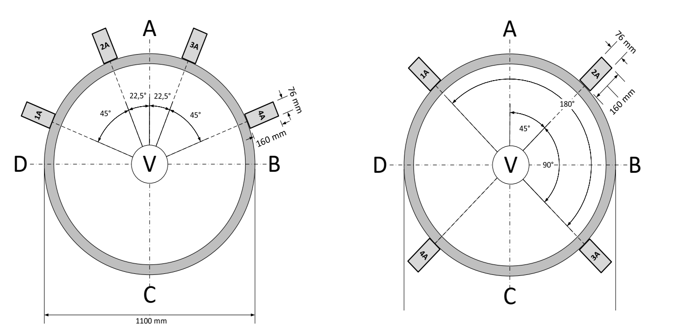
The digital sensor link (DSL) is the crucial link between the sensors and the transmitter. The electronics module receives the analogue signals from the sensors and digitizes them to send them on to the transmitter.
A SITRANS FS230 flow system comes with two options: an integrated DSL or the external variant in an explosion-proof housing. While the integrated DSL version is suited for simple measurements (i.e. pressurized air), the use of the external DSL enbables measurements in hazardous areas (zone 0/1). In these cases, the electronics module is mounted close to the sensors. The short analogue cables allow best possible EMC protection before the analogue signals are then passed on to the transmitter in digitized form.

Transmitter Spotlight: SITRANS FST030

The SITRANS FST030 transmitter was designed and developed for the highest accuracy in billable use. In laboratory conditions the SITRANS FST030 achieves measurement errors of less than 1 % can be achieved (for flow velocities starting from 0.5 m/s). In practice, however, lab-like conditions are seldom in place, often unfavourable inlet and outlet sections complicate the measurement. Clamp-on technology offers the option of mounting additional sensors to improve the measuring performance. To ensure optimim measuring accuracy, the SITRANS FST030 transmitter supports up to four paths.

Challenges in measuring gaseous products

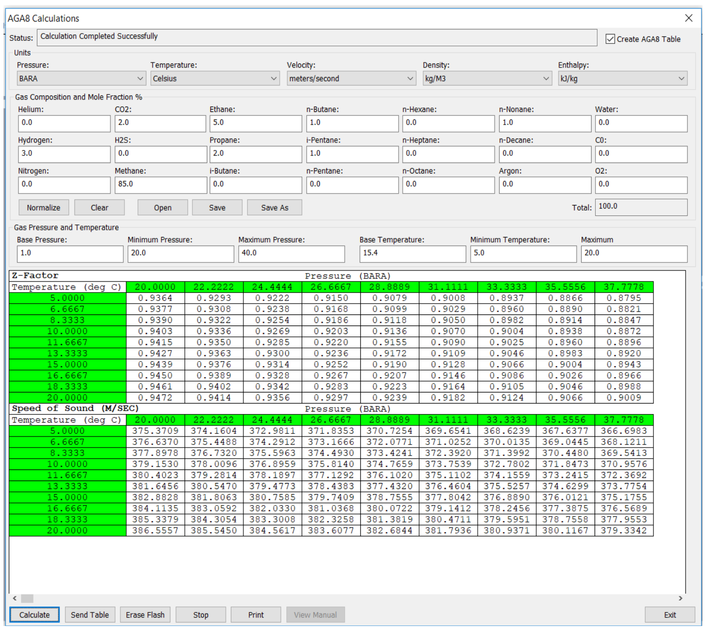
Sending ultrasonic signals through a low density medium such as gas is a challenge. At low pressure conditions, the signals are being scattered a lot more, causing a negative impact on the signal-to-noise ratio. Using Lambwave Sensors with Wide Beam Technology can remedy this. An additional positive influence on measuring accuracy is achieved when utilizing damping foils - matched to the frequency range of a sensor - in order to keep the interference signals as small as possible.
The updated SITRANS FS230 also comes with a frequency pass filter. Upon installing the sensors, it is checked at which frequency the highest measurement signals are obtained. This particular frequency is then retained and kept in a defined range by the help of a bandpass filter to suppress interferences as good as possible.
But there are more challenges with gas measurements: Flow speeds of up to 40 m and more are a common characteristic in gas applications. Clamp-on water measurements on larger pipes would very quickly lose the measurement signal due to the beam blowing effect, proverbially blowing away the signals with the stream. When measuring gas, the lower density of the medium to be measured helps us here, as the angle of incidence is much smaller than in liquid applications and thus the sensor distance is also smaller which mitigates the effect of high flow speeds on the sonic signals. Nevertheless, very high flow velocities must be carefully considered during commissioning; special settings (high flow setting) correct the resulting change in the measurement signals.



Sensor mounting options for 4 path measurements:
Reflect mode (left), Direct X mode (right).

Important: For gas measurements, especially for large pipes, it is very often advisable not to operate the sensors in reflective mode, here the use of sensors in X-Direct mode with only one pipe crossing is the solution. Multipath measurements are strongly recommended.

Pulsating flow is another factor to take into account. This effect often only occurs in certain flow velocity ranges, but is almost always associated with signal loss and measurement failure. In this case, the digital damping behavior must be set - still manually - to ensure that only individual transmit and receive sequences transmit form an average. Here, too, the fast update rate with real 100 Hz proves to be very helpful.
As clamp-on measurements determine the volume flow inside the pipe from the outside, another challenge they are faced with is that they inevitably need to measure through the center of the pipe.
The challenge of gas quantity measurement is therefore to record the different flow velocities present in the pipe, taking pressure and temperature into account, as well as the associated change in viscosity and flow behavior.
Based on the actual measured values of the current flow rate, the measuring device accesses an internal AGA 8 gas table, which was created with the current gas quality, taking pressure and temperature into account. There, the transmitter determines the current viscosity, calculates the Reynolds number and corrects the volume flow accordingly. The measuring device is thus able to output the current volume or to carry out the mass or a standard volume calculation.



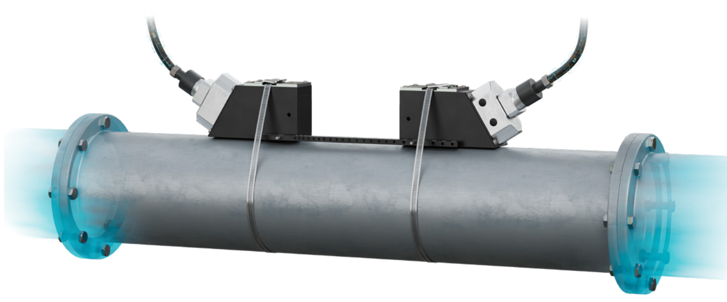
Z-Factor

Temperature (deg C)	Pressure (BARA) 20.0000	22.2222	24.4444	26.6667	28.8889	31.1111	33.3333	35.5556	37.7778
5.0000	0.9364	0.9293	0.9222	0.9150	0.9079	0.9008	0.8937	0.8866	0.8795
6.6667	0.9377	0.9308	0.9238	0.9168	0.9099	0.9029	0.8960	0.8890	0.8821
8.3333	0.9390	0.9322	0.9254	0.9186	0.9118	0.9050	0.8982	0.8914	0.8847
10.0000	0.9403	0.9336	0.9269	0.9203	0.9136	0.9070	0.9004	0.8938	0.8872
11.6667	0.9415	0.9350	0.9285	0.9220	0.9155	0.9090	0.9025	0.8960	0.8896
13.3333	0.9427	0.9363	0.9300	0.9236	0.9172	0.9109	0.9046	0.8983	0.8920
15.0000	0.9439	0.9376	0.9314	0.9252	0.9190	0.9128	0.9066	0.9004	0.8943
16.6667	0.9450	0.9389	0.9328	0.9267	0.9207	0.9146	0.9086	0.9026	0.8966
18.3333	0.9461	0.9402	0.9342	0.9283	0.9223	0.9164	0.9105	0.9046	0.8988
20.0000	0.9472	0.9414	0.9356	0.9297	0.9239	0.9182	0.9124	0.9066	0.9009

Speed of Sound (M/SEC)

Temperature (deg C)	Pressure (BARA) 20.0000	22.2222	24.4444	26.6667	28.8889	31.1111	33.3333	35.5556	37.7778
5.0000	375.3709	374.1604	372.9811	371.8353	370.7254	369.6541	368.6239	367.6377	366.6983
6.6667	376.6370	375.4488	374.2912	373.1666	372.0771	371.0252	370.0135	369.0445	368.1211
8.3333	377.8978	376.7320	375.5963	374.4930	373.4241	372.3920	371.3992	370.4480	369.5413
10.0000	379.1530	378.0096	376.8959	375.8140	374.7659	373.7539	372.7802	371.8473	370.9576
11.6667	380.4023	379.2814	378.1897	377.1292	376.1020	375.1102	374.1559	373.2415	372.3692
13.3333	381.6456	380.5470	379.4773	378.4383	377.4320	376.4604	375.5257	374.6299	373.7754
15.0000	382.8828	381.8063	380.7585	379.7409	378.7555	377.8042	376.8890	376.0121	375.1755
16.6667	384.1135	383.0592	382.0330	381.0368	380.0722	379.1412	378.2456	377.3875	376.5689
18.3333	385.3379	384.3054	383.3008	382.3258	381.3819	380.4711	379.5951	378.7558	377.9553
20.0000	386.5557	385.5450	384.5617	383.6077	382.6844	381.7936	380.9371	380.1167	379.3342

AGA8 calculation to aid the determination of speed of sound in natural and hydro-carbon gases.



Typical applications for SITRANS FS230 flow systems in gas

- Check metering, temporary checking of built-in measurements
- Operating measurements in high-pressure gas networks
- Gas storage: storage and retrieval, balancing
- Chemical industry: production, process monitoring, internal accounting
- Gas power plants: compressor, generally for monitoring and control
- Temporary billing measurements for conversion projects (infield calibration possible)

Technical details	
Nominal sizes	DN 50...DN1500
Pipe wall thickness	2 mm...35 mm (on request)
Min. pressure (steel pipes)	8 bar
Temperature	- 40 °C ... 80 °C, up to 120 °C possible (on request)
Flow speed	up to 40 m/s

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