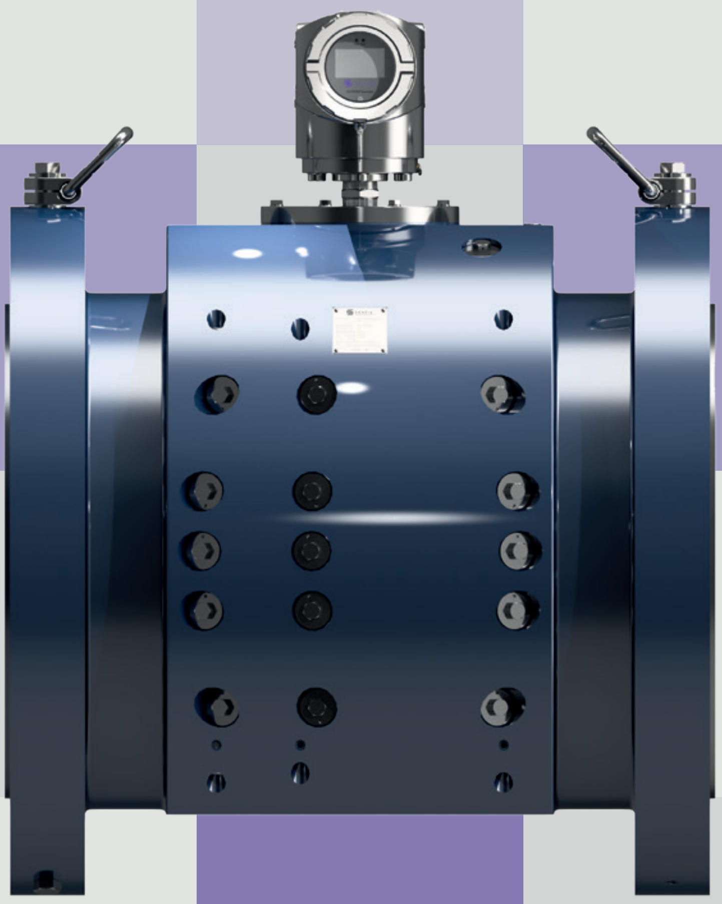
CALDON SVM 389Ci

Self-Verifying Meter for gas

SENSIA

+ MEASUREMENT SOLUTIONS



INTELLIGENT ACTION

Building on our track record of ultrasonic metering excellence

CALDON technology has been at the forefront of high-performance ultrasonic metering for decades. Significant developments over many years have reinforced our ability to deliver optimized solutions for challenging applications.

Over time, ultrasonic meters have continued to evolve with significant improvements in both accuracy and repeatability, as well as the ability to monitor their long-term performance through the use of diagnostic information and Condition-Based Monitoring (CBM) software. As users move away from traditional practices such as master metering or periodic removal for recalibration due to the CAPEX and OPEX considerations, the ability to monitor the performance of the ultrasonic meter has become more important than ever.

For operators who embrace a master meter or a routine recalibration strategy, there are many factors that require consideration. Periodic removal of meters for calibration, comes with safety and logistical issues associated with shutting down and depressurizing pipelines to remove and transport meter runs to a calibration facility. Reproducibility issues owing to changes in traceability or installation at the calibration facility can introduce further concerns. Attempts to circumvent these issues through the use of master/duty or duty/check meter arrangements can be vulnerable to false alarms or undetected common-mode errors, both of which are time-consuming and costly.

In recent times, Condition-Based Monitoring (CBM) software such as CALDON USM Advisor has been used to continuously monitor ultrasonic meter behavior and make essential decisions on meter health and performance. These CBM systems have evolved to become automated and intuitive platforms recognized by many operators and government regulators as means of reducing risk between calibrations and justifying reduction in the frequency of recalibration.

While the ultrasonic meter's rich diagnostic information remains a key differentiator, the use of diagnostic information is qualitative, meaning crucial decisions are made based on supposition rather than hard evidence. Until now, diagnostic data has only given us information about meter behavior. But that data does not have a direct relationship to the accuracy of the measurement. Whereas live uncertainty evaluation is a methodology that provides quantified information about accuracy in the same units as the measurement itself.

Self-Verifying Meter (SVM) technology is a step-change in ultrasonic measurement – the first to deliver a quantitative determination of meter performance with a live uncertainty evaluation derived from first principles.

Live evaluation of measurement uncertainty: an in-situ ultrasonic meter verification breakthrough

The CALDON Self-Verifying Meter is the first high-accuracy ultrasonic metering technology to provide a quantitative evaluation of its own measurement uncertainty.

The CALDON SVM 389Ci is a 16-path meter that incorporates three significant features to produce an ultrasonic meter with unrivaled self-verification ability:

1. Axial velocity measurement verification per chord
2. Fifth chordal measurement plane to facilitate four-chord vs five-chord estimation of flow profile uncertainty
3. Vertical reflective path for detection of entrained liquid or contamination

Based on this unique configuration, the CALDON SVM 389Ci can self-verify each of the variables that contribute to the measurement result – combining these to provide a quantitative evaluation of its own uncertainty.

In addition to being able to continuously output the uncertainty value in volumetric rate or percentage terms, the CALDON SVM 389Ci also incorporates uncertainty totalization in volumetric units. Allowing you to make higher-quality operational decisions based on quantitative determination of meter performance.

Higher confidence, fewer interventions

The CALDON SVM 389Ci uses the same meter body design, transducers, and electronics, as the other meters in the field-proven CALDON 300 series family of meters. The measurement performance of the CALDON SVM 389Ci builds on the foundation of the well-established CALDON LEFM 380Ci, which utilizes an eight-path configuration with crossed paths in four chordal planes, all positioned and weighted according to the rules of Gaussian Integration.

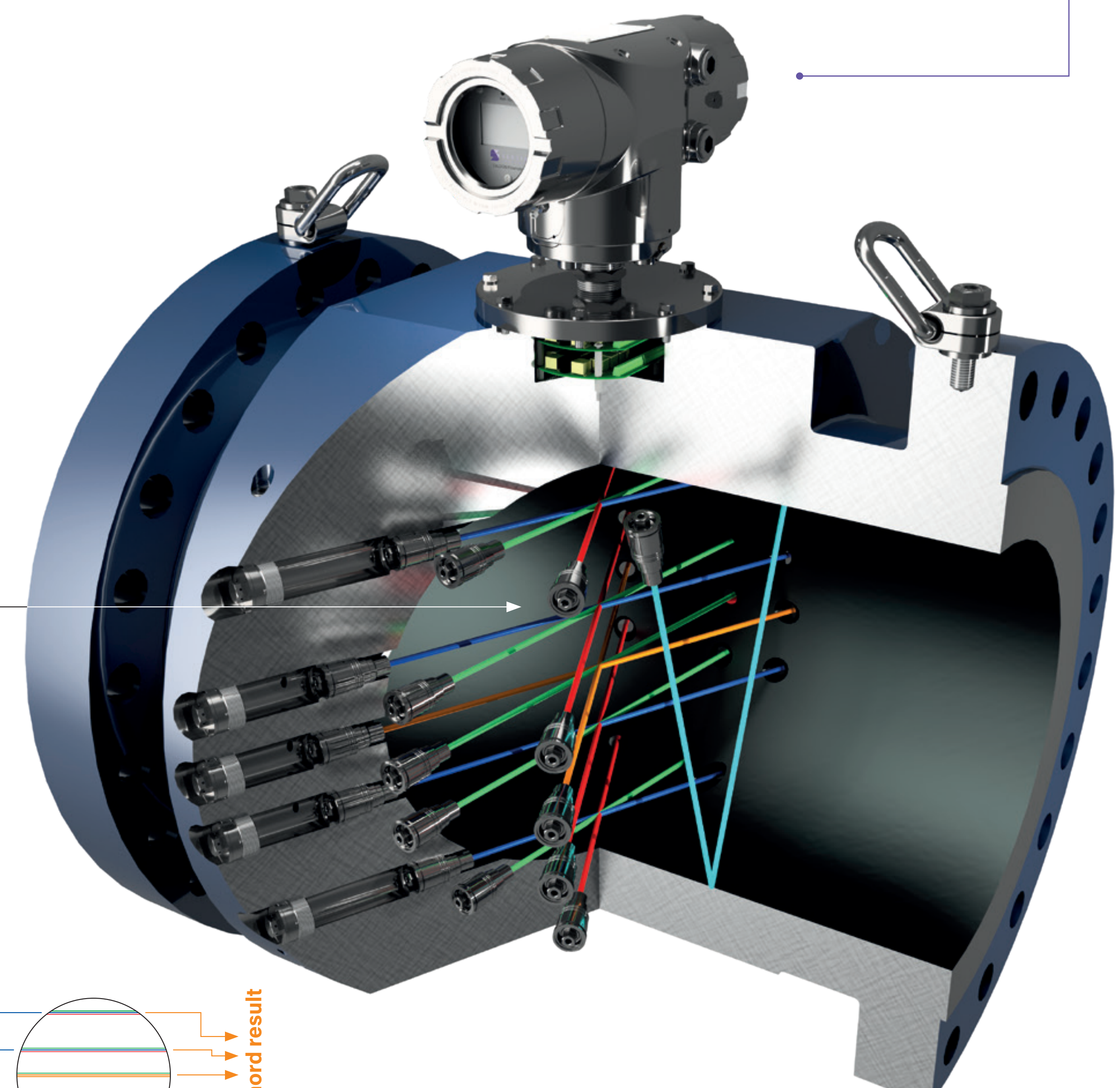
By employing the eight-path configuration for the primary measurement, the CALDON SVM 389Ci is designed to be highly accurate even in swirling flow with distorted axial velocity profiles, and adds the quantitative self-verification features with no compromise in accuracy.

The CALDON SVM 389Ci capabilities represent a significant breakthrough in metering technology, enabling a step-change in operational practices from intervention based on prescribed time intervals and experience to risk-based condition monitoring through quantitative data.

Acceptance of such a breakthrough technology and changes to operational practice requires a high level of confidence in the underlying technology. To address this – alongside the OIML R137 Class 0.5 and MID metrology certifications applicable to the whole CALDON 300 series family – the SVM technology has been subjected to an independent and robust DNV Technology Qualification in accordance with their Classification Scheme for Fiscal Metering. As a result, the CALDON SVM 389Ci gas flow meter meets the most stringent requirements for gas fiscal metering class I-AAA on all aspects tested.

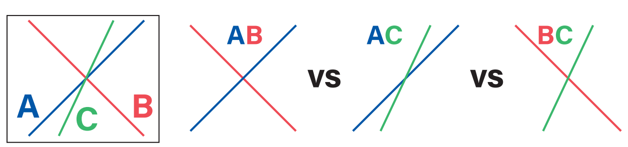
Quantitative and continuous self-verification

Ultrasonic flow meters are well known for their advanced diagnostic capabilities, which can be used to alert a user to a change in meter behavior or process conditions. CALDON SVM technology enhances and surpasses existing capabilities by enabling the meter to continuously quantify its measurement uncertainty.



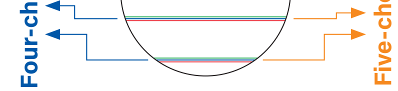
Low installation uncertainty
The CALDON SVM technology employs our proven eight-path configuration for its primary measurements. The eight-path configuration uses crossed paths in each of four chordal planes to effectively cancel the effect of non-axial velocities and accurately integrate the axial velocity profile. The meter is OIML R137 Class 0.5 certified with a minimum requirement of 5D upstream without the need for flow conditioning.

Three paths per chordal plane:
Axial velocity verification

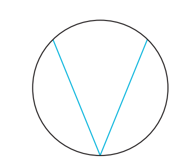


The axial velocities measured on multiple chordal planes are the primary input to an ultrasonic meter's calculation of flowrate. Use of a pair of crossed paths on each chordal plane (paths A and B as used in the eight-path meter) enables the cancellation of the unwanted components of non-axial velocity. The addition of the third (C) path enables the uncertainty of the axial velocity measurements to be determined on each chordal plane by a patented method that compares the axial velocity values from the AB, AC and BC path combinations.

Four-chord versus five-chord:
Velocity profile verification
The integration of the velocity profile in a chordal ultrasonic meter is achieved by calculating a weighted average of the chordal axial velocities. SVM technology incorporates a fifth measurement plane on the diameter. This enables the computation of a four-chord (eight-path) weighted average velocity and a five-chord (ten-path) weighted average velocity using a distinct set of weighting factors. Comparison of the four-chord and five-chord results obtained by this patented method enables quantification of the uncertainty associated with averaging the velocity profile.



Uncertainty totalization
SVM technology enables the simultaneous calculation of measurement uncertainty alongside each flow measurement calculation – updated once per second. In addition to the continuous and instantaneous output of uncertainty in terms of volumetric flowrate or a relative percentage value, CALDON SVM 389Ci totalizes uncertainty values internally. This powerful feature means that measured volume totals and corresponding uncertainty totals can be read at intervals – e.g. daily or weekly – with the measurement uncertainty stated in volumetric terms alongside the transaction volume.

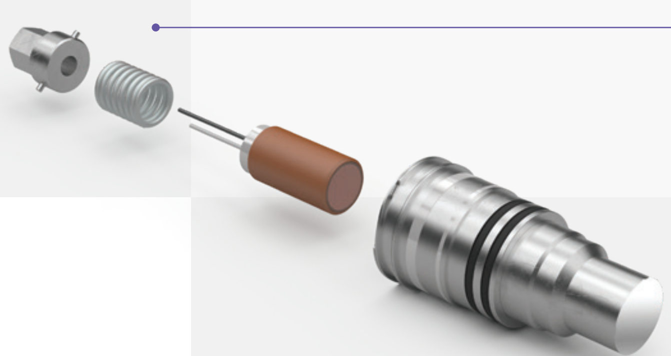


Vertical path:
Cross-sectional area verification
The CALDON SVM 389Ci incorporates a pair of transducers that are used to form a vertical path with a reflection point at the bottom of the measurement cross-section. This path is not used for velocity measurement, its purpose is to enable the CALDON SVM 389Ci to detect if the cross-sectional area of the pipe is partly blocked with liquid or other contaminants, even if the quantity of liquid present is very small. Combined with the measurements from the chordal paths, the measurement results from the vertical path are used to quantify uncertainty in the cross-sectional area of the measurement section.

Accuracy, reliability and certainty, without exception

Built upon proven ultrasonic technology
For over 50 years, CALDON ultrasonic flow meters have provided the industry with highly accurate, reliable, and low-cost-of-ownership measurement solutions. CALDON technology is well proven with installations dating back to the 1970s utilized on a global basis across a wide range of gas applications. The CALDON SVM 389Ci uses the same field-proven meter design elements, transducer and electronics technologies as all other 300 series CALDON ultrasonic meters.

CALDON USM Advisor is an intuitive, intelligent and automated Condition-Based Monitoring system. For SVM models the Advisor screens, warning limits and reports include additional features using the SVM's quantitative evaluation of measurement uncertainty in % or volumetric terms.



Transducer technology:
+ Transducers that are isolated from the process and outside the pressure boundary for ease of service, if required
+ No recalibration or zeroing required if a transducer is replaced
+ In-house transducer manufacturing and testing for maximum quality control

Comprehensive I/O
The CALDON SVM 389Ci delivers a diverse range of I/O which can be configured to suit the needs of the operator.

Communications	RS485 (up to 3 in total) Modbus RTU
	Ethernet copper fiber
	HART (optional)
Pulse Outputs/Alarm	Pulse direction/outputs (4 total)
	Alarm status (4 total)
Analog Inputs	3 total
Analog outputs	2 total

Proprietary corrosion and adhesion-resistant coating
The largest impact on the long-term performance of an ultrasonic meter is corrosion and contamination or deposition that result in changes in cross-sectional area, path lengths or path angles. On carbon steel meters, CALDON apply a field-proven and patented internal coating which significantly reduces or eliminates the risk of corrosion and contamination.

Feedback from end users who deal with pipelines impacted by contamination e.g. black powder, is that manual intervention is often required to depressurize and manually clean the internal diameter, transducer pockets and faces. This is a significant intervention, exposing personnel and the environment to hydrocarbons, increasing operational costs and downtime.

The coating has anti-corrosion properties, high thermal stability, chemical inertness in aggressive environments, and superior adhesion resistance. This solution has been tested in a wide range of conditions and has been employed by CALDON for more than 10 years resolving numerous application challenges.

CALDON USM Advisor software

CALDON USM Advisor is an automated and intuitive Condition-Based Monitoring system which continuously monitors the health of CALDON 200 and 300 series flow meters. Multiple ultrasonic flow meters can be monitored simultaneously, locally or remotely from anywhere in the world.

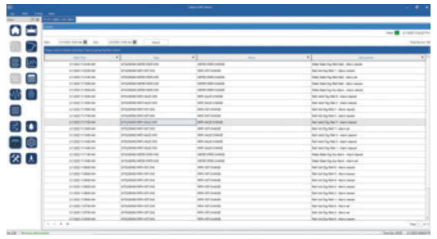
Diagnostic health data is transferred from the meter and stored in the CBM database and is automatically evaluated against customizable warning and alarm limits. Advisor either works with a permanent connection to the meter or can be periodically connected to access data stored within the meters integral SD card for traceability, auditability and general convenience.

Unlike a conventional ultrasonic meter, the SVM delivers a quantitative evaluation of meter performance along with a continuous and instantaneous output of uncertainty in terms of volumetric flowrate and relative percentage values. This information is reported by the CALDON USM Advisor software ensuring that the operator has direct visibility of the meter's uncertainty performance. Additionally, this key information is available over Modbus to the flow computer, supervisory system and/or higher level host systems.

Communication (ethernet and serial)
The diagnostic software can be used with serial communication or ethernet (copper and fiber both available). Ethernet is preferred delivering additional features such as worldwide monitoring, simultaneously analyzing multiple meters and retrieving historical data from the SD card (backfill).

Easy-to-use, icon-driven user interface
Easily monitor the active and historical health status of multiple ultrasonic flow meters from a single overview.

You can also drill down to all available information using an icon-driven interface to get a more intelligent and detailed insight into a specific ultrasonic flow meter in as few as three clicks.



Complete audit trail data integrity
Guaranteed coverage of historical data is provided by the meter's on-board storage of up to 10 years of key diagnostic data. Advisor software uses an SQL database that retains every minute of data that is transferred from the meter, providing long-term records limited only by the storage capacity of the host computer.

Customizable multidimensional fingerprinting
Optimize your decision-making by fingerprinting meter behavior during normal operation under changing process conditions (flow velocity, temperature, pressure, and speed of sound).

Intuitive displays
CALDON USM Advisor provides access to intuitive displays and graphs that report the uncertainty data that is unique to SVM as well as the full complement of standard diagnostics.

Features unique to SVM
When connected to an SVM flow meter, Advisor displays, warnings and reports include unique features based on the meter's determination of live uncertainty.

A powerful alternative to conventional verification techniques

Conventional diagnostics and CBM

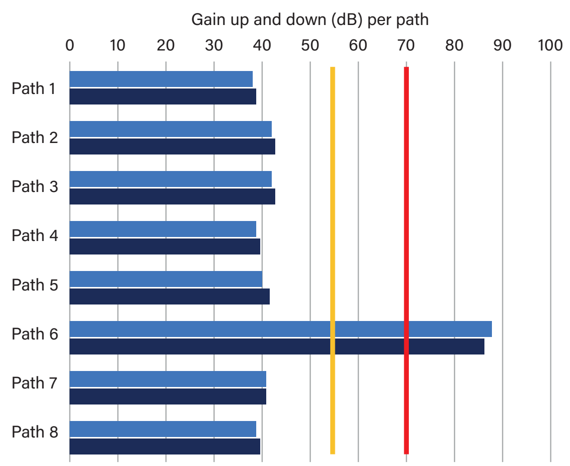
Conventional diagnostics can quickly and clearly alert the user of an ultrasonic meter to a problem. For example, a meter that is having difficulty processing received signals (owing to a transducer problem or adverse conditions), an alert can be raised when the required gain rises above a given threshold indicating a weak signal, or when the percentage of received pulses being successfully processed falls below a certain threshold.

While detection of such problems enable a diagnosis to be performed, the next challenge is to evaluate the severity of the problem and assess the impact that the diagnosed condition will have on the accuracy of the measurement output.

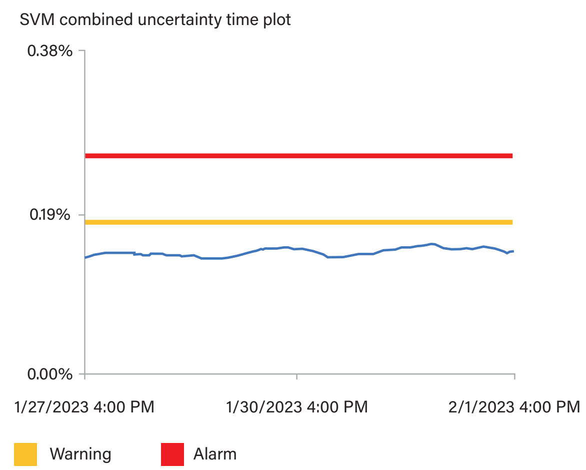
Similarly, with state-of-the-art CBM packages, changes to normal behaviors can be detected automatically and immediately. However, if, for example, a velocity profile metric such as asymmetry changes, then the question is, what is the impact on the accuracy of the measurement? These questions cannot be answered directly by analysis of conventional diagnostics.

As a clear example of the limitation of conventional diagnostics, it can easily be shown that in some cases, change in asymmetry can coincide with measurement errors, but in other cases the actual profile asymmetry can change without impacting the accuracy of the meter.

The CALDON SVM 389Ci is different. The quantitative uncertainty calculations in the CALDON SVM 389Ci are based on the use of additional measurement inputs that have been strategically designed to allow the measurement uncertainty to be quantified. This is what makes the CALDON SVM 389Ci so powerful: the self-verification is delivered in volumetric and % units that can be easily interpreted and actions driven accordingly.



Whilst it is clear that an issue has occurred through the an alarm on signal gain the operator cannot relate this to an uncertainty value.



Unlike the qualitative information from conventional diagnostics, SVM provides direct quantitative output of the measurement uncertainty.

Periodic recalibration strategies

It has become normal practice in certain countries to remove and recalibrate gas ultrasonic meters on a periodic basis, whether that is due to local operational philosophies, local metrology regulations or contractual agreements. It can be argued that removing a gas ultrasonic meter is counter productive due to the following considerations:

+ Depressurization and venting of hydrocarbon lines
+ Potential damage during transportation and handling
+ Availability and reproducibility of calibration facilities
+ Logistics of calibrating the full package including flow conditioner per the recommendations of international standards
+ Overall calibration costs including logistics of transportation, especially from remote regions

The SVM technology has been developed to perform a quantitative evaluation of its performance, providing a live uncertainty output, indicating if and when intervention may be required therefore replacing time-based verification.

Condition-Based Monitoring

Multi-path ultrasonic meters have arguably the largest array of diagnostic capabilities of modern flow metering techniques. Diagnostics are now commonly used to increase the confidence of the user that the meter is functioning accurately between calibrations, which could be a year apart or even longer. Although current ultrasonic meter diagnostics are very powerful, they are qualitative in nature, i.e. they provide an indication if something is wrong or has changed, but they have not yet been able to quantify the possible range of error, correctly termed the measurement uncertainty.

The SVM design reduces the complexity of diagnostic monitoring by delivering a quantitative self-verification through identifying and addressing the components that contribute to measurement uncertainty using a first-principles approach. The results of the uncertainty evaluation are provided as the overall uncertainty in the flow meter's volumetric output and can be presented in units of volumetric rate or as a relative percentage of rate, as well as being totalized internally alongside the volume throughput totals. Uncertainty components that are determined in the process of calculating the overall uncertainty are also available for detailed analysis.

Primary and secondary meters in one body

Given the limitations of qualitative diagnostics and CBM, some users have adopted meter designs that incorporate two separate ultrasonic flow meters in one body. In one of the simplest forms of this meter type, the first meter is a four-path meter and the second meter is a simple one-path meter (often called a 4+1). The fundamental limitation of this approach is that the one-path meter is very sensitive to problems that may not affect the four-path meter significantly. For example, published results show a case at 7 m/s velocity where the influence of a flow conditioner blockage on the four-path result is a change of 0.005% and the corresponding influence on the one-path meter is 3.5%. This difference in sensitivity indicates that the probability of triggering a false alarm when using a 4+1 meter is very high.

SVM is different; it uses multiple strategically placed paths to enable a quantitative uncertainty evaluation that is not prone to false alarms and has been independently validated.

Two multi-path meters in series

Sometimes, two multi-path flow meters are installed in series and compared with one another as a means of in-situ verification. However, when used in this way the meters can be subject to 'common-mode error'. This means that both meters can be affected by a condition to the same degree and, therefore, will have errors that are very close to being equal. Sometimes differences in meter design such as transducer frequency or path configuration will be employed to try to mitigate common mode error, but these differences do not address all forms of common-mode error. Examples include axial velocity profile distortions, contamination build-up or the presence of liquid reducing the cross-sectional area. For instance, the first meter could be over-reading by 1.01% and the second meter by 0.99%, the difference between them would be 0.02% and could be misinterpreted as verification of low uncertainty, but in fact, the average error would be 1%.

SVM technology has been designed to detect and quantify the effects of conditions that cause common-mode error in two meters in series.

Independent verification: DNV technology qualification, class I-AAA

In addition to compliance with AGA, ISO, MID and OIML R137, the CALDON SVM 389Ci has been subjected to a rigorous technology qualification process according to the DNV classification scheme for fiscal metering. This process evaluates the metering technology against its operational measurement uncertainty in real-world conditions, including component failures and process upset conditions. In addition to evaluating the accuracy of the meter, the CALDON SVM live uncertainty output was evaluated by DNV, with the resulting conclusions:

+ The CALDON SVM gas meter has undergone a technology qualification and on all aspects tested it qualified for the most stringent requirements as set for fiscal metering class I-AAA.
+ The CALDON SVM gas meter is a robust meter, that is capable of handling field disturbances efficiently. In most cases the meter is able to cope with field disturbances, in the sense that the flow meter output is hardly affected.
+ The CALDON SVM live uncertainty output were consistent with the deviations determined by testing in 95% of the conditions tested, meaning the derivations were equal to or smaller than expected based on the reported uncertainty values. Even in the cases SVM uncertainties are slightly lower than the actual deviation, those deviations are so high (>3%), that they are detected rapidly.
+ The overall diagnostic ability of this meter, making use of the U-SVM uncertainty evaluation, is very high and it provides a validated and useful tool to determine that the meter has potentially large deviations and action should be taken.


DNV

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TECHNOLOGY CERTIFICATE

Certificate no.: ESNL.C.101469393-1, Rev.1 | Initial date: 2021-Oct-1 | Valid until: 2026-Oct-1

This is to certify that

CALDON SVM gas METER

as detailed in /1/ has been qualified in accordance with DNV-RP-A203 Technology Qualification /2/. DNV considers the technology fit-for-purpose to meet criteria for DNV class I-AAA fiscal metering systems.

Owner: **Sensia LLC,** 1000 McClaren Woods Drive, Coraopolis, PA 15108, USA

Name: Caldon LEFM/ SVM 389Ci ultrasonic gas meter as further detailed in /1/

Use: Accurate gas meter designed for natural gas custody transfer

Conditions: The conditions for evaluation and testing as described in /2/

Involvement: DNV has been involved in the testing and evaluation process as required according to /3/, has evaluated and provided laboratory testing evidence and has verified the results that forms the basis for this certificate

High level results: The Caldon SVM gas meter has undergone a technology qualification and **on all the aspects tested it qualified for the most stringent requirements as set for fiscal metering class I-AAA.**

The Caldon SVM meter is a robust meter, that is capable of handling field disturbances efficiently. In most cases the meter is able to cope very well with the field disturbances, in the sense that the meter flow output is hardly affected.

The SVM live uncertainty output were consistent with the deviations determined by testing in 95% of the conditions tested, meaning the deviations were equal to or smaller than expected based on the reported uncertainty values. Even in the cases SVM uncertainties are slightly lower than the actual deviation, those deviations are so high (>3%), that they are detected rapidly. Overall, it is concluded, that the overall diagnostic ability of this meter, making use of U-SVM uncertainty evaluation, is very high and it provides a validated and useful tool to determine that the meter has potentially large deviations and action should be taken.

Further details of the evaluation can be found in ref. /4/

Reference documents:

/1/ Caldon LEFM gas flow meter: https://www.products.slb.com/-/media/cam/resources/2018/01/23/16/40/lefm-gas-meters-brochure.ashx

/2/ DNV-RP-A203, Recommended Practice on Technology Qualification, September 2019 and DNV GL, Technology Qualification for gas flow meters: https://www.dnvgl.com/services/technology-qualification-of-gas-meter-systems-79390

/3/ Technology Qualification testing and verification plan for ultrasonic SVM, August 29, 2019, DNV ref. GCS.10149393 - 1

/4/ Technology Qualification- Evaluation Results for Caldon SVM gas meter, November 2021, DNV ref. ESNL.182421

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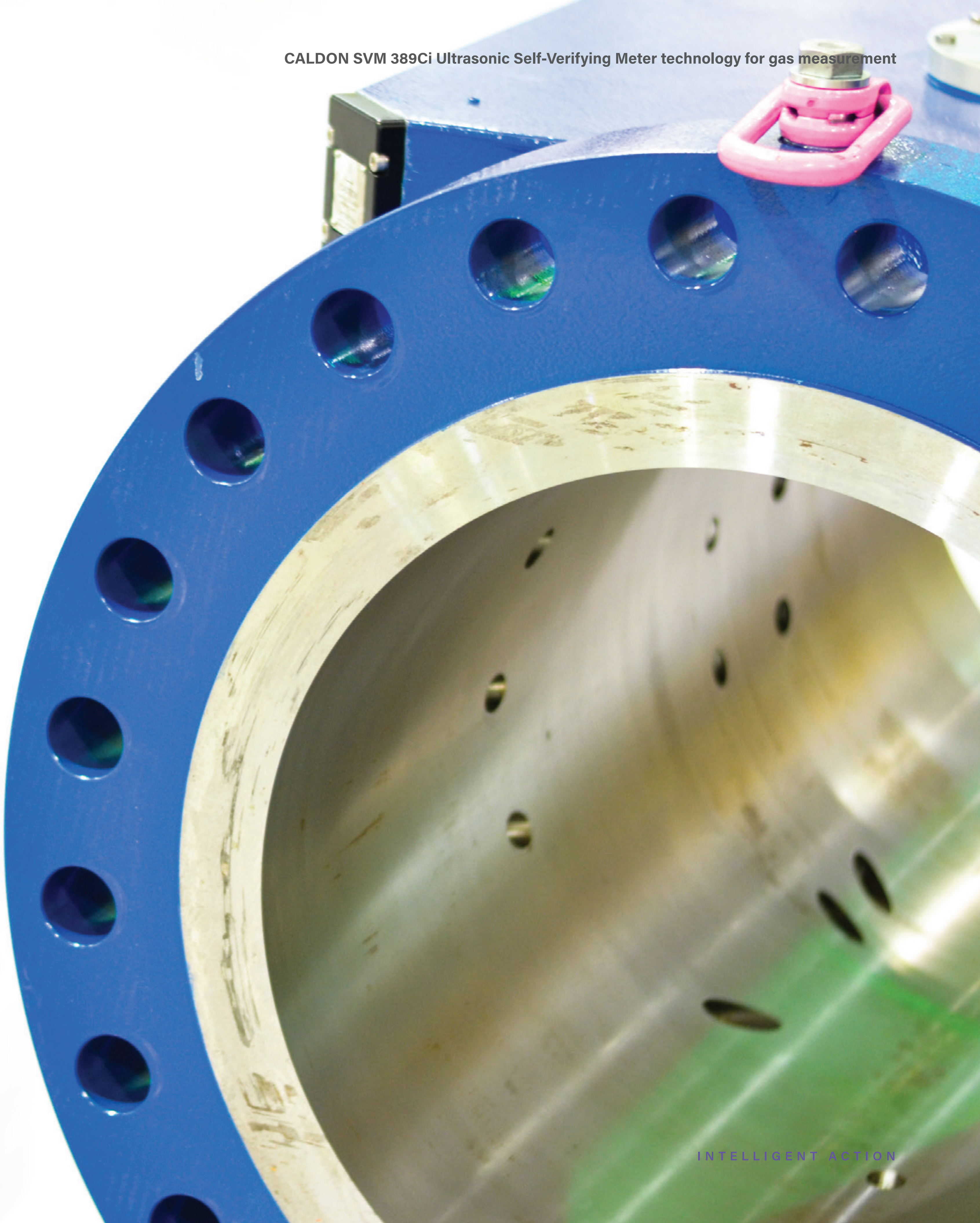
Technology Certificate Caldon SVM TQ V1



Dimensions and weights

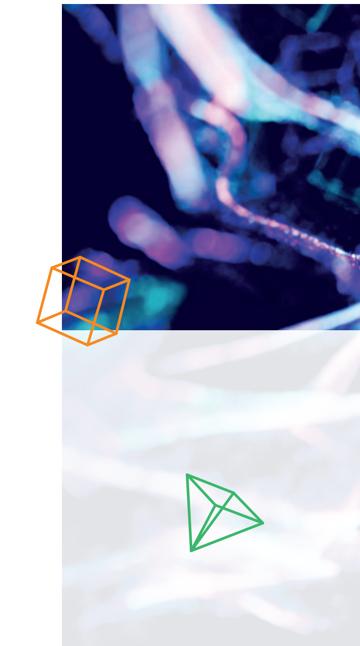
Dimensions and weights for CALDON SVM 389Ci

Nominal pipe size, in [mm]	Flange ANSI class	Width (W), in [mm]	Height (H), in [mm]	Length (L), in [mm]	Meter weight, lbm [kg]
12 [300]	150	22.0 [559]	30.4 [773]	31.8 [806]	1,641 [744]
	300	22.0 [559]	30.4 [773]	33.0 [838]	1,754 [795]
	600	22.0 [559]	30.9 [785]	35.5 [902]	1,927 [874]
14 [350]	150	23.8 [603]	31.9 [809]	25.1 [638]	1,592.2 [722]
	300	23.8 [603]	32.3 [820]	26.4 [670]	1,768.3 [802]
	600	23.8 [603]	32.6 [829]	28.3 [718]	1,916.9 [869]
16 [400]	150	24.0 [610]	32.6 [828]	24.6 [625]	1,481.3 [672]
	300	25.5 [648]	33.6 [854]	26.1 [664]	1,703.0 [772]
	600	27.0 [686]	34.4 [873]	28.8 [730]	1,979.3 [898]
18 [450]	150	26.0 [660]	34.5 [876]	26.1 [664]	1,751.6 [795]
	300	28.0 [711]	36.0 [914]	27.6 [702]	2,052.6 [931]
	600	29.3 [743]	36.6 [930]	29.8 [756]	2,361.0 [1,071]
20 [500]	150	28.0 [711]	36.8 [935]	28.3 [718]	2,192.5 [994]
	300	30.5 [775]	38.3 [973]	29.6 [752]	2,546.6 [1,155]
	600	32.0 [813]	39.0 [992]	32.0 [813]	2,961.2 [1,343]
24 [600]	150	32.0 [813]	41.9 [1,038]	31.1 [791]	2,857.0 [1,296]
	300	36.0 [914]	42.9 [1,089]	32.4 [822]	3,401.1 [1,543]
	600	37.0 [940]	43.4 [1,101]	35.3 [895]	3,966.8 [1,799]

Please consult Sensia for sizes smaller than 12 in and larger than 24 in. or for ANSI ratings above 600.
Typical sizes shown for reference, contact our application specialists for assistance determining the proper meter sizing.
Final dimensions are provided at time of order.

Installation

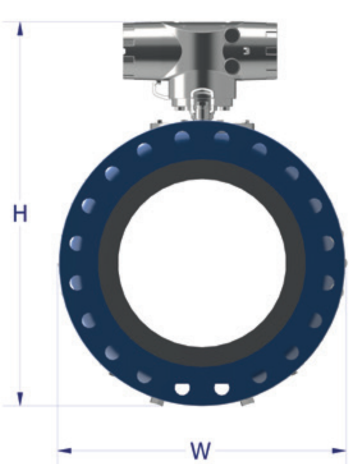
To limit uncertainty caused by hydraulic effects, we recommend installing the flow meter in compliance with the following guidelines

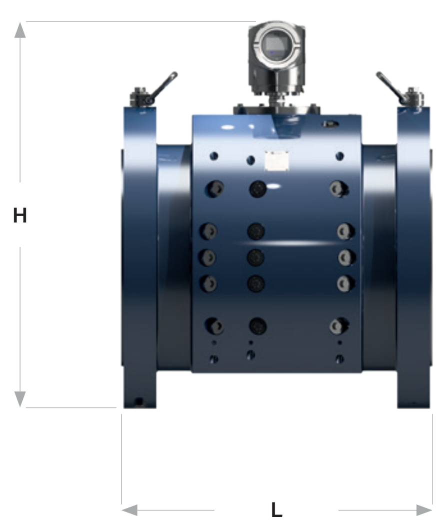


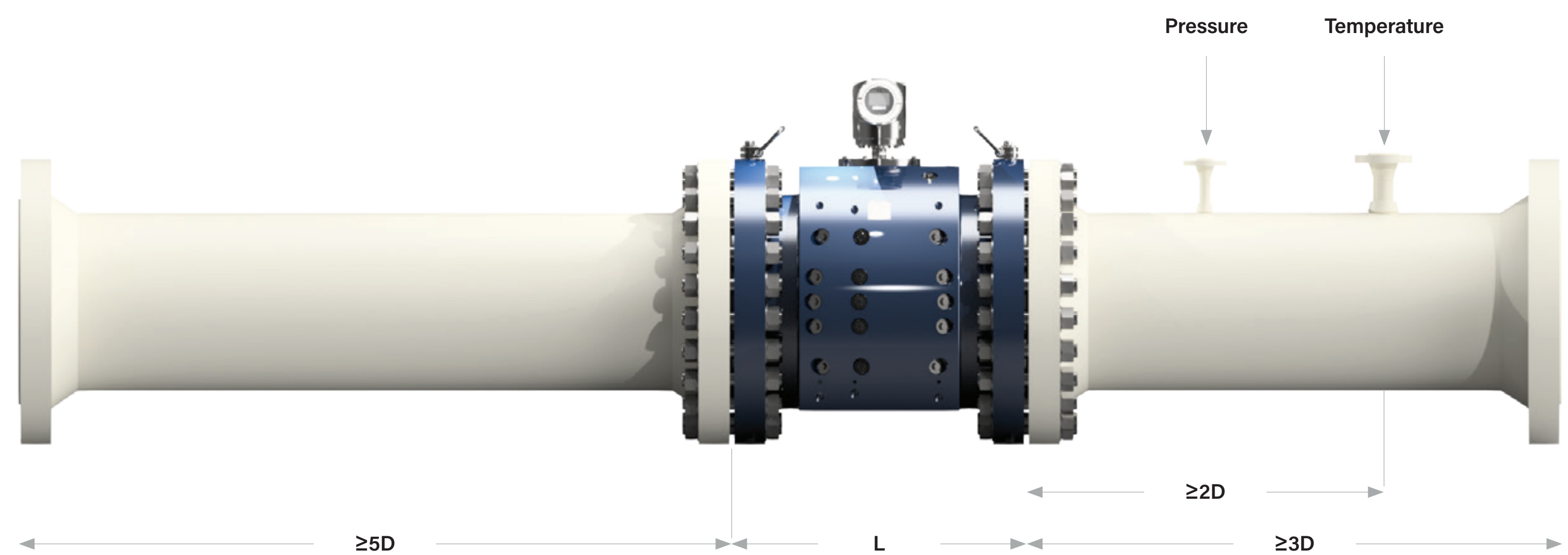
CALDON SVM 389Ci
The adjoining straight pipe should be of the same schedule as the meter. The CALDON SVM 389Ci does not normally require the use of a flow conditioning element.

An uninterrupted upstream pipe 5 diameters (D) in length is adequate in most applications. In situations where there is a constriction upstream of the meter that is smaller than the diameter of the meter run piping (such as a reduced bore valve or filter), it is recommended that this be separated from the meter by a pipe at least 15 pipe diameters in length. Downstream of the meter, there should be a straight length of pipe at least 3 pipe diameters prior to any bends, tees, reducers, expanders or valves etc. In uni-directional applications, temperature elements and pressure connections should be located downstream of the meter. Intrusive temperature elements should be at a distance of at least 2 pipe diameters from the meter. Non-intrusive pressure connections may be located within 2 diameters of the meter.

For application-specific recommendations or more detailed installation guidance, please contact Sensia.







Specifications

Meter body with integral transmitter

Class	II 2 G, Ex db IIC Gb T6	Class I, Div. 1, Groups B,C, and D T6
CALDON SVM 389Ci models		
Temperature, degF [degC]	−58 to 158 [−50 to 70]	−58 to 158 [−50 to 70]

Standard materials of construction (Compliance with Pressure Equipment Directive [PED])

Meter body and flanges	
CALDON SVM 389Ci model	Carbon steel (stainless and duplex optional)
Transducer housings	Inconel and stainless steel.
Junction boxes and transmitter enclosure	Copper-free aluminum (stainless steel optional)

Consult Sensia for other material options.

Standard end connections and maximum working pressure

ANSI B16.5 raised face	Stainless steel, psi [bar]	Carbon steel, psi [bar]
Class 150	275 [19.0]	285 [19.6]
Class 300	720 [49.6]	740 [51.1]
Class 600	1,440 [99.3]	1,480 [102.1]
Class 900	2,160 [148.2]	2,220 [153.2]
Class 1500	3,600 [248.2]	3,705 [255.3]

Consult Sensia for other material options.

Typical meter sizes and flow rates – based on schedule 80 pipe*

Nominal size, in [mm]	Flow rate (actual). ft/^{3} [m^{3}/h]			
	CALDON SVM 389Ci			
	Qmin	Qt	Qmax	Qover-range
12 [300]	2,500 [70.8]	12,501 [354]	254,180 [7,198]	305,016 [8,637]
14 [350]	3,020 [85.5]	15,098 [428]	306,997 [8,693]	368,397 [10,432]
16 [400]	3,959 [112.1]	19,793 [560]	402,453 [11,396]	482,944 [13,675]
18 [450]	5,024 [142.3]	25,122 [711]	510,811 [14,465]	612,973 [17,357]
20 [500]	6,218 [176.1]	31,092 [880]	632,212 [17,902]	758,655 [21,483]
24 [600]	8,985 [254.4]	44,925 [1,272]	913,467 [25,867]	1,096,160 [31,040]

Nominal flow velocity range

Flow rate	Velocity ft/s [m/s]
Qmin	1 [0.3]
Qt	5 [1.5]
Qmax	100 [30.5]
Qover-range	120 [36.6]

* The over-range allows the meter to be used at velocities greater than 100 ft/s in case of unforeseen circumstances. However, we recommend selecting meters such that the velocity at the maximum operating velocity is less than 100 ft/s.

General performance

Meets or exceeds the requirements of AGA-9, ISO 17089-1 class 0.5, OIML R137 class 0.5

CALDON SVM 389Ci performance	
	Qmin to Qmax
Average error (linearized, relative to calibration facility), %	< ± 0.1%
Repeatability, typical at calibration (max error - min error), %	± 0.05
OIML R137 accuracy class	Class 0.5
Measurement Instruments Directive (MID) accuracy class	Class 1.0
Nominal pipe sizes in [mm]	12 to 48" [300 - 1,200mm]

For nominal sizes larger than 48" [1,200mm] please contact Sensia

General specifications: Electronics

Power requirements—DC power	
Voltage required, V DC	24 (18 to 30)
Current draw at 24 V DC, A	0.25
Power consumption, W	6
Power requirements—AC power	
Voltage, V AC	120 (60 Hz); 230 (50 Hz)
Voltage range, V AC	108–253
Frequency range, Hz	47–63
Current draw, A	0.14
Protection	Ingress Protection (IP) 66; Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA) type 4 and 4X
Relative humidity, %	0–95
Operating temperature, degF [degC]	−58 to 158 [−50 to 70]
Local display, px	400 × 240 LCD showing flow, diagnostics data, and alarms
Analog inputs (three), mA	4–20 configurable
RTD input	Meter body temperature
Analog outputs (two), mA	4–20 (configurable 650-ohm maximum load)
Digital outputs	
Flow	Four pulse output channels
	Programmable K-factor
	Programmable configuration
	1. Dual frequency set-up, 50/50 duty cycle
	Channel B lags channel A by 90° for forward flow
	Channel B leads channel A by 90° for reverse flow
	2. Frequency and direction, 0 duty cycle
	Channel B indicates flow direction
	Forward flow = 0
	Reverse flow = high (5 or 12 V DC)
	3. Alternating, forward-flow frequency on
	Channel A only reverse-flow frequency
	On channel B only 50/50 duty cycle
Alarm status	Four outputs, 0–5 or 0–12 V DC selectable (0 V = alarm)
Communication	Three serial or two serial and HART protocol
	Ethernet (copper or fiber optic) or fiber modem

Count on CALDON

CALDON continue to be a pioneer in the use of high accuracy ultrasonic meters within the oil and gas industry. Following the success of our CALDON LEFM 300 Series platform, the CALDON SVM 389Ci is the latest addition to our portfolio and another major step-change in ultrasonic metering technology.

2024
First Subsea ultrasonic meter for gas, liquid, Carbon Capture and Storage. Jointly developed by SLB and Sensia.

2023
First USM for dense, supercritical and liquid phase CO_2, the CALDON LEFM 500 Series.

2021
First self-verifying high accuracy meter.

2020
CALDON USM Measurement Advisor; continuous, remote monitoring of multiple ultrasonic flow meters worldwide in combination with SQL database storage.

2016
First microbore subsea chemical injection metering valve using ultrasonic metering technology jointly developed with SLB/Cameron.

2010
First eight-path custody transfer gas USM with patented non-wetted transducers, OIML R137 Class 0.5 with 5D, no flow conditioner and a proprietary coating for the internal meter I.D. and transducer faces for long term performance.

2008
LEFM 280CiRN: Approval for custody transfer of heavy, viscous crude oils up to 3,000 mm²/s according to OIML R117 Class 0.3. Enhanced repeatability and provability versus conventional full bore USMs.

2007
World class hydrocarbon flow facility opened, accredited to ISO 17025 accredited by NVLAP and CMC certified by VSL.

2005
Pioneered the use of ultrasonic technology for high accuracy cryogenic fluids with first LNG installation.

2003
First application for custody transfer of Liquid hydrocarbons.

1995
First military-specification flow meter.

1994
First measurement uncertainty recapture uprate at nuclear facilities.

1989
CALDON formed by Mr Cal Hastings. CALDON obtains Westinghouse Leading Edge Flow Meter technology in a full technology transfer acquisition.

1974
First crude oil application.

1970
First nuclear reactor coolant application.

1965
Westinghouse develop the LEFM product line, the first to use a chordal multipath design based on Gaussian integration, and predecessor to the CALDON product line.

Solving challenges from the reservoir to refinery. One challenge at a time.

We collaborate with all stakeholders to make the production, transportation and processing of oil & gas simpler, safer, more secure, more productive and better understood from end-to-end. Sensia is making the advantages of industrial-scale digitalization and seamless automation available to every oil & gas company.

Now every asset can operate more productively and more profitably.

US Patent No. 9,304,024: Acoustic Flow measurement device including a plurality of chordal planes each having a plurality of axial velocity measurements using transducer pairs.

US Patent No. 10,288,462: Acoustic Flow measurement device including a plurality of chordal planes each having a plurality of axial velocity measurements using transducer pairs.

US Patent No. 10,928,230: Acoustic Flow measurement device including a plurality of chordal planes each having a plurality of axial velocity measurements using transducer pairs.

US Patent No. 10,393,568: Ultrasonic meter employing two or more dissimilar chordal multipath integration methods in one body.

US Patent No. 11,549,841: Ultrasonic meter employing two or more dissimilar chordal multipath integration methods in one body.

US Patent No. 9,170,140: Ultrasonic Flow Meter with internal surface coating and Method.

US Patent No. 10,107,658: Ultrasonic Flow Meter with internal surface coating and Method.

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