

# 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 Bundled Wave Technology
- Full bore design, zero pressure drop
- High accuracy to overcome limitations of tank level gauging
- Completely optimised ultrasonic path configuration by 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 an absolute 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 whatsoever. 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.

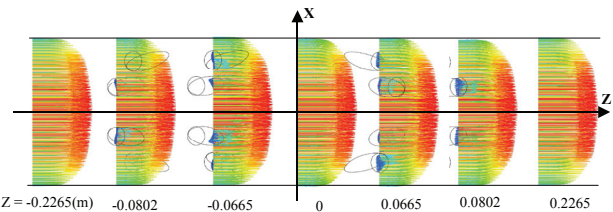
Sentinel LNG packs significant power in a simple package available with several standard output options. Customer wiring is kept in a separate location for safety. It can be mounted on the flowcell section or can be mounted up to 50 ft (15 m) away. Full access to cable connections is still possible even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

## The Ultimate in Ultrasonic 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.

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

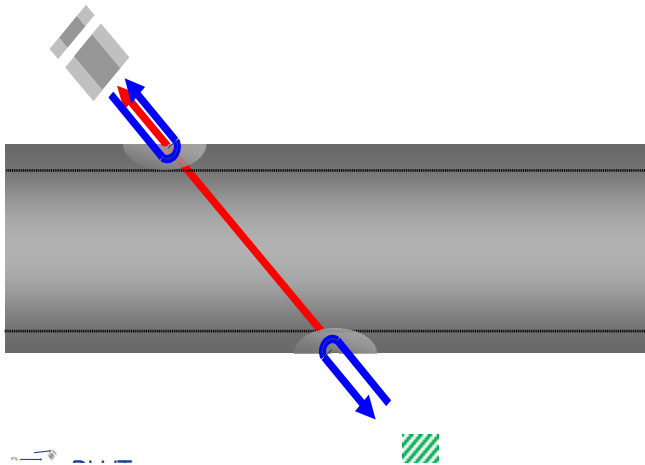
Measuring the volume of LNG in a tank is more than just measuring the level of the (boiling) LNG inside the tank. The temperature in the tank might not be constant causing density variation. Corrections need to be made for tank expansion caused by the weight of the LNG inside. In case of level measurement 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 TM

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.

## Pulse Echo

Ultrasonic flowmeters use transit time to determine the liquid or gas flow in a pipeline. Measured transit time does however not only consists of the time the ultrasonic signal spends in a fluid, it also consists of a portion '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 life 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.

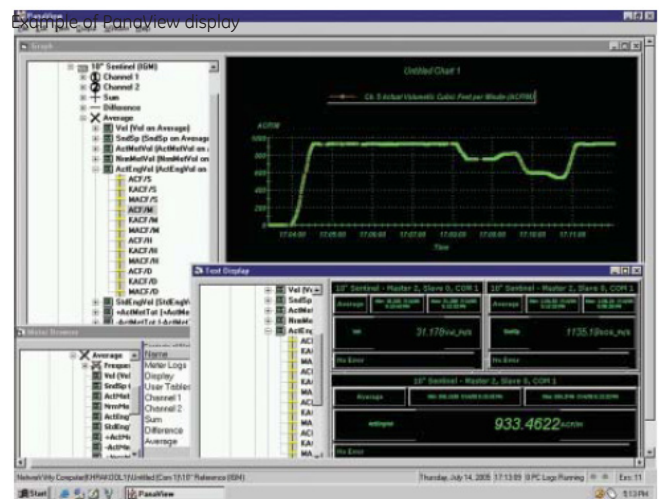
## Advanced Electronics

Sentinel LNG has an 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 50 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 your 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 in english units

Diameter	Flange	A (inches)	C (inches)	Weight (lbs)
4	150#	20	23.5	149
	300#	20	24.0	176
	600#	20	24.4	200
6	150#	22	25.8	209
	300#	24	26.5	265
	600#	26	27.3	338
8	150#	26	27.6	268
	300#	28	28.3	343
	600#	30	29.1	452
10	150#	28	29.8	367
	300#	30	30.6	487
	600#	32	31.8	739
12	150#	30	32.6	478
	300#	32	33.3	681
	600#	36	34.1	957
14	150#	36	34.1	790
	300#	38	35.1	1079
	600#	40	35.5	1339
16	150#	38	36.8	989
	300#	40	37.8	1348
	600#	42	38.6	1770
18	150#	38	37.8	1056
	300#	40	39.3	1527
	600#	44	40.0	2076
24	150#	48	44.6	1990
	300#	50	46.6	2947
	600#	52	47.1	3946

Dimensions and weights in metric units

Diameter	Flange	A (mm)	C (mm)	Weight (kg)
4	150#	508	597	68
	300#	508	609	80
	600#	508	619	91
6	150#	559	654	95
	300#	610	673	120
	600#	660	692	153
8	150#	660	701	122
	300#	711	720	156
	600#	762	739	205
10	150#	711	758	166
	300#	762	777	221
	600#	813	809	335
12	150#	762	828	217
	300#	813	847	309
	600#	914	866	434
14	150#	914	866	358
	300#	965	891	489
	600#	1016	901	607
16	150#	965	936	449
	300#	1016	961	611
	600#	1067	980	803
18	150#	965	961	479
	300#	1016	999	693
	600#	1118	1015	942
24	150#	1219	1133	903
	300#	1270	1183	1337
	600#	1321	1196	1790

# Specifications

## Performance

### Fluid Types

Liquid hydrocarbons

### Flow Measurement

Correlation Transit Time mode

### Accuracy

< ± 0.25% of measured volume for flow rates between 3 and 30 ft/s

### Zero Stability

< 0.007 ft/s

### Process Temperature

- 200° to +120°C

### Ambient Temperature

- 40° to +60°C

### Storage Temperature

- 40° to +80 C

## Meter Body

### Path Configuration

4 path Gaussian Quadrature

### Meter Body Materials

Stainless steel A182, Gr 304/304L

Stainless steel A182, Gr 316/316L

Others on request

### Pipe Sizes

4" (100 mm) to 36" (900 mm)

Others on request

### Flange Ratings

150 #

300 #

Others on request

## Pipe Schedules

10S

40S

Others on request

## PED Compliance

System complies with 73/23/EEC LVD

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 (lxhxd): 13 x11x 9" (33x27x23 cm)

### Environmental Protection

USA: Type 4

Europe: IP66

### Power Supply

100 – 240 VAC

12 - 32 VDC

### Power Consumption

< 20 Watt

### Display

High contrast 128 x 64 pixel graphical display with LED illumination.

### Outputs

Two frequency/pulse outputs optically insulated 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  
PanaLink over RS232/485/USB  
Modbus over RS232/485 (option)

### **Flow Computer Functionality**

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

### **Hazardous Area Classification**

USA: Class 1, Div 1, groups B, C,&D  
Europe: ATEX II 2D EEx d IIC (EEx de as option)

### **EMC Compliance**

73/23/EEC LVD

**Sentinel Electronics SEN898 ordering information**

**SEN898** SEN 898 electronics for Custody Transfer Measurement

**Feature 1: Power**

- 1 100 to 240 VAC operating voltage
- 2 12 to 32 VDC operating voltage

**Feature 2: Inputs**

- 0 None (not possible for LNG due to active temperature compensation)
- 1 One 100 Ohm RTD input, Two 4-20mA inputs
- 2 Three 4-20mA inputs

**Feature 3: Communications**

- 0 None
- 1 Modbus RTU over RS232/RS485

**Feature 4: Flow Computer**

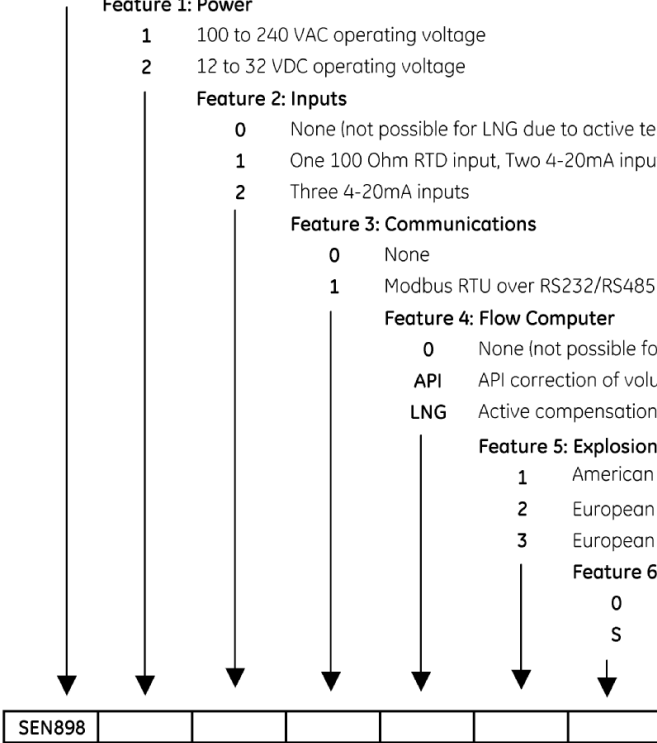
- 0 None (not possible for LNG due to active temperature compensation)
- API API correction of volume per API Chapter 11.1 (for LCT only, 3 inputs required)
- LNG Active compensation for tube contraction (for LNG only, 3 inputs required)

**Feature 5: Explosion Proof**

- 1 American Explosion Proof, Class 1, Div 1, groups B, C, D
- 2 European Explosion Proof, II 2G EEx d IIC
- 3 European Explosion Proof increased safety, II 2G EEx de IIC

**Feature 6: Special requirements**

- 0 None
- S Special



# 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
- 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
- 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/STD Schedule size 40S
- 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)

**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

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