PROCESS INSTRUMENTATION

Clamp-on ultrasonic flow measurement for oil

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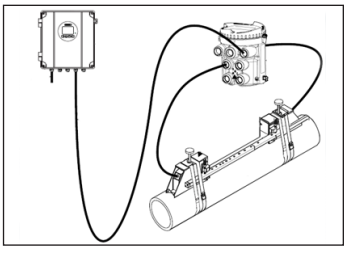
Clamp-on technology for flow measurement
With more than 50 years of experience, Siemens continues to set new standards in clamp-on ultrasonic flow measurement technology. With our WideBeam (or Lamb-wave) process, we created the basis for outstanding accuracy in both liquid and gas flow measurement – even in difficult conditions. Our clamp-on meters intelligently integrate the pipe wall into the measuring system, leading to significantly stronger sound waves that spread over a broad section of the flow profile. The result is an improved signal-to-noise ratio and a higher measuring accuracy, even with variations in the medium (e.g. temperature, pressure or changes in product makeup). WideBeam sensors transmit waves that are individually adapted to the resonance range of the pipe for each measurement. This is the key to data acquisition for high-precision measurements of petroleum products.

With the SITRANS FS230 ultrasonic flow meter, Siemens is rewriting the rules for how clamp-on flow measurement works and adapts to its environment to increase the quality of your measurements.

Measuring oil with the SITRANS FS230 flow system
A SITRANS FS230 consists of an FST030 transmitter, an internal or external FS-DSL Digital Sensor Link (DSL), and one or more pairs of FSS200 clamp-on sensors. The sensors are individually clamped onto the pipe for each measurement. The DSL is an electronic module that generates analog signals, which are evaluated by the sensors and recorded as measured values.

The analog measured values are thus digitized as early as possible and sent to the transmitter. There, the digital signals are processed, corrected, displayed, counted and saved.



Schematic drawing of a FS230 flow system consisting of the FST030 transmitter, the external FS-DSL and the FSS200 sensors.

Benefits of the SITRANS FS230 for hydrocarbon flow measurement include:

- Suitable for new installations as well as retrofitting
- Robust sensor assembly and device structure for years of operation
- Measurement without media contact: safe and easy to maintain
- Fast value acquisition with real 100 Hz signal update
- Very high accuracy
- Easily expandable up to 4-path measurement
- Reynolds compensation for multiproduct pipelines
- State-of-the-art diagnostics, data backup and data output
- Designed according to NAMUR requirements and Industry 4.0, with a wide range of diagnostic options

Measuring principle - Why the SITRANS FS230 is ideal for hydrocarbon applications

Ultrasonic flow meters based on the transit-time difference method are volumetric measuring devices. In order to correctly determine the volume flow, it is necessary to observe the flow profile in the pipe (i.e., faster flow speeds in the middle of the pipe compared to near the pipe wall). The flow profile is described by the Reynolds number, a dimensionless number calculated from the mean flow rate, the viscosity of the liquid in the pipe and the inside diameter of the pipe.

Challenges in measuring hydrocabon products

The challenge of hydrocarbon measurements in particular is to record the different flow rates, taking into account different margins or products in the pipe, temperature changes, the associated change in viscosity and flow behavior. A temperature measurement is necessary, either directly via a sensor or as an external analog input signal. Pressure changes are usually not relevant, but can also be recorded. Based on the actual measured values of the current speed of sound, the measuring device accesses an internal liquid table taking into account the current temperature. Aided by the table, the transmitter identifies the measured liquid, determines the current viscosity, calculates the Reynolds number and corrects the volume flow accordingly. The measuring device always shows the currently recognized liquid on the display, but is also able to output the current mass or a standard volume calculation.

	Read Oil Table	Write Oil Table	Sort table	Store Table In Flash	End User Password entered Command executed Flash successfully updated				
	Liquident	**Liquident Identifier**	**MPMS 11.1 Reference Density**	**Viscosity Values**		**Liquid Classification Coefficients**			
Unit	$\left[\frac{m^3}{s}\right]$	N/A	$\left[\frac{kg}{m^3}\right]$	$\left[\frac{m^2}{s}\right]$	$\left[\frac{m^2}{s}\right]$	$\left[\frac{kg^2}{m^6 \cdot K}\right]$	$\left[\frac{kg}{m^3 \cdot K}\right]$	$\left[\frac{1}{K}\right]$	
index	PID_OilTable_Liquident @ T3 & Pref	PID_OilTable_LiquidIdentifier [0;255]	PID_OilTable_MPMSReferenceDensity @ T3 & Pref	PID_OilTable_ReferenceViscosity1 + 2		PID_OilTable_LiquidCoefficientK0 + 1 + 2			
1	1100	1 - MTBE	640	1E-06	6E-07	346,4228	0,4388	0,0000	
2	1180	2 - LFB	717	1E-06	6E-07	346,4228	0,4388	0,0000	
3	1200	3 - LR	733	1E-06	6E-07	346,4228	0,4388	0,0000	
4	1330	4 - Kerosene	775	3,5E-06	2,2E-06	594,5418	0,0000	0,0000	
5	1350	5 - AVJET	818	3,5E-06	2,2E-06	594,5418	0,0000	0,0000	
6	1380	6 - HS Diesel	819	5,5E-06	3,5E-06	186,9696	0,4862	0,0000	
7	1410	7 - LS Diesel	885	5,5E-06	3,5E-06	186,9696	0,4862	0,0000	
8	1420	8 - GASOIL	959	2E-05	8,00E-06	186,9696	0,4862	0,0000	
9	1490	9 - FO	930	0,000119	3E-05	186,9696	0,4862	0,0000	
10	1579	10 - HFO	960	0,001049	0,0003	186,9696	0,4862	0,0000	
11									

Catering to different liquid types

The internal liquid table can record up to 32 different liquids. A set of values for common products such as petrol, diesel or kerosene is already stored in the device. Crude oil blends with different margins, however, are almost always unique and must therefore be adjusted together. Another option in the liquid table is the detection of acid or alkali mixtures. Depending on the acid content, different sound velocities are measured and assigned. For all these measurements, the temperature must be observed continuously as a point of reference for the device to calculate the correct volumetric flow going through the pipe. Rapid changes in flow can be detected and logged to create trend views over a defined time period.

Reliable leak detection

When used for leak detection, the FS230 demonstrates its outstanding strengths. Depending on the pipeline topology, two meters can each monitor a defined section of a pipeline up to a distance of 31 miles. Deviations in the balance quantity (i.e., the difference between the input measurement and the output measurement of a segment) very quickly indicate a leak and the balance difference provides information about the size of the leak. The very high accuracy of the transmitter, the use of the same liquid tables in each transmitter, the fast measuring cycles with an update rate of 100 Hz as well as the use of up to four measuring paths per pipe are of crucial importance for safe pipeline monitoring. This applies to smaller pipes from 2 inches up to 40 inches and beyond. Various operating conditions such as slow or fast transport, changing concentrations or starting operations are also monitored.

Integrated pig alarm

The built-in pig alarm on a SITRANS FS230 is another feature relevant for hydrocarbon measurements. Cleaning or leak detection pigs briefly interrupt the ultrasonic measuring paths and are thus reliably recognized as a pig run. Depending on the pipe size, flow velocities and the type of pig used, this function can be parameterized and adapted in the transmitter. Faults caused by loosened deposits in front of the cleaning pigs are also taken into account. Thus, false alarms can be avoided.

Multipath technology guarantees precise and continuous
Clamp-on flow meters measure through the center of the pipe, which is accomplished with multiple measuring paths. The unexpected failure of a channel might cause a decrease in measurement accuracy, but never a total loss of the measurement itself. Installing more than one measuring path also compensates for run-in conditions. Measurements always increase in precision as the number of measuring paths increases. While a single-path measurement will suffice for standard applications and smaller pipes, pipe sizes above 20 inches are improved using multi path measurements.

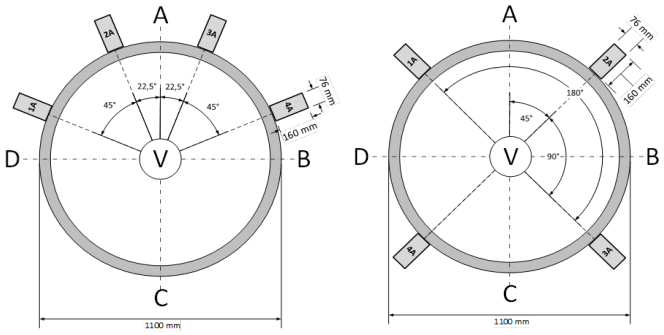
New installation or retrofit – the SITRANS FS230 can be used for both
The SITRANS FS230 is ideal for new systems, but its greatest strength is the possibility to retrofit the device. Without interfering with the pipeline, interrupting the process or disrupting existing security measures, leak detection segments can be integrated into most existing pipeline management systems. The SITRANS FS230 offers a cost-effective way to retrofit existing pipelines, improve safety by reducing risks and make pipeline systems future-proof.

Sensor spotlight – SITRANS FSS200
The new SITRANS FSS200 sensors are a continuation of the proven 1011 sensors of the SITRANS 1010 ultrasonic flow system. The new SITRANS FS230 is backward compatible with these older systems, allowing a straightforward plug-and-play startup.

For hydrocarbon measurements, high-precision WideBeam sensors are the devices of choice. Our portfolio offers 10 different types of high-precision sensors tailored for different areas of application and pipe wall thicknesses. Each sensor can be ordered in two temperature variants, generally from -40 °F to 250 °F.

External DSL spotlight – SITRANS FS DSL
Measuring in hydrocarbon applications makes Ex protection of all measurements indispensible. The SITRANS FS230 system allows oil flow measurements up to Class 1 Division 1. The external FS-DSL electronics module is encapsulated in a pressure-tight housing. It is mounted as close as possible to the sensors on the pipe. Short analog cables to the sensors offer the best possible EMC protection and also reduce the cable costs. Analog inputs for pressure and temperature are also available. The power supply is intrinsically safe via the transmitter up to a maximum distance of 500 feet. The DSL cable is connected either via screw terminals or optionally via explosion-proof connectors at both ends.

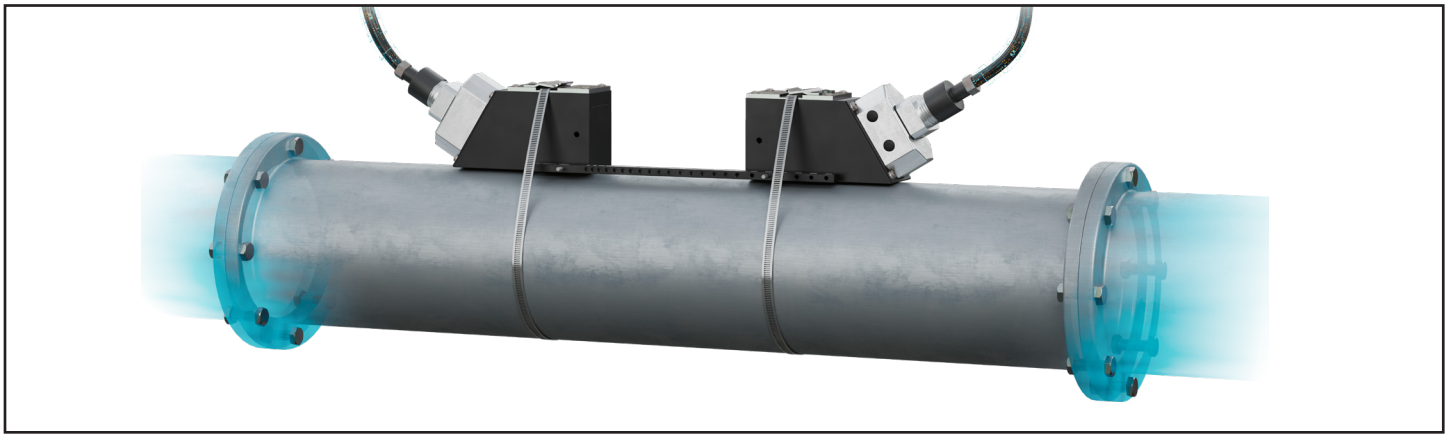
Transmitter spotlight - SITRANS FST030
In general, clamp-on field measurements are difficult to calibrate as the pipe is always part of the measuring system and cannot easily be installed on a test bench. As a result, a high-accuracy transmitter is particularly important for clamp-on measurements. Under laboratory conditions, the measurement deviation of the SITRANS FS230 is < 0.3.



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

Pipe quality plays a major role, but poor measuring accuracy can also be attributed to unfavorable inlet and outlet conditions bends just before the measuring point, or changes in pipe diameter). A multipath measurement can compensate for unfavorable conditions. The rule of thumb is: the more paths, the better the detection of deviating flow profiles.

Possible applications
- Operational measurements for product pipelines
- Oil storage, storage, retrieval, relocation, balancing
- Chemical industry: production, processing monitoring, internal accounting
- Crude oil pipelines
- Check metering (temporary checks of built-in measurements)
- Leak detection



Measuring everything that matters:

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