

Sentinel LNG

Panametrics Ultrasonic Flowmeter for Cryogenic Liquids



Benefits

- Improved performance, reduced maintenance and dynamic flow measurement is now available for cryogenic liquids.
- Fully welded construction with no moving parts.
- Ultrasonic transducers protected from cryogenic temperatures using Bundle Waveguide™ Technology.
- Full bore design, zero pressure drop.
- High accuracy to overcome limitations of tank level gauging.
- Robust Path Configuration™ through extensive use of CFD (Computational Fluid Dynamics).

Applications

- Liquefied Natural Gas (LNG)
- Cryogenic fluid allocation
- Custody transfer
- Marine Cargo Verification



Cryogenic Flow Measurement from GE

GE introduces Sentinel LNG, a new addition to our series of advanced ultrasonic flowmeters. Sentinel LNG demonstrates new levels of performance, reacts to changes in flow rate with incredible speed and accuracy, and is based on proven technologies. Sentinel LNG extends the use of ultrasonic technology into cryogenic applications for measuring liquefied natural gas (LNG) with unbeatable performance, reliability and safety.

Sentinel LNG Design

The design philosophy behind Sentinel LNG was simple; building a reliable flow meter to overcome the accuracy limitation of LNG tank level measurement. Sentinel LNG is an ultrasonic flowmeter with a fully welded construction that has no moving parts. The acoustic transducers are placed outside the cryogenic liquid to avoid any long-term degradation due to temperature. The design is full bore; as a result, the pressure drop over the meter is simply equal to a section of pipe with the same length.

Advanced Electronics

Sentinel LNG measures flow using advanced digital-signal processing and improved algorithms that enable the meter to measure flow with an exceptional response speed.

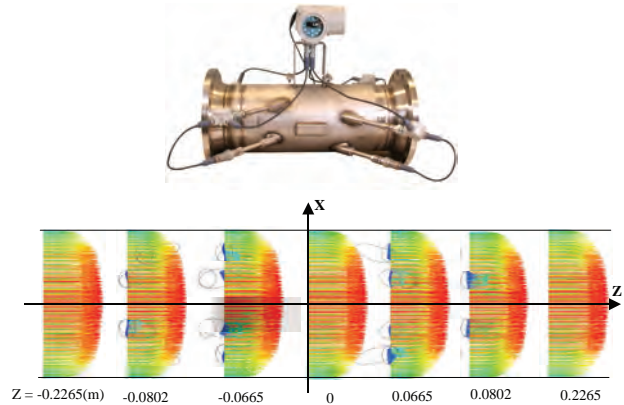
Sentinel LNG packs significant power in a simple package available with several standard output options. Customer wiring is kept in a separate location for safety. It can be mounted on the flowcell section or can be mounted up to 50 ft (15 m) away. Full access to cable connections is still possible even when mounted directly to a wall.

Full diagnostic capability can be checked locally on the display, remotely by PC or outputted via a variety of digital interfaces for continuous verification and preventative maintenance.

Robust Path Configuration™

Before Sentinel LNG was ever tested on a calibration loop, the meter was already extensively tested in the virtual world. Computational Fluid Dynamics (CFD) was used to simulate different path configurations under different flow scenarios. To give an idea of the level of detail we went into, the CFD was done with the same set-up that GE Aviation uses to model the flow in aircraft engines. The result of the CFD is filed as a GE patent and is reflected in the choice of Robust Path Configuration™.

CFD allowed us to test different ultrasonic path configurations under highly turbulent flow regimes that are typically seen in LNG measurements. Only after CFD simulation provided the optimal path configuration, Sentinel LNG was tested in a calibration loop to prove the CFD results.



CFD Simulation of Acoustic Port Effects Under Highly Turbulent Flow

Limitations of Tank Level Gauging

Measuring the volume of LNG in a tank is more than just measuring the level of the (boiling) LNG inside the tank. The temperature in the tank might not be constant, causing density variation. Corrections need to be made for tank expansion caused by the weight of the LNG inside. In case of level measurement on a ship, a pitch or even movement because of wave motion may need to be compensated for. By making a direct volume measurement, Sentinel LNG overcomes all these additional sources of uncertainty.

Bundle Waveguide Technology™

The Bundle Waveguide Technology acts as a buffer rod between the transducer and the flowing cryogenic liquid. These buffer assemblies use waveguide bundles to efficiently concentrate a greater amount of transducer ultrasonic signal into the process. At the same time, the bundles act as a buffer to protect the transducer from the cryogenic temperatures. The buffer is an all-metal construction with no moving parts. As a result, transducers can be safely removed from service without opening the pipeline. An insertion mechanism or expensive valves are not required.

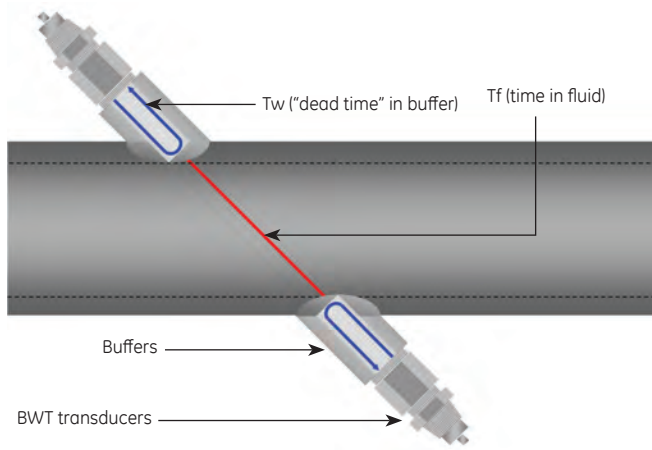


Water Calibration

The Sentinel LNG meter is equipped with time tested correction curves that can translate a water calibration into high accuracy performance at cryogenic temperatures.

Active Temperature Compensation™

Ultrasonic flowmeters use transit time to determine the liquid or gas flow in a pipeline. Measured transit time consists not only of the time the ultrasonic signal spends in a fluid; it also consists of a portion of “dead time,” being the time that the electrical signal is converted into an acoustical signal and the time the acoustic signal travels inside the transducer. To allow for the utmost accuracy, Sentinel LNG uses pulse echo to actively measure the dead time. By sending a pulse and measuring its reflection at the end of the transducer, the dead time is measured in real time rather than using a preset value. As a result of this GE invention, Sentinel LNG guarantees a flow measurement of the highest accuracy.



Active Flow Compensation

Fluctuations in temperature, especially in cryogenic applications, can affect flow accuracy. These fluctuations change the characteristics of the fluid traveling through the pipe, flowcell dimensions and the acoustic characteristics of the flowmeter. Based on a live temperature input, Sentinel LNG monitors the application temperature and calculates the changes in the flowcell dimensions. The transducer's transit time signal changes relative to temperature. Sentinel LNG's SEN898 electronics actively measure the transducer transit time signal to ensure accurate overall transit time measurement. The meter automatically and continuously makes adjustments as the application and ambient conditions change to ensure accurate measurement without user intervention.

Advanced Electronics

Sentinel LNG has advanced digital signal processors that pack significant power in a simple package. Several output options are standard. The electronics can be mounted on the flowcell section or up to 300 feet away. Cable connections can easily be accessed, even when the meter has been mounted to a wall. HART is standard on all meters. Local diagnostics can be done via magnetic contacts through the glass, or by using the USB connection and our PanaView™ software.



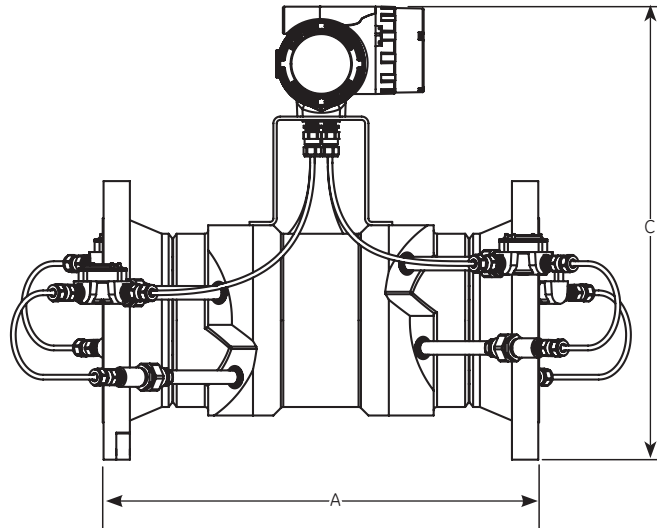
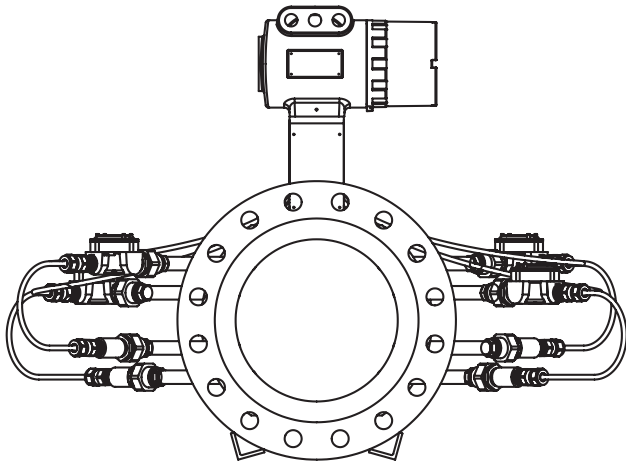
PanaView™ for Diagnostics

PanaView software facilitates communication between a PC and the Sentinel LNG flowmeter. This software monitors the Sentinel flowmeter to provide a secure and comprehensive check on the meter configuration with a full audit trail. It also allows live flow readings and tracking of flow diagnostics.



Example of PanaView Display

Dimensions and Weights



Weights are based on stainless steel.

| Dimensions and weights in English units | | | | |
|---|--------|--------|--------|-------------|
| Diameter | Flange | A (in) | C (in) | Weight (lb) |
| 4 | 150# | 20 | 23.49 | 150 |
| | 300# | 20 | 23.99 | 178 |
| | 600# | 20 | 24.36 | 202 |
| 6 | 150# | 22 | 25.76 | 211 |
| | 300# | 24 | 26.51 | 268 |
| | 600# | 26 | 27.26 | 341 |
| 8 | 150# | 26 | 27.59 | 271 |
| | 300# | 28 | 28.34 | 346 |
| | 600# | 30 | 29.09 | 457 |
| 10 | 150# | 28 | 29.84 | 371 |
| | 300# | 30 | 30.59 | 492 |
| | 600# | 32 | 31.84 | 746 |
| 12 | 150# | 30 | 32.59 | 483 |
| | 300# | 32 | 33.34 | 688 |
| | 600# | 36 | 34.09 | 967 |
| 14 | 150# | 36 | 34.09 | 798 |
| | 300# | 38 | 35.09 | 1090 |
| | 600# | 40 | 35.46 | 1352 |
| 16 | 150# | 38 | 36.84 | 989 |
| | 300# | 40 | 37.84 | 1361 |
| | 600# | 42 | 38.59 | 1788 |
| 18 | 150# | 38 | 37.84 | 1067 |
| | 300# | 40 | 39.34 | 1542 |
| | 600# | 44 | 39.96 | 2097 |
| 20 | 150# | 46 | 41.25 | 1438 |
| | 300# | 48 | 42.75 | 2141 |
| | 600# | 50 | 43.50 | 2847 |
| 24 | 150# | 48 | 44.59 | 2010 |
| | 300# | 50 | 46.59 | 2976 |
| | 600# | 52 | 47.09 | 3985 |

| Dimensions and weights in metric units | | | | |
|--|--------|--------|--------|-------------|
| Diameter | Flange | A (mm) | C (mm) | Weight (kg) |
| 4 | 150# | 508 | 597 | 68 |
| | 300# | 508 | 609 | 81 |
| | 600# | 508 | 619 | 92 |
| 6 | 150# | 559 | 654 | 96 |
| | 300# | 610 | 673 | 121 |
| | 600# | 660 | 692 | 155 |
| 8 | 150# | 660 | 701 | 123 |
| | 300# | 711 | 720 | 157 |
| | 600# | 762 | 739 | 207 |
| 10 | 150# | 711 | 758 | 168 |
| | 300# | 762 | 777 | 223 |
| | 600# | 813 | 809 | 339 |
| 12 | 150# | 762 | 828 | 219 |
| | 300# | 813 | 847 | 312 |
| | 600# | 914 | 866 | 438 |
| 14 | 150# | 914 | 866 | 362 |
| | 300# | 965 | 891 | 494 |
| | 600# | 1016 | 901 | 613 |
| 16 | 150# | 965 | 936 | 463 |
| | 300# | 1016 | 961 | 618 |
| | 600# | 1067 | 980 | 811 |
| 18 | 150# | 965 | 961 | 484 |
| | 300# | 1016 | 999 | 700 |
| | 600# | 1118 | 1015 | 951 |
| 20 | 150# | 1168 | 1048 | 646 |
| | 300# | 1219 | 1086 | 962 |
| | 600# | 1270 | 1105 | 1280 |
| 24 | 150# | 1219 | 1133 | 912 |
| | 300# | 1270 | 1183 | 1350 |
| | 600# | 1321 | 1196 | 1808 |

Specifications

Performance

Fluid Types

Liquid hydrocarbons

Flow Measurement

Correlation transit time mode

Accuracy

< ± 0.25% of measured volume for flow rates between 2 and 30 ft/s (0.5 and 10 m/s)

Repeatability

<±0.02%

Zero Stability

< 0.007 ft/s (0.002 m/s)

Process Temperature

-200° to +120°C (-328° to 248°F)

Ambient Temperature

-40° to +60°C (-40° to 140°F)

Storage Temperature

-40° to +80°C (-40° to +176°F)

Meter Body

Path Configuration

Four-path Robust Path Configuration™

Meter Body Materials

- Stainless steel A182, Gr 304/304L
 - Stainless steel A182, Gr 316/316L
- Others on request.

Pipe Sizes

4 in (100 mm) to 36 in (900 mm)
Others on request.

Flange Ratings

- 150 #
 - 300 #
- Others on request.

Pipe Schedules

- 10S
 - 40S
 - STD
- Others on request.

PED Compliance

PED Cat III, module H

Installation Requirement

Meter must be installed with 20D straight piping upstream and 5D straight piping downstream. Inlet and outlet piping ID must meet meter ID.

Pressure, temperature and density connections must be located in the downstream piping. The 20D upstream piping must be free of any nozzles that could disturb the flow profile.

Electronics

Electronics Enclosure Material

Epoxy coated aluminium

Dimensions

- Weight 25 lb (11.5 kg)
- Size (l x h x d): 13 x 11 x 9 in (33 x 27 x 23 cm)

Environmental Protection

IP66

Power Supply

- 100 to 240 VAC
- 12 to 32 VDC

Power Consumption

< 20 watt

Display

High contrast 128 x 64 pixel graphical display with LED illumination

Outputs

- Two frequency/pulse outputs optically isolated from DC
- Two alarm relays
- One 4/20 mA output with HART

Inputs

Two 4/20 mA and one 100 ohm RTD input for density, pressure and temperature input (option). Three 4/20 mA inputs for density, pressure and temperature input (option).

Digital Interfaces

- HART over 4/20 mA output
- PandLink over RS232/485/USB
- Modbus over RS232/485 (option)

Hazardous Area Certifications

- USA/Canada: Class 1, Div 1, groups B, C, & D
- Europe: ATEX II 2 G, Ex de IIC (Ex d IIC as option)
- IEC Ex: Ex de IIC (Ex d IIC as option)

CE Compliance

- 2004/108/EC EMC Directive
- 2006/95/EC LVD

Flow Computer Functionality

Integrated flow computer with full P and T volume corrections according to API 11.1

Flow Ranges

| | | 0.5 m/s | 10 m/s | 0.5 m/s | 10 m/s | 0.5 m/s | 10 m/s |
|------------------|-----|---------------------|---------------------|-----------|---------|-----------|---------|
| Nominal Diameter | | 1.69 ft/s | 33 ft/s | 1.69 ft/s | 33 ft/s | 1.69 ft/s | 33 ft/s |
| in | mm | (m ³ /h) | (m ³ /h) | (GPM) | (GPM) | (BBL/h) | (BBL/h) |
| 4 | 100 | 15 | 280 | 66 | 1230 | 94 | 1760 |
| 6 | 150 | 33 | 630 | 145 | 2770 | 207 | 3960 |
| 8 | 200 | 58 | 1130 | 255 | 4980 | 364 | 7120 |
| 10 | 250 | 91 | 1800 | 400 | 7900 | 573 | 11300 |
| 12 | 300 | 131 | 2500 | 580 | 11000 | 825 | 15700 |
| 14 | 350 | 179 | 3500 | 790 | 15400 | 1130 | 22000 |
| 16 | 400 | 233 | 4500 | 1030 | 19800 | 1470 | 28300 |
| 18 | 450 | 296 | 5700 | 1300 | 25100 | 1860 | 35900 |
| 20 | 500 | 365 | 7000 | 1600 | 30800 | 2300 | 44000 |
| 24 | 600 | 525 | 10000 | 2310 | 44000 | 3300 | 63000 |

Typical flow rates for 0.5 m (19.6 in) per second and 10 m (393 in) per second are listed above. The Sentinel LNG is a full bore meter and the flow range is a function of the pipe and not the meter itself.

Sentinel LNG Liquid Custody Transfer Flowmeter

SEN898 Sentinel Liquid Custody Transfer Flowmeter

Feature 1: Diameter

- 4 4" flowspool with RF flanges acc to ASME B16.5 (See Flow Rates table for metric conversion)
- 6 6" flowspool with RF flanges acc to ASME B16.5
- 8 8" flowspool with RF flanges acc to ASME B16.5
- 10 10" flowspool with RF flanges acc to ASME B16.5
- 12 12" flowspool with RF flanges acc to ASME B16.5
- 14 14" flowspool with RF flanges acc to ASME B16.5
- 16 16" flowspool with RF flanges acc to ASME B16.5
- 18 18" flowspool with RF flanges acc to ASME B16.5
- 20 20" flowspool with RF flanges acc to ASME B16.5
- 24 24" flowspool with RF flanges acc to ASME B16.5
- 28 28" flowspool with RF flanges acc to ASME B16.47
- 30 30" flowspool with RF flanges acc to ASME B16.47
- 32 32" flowspool with RF flanges acc to ASME B16.47
- 36 36" flowspool with RF flanges acc to ASME B16.47

Feature 2: Pressure class

- 150 150 lbs pressure rating
- 300 300 lbs pressure rating

Feature 3: Material

- 304 Stainless steel, A182 Grade 304/304L
- 316 Stainless steel, A182 Grade 316/316L

Feature 4: Schedule

- 10S Schedule size 10S
- 40S Schedule size 40S
- STD Schedule size STD
- S Special

Feature 5: Design Criteria

- A ASME B31.3
- P ASME B31.3 with PED approval

Feature 6: Electronics Mounting

- S Remote mounting, cable length selectable (max 300 ft or 91 m)

Feature 7: Material certs

- 0 None
- 1 Material certs
- 2 Material certs with EN 10204 3.1 inspection certificate

Feature 8: NACE Requirements

- 0 None
- 1 NACE MR0175
- 2 NACE MR0103

Feature 9: Special Requirements

- 0 None
- S Special

