CAMERON
A Schlumberger Company

CALDON LEFM Ultrasonic Flowmeters for Gas Applications

Integrating experience, proven technology, and innovation

Four-path CALDON LEFM 340Ci ultrasonic flowmeter.

Contents

Count on Cameron

CALDON LEFM* ultrasonic flowmeters provide the industry with durable, stable, and low-cost-of-ownership ultrasonic measurement options. Cameron is constantly developing cutting-edge ultrasonic technology to better meet industry demands for custody transfer. Our multipath inline ultrasonic flowmeters are backed by more than 50 years of experience and a history of technological firsts for their use.

Designed to help satisfy customer needs with the broadest product range for custody transfer of natural gas, CALDON LEFM flowmeters provide

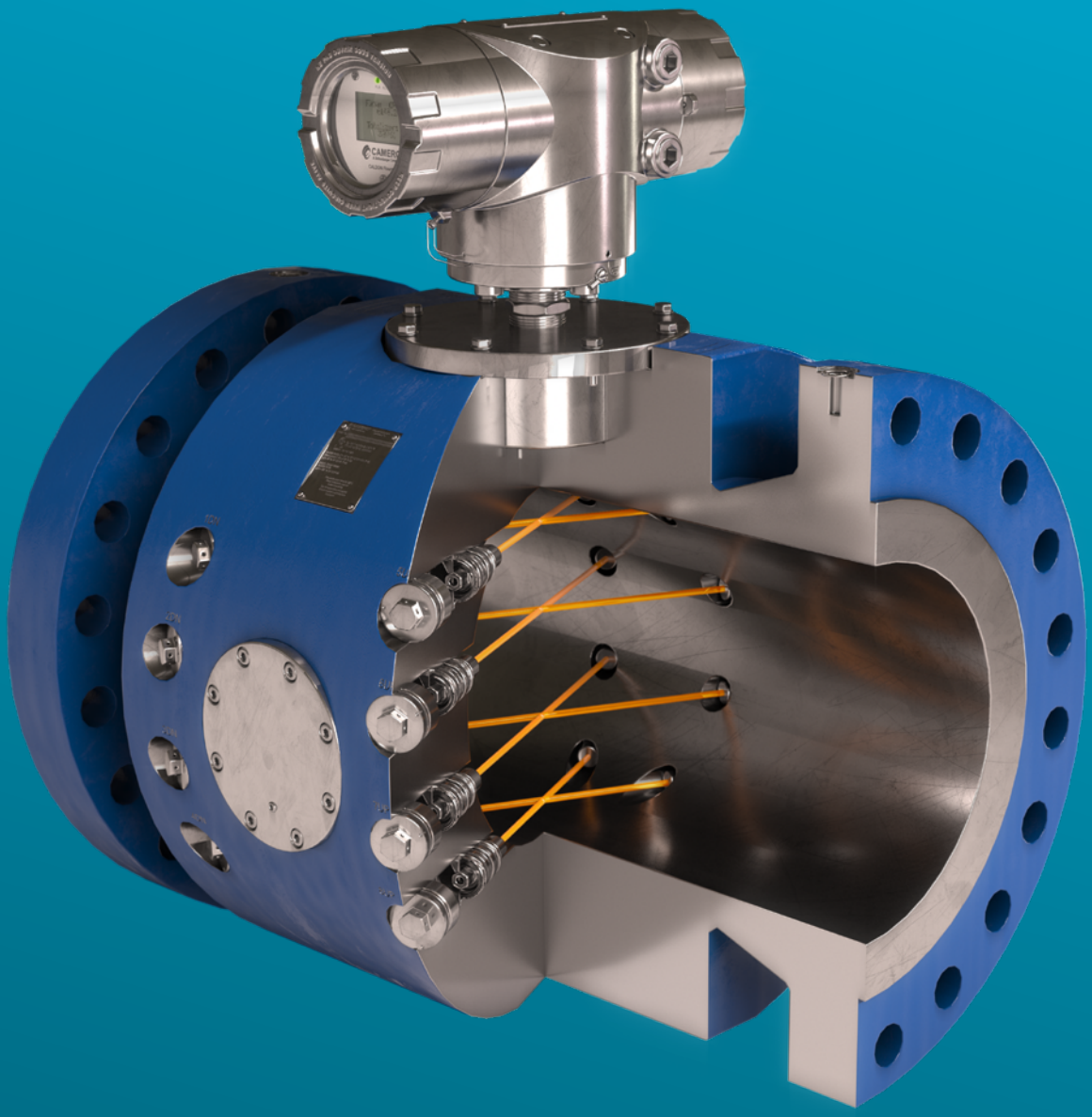
- improved meter reliability over a wide range of application conditions
- improved safety for technicians when replacing transducers
- simplified installation, reduced meter footprint, and overall metering section weight
- reduced maintenance.

The CALDON LEFM ultrasonic flowmeters create a unique offering to address operator concerns by integrating three crucial design elements:

- engineered transducer configurations in industry-standard four-path flowmeters and premium-performance eight-path flowmeters to maximize measurement accuracy without the need for flow conditioners, reducing upstream piping
- optional proprietary coating that effectively mitigates potential corrosion and contamination from components in the gas stream
- transducers fully isolated from the gas in industry's first custody-transfer gas ultrasonic meter, enabling safe replacement in the unlikely event that a transducer replacement is required.

CALDON LEFM flowmeter firsts

1965–70	First chordal multipath flowmeters
1970–75	First nuclear reactor coolant application
1974–75	First crude oil application
1994–99	First measurement uncertainty recapture uprate at nuclear facilities
1995	First military-specification flowmeter
2003	First application for custody transfer of liquid hydrocarbons
2005	First application for custody transfer of LNG
2008	First application for custody transfer of heavy, viscous crude oils up to 3,000 mm^2/s
2010	First CALDON LEFM 380Ci flowmeters installed on natural gas pipelines with isolated transducers



Eight-path CALDON LEFM 380Ci ultrasonic flowmeter.

Advantages

- Compliance with American Gas Association (AGA) Report 9, International Organization of Legal Metrology (OIML) Recommendation R 137, and ISO 17089-1
- Four- and eight-path chordal designs for optimal linearity and repeatability
- Industry-leading eight-path chordal design with immunity to swirl and asymmetry effects at 5D upstream and no requirement for flow conditioner, which reduces total cost of ownership
- Advanced signal processing with real-time diagnostic analysis, including best-in-class update rate
- Transducers that are isolated from the process, providing a safety barrier if service is required
- No recalibration or zeroing required if transducer is replaced
- Superior transducer quality with no drift
- Internal resistance temperature detector (RTD) for thermal expansion compensation
- Continuous logging capabilities
- Optional corrosion- and contamination-resistant internal coating

Product Features

CALDON LEFM ultrasonic flowmeters for gas applications feature our multiple-path, chordal flowmeter designs that use only direct measurement paths for optimal performance. Cameron has conducted extensive research and testing to develop, validate, and refine the configurations for accurate measurement of flow containing both asymmetry and swirl.

For our eight-path flowmeters, velocity measurements are averaged over the eight chordal paths in two vertical planes. Swirl effects in one plane will be equal but opposite in magnitude to the effects in the second plane. Combining the results from the two vertical planes has a net result of resolving any effects due to swirl on the overall measurement.

CALDON LEFM ultrasonic flowmeters for gas applications meet the requirements of ISO 17089-1, AGA Report 9, and OIML Recommendation R 137.

Eight-path chordal design that ensures accurate measurements without additional flow conditioners, even in flows containing swirl and asymmetry.

Fully isolated transducer housing design

Our ultrasonic flowmeters for gas applications have transducers that are installed into INCONEL® material transducer housings. The transducer housing is a pressure boundary between the transducer assembly and the process. This feature is a first for an ultrasonic natural gas flowmeter.

The operator does not have to block and depressurize the meter if a CALDON LEFM flowmeter transducer should ever need to be replaced. A transducer can be replaced safely with gas flowing in the meter. The design does not require any special tools or extraction devices for transducer replacement.

Gas transducer housing assembly, which does not require specialized tooling for replacement.

Proprietary internal coating

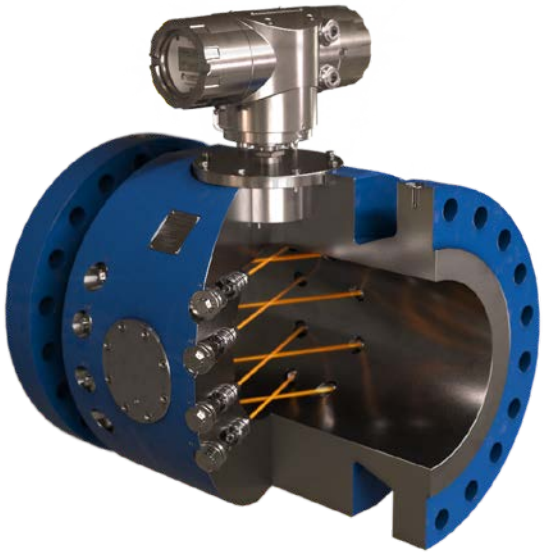
Corrosion and contamination of the flowmeter and adjacent piping can be problematic in regards to meter performance. The CALDON LEFM ultrasonic flowmeter for gas applications has an optional proprietary internal coating that significantly reduces or eliminates the risk of corrosion, contamination, or both. The coating has anticorrosion properties, high thermal stability, chemical inertness in aggressive environments, and superior adhesion resistance. Cameron can also provide upstream and downstream pipe spools with this coating at the operator's preference.

Optional internal coating, which significantly reduces corrosion and contamination risks.

CALDON LEFM Flowmeter Models for Gases

380Ci

The eight-path CALDON LEFM 380Ci ultrasonic flowmeter is a compact, high-performance unit designed to meet the most stringent requirements of custody transfer and fiscal metering applications. This model is insentitive to swirl and flow profile effects without requiring a flow conditioner. It was the first to achieve OIML R 137 Accuracy Class 0.5 requirements with only 5 diameters of straight upstream pipe.

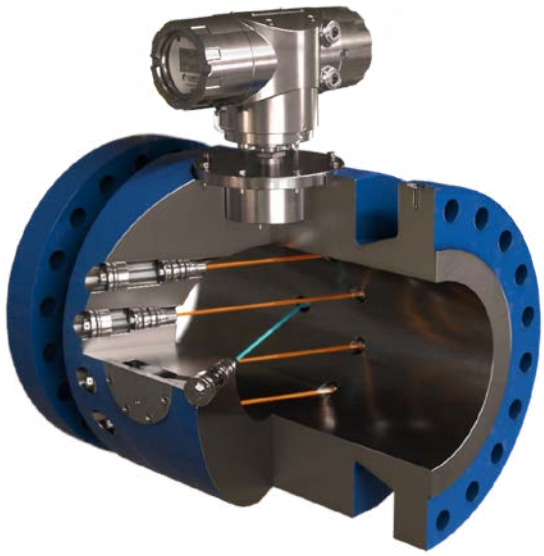


340Ci

The industry-standard four-path CALDON LEFM 340Ci ultrasonic flowmeter excels in performance and reliability, making it ideal for custody transfer or fiscal metering applications.

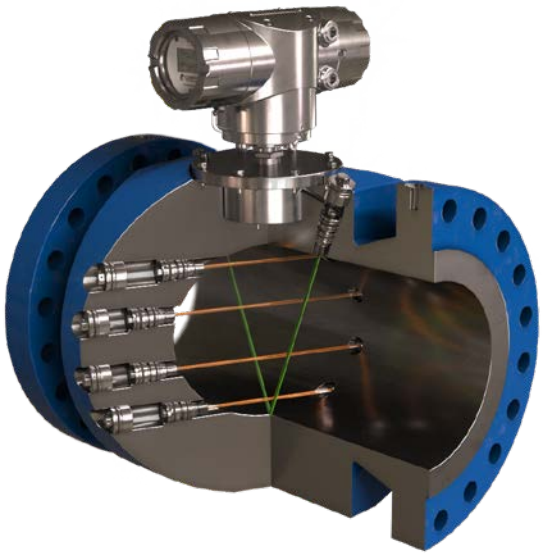
341Ci

The CALDON LEFM 341Ci ultrasonic flowmeter retains all the features and benefits of the four-path 340Ci model and adds a diametric single-path measurement for enhanced diagnostic purposes, such as detection of flow conditioner blockage.



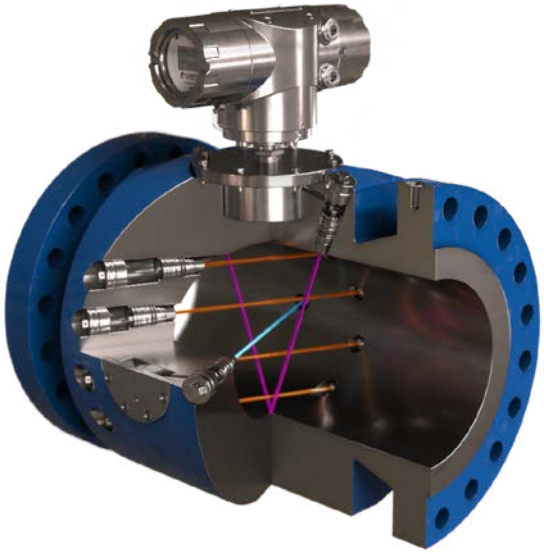
342Ci

The CALDON LEFM 342Ci ultrasonic flowmeter retains all of the advantages of the four-path 340Ci model and incorporates a vertical reflective path for detecting the presence of moisture or contamination along the bottom of the pipe.



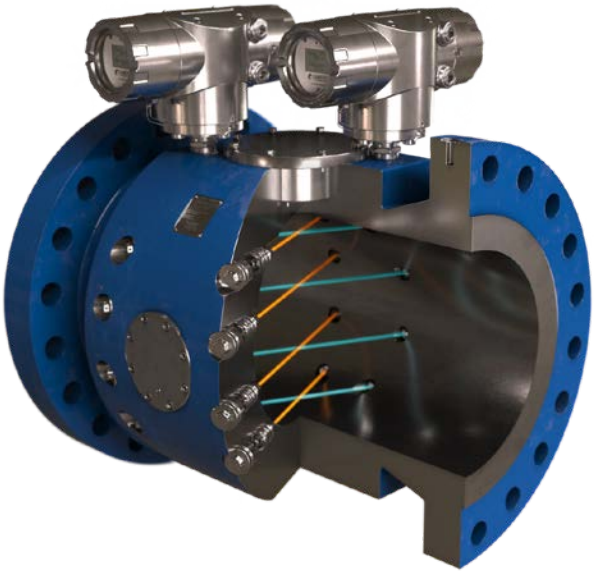
343Ci

The four-path, chordal-measurement CALDON LEFM 343Ci ultrasonic flowmeter combines both a secondary diametric single-path measurement for enhanced diagnostics and a vertical reflective path for detecting the presence of moisture or contamination along the bottom of the pipe.



344Ci

The CALDON LEFM 344Ci ultrasonic flowmeter features two independent four-path flowmeters in one compact meter body. The four-path-plus-four-path design meets all custody-transfer requirements while offering full redundancy and meter-to-meter comparison for in situ validation.

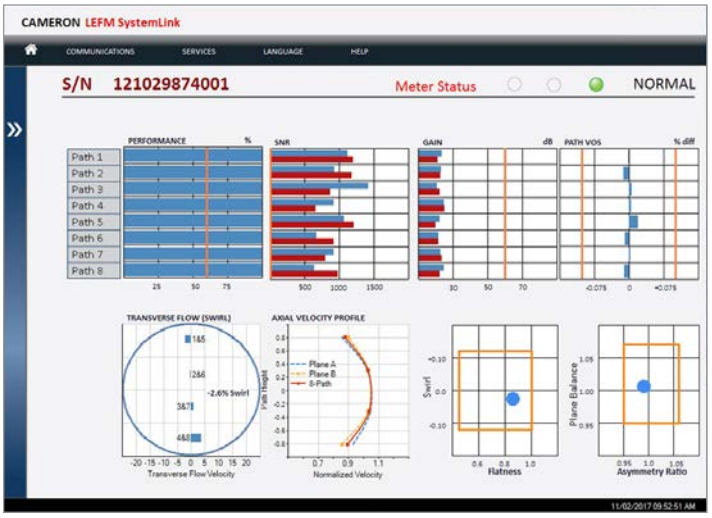


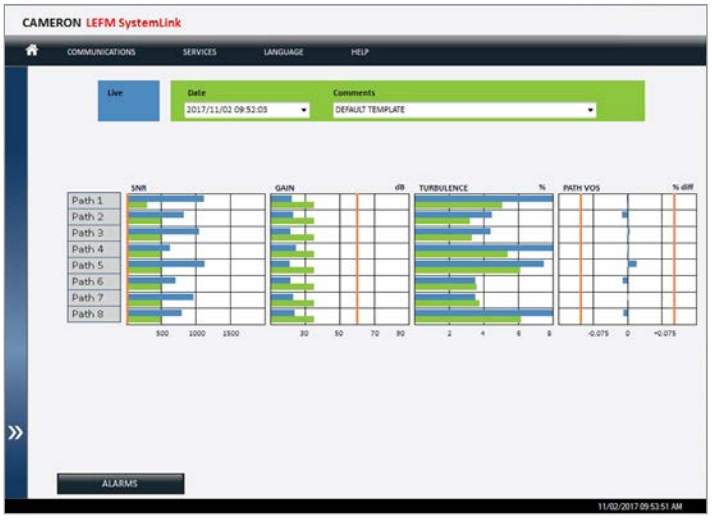
CALDON LEFM SystemLink technology

Our CALDON LEFM SystemLink* user interface software technology enables access to real-time diagnostic data, historical data, and event logs from the ultrasonic flowmeter transmitter by using an Ethernet or fiber-optic modem or serial connection. Historical data and event logs are stored within the transmitter for later retrieval, enabling operators to monitor and analyze critical diagnostics and mitigate unplanned downtime.

Features

- Health overview report showing the current meter status and meter process measurements, including flow rate, temperature, and pressure
- Detailed charts and graphs that present the meter diagnostic information in an easy-to-understand format with alarm limits that help identify issues
- User-defined reference points built using the meter's stored data that enable the user to graphically compare current meter performance against those reference points (e.g., current performance against calibration or commissioning data)
- Data exporting as predefined PDF reports or to customer-defined spreadsheets





Specifications

	Meter Body with Integral Transmitter		Meter Body with Remote Transmitter	
	CE Ex	ETL CSA	CE Ex	ETL CSA
Class	II 2 G, Ex d IIC Gb T6	Class I, Div. 1, Groups B,C, and D T6	II 2 G, Ex d IIC Gb T3	Class I, Div. 1, Groups B,C, and D T3C
Temperature	–58 to 158 degF [–50 to 70 degC]	–58 to 158 degF [–50 to 70 degC]	–58 to 257 degF [–50 to 125 degC]	–58 to 257 degF [–50 to 125 degC]

Standard Materials of Construction (Compliance with Pressure Equipment Directive [PED])	
Meter body and flanges	Carbon steel (stainless and duplex optional)
Transducer housings	INCONEL material
Junction boxes and transmitter enclosure	Copper-free aluminum (stainless steel–optional)

General Performance

Meets or exceeds the requirements of AGA 9, ISO 17089-1, and OIML R 137

Typical Meter Sizes and Flow Rates—Schedule 80 Pipe†

Meter Size	Flow Rate (Actual), ft^3/h [m^3/h]			
Nominal Size, in [mm]	Q_{min}	Q_t	Q_{max}	$Q_{over\text{-}range}$
4 [100]	283 [8.0]	2,876 [81]	28,761 [814]	34,513 [977]
6 [150]	641 [18.2]	6,521 [185]	65,209 [1,847]	78,251 [2,216]
8 [200]	1,124 [31.8]	11,423 [323]	114,234 [3,235]	137,081 [3,882]
10 [250]	1,767 [50.0]	17,964 [509]	179,644 [5,087]	215,573 [6,104]
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]
22 [550]	7,538 [213.5]	37,691 [1,067]	766,388 [21,702]	919,666 [26,042]
24 [600]	8,985 [254.4]	44,925 [1,272]	913,467 [25,867]	1,096,160 [31,040]

† Consult Cameron for other pipe schedules or meter sizes and applications outside the range of this table.

Nominal Flow Velocity Range

Flow Rate		Velocity, ft/s [m/s]
Q_{min}		1 [0.3]
Q_t	4- to 10-in meters	10 [3]
	12-in and larger meters	5 [1.5]
Q_{max}		100 [30.5]
$Q_{over\text{-}range}$†		120 [36.6]

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

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]

† Meters can be supplied with various end fittings. Consult Cameron for further information.

Performance

	380Ci					34xCi Series with Flow Conditioner					
	4 in		6–10 in		≥12 in	4 in		6–10 in		≥12 in	
	$Q_{min\ to}\ Q_t$	Q_t to Q_{max}	$Q_{min\ to}\ Q_t$	Q_t to Q_{max}	Q_{min} to Q_{max}	$Q_{min\ to}\ Q_t$	Q_t to Q_{max}	$Q_{min\ to}\ Q_t$	Q_t to Q_{max}	$Q_{min\ to}\ Q_t$	Q_{min} to Q_{max}
Average error (linearized, relative to calibration facility), %	< ± 0.3	< ± 0.1	< ± 0.2	< ± 0.1	< ± 0.1	< ± 0.42	< ± 0.1	< ± 0.28	< ± 0.1	< ± 0.14	< ± 0.1
Repeatability, typical at calibration (max error – min error), %	± 0.15	± 0.05	± 0.1	± 0.05	± 0.05	± 0.21	± 0.05	± 0.14	± 0.05	± 0.07	± 0.05
OIML R 137 accuracy class	OIML and MID certification pending		Class 0.5			OIML and MID certification pending		Class 1.0			
Measurement Instruments Directive (MID) accuracy class			Class 1.0					Class 1.0			

Size

	380Ci	340Ci	341Ci and 344Ci	342Ci and 343Ci
Nominal pipe sizes†, in [mm]	4 to 48 [100 to 1200]	4 to 48 [100 to 1200]	8 to 48 [200 to 1200]	10 to 48 [250 to 1200]

†For nominal sizes larger than 48 in [1,200 mm], contact Cameron.

For sizes 4 in and 6 in and flange ratings Cl 900 and Cl 1500, previous-generation body shape may be used.

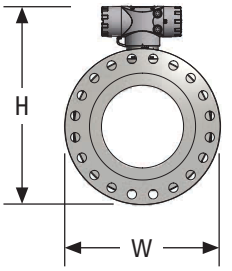
General Specifications	
Electronics	
Power requirements—DC power	
Voltage required, V DC	24 (18 to 30)
Current draw at 24 V DC, A	0.25
Power consumption, W	6
Power requirements—AC power	
Voltage, V AC	120 (60 Hz); 230 (50 Hz)
Voltage range, V AC	108–253
Frequency range, Hz	47–63
Current draw, A	0.14
Power consumption, W	7.3
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
Remote mounting electronics from meter, ft [m]	328 [100]
Analog inputs (three), mA	4–20 configurable for pressure, temperature, or other
RTD input	Meter body temperature
Analog outputs (two), mA	4–20 (650-ohm maximum load)
Digital outputs	
Flow	Four pulse output channels
	Programmable K-factor
	Programmable configuration
	1. Dual-frequency setup, 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, 50/50 duty cycle Channel B indicates flow direction Forward flow = 0 Reverse flow = high (5–12 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 V DC or 0–12 V DC selectable (0 V = alarm)
Communication	Three serial
	Ethernet (copper or fiber optic) or fiber modem
Meter body	
Relative humidity, %	0–95
Operating temperature, degF [degC]	–58 to 257 [–50 to 125]

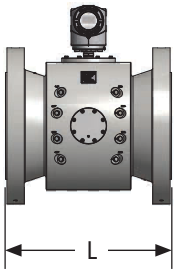
Dimensions and Weights

Dimension and Weights for 340Ci, 341Ci, 342Ci, 343Ci, 344Ci, and 380Ci Models

Nominal Pipe Size, in [mm]	Applicable Model	Flange ANSI Class	Width (W), in [mm]	Height with Transmitter (H), in [mm]	Overall Length (L), in [mm]		Weight with Components, lbm [kg]	
					Compact	3D Meter	Compact	3D Meter
4 [100]	340Ci and 380Ci	150	13.9 [354]	19.1 [485]	16.8 [426]	–	318.3 [144]	–
		300	13.9 [354]	19.6 [498]	17.5 [445]	–	759.7 [345]	–
		600	10.7 [273]	22.7 [576]	19.3 [489]	–	334.7 [152]	–
		900	13.9 [354]	20.4 [517.1]	20.3 [514]	–	402.8 [183]	–
		1500	13.9 [354]	20.7 [526.5]	21.0 [533]	–	437.6 [199]	–
6 [150]	341Ci and 380Ci	150	11.0 [279]	20.5 [520]	18.5 [470]	–	385.8 [175]	–
		300	12.5 [318]	21.2 [539]	19.3 [489]	–	440.9 [200]	–
		600	14.0 [356]	22.0 [558]	21.3 [540]	–	509.3 [231]	–
		900	15.0 [381]	22.5 [571.0]	23.0 [584]	–	586.4 [266]	–
		1500	15.5 [394]	22.7 [577.0]	25.5 [648]	–	734.1 [333]	–
8 [200]	340Ci, 341Ci, 344Ci, and 380Ci	150	17.0 [432]	23.9 [606]	18.4 [467]	23.6 [600]	548.0 [249]	574.7 [261]
		300	17.0 [432]	24.4 [619]	19.1 [486]	23.6 [600]	604.6 [274]	627.5 [285]
		600	17.0 [432]	25.1 [638]	21.0 [533]	23.6 [600]	700.0 [317]	713.3 [324]
		900	18.5 [470]	25.5 [647.0]	25.7 [654]	–	928.1 [421]	–
		1500	19.0 [483]	25.7 [654.0]	29.8 [756]	–	1,155.2 [524]	–
10 [250]	All	150	20.0 [508]	28.2 [716]	19.4 [492]	29.5 [750]	852.4 [387]	931.8 [423]
		300	20.0 [508]	28.2 [716]	20.6 [524]	29.5 [750]	940.9 [427]	1,010.4 [458]
		600	20.0 [508]	28.7 [728]	23.5 [597]	29.5 [750]	1,128.3 [512]	1,175.4 [533]
		900	21.5 [546]	27.9 [708.0]	28.3 [718]	29.5 [750]	1,305.1 [592]	1,327.2 [602]
		1500	23.0 [584]	28.6 [727.0]	33.7 [857]	29.5 [750]	1,799.0 [816]	1,721.8 [781]
12 [300]	All	150	22.0 [559]	30.7 [779]	23.1 [587]	35.4 [900]	1,272.0 [577]	1,416.9 [643]
		300	22.0 [559]	30.7 [779]	24.4 [619]	35.4 [900]	1,389.0 [630]	1,519.1 [689]
		600	22.0 [559]	30.9 [785]	26.5 [673]	35.4 [900]	1,565.2 [710]	1,670.3 [758]
		900	24.0 [610]	30.4 [771.0]	30.5 [775]	35.4 [900]	1,754.9 [796]	1,858.5 [843]
		1500	26.5 [673]	31.6 [803.0]	37.0 [940]	35.4 [900]	2,605.9 [1,182]	2,568.4 [1,165]
14 [350]	All	150	23.8 [603]	31.9 [809]	25.1 [638]	41.3 [1,050]	1,592.2 [722]	1,813.6 [823]
		300	23.8 [603]	32.3 [820]	26.4 [670]	41.3 [1,050]	1,768.3 [802]	1,972.6 [895]
		600	23.8 [603]	32.6 [829]	28.3 [718]	41.3 [1,050]	1,916.9 [869]	2,095.6 [951]
		900	25.2 [641]	31.7 [806.0]	32.0 [813]	41.3 [1,050]	2,083.4 [945]	2,321.5 [1,053]
		1500	29.5 [749]	33.9 [860.0]	38.7 [984]	41.3 [1,050]	3,318.0 [1,505]	3,390.7 [1,538]
16 [400]	All	150	24.0 [610]	32.6 [828]	24.6 [625]	47.2 [1,200]	1,481.3 [672]	1,905.1 [864]
		300	25.5 [648]	33.6 [854]	26.1 [664]	47.2 [1,200]	1,703.0 [772]	2,098.6 [952]
		600	27.0 [686]	34.4 [873]	28.8 [730]	47.2 [1,200]	1,979.3 [898]	2,325.8 [1,055]
		900	27.8 [705]	34.3 [870.0]	33.3 [845]	47.2 [1,200]	2,597.0 [1,178]	3,024.7 [1,372]
		1500	32.5 [826]	36.6 [930.0]	40.7 [1,035]	47.2 [1,200]	4,277.0 [1,940]	4,504.0 [2,043]
18 [450]	All	150	26.0 [660]	34.5 [876]	26.1 [664]	53.1 [1,350]	1,751.6 [795]	2,359.6 [1,070]
		300	28.0 [711]	36.0 [914]	27.6 [702]	53.1 [1,350]	2,052.6 [931]	2,626.9 [1,192]
		600	29.3 [743]	36.6 [930]	29.8 [756]	53.1 [1,350]	2,361.0 [1,071]	2,887.5 [1,310]
		900	31.0 [787]	36.8 [935.0]	35.0 [889]	53.1 [1,350]	3,364.3 [1,526]	4,049.9 [1,837]
		1500	36.0 [914]	39.3 [998.0]	42.8 [1,086]	53.1 [1,350]	5,496.1 [2,493]	5,943.7 [2,696]
20 [500]	All	150	28.0 [711]	36.8 [935]	28.3 [718]	59.1 [1,500]	2,192.5 [994]	3,010.7 [1,366]
		300	30.5 [775]	38.3 [973]	29.6 [752]	59.1 [1,500]	2,546.6 [1,155]	3,328.2 [1,510]
		600	32.0 [813]	39.0 [992]	32.0 [813]	59.1 [1,500]	2,961.2 [1,343]	3,679.8 [1,669]
		900	33.7 [857]	39.2 [995.0]	37.5 [953]	59.1 [1,500]	4,142.5 [1,879]	5,088.3 [2,308]
		1500	38.7 [984]	41.7 [1,058.0]	46.0 [1,168]	59.1 [1,500]	6,803.5 [3,086]	7,464.8 [3,386]
24 [600]	All	150	32.0 [813]	40.9 [1,038]	31.1 [791]	70.9 [1,800]	2,857.0 [1,296]	4,273.8 [1,939]
		300	36.0 [914]	42.9 [1,089]	32.4 [822]	70.9 [1,800]	3,401.1 [1,543]	4,773.3 [2,165]
		600	37.0 [940]	43.4 [1,101]	35.3 [895]	70.9 [1,800]	3,966.8 [1,799]	5,236.6 [2,375]
		900	41.0 [1,041]	44.3 [1,125.0]	42.8 [1,086]	70.9 [1,800]	6,552.1 [2,972]	7,881.5 [3,575]
		1500	46.0 [1,168]	46.8 [1,189.0]	51.25 [1302]	70.9 [1,800]	10,238.3 [4,644]	11,318.5 [5,134]

Consult Cameron for sizes larger than 24 in.





Meter body with integral transmitter.

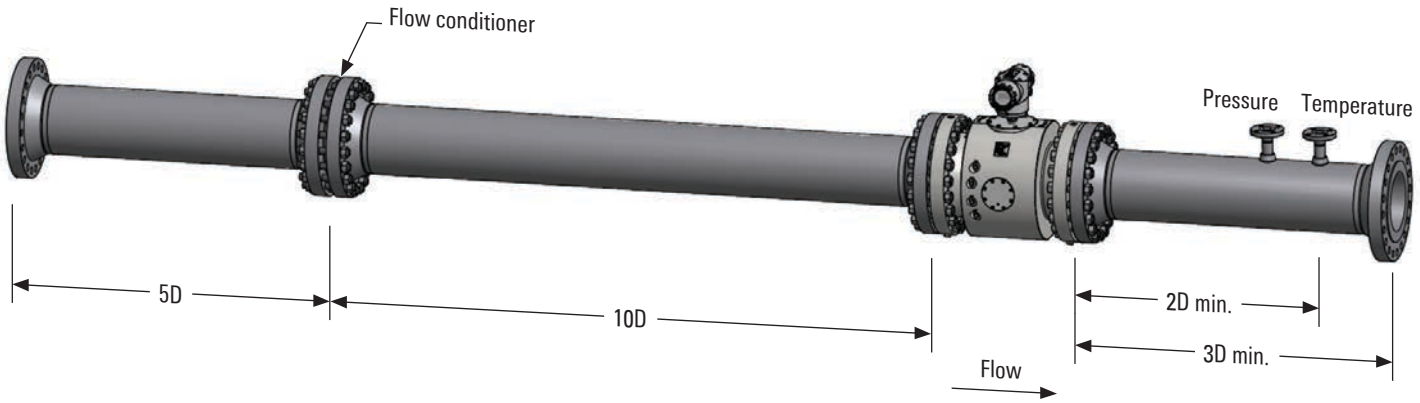
Optional pressure port per AGA.

Installation

34xCi family

To limit uncertainty caused by hydraulic effects, we recommend installing the CALDON LEFM 340Ci, 341Ci, 342Ci, 343Ci, and 344Ci flowmeters to comply with the following guidelines. The adjoining straight pipe should be of the same schedule as the meter. Temperature elements and pressure connections should be located downstream, with thermowells situated between two and five pipe diameters from the meter. We recommend installing the meter downstream of a 10-pipe-diameter section that includes a flow-conditioning element at its inlet. Downstream of the meter, there should be straight pipe section at least three pipe diameters in length.

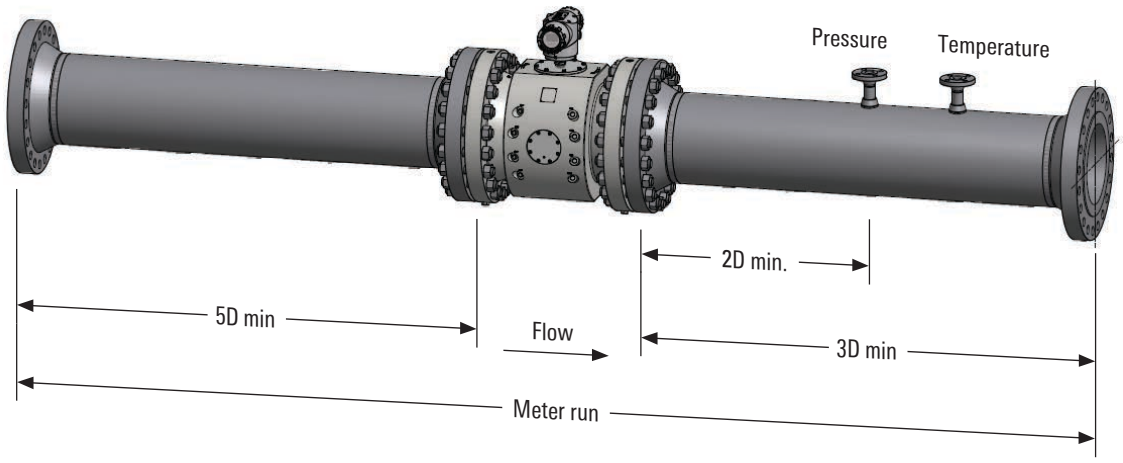
For effective flow conditioning, it is generally recommended that there be an additional straight pipe of approximately five diameters in length located upstream of the flow conditioner. Flow conditioners can be supplied by Cameron, or alternatively please consult Cameron for advice regarding the suitability of different makes and types of flow conditioner.



For best measurement performance, follow guidelines regarding the placement of the flow conditioner, temperature elements, pressure connections, and straight pipe.

380Ci

The 380Ci does not require the use of a flow-conditioning element. To limit uncertainty caused by hydraulic effects, we recommend installing the CALDON LEFM 380Ci flowmeter to comply with the following guidelines. Temperature elements and pressure connections should be located downstream of the meter. An uninterrupted upstream pipe five pipe diameters in length is sufficient downstream of piping elements such as elbows, tees, and reducers. 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 partially open or reduced bore valve), it is recommended that this be separated from the meter by 15 pipe diameters in length. Downstream of the meter, there should be a straight pipe section of at least three pipe diameters in length. Thermowells should be installed at a distance of between two and five diameters downstream of the meter.

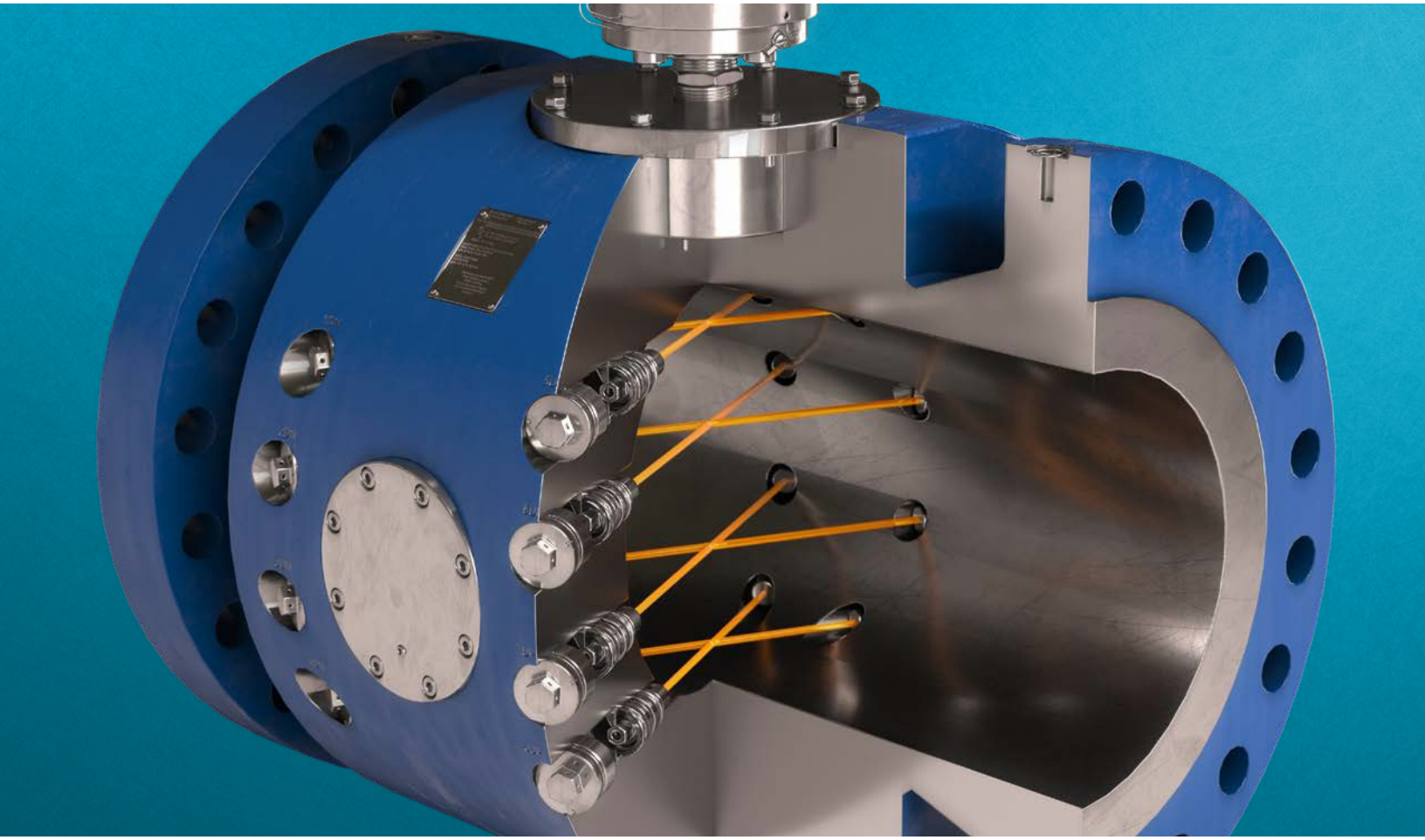


For best measurement performance, follow guidelines regarding the placement of temperature elements, pressure connections, and straight pipe.

For application-specific recommendations or more detailed installation guidance, please consult Cameron.

Notes

CALDON LEFM Ultrasonic Flowmeters for Gas Applications



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