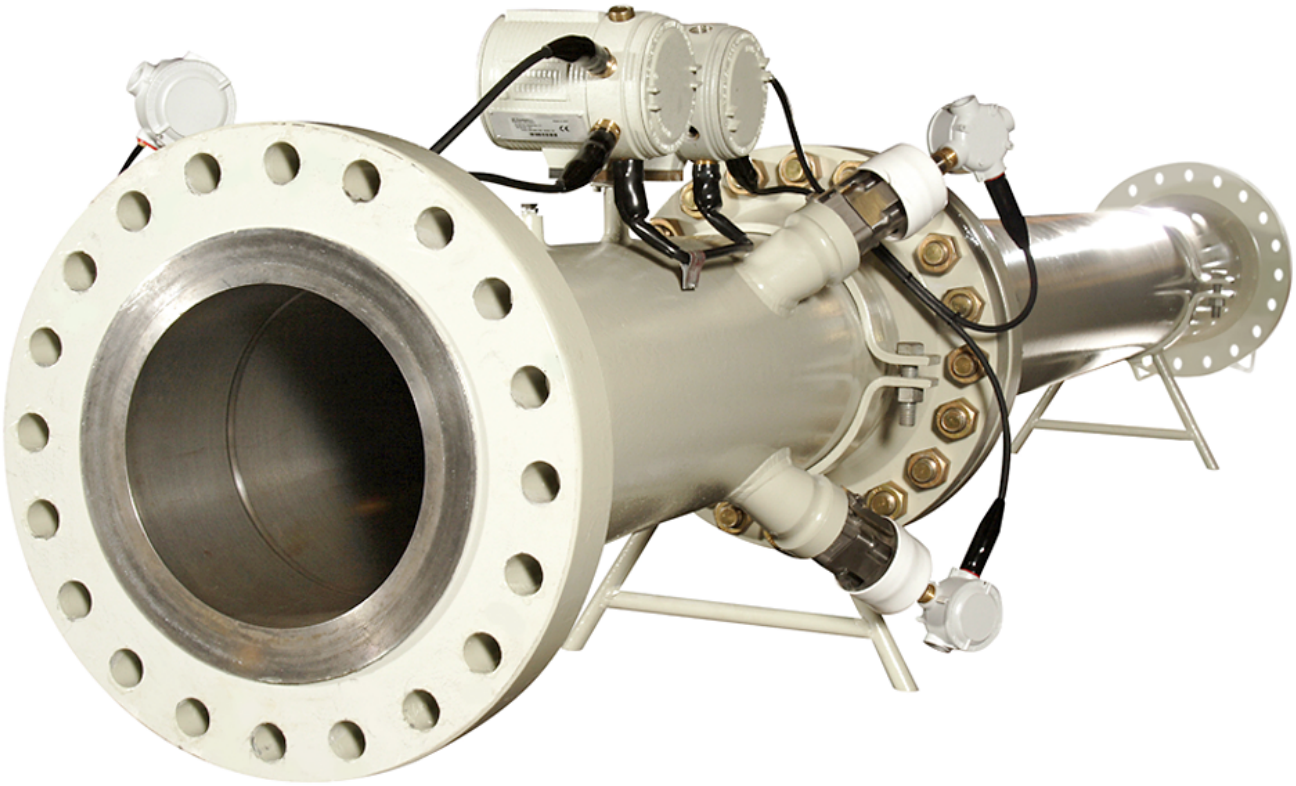
Panametrics
a Baker Hughes business

Sentinel™

User's Manual



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panametrics.com

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Information Paragraphs

Note: *These paragraphs provide information that provides a deeper understanding of the situation, but is not essential to the proper completion of the instructions.*

IMPORTANT: These paragraphs provide information that emphasizes instructions that are essential to proper setup of the equipment. Failure to follow these instructions carefully may cause unreliable performance.

CAUTION! **This symbol indicates a risk of potential minor personal injury and/or severe damage to the equipment, unless these instructions are followed carefully.**

WARNING! **This symbol indicates a risk of potential serious personal injury, unless these instructions are followed carefully.**

Safety Issues

WARNING! **It is the responsibility of the user to make sure all local, county, state and national codes, regulations, rules and laws related to safety and safe operating conditions are met for each installation.**

Auxiliary Equipment

Local Safety Standards

The user must make sure that he operates all auxiliary equipment in accordance with local codes, standards, regulations, or laws applicable to safety.

Working Area

WARNING! **Auxiliary equipment may have both manual and automatic modes of operation. As equipment can move suddenly and without warning, do not enter the work cell of this equipment during automatic operation, and do not enter the work envelope of this equipment during manual operation. If you do, serious injury can result.**

WARNING! **Make sure that power to the auxiliary equipment is turned OFF and locked out before you perform maintenance procedures on the equipment.**

Qualification of Personnel

Make sure that all personnel have manufacturer-approved training applicable to the auxiliary equipment.

Personal Safety Equipment

Make sure that operators and maintenance personnel have all safety equipment applicable to the auxiliary equipment. Examples include safety glasses, protective headgear, safety shoes, etc.

Unauthorized Operation

Make sure that unauthorized personnel cannot gain access to the operation of the equipment.

Environmental Compliance

Waste Electrical and Electronic Equipment (WEEE) Directive

Panametrics is an active participant in Europe's *Waste Electrical and Electronic Equipment* (WEEE) take-back initiative, directive 2012/19/EU.

The equipment that you bought has required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment.

In order to avoid the dissemination of those substances in our environment and to diminish the pressure on the natural resources, we encourage you to use the appropriate take-back systems. Those systems will reuse or recycle most of the materials of your end life equipment in a sound way.

The crossed-out wheeled bin symbol invites you to use those systems.

If you need more information on the collection, reuse and recycling systems, please contact your local or regional waste administration.

Chapter 1. Installation

Chapter 2. Initial Setup

Chapter 3. Operation

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Chapter 1. Installation

1.1 Introduction

The Panametrics Sentinel, shown in *Figure 1* below, is a flow measurement system that includes a multi-path ultrasonic flowmeter, associated upstream piping, and a flow conditioner. The entire system is shipped fully assembled and configured. The system was designed specifically for the natural gas custody transfer industry and meets or exceeds all requirements of AGA Report No. 9.

1.2 Advantages

The Sentinel Flow Measurement System features numerous unique advantages:

- High turndown ratio
- Low sensitivity to many upstream flow disturbances
- Capability of bi-directional flow measurement with equal accuracy
- Minimal maintenance
- Transducer replacement without the need for pipe shutdown or recalibration

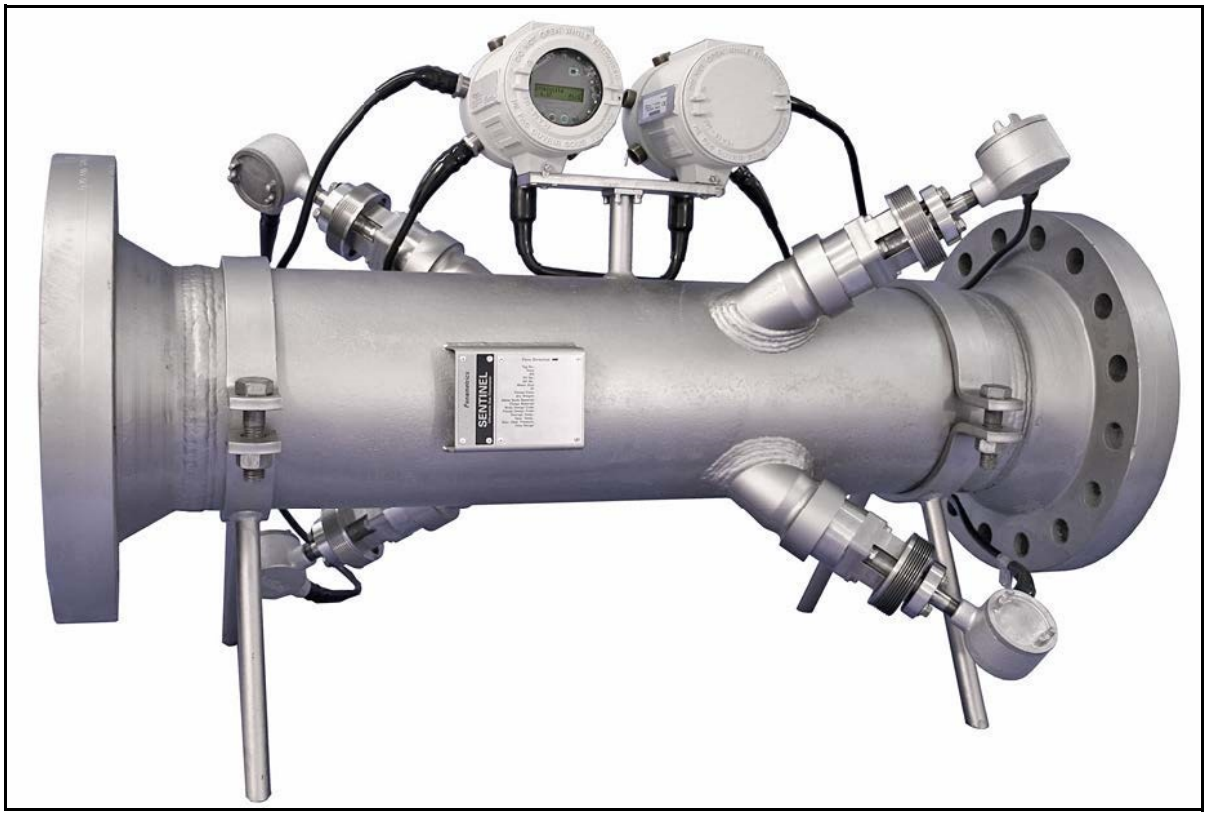


Figure 1: Sentinel Flow Measurement System

1.3 Meter Components

Figure 19 on page xxxvii shows the complete Sentinel system and each item is described in *Table 1* and *Table 2* below.

1	Meter Body	Measurement section of a Sentinel System.	1
2	Name and Specification Plate	All pertinent information in a single location.	1
3	Transducer Holder Assembly	Device to support a transducer and provide a mounting point for the Insertion Mechanism.	4
4	Transducer	Flow sensor to transmit and receive ultrasonic waves.	4
5	Cable Assembly - Transducer to Electronics Unit	Conductors assembled and rated for hazardous areas.	4
6	Explosion-Proof Junction Box	Housing for electrical connections in hazardous area.	4
7	Electronics Unit	Meter electronics equipment, including power supply, processing unit and communications.	1
8	External Conduits Connection	Location for power and communications connections. Cable glands are 3/4" NPT.	4
9	Upstream Spoolpiece (length = 10 x ID)	Meter run section (downstream of the flow conditioner) which allows the flow to develop before entering the meter body.	1
10	Flow Conditioner Model CPA 50E	Device to reduce the effects of upstream piping configurations.	1
11	Downstream Spoolpiece* (length = 10 x ID)	Meter run section (downstream of the flow conditioner) which allows the flow to develop before entering the meter body.	1*
12	Flow Conditioner* Model CPA 50E	Device to reduce the effects of upstream piping configurations.	1*
13	Nuts and Bolts	Hardware to hold flanges together.	AR
14	Gasket	Seal between each set of flanges.	AR
15	Flowcell Stand (removed after installation)	Structure to support the meter body during shipping and storage.	2
16	Pressure Port	1/4" female NPT (shipped with pipe plug installed).	1
* Optional items for bi-directional flow applications.			

Pipe Flanges and Fittings	Carbon Steel (A105 or A350 LF2*)
Pipe Sections	Carbon Steel (A106 Gr. B or A333 Gr. 6*)
Transducer Holder Parts	Stainless Steel 316/316L (A276)
T11 Transducers	Titanium CP Gr. 2 (B348/B381) or Stainless Steel 316/316L (A276)
* A350 LF2 and A333 Gr. 6 are used for low temperature service and are specified by the customer.	

1.4 Name and Specification Plate

The location of the Sentinel specification plate is shown in *Figure 1 on page xi* and *Figure 19 on page xxxvii*. *Figure 2* below shows a blank plate. The specifications can be filled in by the user, for quick reference while using the manual.

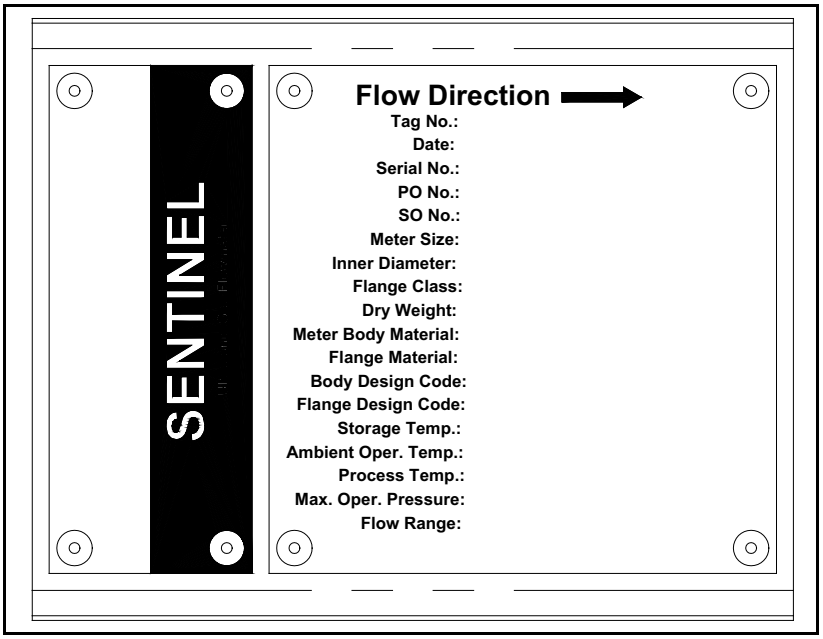


Figure 2: Sentinel Data Plate

1.5 Principles of Operation

The Sentinel Measurement System uses ultrasonic transit-time technology. A brief description of transit-time theory follows. For more information about the theory, and the use of Panametrics ultrasonic flowmeters for measuring flow, please refer to *Ultrasonic Measurements for Process Control* by L.C. Lynnworth (Academic Press, 1989).

1.5.1 Transit-Time Method

The transit time technique uses a pair of transducers, with each transducer alternately sending and receiving coded ultrasonic signals through the fluid. *Figure 3* below shows the paths used in the Sentinel. When the fluid is flowing, signal transit time in the downstream direction is shorter than in the upstream direction; the difference between these transit times is proportional to the flow velocity. The Sentinel measures this very small time difference and, using various digital signal processing techniques combined with programmed pipe parameters, determines the flow rate and direction.

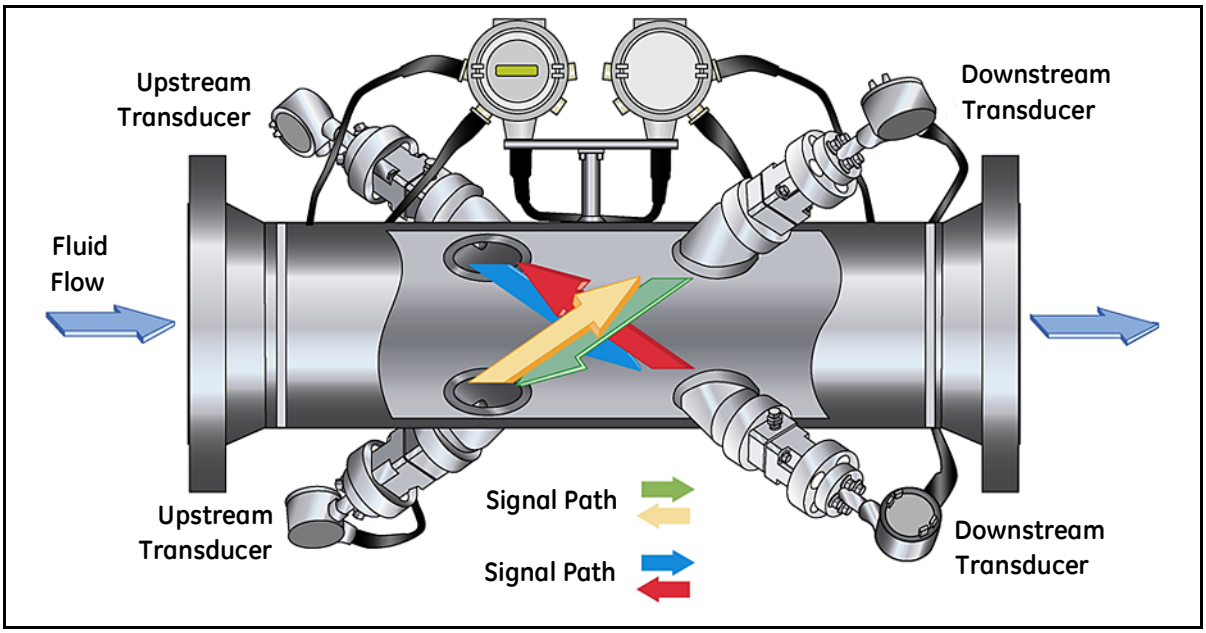


Figure 3: Path Configuration

1.5.2 Transducers

When in a transmit cycle, transducers convert electrical energy into ultrasonic pulses and then convert the ultrasonic pulses back to electrical energy when in a receive cycle. In other words, they act like loudspeakers when transmitting the signal and like microphones when receiving it. They perform the actual data transmission and collection, thus interrogating the flow.

The transducers in the Sentinel Measurement System were specifically designed to work with the available Insertion Mechanism. In the event that a transducer becomes damaged or non-functional, it can be replaced without shutting down the pipeline. The insertion mechanism is an option available with all offered versions of the Sentinel. To keep the fluid from escaping while the transducer is being replaced, it is recommended that a shutoff valve be part of the original transducer holder assembly.

1.5.3 Multi-Path Design

Multi-path ultrasonic flowmeters are designed with more than one pair of transducers to interrogate the flow field in different locations and more accurately determine the actual flow rate. The Sentinel Measurement System uses two measurement locations. Both measurement paths are located along a diameter of the meter body and tilted at an angle. The two measurement paths are orthogonal to each other (see *Figure 3 on page xiv*).

1.5.4 Flow Profile

One of the main factors affecting an ultrasonic flow measurement is the flow profile. If the flow profile is known, mathematical modeling of the flow and the relationships between the paths' raw data can be made. This justifies the required use of a flow-conditioning device with this system. A simulation example of how the flow conditioner reduces secondary flow is shown in *Figure 4* below. Maintaining a constant flow-profile shape across all flow velocities, pipe sizes and upstream flow disturbances is difficult. For this reason, the factory has tested the Sentinel under various conditions in an effort to determine its operational limits.

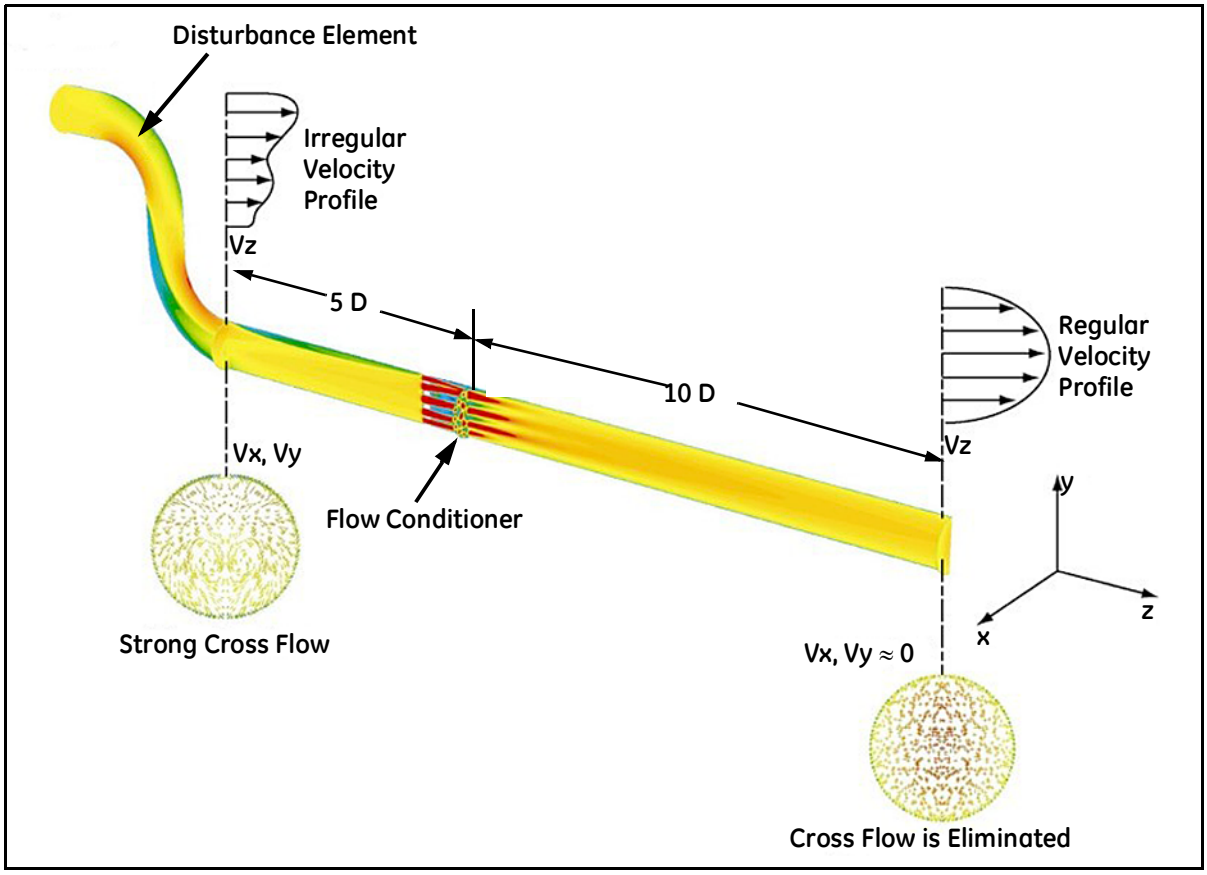


Figure 4: Using a Flow Conditioner to Influence Flow Profile

1.5.5 Maximum and Minimum Flow

Maximum and minimum flow rates through the *Sentinel Flow Measurement System* are based on the pipe diameter and the process fluid pressure. The information in the following tables is approximate, and is based on representative natural gas components at a process temperature of 70°F (21°C). See *Table 3* and *Table 4* below for English units and *Table 5 on page 7* and *Table 6 on page 7* for metric units.

100	16.2	28.0	44.2	47.3	57.2	74.7	94.5	117.5	169.9
200	30.7	53.2	83.9	89.8	108.6	141.8	179.5	223.1	322.6
400	61.1	105.9	166.8	178.6	215.9	282.0	357.0	443.6	641.6
600	93.3	161.5	254.6	272.6	329.5	430.4	544.8	677.0	979.1
800	127.3	220.4	347.4	371.9	449.4	587.1	743.2	923.4	1335.6
1000	163.0	282.2	444.9	476.3	575.6	751.9	951.8	1182.7	1710.5
1200	200.3	346.8	546.7	585.3	707.3	924.0	1169.6	1453.3	2102.0
1400	238.8	413.6	651.9	697.9	843.5	1101.9	1394.7	1733.1	2506.6
1480	254.5	440.7	694.7	743.7	898.8	1174.1	1486.2	1846.8	2671.0
Maximum flow rates are based on 118 ft/sec flow velocity for 6” through 10” diameter pipes, and on 89 ft/sec for 12” through 24” diameter pipes.									

100	0.3	0.6	0.9	0.8	1.0	1.2	1.6	2.0	2.8
200	0.6	1.1	1.7	1.5	1.8	2.4	3.0	3.7	5.4
400	1.2	2.1	3.3	3.0	3.6	4.7	5.9	7.4	10.7
600	1.9	3.2	5.1	4.5	5.5	7.2	9.1	11.3	16.3
800	2.5	4.4	6.9	6.2	7.5	9.8	12.4	15.4	22.2
1000	3.3	5.6	8.9	7.9	9.6	12.5	15.8	19.7	28.4
1200	4.0	6.9	10.9	9.7	11.8	15.4	19.4	24.2	35.0
1400	4.8	8.3	13.0	11.6	14.0	18.3	23.2	28.8	41.7
1480	5.1	8.8	13.9	12.4	14.9	19.5	24.7	30.7	44.4
Minimum flow rates are based on 2.36 ft/sec flow velocity for 6” through 10” diameter pipes, and on 1.48 ft/sec for 12” through 24” diameter pipes.									

1.5.5 Maximum and Minimum Flow (cont.)

7	9.2	15.9	25.0	22.3	26.9	35.2	44.5	55.3	80.0
14	17.4	30.1	47.5	42.3	51.1	66.8	84.5	105.0	151.9
28	34.6	59.9	94.5	84.1	101.7	132.8	168.1	208.9	302.1
41	52.8	91.5	144.2	128.4	155.1	202.7	256.5	318.8	461.0
55	72.1	124.8	196.7	175.1	211.6	276.5	349.9	434.8	628.9
69	92.3	159.8	251.9	224.3	271.0	354.1	448.2	556.9	805.5
83	113.4	196.4	309.6	275.6	333.1	435.1	550.7	684.3	989.8
96	135.3	234.2	369.2	328.6	397.2	518.9	656.8	816.1	1180.3
102	144.1	249.6	393.4	350.2	423.2	552.9	699.8	869.6	1257.8
Maximum flow rates are based on 0.72 m/sec flow velocity for 15 cm through 25 cm diameter pipes, and on 0.45 m/sec for 30 cm through 61 cm diameter pipes.									

7	0.5	0.8	1.3	1.3	1.6	2.1	2.7	3.3	4.8
14	0.9	1.5	2.4	2.5	3.1	4.0	5.1	6.3	9.1
28	1.7	3.0	4.7	5.1	6.1	8.0	10.1	12.6	18.2
41	2.6	4.6	7.2	7.7	9.3	12.2	15.4	19.2	27.7
55	3.6	6.2	9.8	10.5	12.7	16.6	21.0	26.1	37.8
69	4.6	8.0	12.6	13.5	16.3	21.3	27.0	33.5	48.4
83	5.7	9.8	15.5	16.6	20.0	26.2	33.1	41.2	59.5
96	6.8	11.7	18.5	19.8	23.9	31.2	39.5	49.1	71.0
102	7.2	12.5	19.7	21.1	25.5	33.2	42.1	52.3	75.6
Minimum flow rates are based on 36 m/sec flow velocity for 15 cm through 25 cm diameter pipes, and on 27 m/sec for 30 cm through 61 cm diameter pipes.									

1.6 Installation Guidelines

This section provides general information with respect to the mechanical and electrical installation, and should be thoroughly reviewed before the system is installed. To ensure safe and reliable operation of the Sentinel, the system must be installed in accordance with the guidelines established by Panametrics, as explained in this chapter.

WARNING! **The Sentinel Flow Measurement System can measure the flow rate of many gases, some of which are potentially hazardous. The importance of proper safety practices cannot be overemphasized.**

WARNING! **Be sure to follow all applicable local safety codes and regulations for installing electrical equipment and working with hazardous gases or flow conditions. Consult company safety personnel or local safety authorities to verify the safety of any procedure or practice.**

WARNING! **To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.**

1.6.1 Sentinel Location

For both uni-directional and bi-directional flow (see *Figure 5* and *Figure 6* below), a minimum of five diameters of straight pipe shall be provided by the customer on either side of the meter run, directly upstream of the flow conditioning plate and downstream of any disturbances or pipe bends. An additional length of straight pipe will help produce a more symmetrical flow profile, thus reducing the measurement uncertainty.

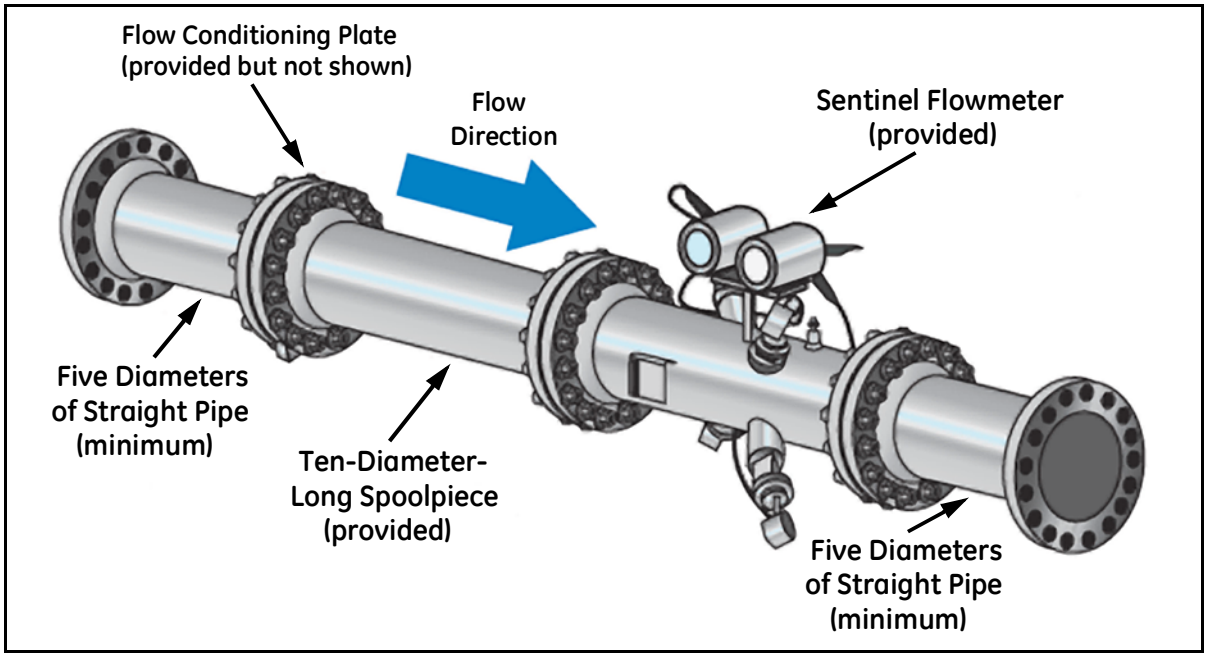


Figure 5: Typical Sentinel Installation, Uni-Directional Flow

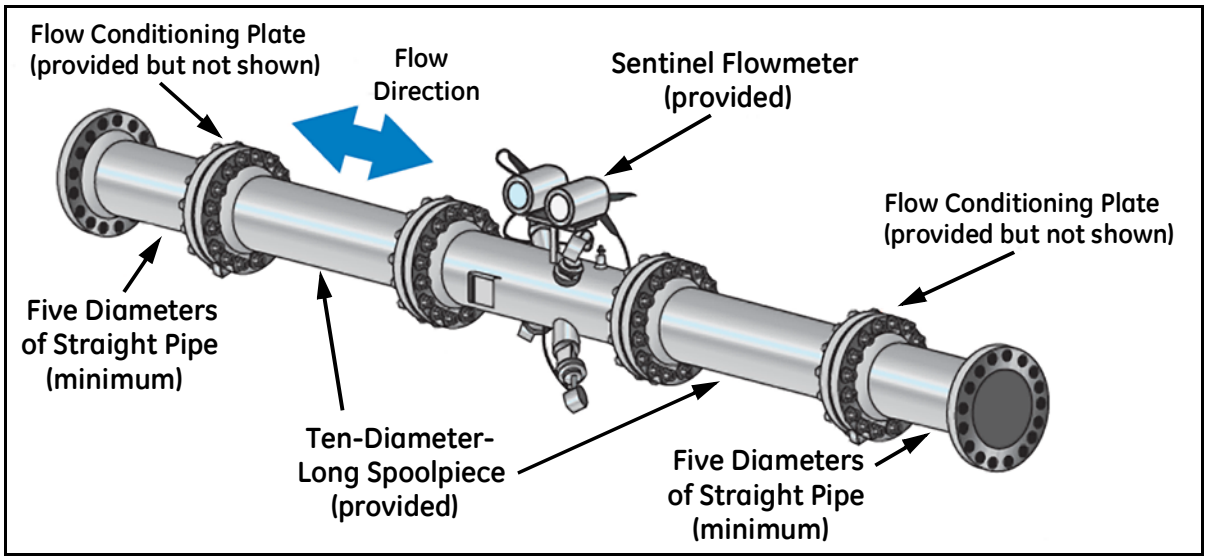


Figure 6: Typical Sentinel Installation, Bi-Directional Flow

1.6.2 Pressure Drop

The flow conditioning plate causes a pressure drop through the line. This pressure drop is directly related to the gas composition and properties, and to the flow velocity through the pipe.

Using a representative natural gas composition at 70° F, an estimate of the associated pressure drop can be computed for reference. *Figure 7* below shows pressure drop as a function of velocity for a uni-directional flow installation with a single flow conditioning plate at various line pressures. The pressure drop through the meter section would be doubled for a bi-directional installation with two flow conditioning plates.The example shown is for natural gas, flowing at
40 ft/sec through a pipe with a pressure of 1000 psi. The pressure drop across the flow conditioning plate is about 1 psid.

When the actual gas properties are known, a more accurate calculation can be performed using the following basic equation for the pressure drop:

$$\Delta P = \frac{1}{2} k \rho V^2$$

where ΔP is the pressure drop across the flow conditioning plate, k is the loss coefficient for the plate (1.6), ρ is the gas density (based on pressure, temperature, and gas composition), and V is the flow velocity through the pipe.

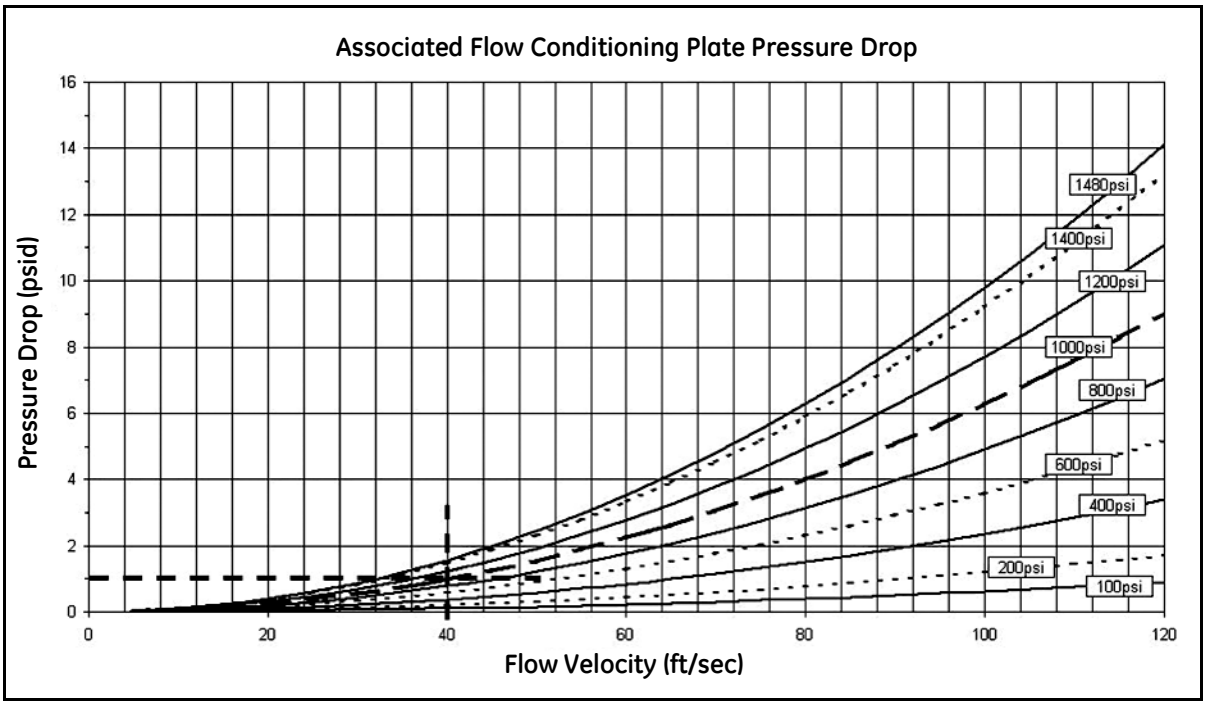


Figure 7: Flow Conditioning Plate Pressure Drop

1.6.3 Test Results

Testing and analysis show that the meter, in conjunction with a flow conditioning plate, installed as described above, can tolerate the following upstream disturbances:

- Simple straight pipe runs (minimal internal pipe disturbances)
- Single elbow
- Double elbows, in plane
- Double elbows, out of plane

Table 7 below lists the test results of a Sentinel Flow Measurement System installed in a straight run of pipe, compared to the requirements of AGA9.

% Error	± 0.5%	± 1.0%
Max Peak-To-Peak Error	0.4%	0.7%
Repeatability	± 0.2%	± 0.2%
Resolution	0.003 ft/sec	0.003 ft/sec
Velocity Sampling Interval	0.2 sec	≤ 1 sec
Zero Flow Reading	≤ 0.007 ft/sec	< 0.040 ft/sec

Testing with the meter installed with the other pipe configurations listed above, shows that the meter continues to meet the requirements of AGA9. The error percentage is never more than 0.3% additional uncertainty for such upstream configurations.

Testing also shows that variations of pressure, temperature and natural gas composition, within the range of the AGA9 specifications, do not affect Sentinel accuracy in meeting AGA9 requirements.

1.6.4 Installation Precautions

Any questions with respect to the installation should be addressed prior to beginning the installation. Failure to install the Sentinel correctly can increase measurement uncertainty.

CAUTION! **To avoid possible strain, refer to the Sentinel label for the assembly weight, use a properly-rated lifting assembly, and place the lifting straps in the indicated locations (see *Figure 8* below).**

All the mechanical and electronic components are shipped fully assembled (see *Figure 1 on page xi*), however the following precautions should be observed:

- Make sure the difference between the inside diameter of the pipe and that of the Sentinel spoolpiece does not exceed 1%. Changes in internal diameters will cause flow profile disturbances.
- Make sure any non-symmetrical offset does not exceed 1%. Misalignment between the piping and the spoolpiece may cause flow profile disturbances.
- Make sure the gasket is centered on the flange faces and does not protrude into the pipe. Protrusion of the gasket into the pipe may cause flow profile disturbances.
- Make sure the Sentinel is oriented with the flow transmitter in a vertical position at the top (see *Figure 10 on page xxiii*).

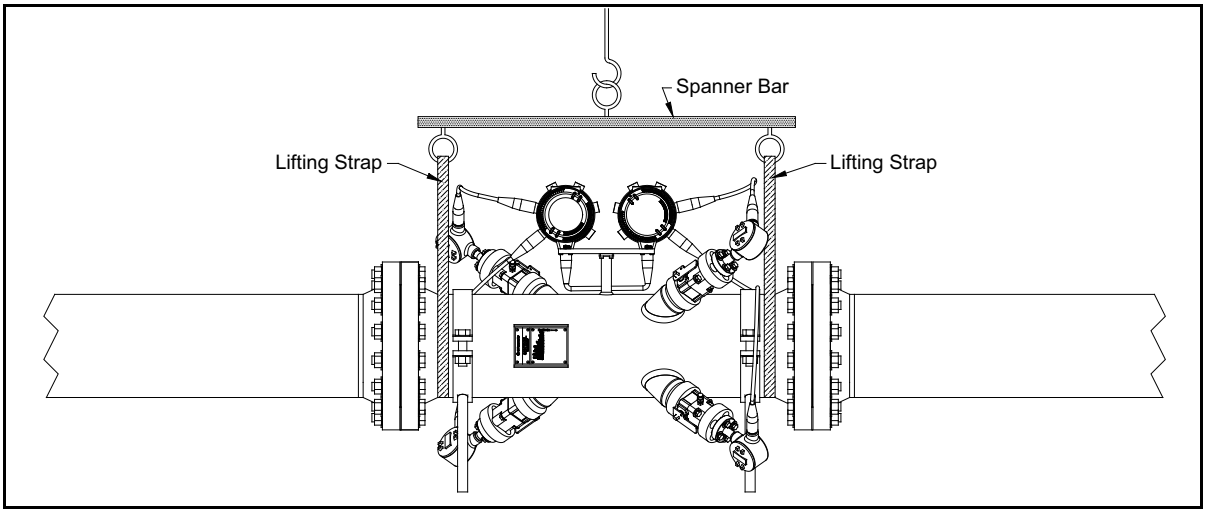


Figure 8: Lifting Strap Locations

1.6.4 Installation Precautions (cont.)

- Make sure to leave enough clearance on the top and sides of the system to allow for maintenance work.

IMPORTANT: If a Transducer Insertion Mechanism is required, the recommended minimum clearance for transducer replacement is a space 18" in diameter by 36" long around each transducer (see Figure 9 below).

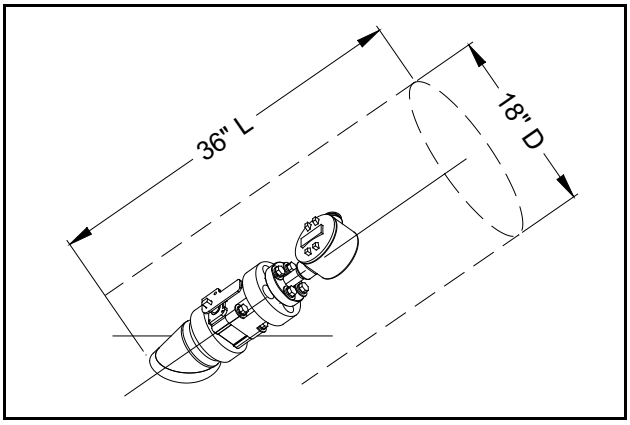


Figure 9: Insertion Mechanism Minimum Clearance

1.7 Installing the System

Being mindful of the *"Installation Precautions" on page xxii*, complete the following steps:

1. Make sure the gaskets are in place on the flanges.
2. Support the Sentinel between the flanges on the pipe.
3. Align the flange mounting holes (see *Figure 10* below).
4. Secure the spoolpiece to the pipe by using the appropriate hardware.

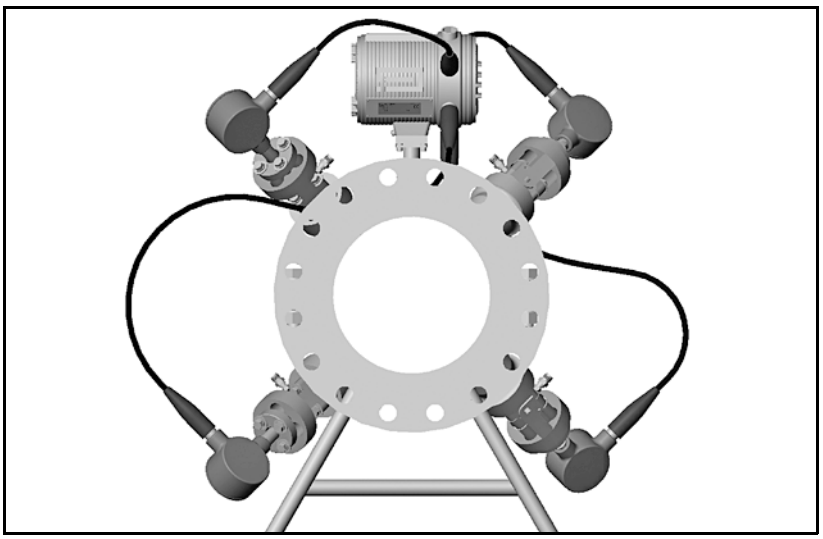


Figure 10: Sentinel End View – Mounting Flange

1.8 Making the Electrical Connections

This section contains instructions for making the necessary electrical connections to the flow transmitter (see *Figure 11* below). The wiring between transmitter and transducers has been accomplished at the factory. No further work is required on this portion of the wiring.

WARNING! **To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.**

IMPORTANT: The meter spoolpiece is grounded to the electronics. This configuration must be considered when applying cathodic protection to the pipe line. The power ground applied to the instrument should be at the cathodic protection voltage level.

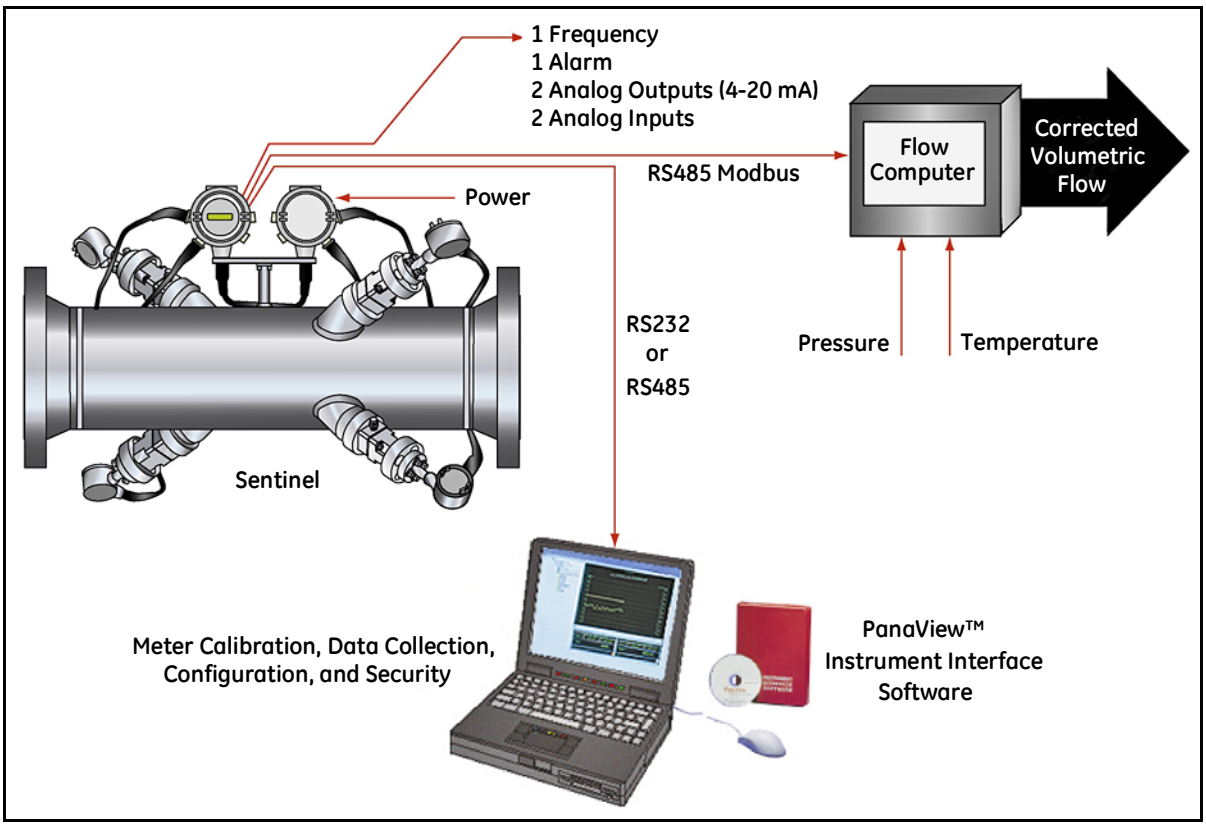


Figure 11: Sentinel Flow Measurement System Electrical Connections

1.8.1 Removing the Covers

WARNING! **Always disconnect the line power from the meters before removing either the front covers or the rear covers. This is especially important in a hazardous environment.**

1. Disconnect any previously wired power line from the flow transmitter enclosure #2 (without a display).
2. Loosen the set screw on one or both rear covers, as required to access the needed electrical connections.
3. Place a rod or long screwdriver across a cover in the slots provided, and rotate the cover counterclockwise until it comes free from the enclosure. If necessary, repeat for the other cover.
4. Note the label inside each rear cover (see *Figure 12* below) to assist in wiring the power (enclosure #2) and the option card connections (enclosure #1).

Proceed to the appropriate section of this chapter to make the required wiring connections.

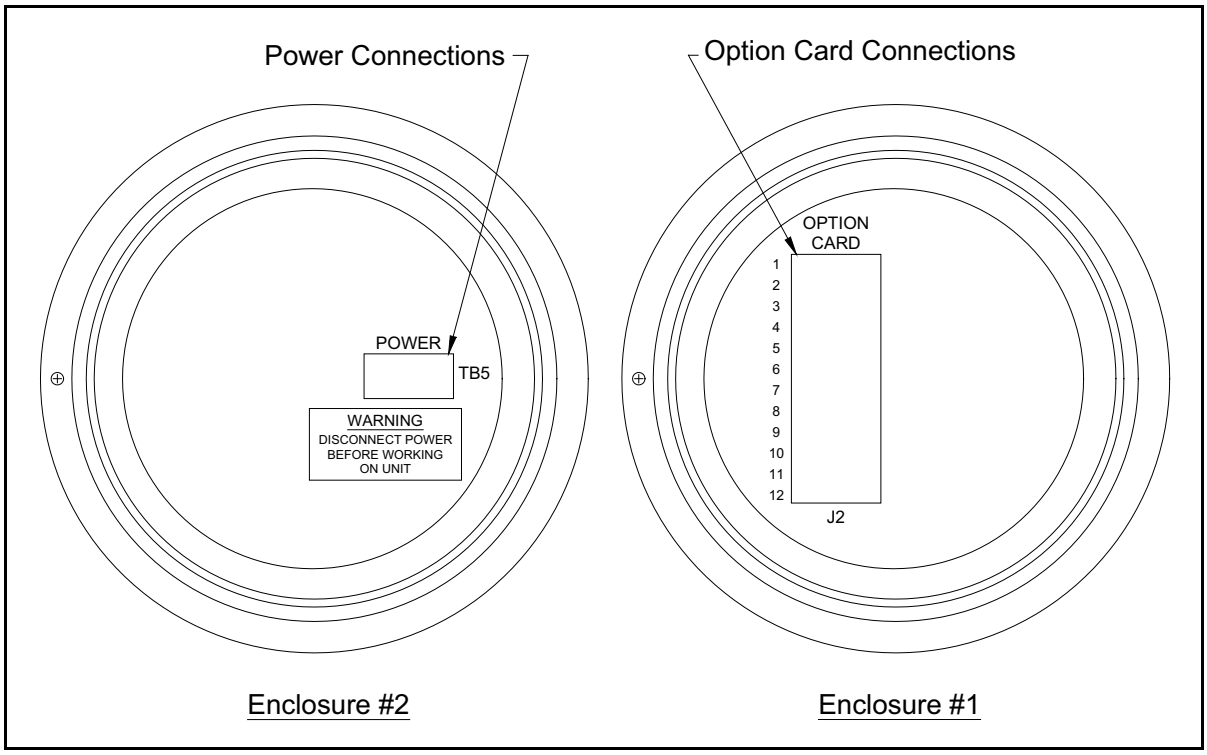


Figure 12: Connection Labels Inside Rear Covers

1.8.2 Wiring the Line Power

The Sentinel may be ordered for operation with a power input of either 85-264 VAC or 18–35 VDC (see *"Electronics Ordering Information" on page cxxviii*). The label on the side of the electronics enclosure lists the required line voltage and power rating for the meter. Be sure to connect the Sentinel to the specified line voltage only.

Note: *For compliance with the EU Low Voltage Directive, this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the* unit.

Note: *Use only* Class 2 *rated power supplies for the line power to DC instruments.*

IMPORTANT: Use cable and cable glands approved for Class I, Division 1 locations.

See *Figure 13 on page xxvii* to locate terminal block TB5 and connect the line power to the Sentinel as follows:

WARNING! **Improper connection of the line power leads or connecting a Sentinel to the incorrect line voltage may damage the unit. It may also result in hazardous voltages at the meter body and associated piping as well as within the electronics enclosure.**

1. Prepare the line power leads by trimming the line and neutral AC power leads (or the positive and negative DC power leads) to a length 0.5 in. (1 cm) shorter than the ground lead. This ensures that the ground lead is the last to detach if the power cable is forcibly disconnected from the meter.
2. Install a suitable cable gland in the Power Cable Inlet conduit hole indicated in *Figure 13 on page xxvii*. If possible, avoid using the other conduit holes for this purpose, to minimize any interference in the circuitry from the AC power line.

WARNING! **To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.**

3. Strip 1/4-in. of insulation from the end of each of the three line power leads.
4. Route the cable through the chosen conduit hole of enclosure #2 and connect the line power leads to terminal block TB5, using the pin number assignments shown in *Figure 21 on page xxxix* and *Figure 13 on page xxvii*.
5. Leaving a bit of slack, secure the power line with the cable clamp.

1.8.2 Wiring the Line Power (cont.)

WARNING! **Make sure the front and rear covers of both enclosures, along with their O-ring seals, are installed on the transmitters, and the set screws tightened before applying power in a hazardous environment.**

6. After the line power has been connected to the flow transmitter (enclosure #2), replace the rear cover, tighten the set screw, and proceed to the next section.

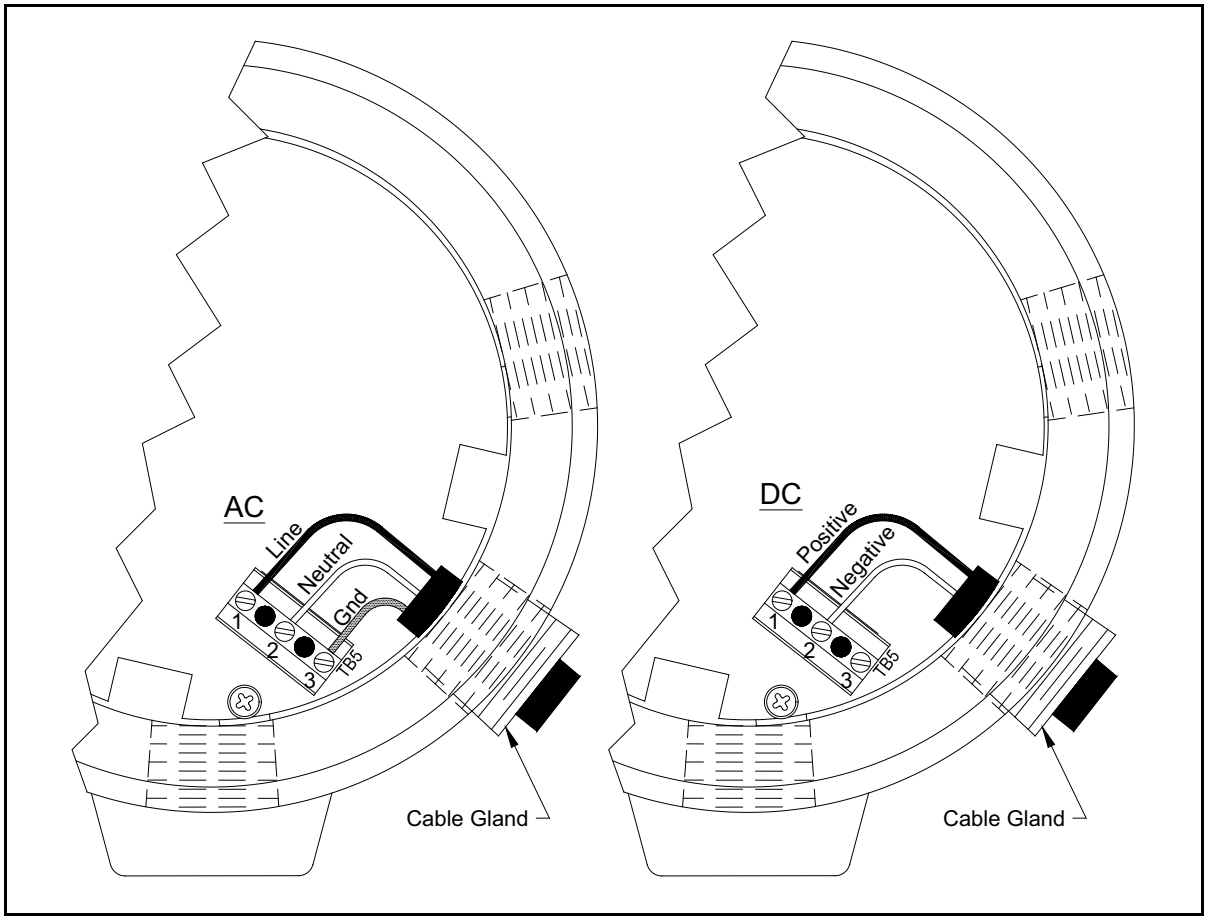


Figure 13: Enclosure #2 - Wiring the AC or DC Line Power

Note: *Use only Class 2 rated power supplies for the line power to DC instruments.*

1.8.3 Wiring the Serial Port

The flow transmitter is equipped with a built-in serial communications port. The standard port is an RS485 interface, but an optional RS232 interface is available upon request. For more information on serial communications refer to the Panametrics *EIA-RS Serial Communications* manual (916-054).

1.8.3.1 Wiring the RS485 Interface

Upon request, the standard RS485 port on the meter may be configured as a three-wire RS232 interface. However, the meter must be configured at the factory for RS232 operation.

Note: *Use the optional RS485-to-RS232 converter to connect the flow transmitter with RS485 serial port to a computer with an RS232 serial interface port.*

To wire the RS485 serial port, refer to *Figure 20 on page xxxviii* and either *Figure 22 on page xl* (AC) or *Figure 23 on page xli* (DC) and complete the following steps:

1. Disconnect the main power to the meter and remove the rear cover of enclosure #1.
2. Install the required cable clamp in the chosen conduit hole on the side of the electronics enclosure.
3. Feed one end of the cable through the conduit hole, wire it to terminal block J1 and secure the cable clamp. Connect the other end of the cable to the converter, as shown in *Figure 14* below.

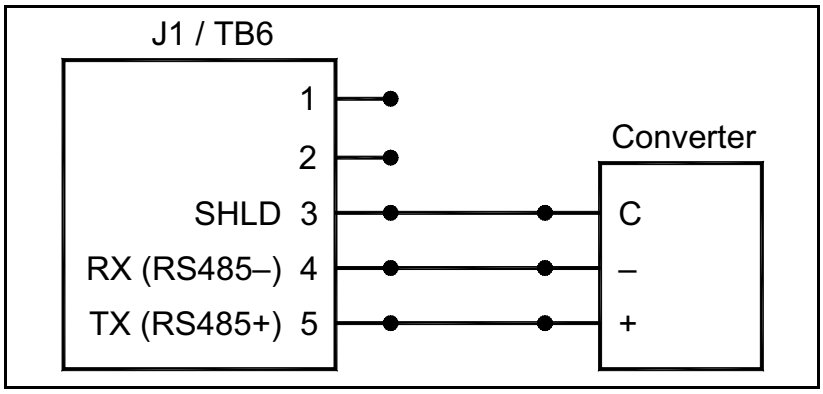


Figure 14: Typical RS485 Connections

WARNING! **To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.**

4. If the wiring of the unit has been completed, reinstall the rear cover on enclosure #1 and tighten the set screw.

1.8.4 Wiring the Modbus Communications Line

The Sentinel uses the RS485 interface with the *Modbus* communications protocol for a maximum line distance of up to 4000 ft (1200 m). Panametrics recommends using shielded 22-gauge (22 AWG) cable having a characteristic impedance of
120 ohms, with a 120 ohm termination at each end of the communications line.

Connect the two leads and the shield of the *Modbus* line to terminal block J5, slot 2 of the flowmeter*., as shown in Figure 20 on page xxxviii* and either *Figure 22 on page xl* (AC) or *Figure 23 on page xli* (DC).

1.8.5 Wiring the Input/Output (I/O) Card

The Sentinel can be configured with the following I/O functions:

- Two 0/4 to 20mA isolated outputs, 600Ω maximum load
- One frequency (HF) output, optically isolated, from DC to 10 kHz maximum
- One hermetically sealed Form C alarm relay that can be applied to indicate flow direction or fault
- Two isolated 4 to 20mA inputs and 24V loop power for pressure and temperature
- Optional two HF outputs and two alarm outputs or one HF output and 4 to 20mA inputs

Wiring any I/O function requires completion of the following general steps:

1. Disconnect the main power to the flowmeter and remove the rear cover of enclosure #1.
2. Install a cable clamp in the chosen conduit hole on the top of the electronics enclosure and feed a standard twisted-pair cable through this conduit hole.
3. Locate the 12-pin terminal block (J2) in *Figure 20 on page xxxviii* and wire the I/O terminal as indicated on the label inside the rear cover (see *Figure 13 on page xxvii* and *Figure 20 on page xxxviii*). For wiring diagrams, see either *Figure 22 on page xl* (AC) or *Figure 23 on page xli* (DC).
4. Secure the cable clamp.

WARNING! **To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.**

5. If wiring of the unit has been completed, reinstall the rear cover on the enclosure and tighten the set screw.

1.8.6 Wiring the Alarm Relay

The maximum electrical rating for the relay is listed in Chapter 7, *Specifications*. The alarm relay can be wired as either *Normally Open* (NO) or *Normally Closed* (NC).

An alarm relay should be wired for *fail-safe* operation. In *fail-safe* mode, the alarm relay is constantly energized, except when it is triggered or a power failure or other interruption occurs. See *Figure 15* below for the operation of a normally open alarm relay in *fail-safe* mode.

Connect the alarm relay in accordance with the wiring instructions shown on the label inside the enclosure #1 rear cover (see *Figure 13 on page xxvii* and *Figure 20 on page xxxviii*). For wiring diagrams, see either *Figure 22 on page xl* (AC) or *Figure 23 on page xli* (DC).

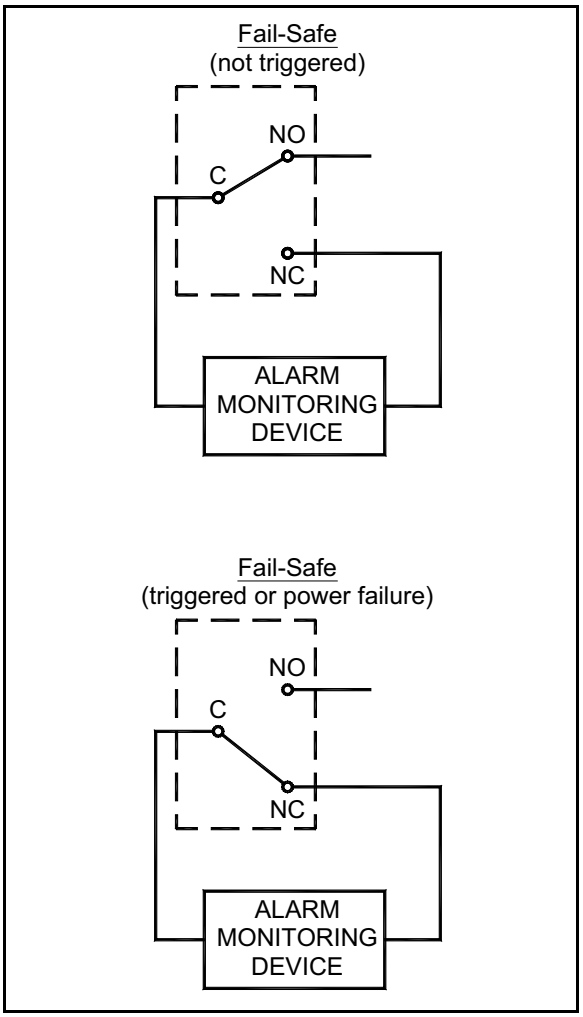


Figure 15: Fail-Safe Operation

1.8.7 Wiring 0/4-20 mA Analog Inputs

The two isolated 0/4-20 mA analog inputs (designated as C and D), each include a 24 VDC power supply for loop-powered transmitters. Either input may be used to process a temperature signal, while the other input can be used to process the pressure signal.

Note: *To enter programming data during operation of the Sentinel, it will be necessary to know which input is assigned to which process parameter. This information should be entered in Appendix B,* Data Records.

The analog inputs, which have an impedance of 118 ohms, should be connected with standard twisted-pair wiring. Power to the transmitters may be supplied either by the internal 24 VDC power supply on the analog input terminal or by an external power supply. *Figure 16* below shows typical wiring diagrams, with and without an external power supply, for one of the analog inputs. Wire the analog inputs as shown on the label in the enclosure #1 rear cover (see *Figure 13 on page xxvii* and *Figure 20 on page xxxviii*).

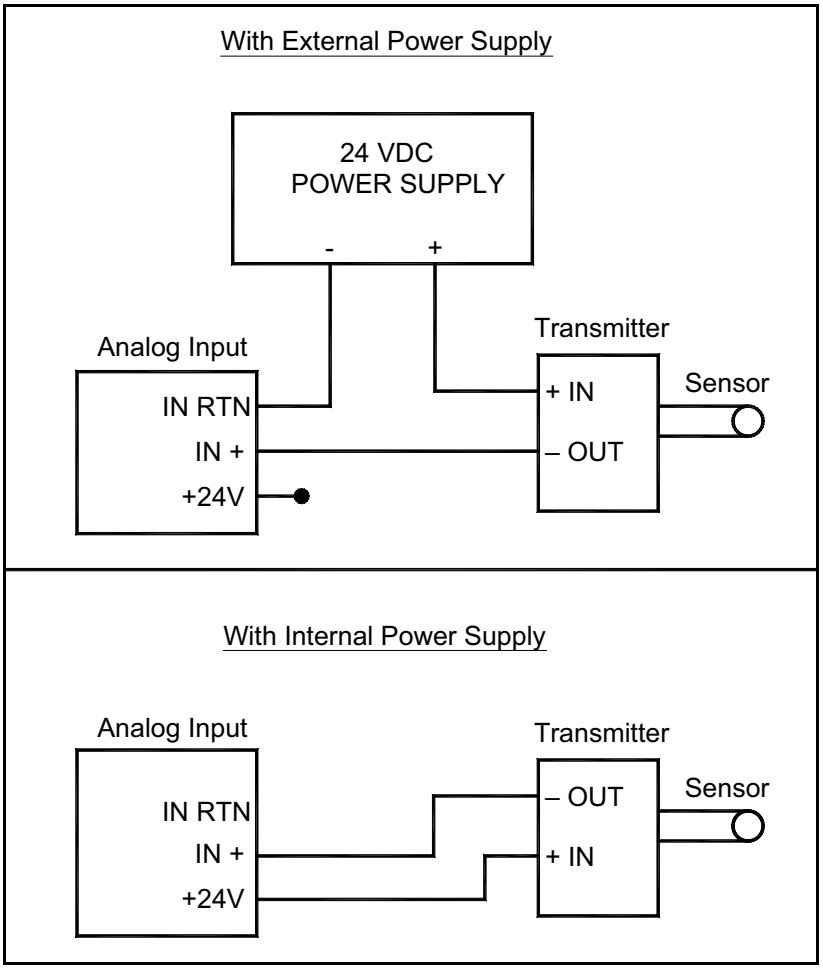


Figure 16: Analog Input Wiring Diagram

1.8.8 Wiring the Frequency/Totalizer Output

Figure 17 and *Table 8* below shows sample wiring diagrams and terminal pin functions for a totalizer output circuit and a frequency output circuit (designated as **Output A**).

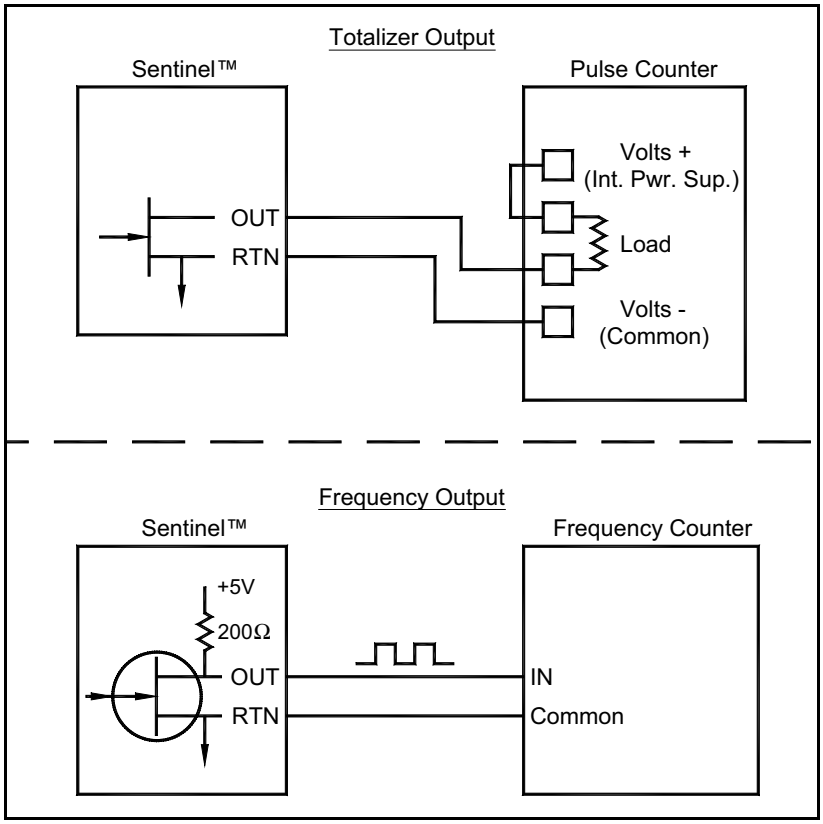


Figure 17: Totalizer and Frequency Output Wiring

1	A - Freq. Out
2	A - Freq. Rtn
3	A - NC
4	B Alarm - NO
5	B Alarm - COM
6	B Alarm - NC
7	C - +24V Out
8	C - Analog In +
9	C - Analog In Rtn
10	D - +24V Out
11	D - Analog In +
12	D - Analog In Rtn

1.8.9 Wiring the Std 0/4-20 mA Analog Output

The standard configuration of the flow transmitter includes two isolated 0/4-20 mA analog outputs (designated as outputs 1 and 2 on the hardware, corresponding to outputs A and B in the software). Connections to these outputs may be made with standard twisted-pair wiring, but the current loop impedance for these circuits must not exceed 600 ohms. To wire the analog outputs, complete the following steps:

1. Disconnect the main power to the flowmeter and remove the enclosure #1 rear cover.
2. Install the required cable clamp in the chosen conduit hole on the side of the electronics enclosure.
3. Refer to *Figure 20 on page xxxviii* for the location of the J1 terminal block and wire the analog outputs as shown. Secure the cable clamp.

WARNING! **To meet CE Mark requirements, all cables must be installed as described in Appendix A, *CE Mark Compliance*.**

4. If wiring of the unit has been completed, reinstall the rear cover on the enclosure and tighten the set screw.

After the Sentinel has been completely installed and wired, proceed to Chapter 2, *Initial Setup*, to program the flowmeter.

WARNING! **Make sure both covers, with their o-ring seals, are installed, and the set screws tightened, before applying power in a hazardous environment.**

1.8.10 Adjusting the LCD Contrast and Brightness

CAUTION! **If the Sentinel is to be installed in a hazardous area, be sure to adjust the backlight brightness and display contrast of the meter LCD display in enclosure #1 before mounting the system. The meter covers should not be removed in a hazardous area while the line power is on.**

Both the contrast and the brightness of the flowmeter LCD display may be adjusted to suit individual needs. There are two 3/4-turn adjustment potentiometers located on the LCD circuit board in enclosure #1 (see *Figure 18* below).

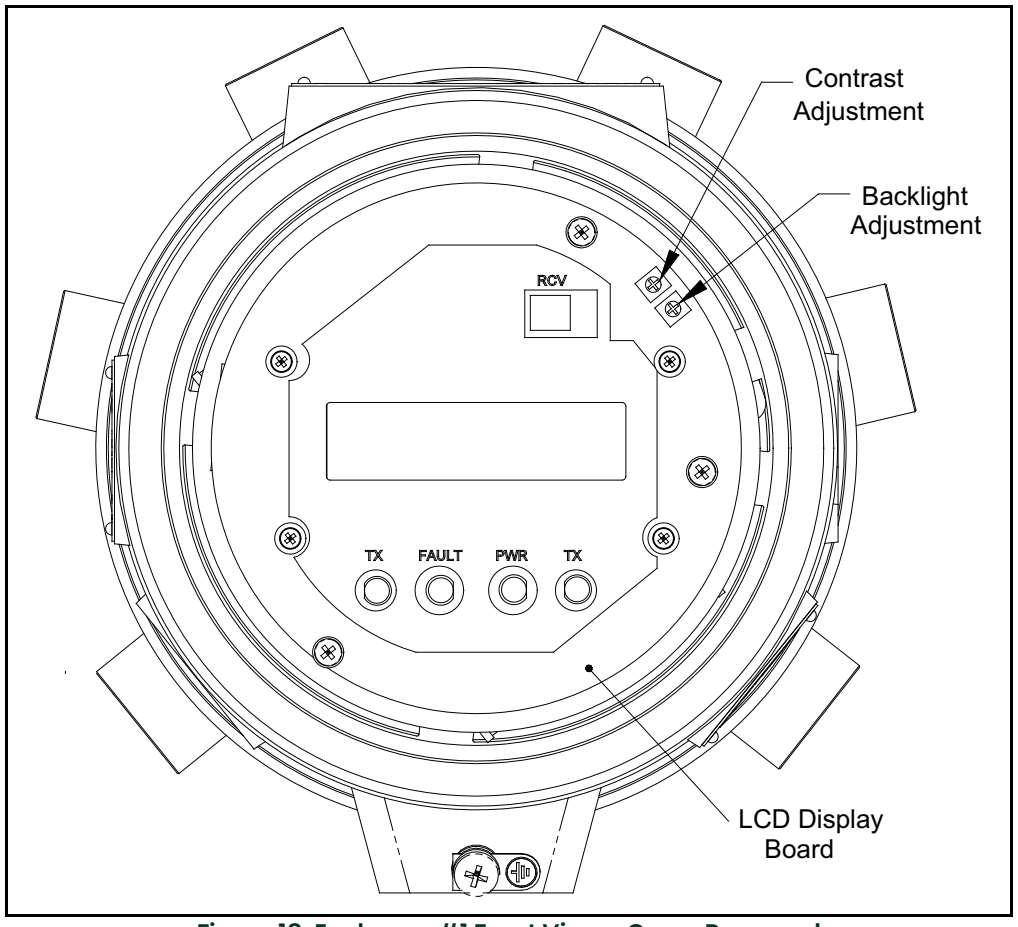


Figure 18: Enclosure #1 Front View - Cover Removed

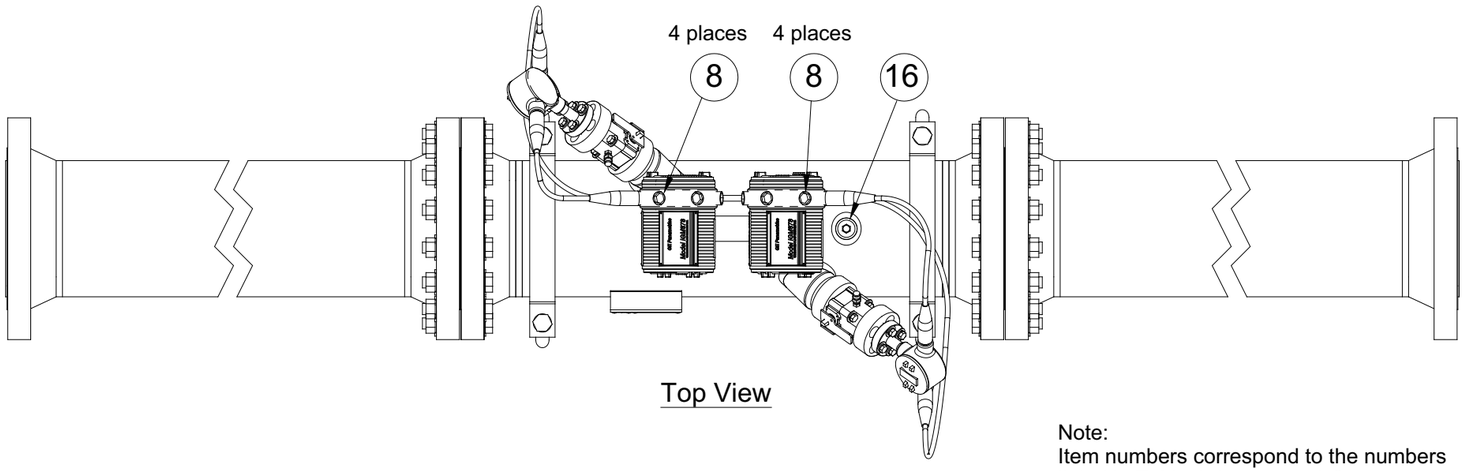
1.8.10 Adjusting the LCD Contrast and Brightness

Using these potentiometers for the LCD adjustment, complete the following steps:

Note: *If the Sentinel is to be mounted in a non-hazardous location, the following adjustments may be made after the installation is complete.*

WARNING! **Never remove the covers from the flowmeter in a hazardous environment while the line power is on.**

1. Make sure the Sentinel is in a safe environment.
2. Loosen the set screw on the enclosure #1 front cover.
3. Place a rod or long screwdriver across the cover in the slots provided, and rotate the front cover counterclockwise until it comes free from the enclosure.
4. With power applied to the meter (see *"Wiring the Line Power" on page xxvi*), carefully use a small screwdriver to adjust the LCD brightness. Turning the **BKLT** (backlight) pot fully clockwise yields maximum brightness.
5. In a similar manner, adjust the **CONT** (contrast) pot to set the LCD contrast as desired. At either extreme of the **CONT** pot, the display is unreadable. Turn the pot fully counterclockwise and then turn it clockwise very slowly until the display is clear.
6. After the desired LCD adjustments have been made, replace the meter front cover and proceed with the installation.

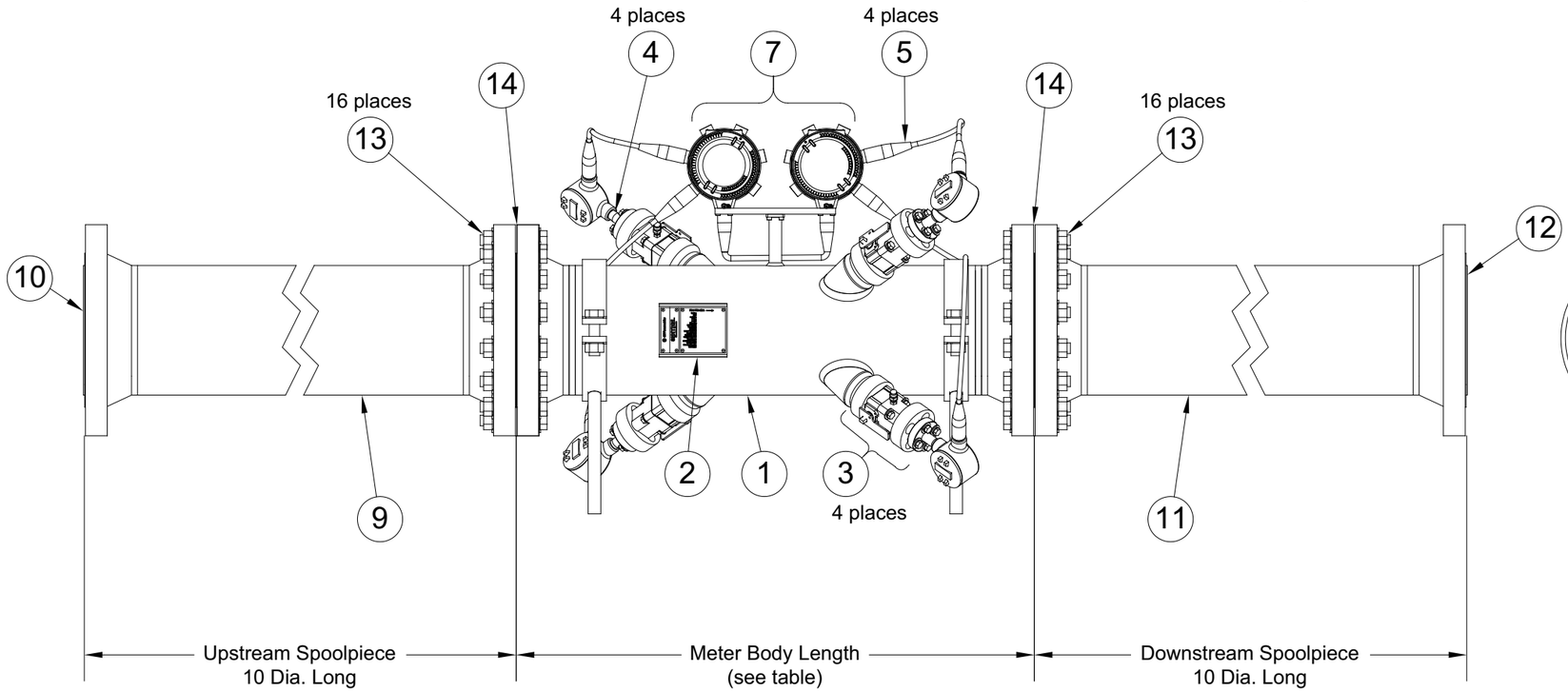


Top View

Note:
Item numbers correspond to the numbers listed in Table 1-1 on page 1-2.

Meter Body Length
(Flange Face-to-Face)

Nominal Pipe Size	Distance (in.)
6	45
8	48
10	52
12	56
14	58
16	60
18	63
20	67
24	74

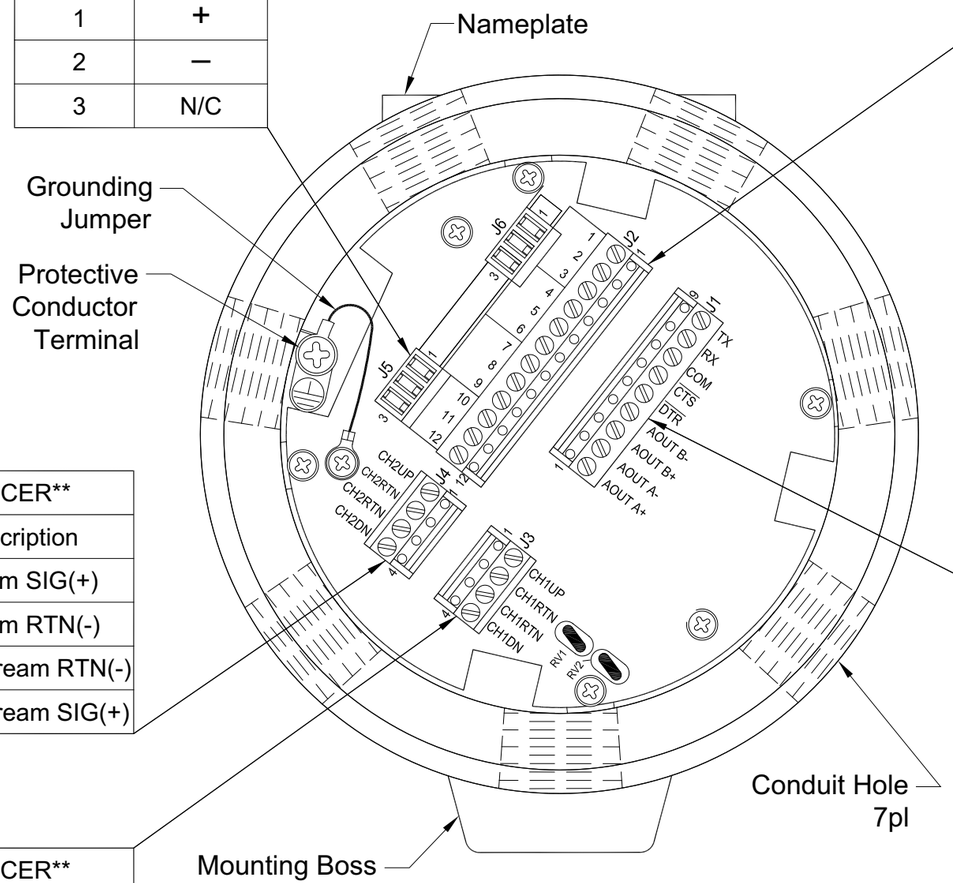


Side View

End View

Figure 1: Sentinel Flow Measurement System Assembly

NOTE: Enclosure #1 is shown from the rear with the rear cover removed.



MODBUS CONN.	
J5 Pin No.	Description
1	+
2	–
3	N/C

J2 - INPUT/OUTPUT CONN.*	
Pin #	Description
1	OUT - A
2	RTN - A
3	N/C
4	ALARM NO - B
5	ALARM COM - B
6	ALARM NC - B
7	OUT C - +24V
8	INPUT C - +
9	INPUT C - RTN
10	OUT D - +24V
11	INPUT D - +
12	INPUT D - RTN

*See wiring label inside rear cover.

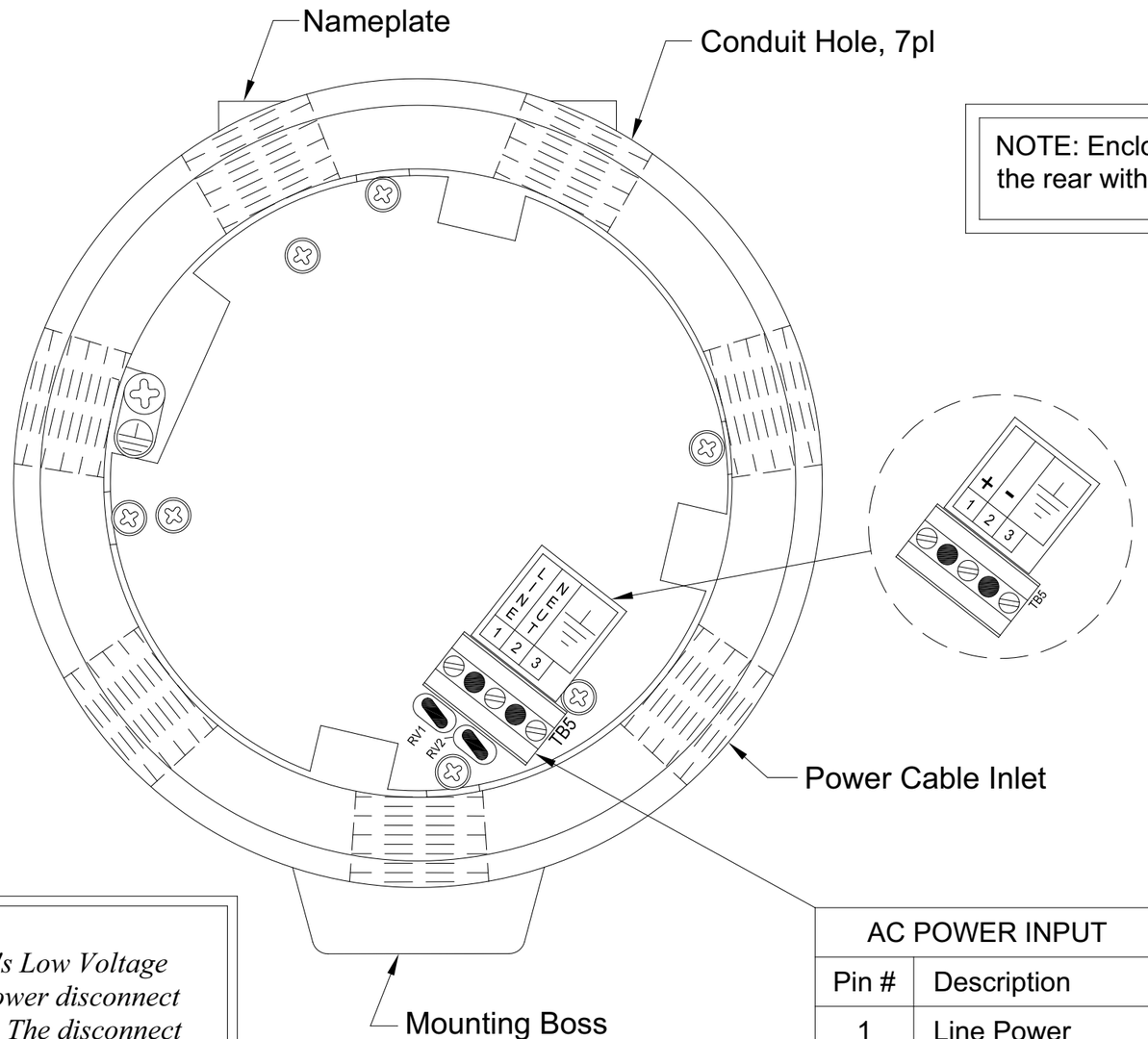
J4 - CH2 TRANSDUCER**		
Pin #	Desig.	Description
1	CH2UP	Upstream SIG(+)
2	CH2RTN	Upstream RTN(-)
3	CH2RTN	Downstream RTN(-)
4	CH2DN	Downstream SIG(+)

J3 - CH1 TRANSDUCER**		
Pin #	Desig.	Description
1	CH1UP	Upstream SIG(+)
2	CH1RTN	Upstream RTN(-)
3	CH1RTN	Downstream RTN(-)
4	CH1DN	Downstream SIG(+)

**Important:
Transducer connections and other wiring accomplished at the factory are shown for information purposes only and should not be changed by the user.

J1 - ANALOG & RS232/RS485		
Pin #	Desig.	Description
1	AOUT A+	Analog Output A+
2	AOUT A-	Analog Output A-
3	AOUT B+	Analog Output B+
4	AOUT B-	Analog Output B-
5	$\overline{\text{DTR}}$	Data Term. Ready
6	$\overline{\text{CTS}}$	Clear to Send
7	COM	Ground
8	RX	Receive / –
9	TX	Transmit / +

Figure 2: Sentinel Enclosure #1 – Terminal Block Layout



DC POWER INPUT	
Pin #	Description
1	Line Positive
2	Line Negative
3	No Connection

AC POWER INPUT	
Pin #	Description
1	Line Power
2	Line Neutral
3	Earth Ground

NOTE: *For compliance with the European Union's Low Voltage Directive, this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible and located within 1.8 m (6 ft) of the meter.*

Figure 3: Sentinel Enclosure #2 - Power Connections

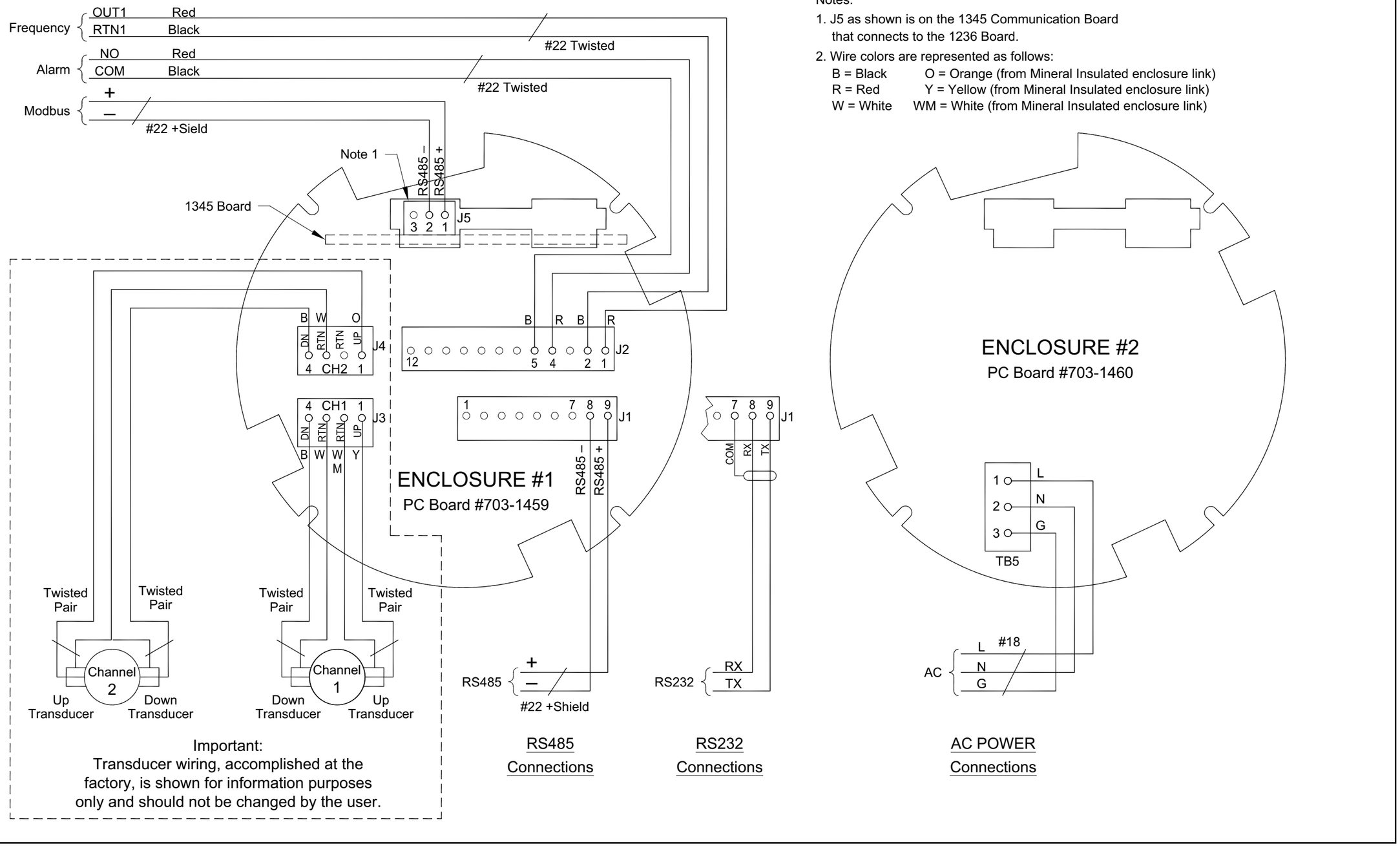
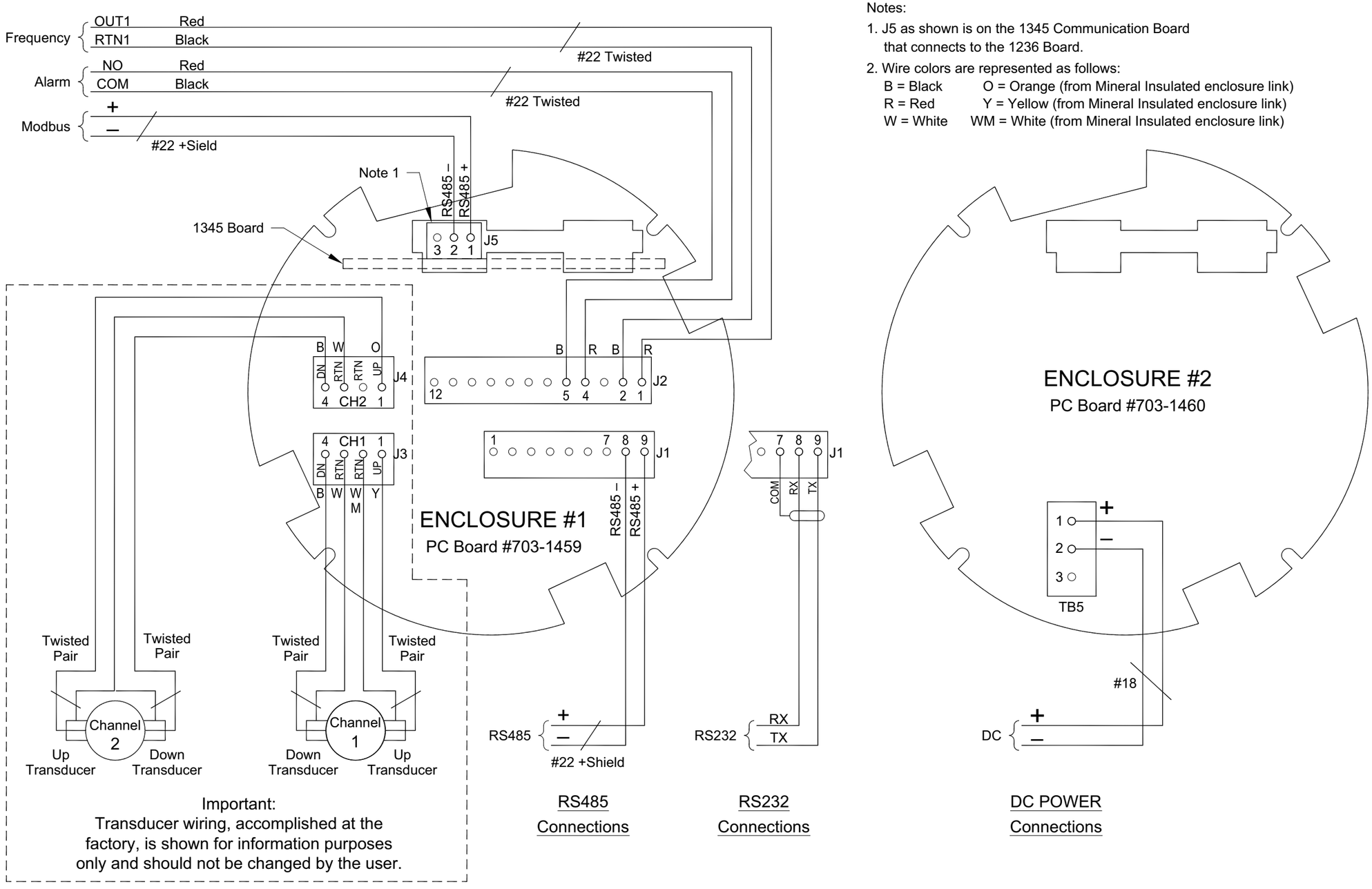


Figure 4: Sentinel AC Wiring Diagram (ref dwg #702-496)



Notes:

1. J5 as shown is on the 1345 Communication Board that connects to the 1236 Board.
2. Wire colors are represented as follows:
   B = Black O = Orange (from Mineral Insulated enclosure link)
   R = Red Y = Yellow (from Mineral Insulated enclosure link)
   W = White WM = White (from Mineral Insulated enclosure link)

RS485 Connections

RS232 Connections

DC POWER Connections

Figure 5: Sentinel DC Wiring Diagram (ref dwg #702-497)

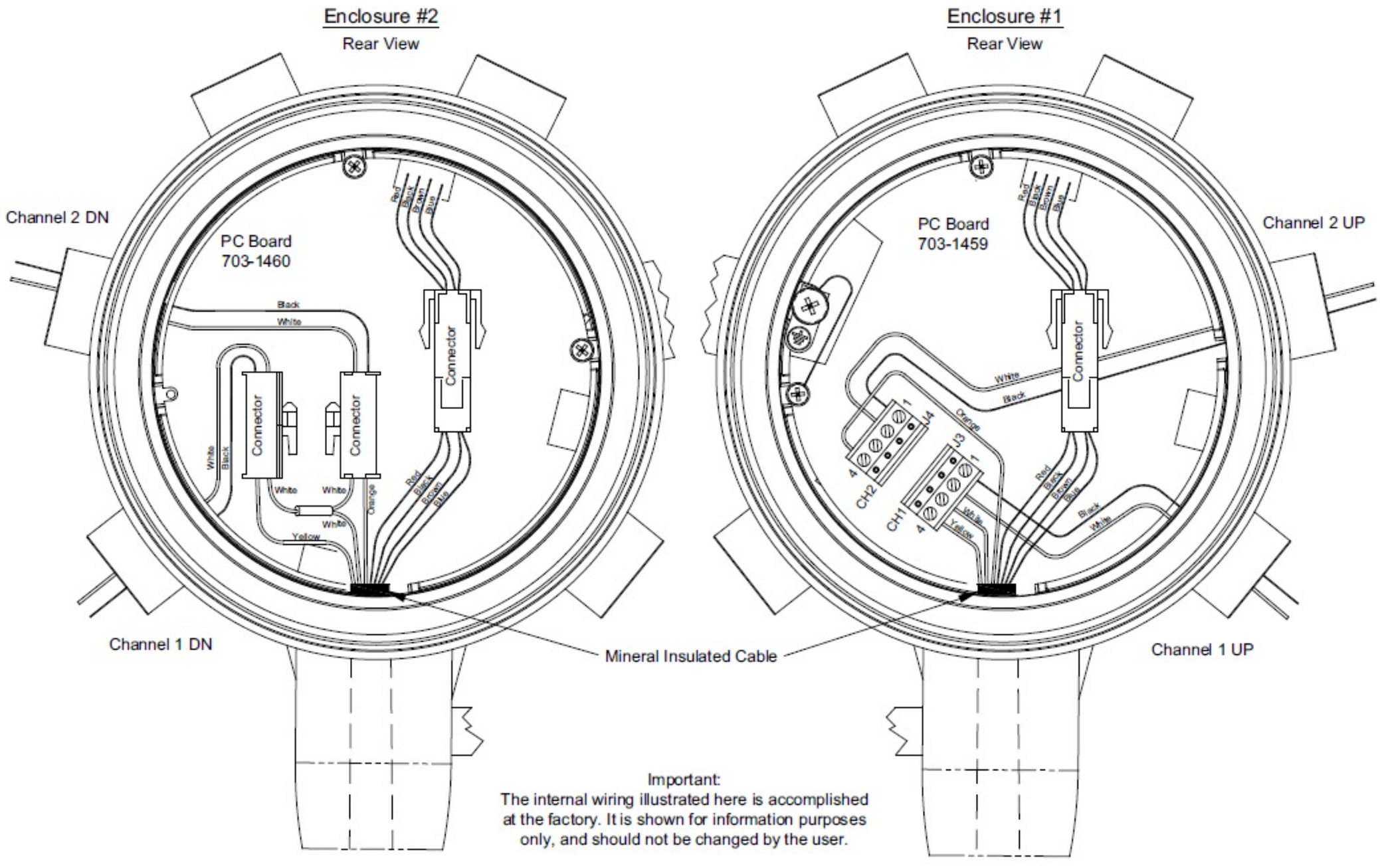


Figure 6: Sentinel Flow Transmitter – Internal Wiring (ref dwg #705-1093)

Chapter 2. Initial Setup

2.1 Introduction

This chapter provides comprehensive instructions for programming the minimum amount of data required to place the Sentinel Flow Measurement System into operation. In order to program the Sentinel, the user must have a personal computer connected to the meter and the *PanaView*™ software, which shipped with the unit, installed on that PC.

Note: *See the PanaView* Graphical User Interface *User's Manual (910-211) for information on those User Program features not covered in this chapter. The Sentinel is designed to be programmed and operated with PanaView software only.*

2.2 Adding a Communications Port

Under File open a New Meter Browser. The browser is designed to access computers and instruments with the look and feel of a file management system. To connect to the instrument using a remote computer, first add that computer to your network. If the computer is connected directly to the instruments, add the communication ports to the browser network.

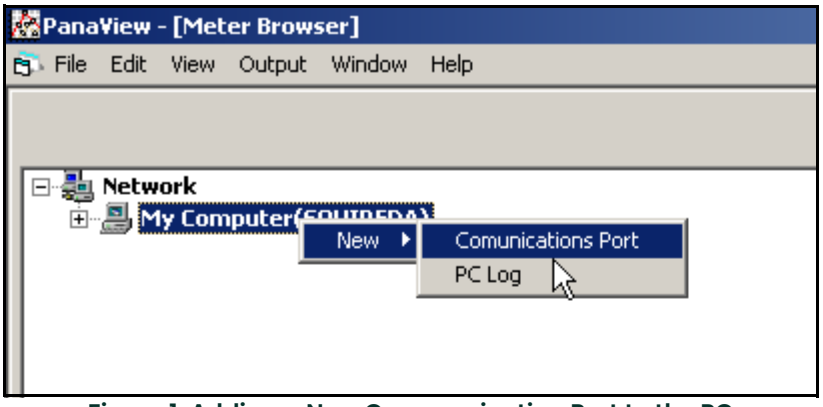


Figure 1: Adding a New Communication Port to the PC

Place the mouse pointer over the name of the computer and press the right mouse button. This activates the selection menu for this object (see *Figure 25* above).

Select My Computer > New > Communications Port > and add a port by pressing the left mouse button.

2.2 Adding a Communications Port (cont.)

After the port is added, the port properties will need to be set. See *Figure 26* below, which shows the default properties for the meter. The communication settings can be modified at any time by selecting the port on the network tree with the right mouse button and choosing Properties.

Note: *Refer to* Adding a New Communication Port *in Chapter 4 of the* PanaView Instrument Interface Software Operation and Installation Guide *(910-211).*

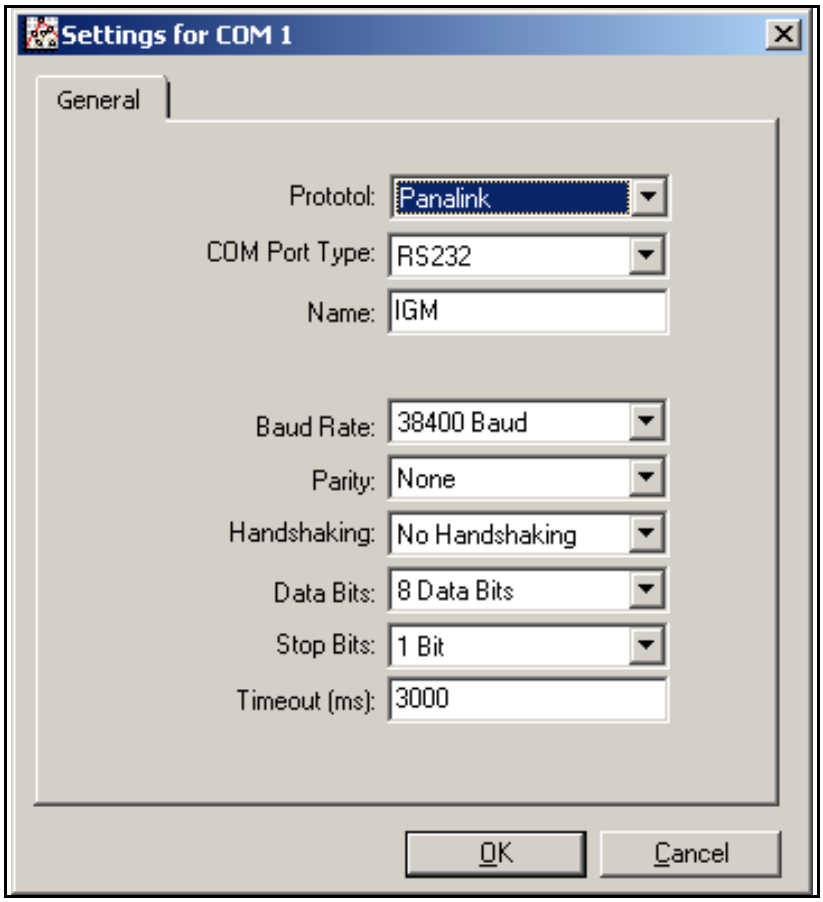


Figure 2: Default Communication Parameters

2.3 Adding the Sentinel to the Communications Port

Select the desired communication port by clicking once on it with the left mouse button (see *Figure 27* below). Then press the right mouse button to activate the pop-up menu. Select New > Meter > from the pop-up menu.

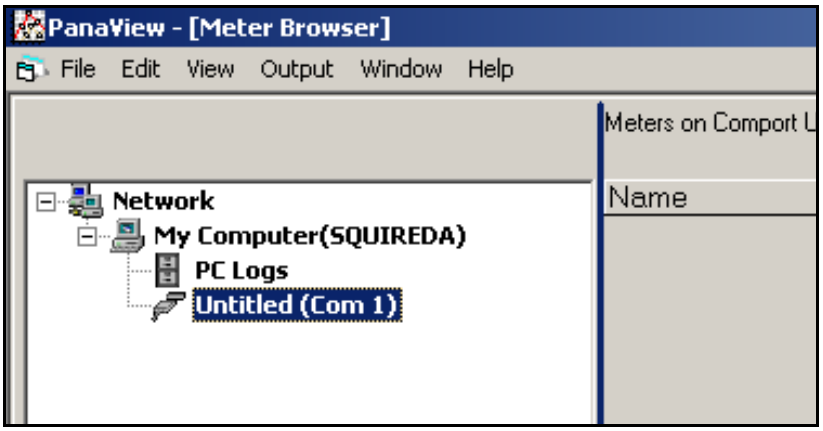


Figure 3: Adding the Sentinel to the Comm Port

If the node ID is known, select "I know the node ID of the meter I am adding to the network," then click the OK button (see *Figure 28* below). If the node ID is not known proceed to *page xlvii*)

Note: *The default node ID is 2. If another node ID was previously programmed, that data must be available in order to select* "I know the node ID of the meter I am adding to the network."

Note: *The network referred to in* Figure 28 *below is the network of meters under a single communication port. Up to sixteen meters can be connected to form a PanaView meter network.*

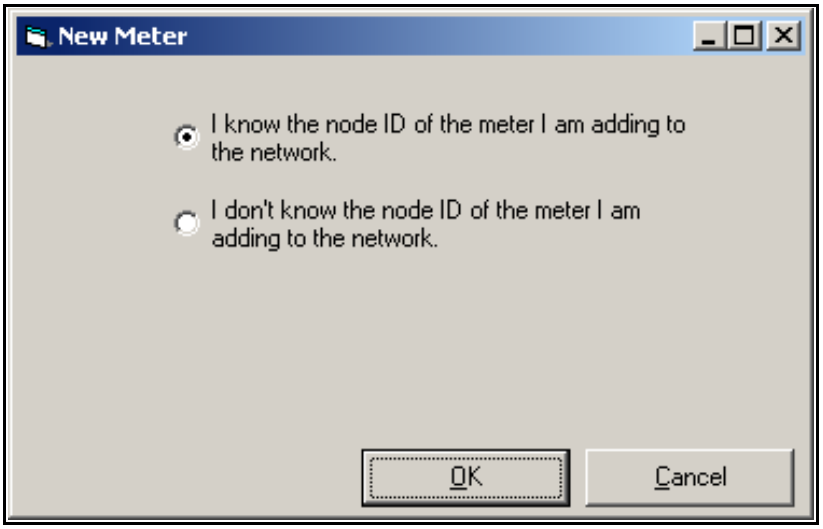


Figure 4: Instrument Node ID Acknowledgement

2.3 Adding the Sentinel to the Communications Port (cont.)

Refer to *Figure 29* below, and enter the ID number in the ID: entry, a meter name in the Name: entry, and then click on the OK button.

Note: *Do not enter any data in the* Clock:*,* Master ID: *or* Slave ID: *entries.*

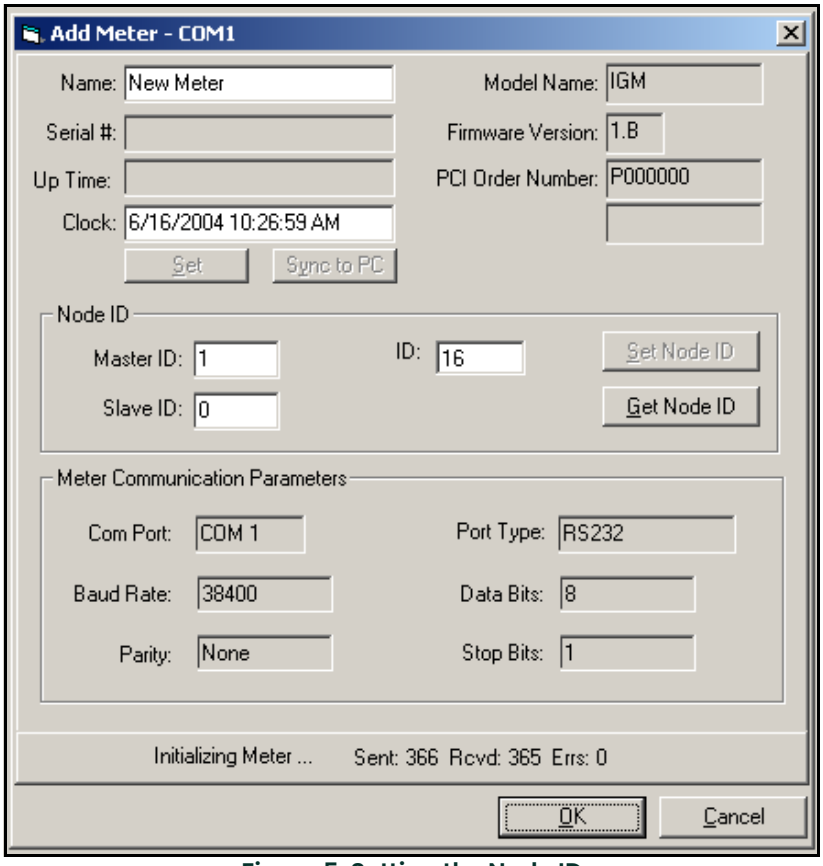


Figure 5: Setting the Node ID

Adding the Sentinel to the Communications Port (cont.)

If the node ID is not known, select "I don't know the node ID of the meter I am adding to the network" and then click on the OK button (see *Figure 30* below).

Note: *The network referred to in Figure 2-6 below is the RS485 connection between the instrument and the computer RS232-to-RS485 connector.*

Note: *The new meter must be the only powered meter on the network.*

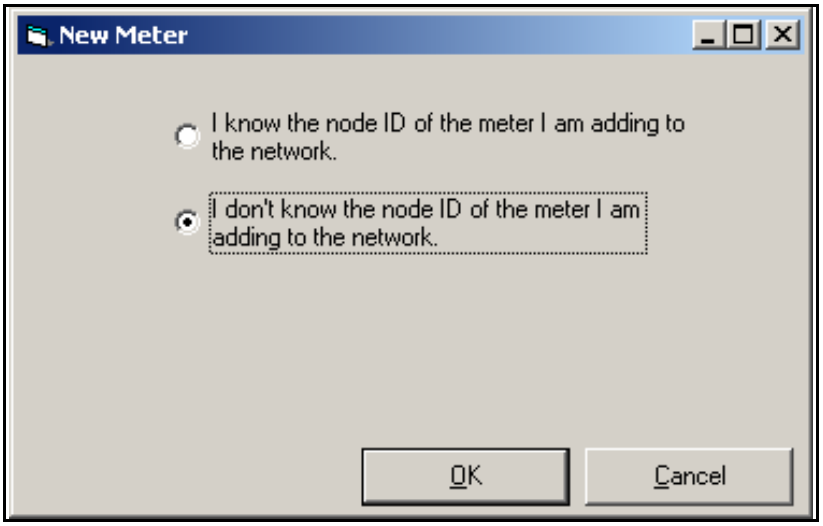


Figure 6: Instrument Node ID Unknown

At the next prompt (see *Figure 31* below) select "It is the only meter connected to the communication port" and then click on OK.

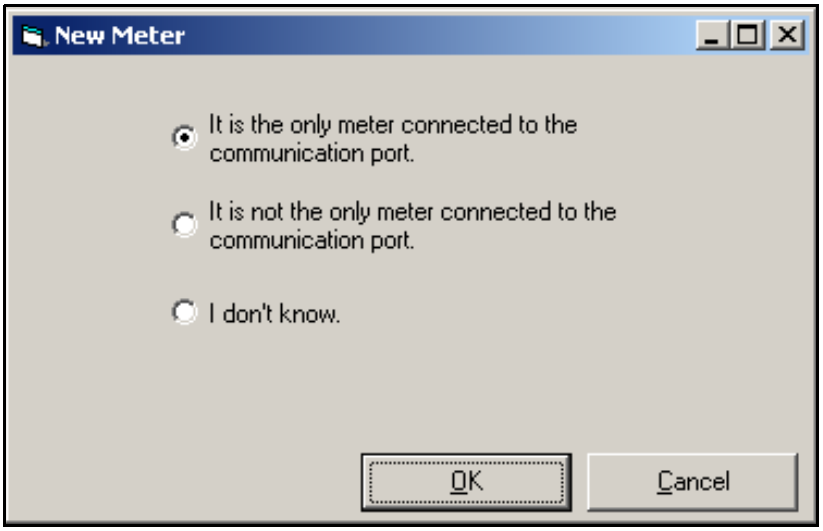


Figure 7: Searching the Port for Instrument Node ID

2.3 Adding the Sentinel to the Communications Port (cont.)

If *PanaView* found the meter, a window will pop up and inform the user which Node ID the meter is set to. The operator can select to use the existing Node ID or a different Node ID (see *Figure 32* below).

Note: *The Node ID can be changed later on by going to the meter properties.*

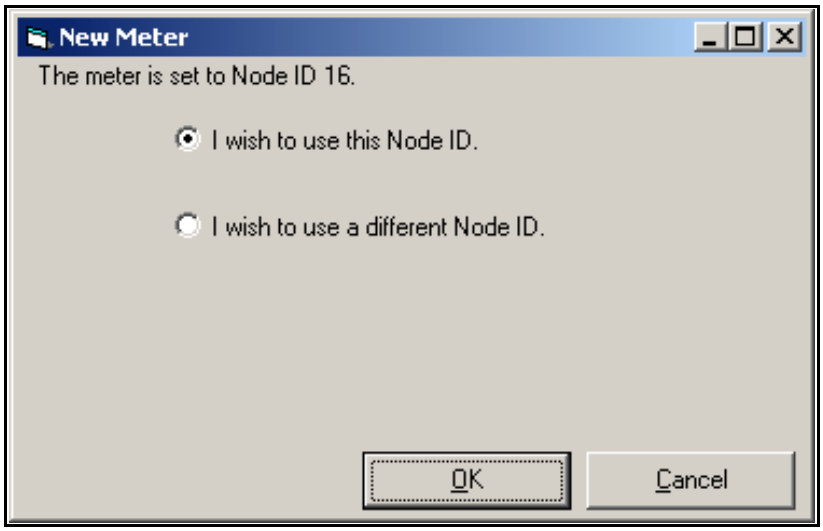


Figure 8: Selecting the Node ID

After communication has been established, the Node ID can be set to any "master" Node ID. A "master" Node ID is an integer which is a multiple of 16.

Note: *A "slave" Node ID is all the numbers between two consecutive masters. However the term "slave" does not apply to the Sentinel.*

If "I wish to use a different Node ID" is selected, the window in *Figure 29 on page xlvi* appears, and the user must then enter the Node ID number in the ID entry.

After the Node ID is entered in the Add Meter window ID box, click on the OK button to add the meter to the *PanaView* network.

2.4 Meter Security

After the node address is set, the instrument will be added to the network of instruments on *PanaView* and the operator will be given the opportunity to program the flowmeter parameters. Before any meter parameters can be changed, the operator must be specified.

Click the mouse right button and then click on Properties. Press the Security button on the Properties Form to bring up the Security Form. Access the required security level by typing the User Name and Password dialog boxes (see *Figure 33* below).

The meter provides three security levels:

- **Level 1** security is available to Panametrics service engineers only. It gives access to configuration parameters that should be adjusted only during commissioning or repair.
- **Level 2** security is for the supervisor who has overall responsibility for the meter. The supervisor may change his or her password and the passwords of the three user's accounts. The default User Name and Password are:

  User Name: Supervisor
  Password: [The assigned Serial Number]

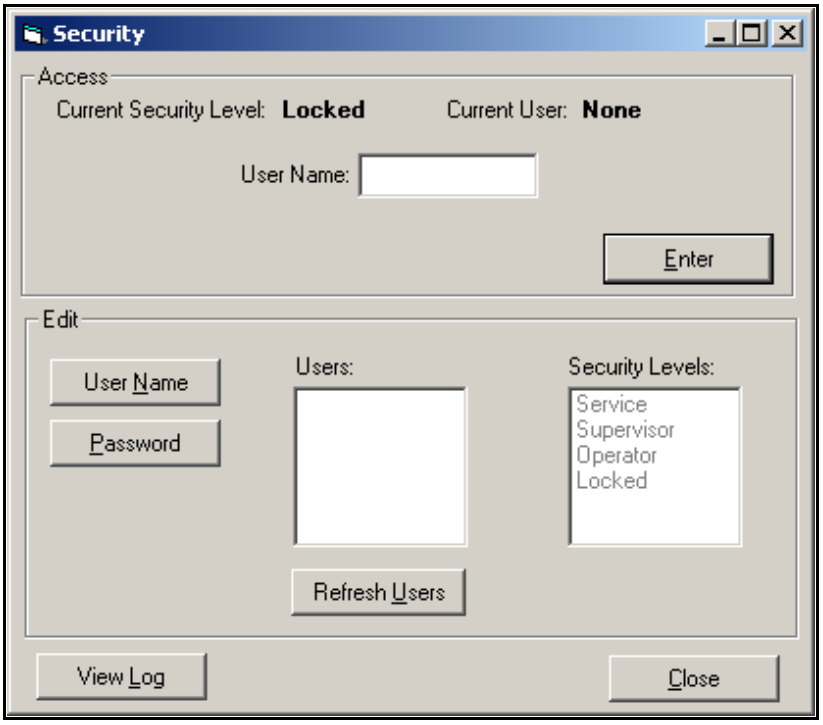


Figure 9: Security Form

2.4 Meter Security (cont.)

- **Level 3** security are the users' accounts. The meter provides for three separate users. These accounts are:

  User Name: User1
  Default Password: User1

  User Name: User2
  Default Password: User2

  User Name: User3
  Default Password: User3

The system supervisor must initialize all three user accounts with new passwords, whether used or not, to prevent unauthorized access to the meter parameters.

For additional accountability, an Audit Trail log is kept in permanent memory. This file cannot be erased except by physical access to the main board of the meter electronics. To view the log, right click on the desired meter in the meter browser, select Properties, then Security, then View Log. No password is needed to view the log. In addition to parameter modification, the log records if the meter has been reset and/or when power to the electronics has been interrupted (see *Figure 34* below).

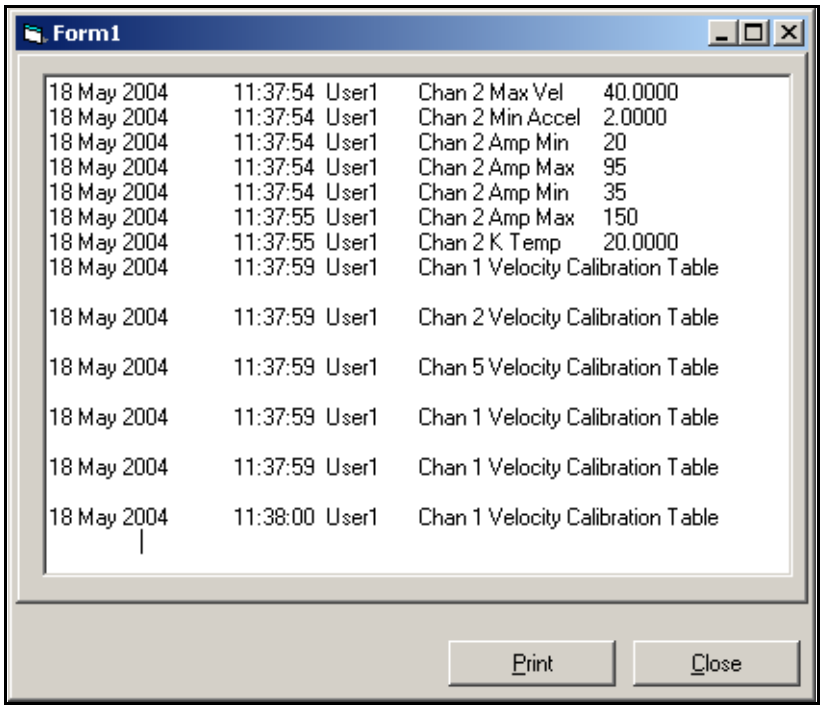


Figure 10: Example Audit Trail Log

2.5 Meter Properties

Place the mouse pointer over the selected meter and press the right mouse button and then Properties, this will open the form shown in *Figure 35* below.

All the fields with white background can be changed without the security setup and sent to the meter by clicking on the OK button. Click the More button to display a list of the instrument firmware revisions.

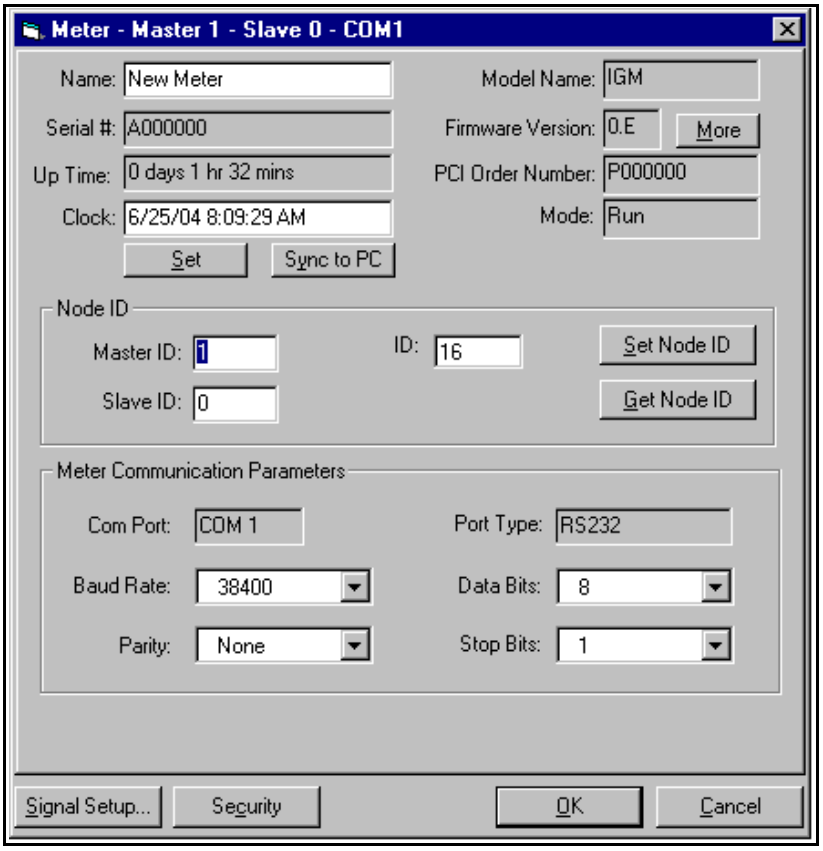


Figure 11: Meter Properties Display

2.6 Signal Setup

Click on Signal Setup at the bottom of the Meter Properties Form and the Signal Setup form appears (see *Figure 36* below).

Note: *In order to access the* Program *node, you must first sign in. Click on the* Set User *button and then log in with the correct user name and password.*

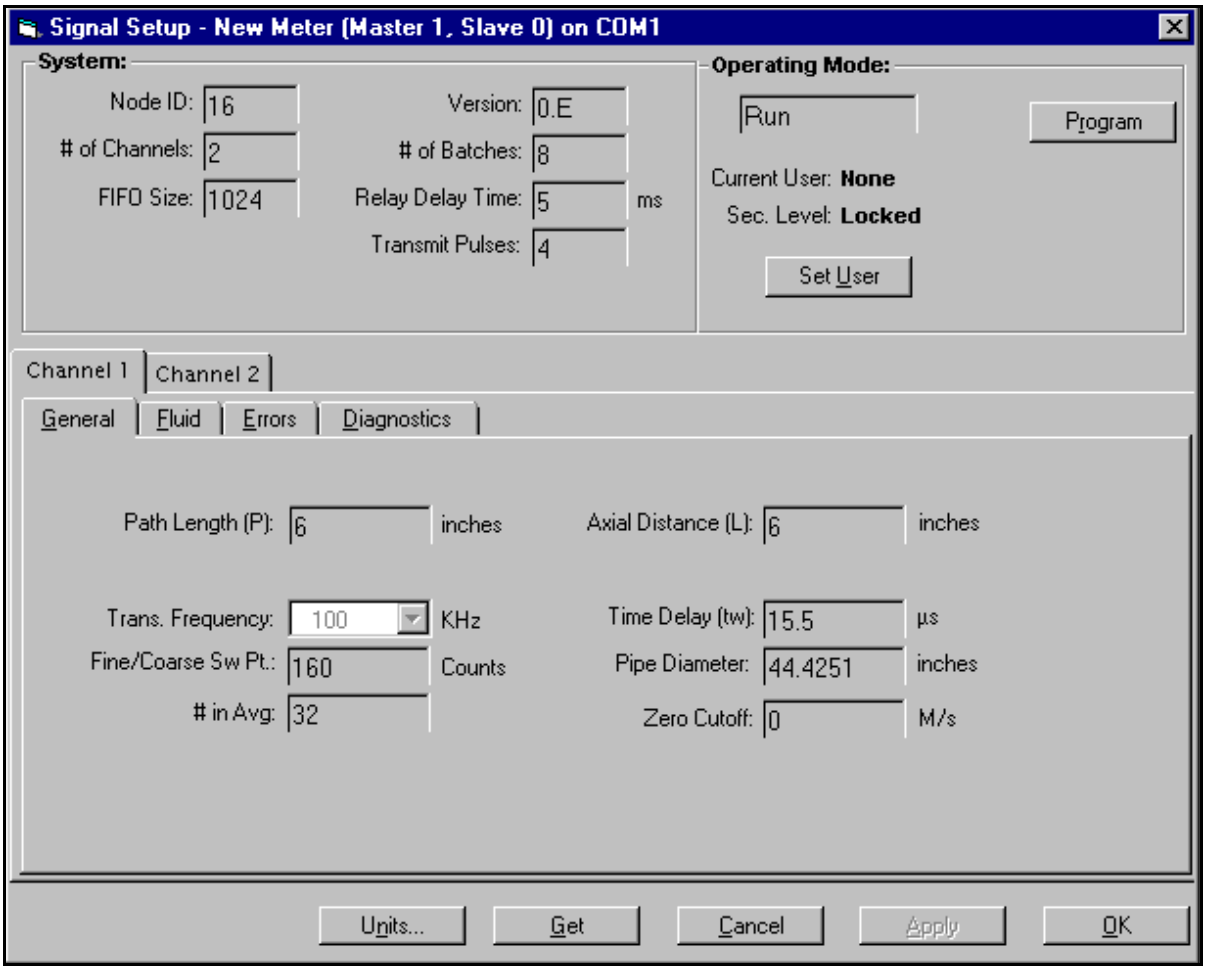


Figure 12: Signal Setup Display

2.6 Signal Setup (cont.)

The following information appears on the Signal Setup screen:

- **Node ID:** This is a display of the Node ID assigned to the instrument. It cannot be changed from this form but rather by using the Properties form.
- **Version:** This is the Main Firmware version as tabulated in the firmware signature
- **# of Channels:** The default number of channels is 2. The 2-path meter is using both channels of the electronics.
- **# of Batches:** The default value is 8. This is the number of transmit/receive signals sent prior to transmit direction change (upstream/downstream). The firmware will average the receive signal prior to the instant velocity calculation.
- **FIFO Size:** This is the FIFO function size as reported by the firmware. In the event that the FIFO size is increased due to hardware upgrade, the firmware will report the new size.
- **Relay Delay Time:** The default time is 5ms. This is the minimum time between relays of two consecutive relay switches.
- **Transmit Pulses:** The default value is 4. This is the number of transmit pulses which send to the transducers in each transmit state.
- **Program/Run button:** The default mode is Run and the button then displays Program. To switch the mode to Program, click on the button and then the window will display Run.

Note: *The user must be logged-in to enter the* Program *mode.*

Note: *The instrument will switch to* Run *mode after five minutes of no input from the user.*

- **Operating mode:** This display indicates if the instrument is in idle in the program mode or normally operating in run mode.

2.6.1 Channel Tabs

Use this section to program the meter parameters, which requires the user to login before any parameters can be changed.

2.6.1.1 General

Figure 37 on page lv shows a typical General tab display:

- **Path Length (P):** This is the acoustics path length. The value is measured on the assembled meter.
- **Axial Distance (L):** The value of the axial distance is measured on the assembled meter or derived from Quality Control Report measurement.
- **Pipe Diameter:** This is the inside diameter of the meter. This parameter is used by the meter as a factor in volumetric calculation. The value is measured on the assembled meter or derived from Quality Control Report measurement.
- **Transducer Frequency:** Select from a drop down menu the specified frequency for a pair of transducers.
- **Fine/Coarse Switch Point:** This is the number of points corresponding to the delta T at which the velocity calculation will switch from Mode 2 to Mode 3.

The formula for converting from velocity to count number is:

$$\text{Counts} = V ¥ \frac{32LF}{SOS ¥ SOS}$$

Where,V = velocity (meters/second)
SOS = speed of sound (meters/second)
L = axial length (meters)
F = programmed transducer frequency (hertz)

Note: *The meter will be shipped with the correct count number to insure that the meter operates correctly.*

- **# in Avg:** This is the number of parameters averaged together before being reported on average outputs. For the critical parameters, like velocity and volumetric, it is the number of averaged measurements. This number is carefully selected by the manufacturer to meet the meter specification as well as optimize the meter performance.
- **Time delay (Tw):** The delay time is a number which includes various delays in the transducers, electronics and cables. The manufacturer determines the exact Tw number during the zero flow calibration procedure.
- **Zero cutoff:** The value below which the velocity reading is forced to zero.

2.6.1.1 General (cont.)

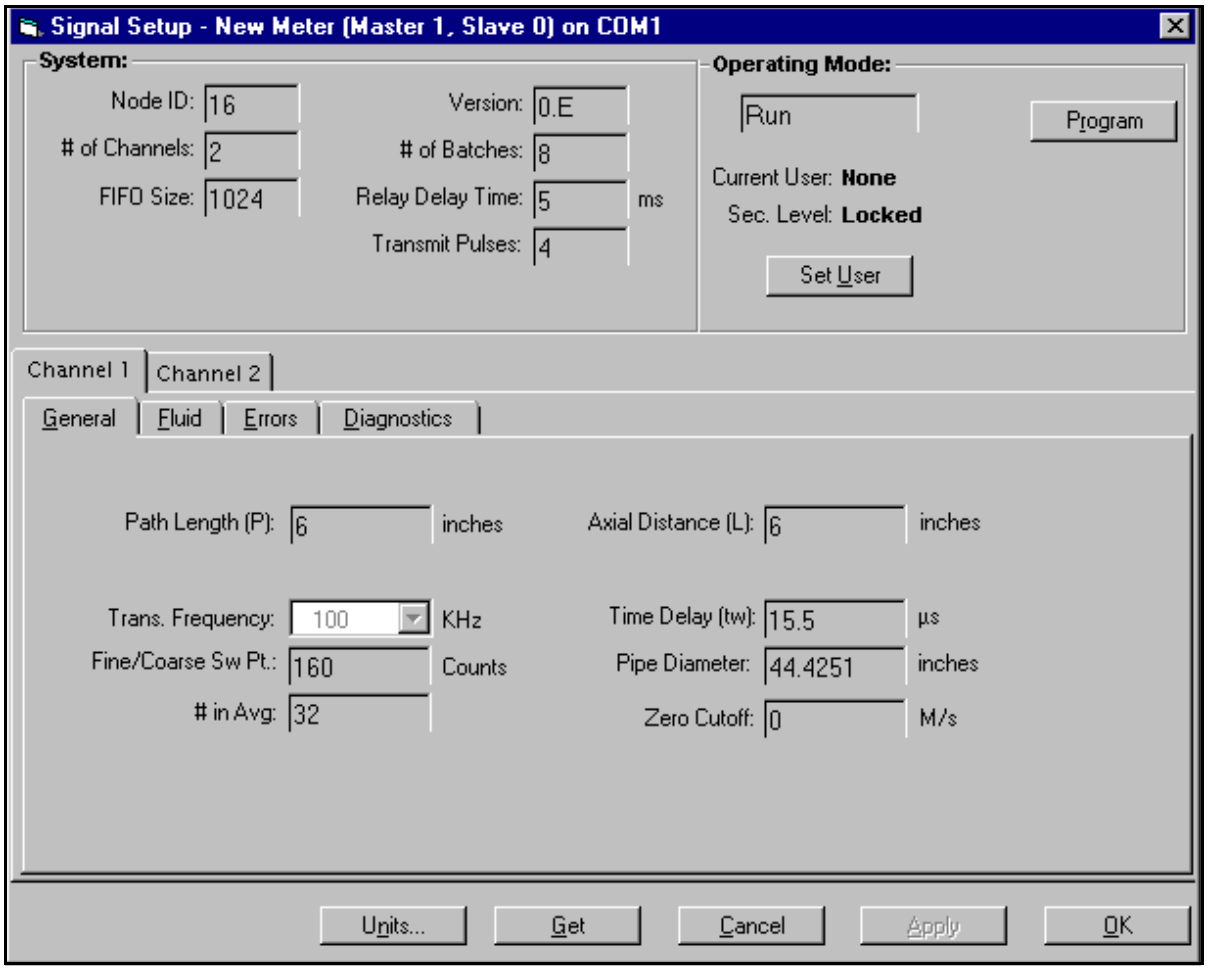


Figure 13: General Tab Display

2.6.1.2 Fluid

Figure 38 on page lvii shows a typical Fluid tab display:

- **Fluid:** Choose the fluid from the list box. The system will suggest theoretical soundspeeds. These suggested soundspeeds can be overwritten by selecting “Other” from the list. Other fluids can be measured by selecting “Other” and entering the fluid’s calculated soundspeed.
- **C3 Theory:** The theoretical soundspeed of the fluid being measured.
- **K Viscosity:** The kinematic viscosity of the fluid being measured.
- **Const Press:** The pressure of the measured fluid. If analog inputs are used for pressure measurement, this box will not be editable and will show the device number of the analog input.
- **Base Press:** The base pressure used for standard volumetric measurement calculations.
- **Const Temp:** The temperature of the measured fluid. If analog inputs are used for temperature measurement, this box will not be editable and will show the device number of the analog input.
- **Base Temp:** The base temperature used for standard volumetric measurement calculations.

2.6.1.2 Fluid (cont.)

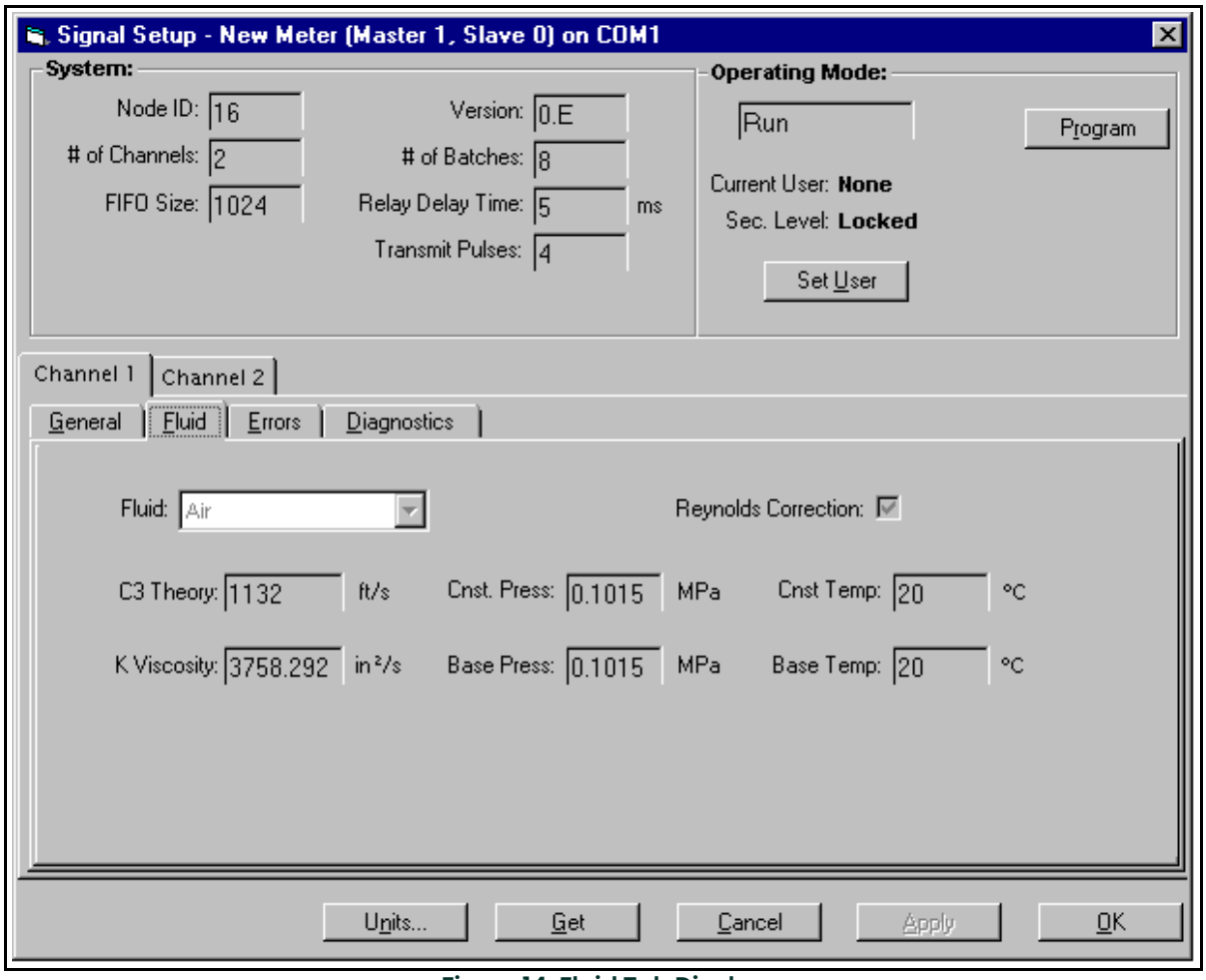


Figure 14: Fluid Tab Display

2.6.1.3 Errors

To set limits for possible errors, see *Figure 39 on page lix* and consider the following:

Note: *In the event that one of the following errors exceeds its limit, a corresponding error notice, described in Chapter 4,* Troubleshooting*, will be displayed by* PanaView *and* Modbus. *Also, the alarm relay will change state and the 4-20mA output and the Frequency output will be able to be programmed to identify the presence of an error.*

- **Soundspeed:** The soundspeed % Theory is set to cover the range at which the gas soundspeed may vary as a function of its composition, pressure and temperature. Setting the number too low may cause the meter to get into an error mode and stop working. Setting the number too high may cause the meter to fail to detect instrument malfunctions.
- **Signal Strength Limits:** The meter can operate in a very wide range of signal strength. The low limit should be set to allow the Signal to Noise Ratio to be large enough to ensure that the meter will maintain the specified accuracy. The upper limit needs to be set to ensure that the meter will not be overloaded and the signal be undetected.
- **Amplitude Limits:** The steady state amplitude is 100%. In case of a sudden change in the system gain, it may take time for the AGC to stabilize the amplitude to 100%. An error will be indicated if the amplitude exceeds the limits.
- **Velocity:** The velocity limits should be set higher than the maximum possible flow.
- **Acceleration:** The meter is testing for a change in velocity differential between each set of two consecutive velocity calculations. In some applications a sharp change in velocity is expected. In that case the meter should be programmed with a higher value than the default, which is 1.5 m/s.

2.6.1.3 Errors (cont.)

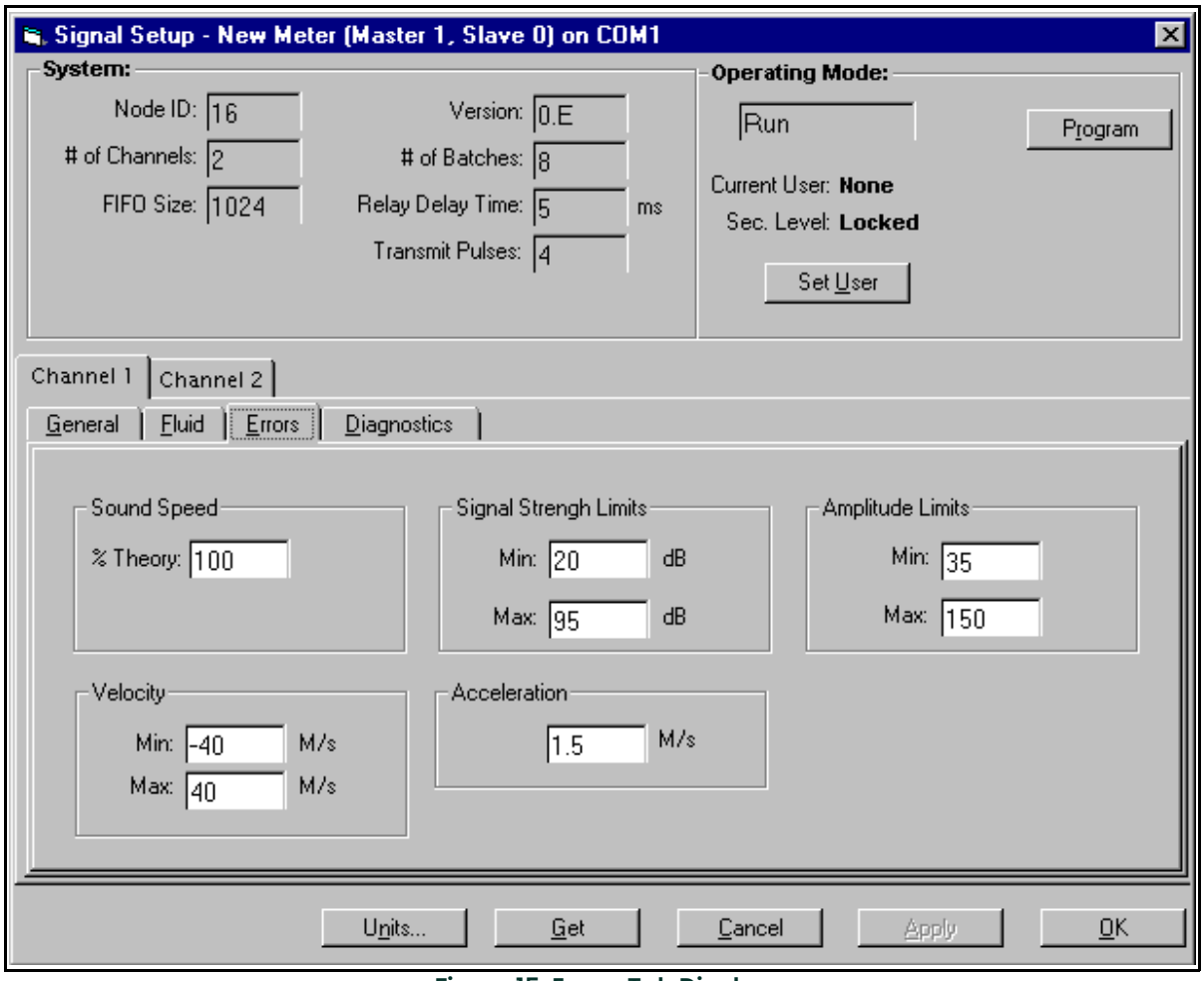


Figure 15: Errors Tab Display

2.6.1.4 Diagnostics

The diagnostics tab allows the user to display the following real time data, and to record some of the data as well (refer to *Figure 40 on page lxi*):

- **Flow Velocity:** This is the un-averaged, instantaneous velocity.
- **Sound Speed:** This is the un-averaged, instantaneous speed of sound.
- **Signal Max:** This is the un-averaged instantaneous percent signal relative to the ADC reference.
- **Delta T:** This is the un-averaged instantaneous delta between up and down transmit time
- **Delta T Offset:** The Delta T Offset is an entry which belongs in the general tab. It is used to compensate for system zero flow offset.
- **Error:** This display indicates the error number in the event that the meter has a error.
- **Mode:** There are three different regions at which the meter determines the topology for calculating the transmit time. Each region is assigned a mode:
  Mode 0: Phase mode
  Mode 1: 2T to Fine/Course switch point = Chai
  Mode 2: Bipolar Envelope
  Mode 3: Unipolar Envelope
- **% Error:** The percent error indicates that the measurement system is rejecting reading due to error. It will display the percent error which is proportion to the rejected data.

Up Stream/Down Stream:

- **Signal:** This is the signal strength in dB. The strength is inversely proportion to the receiver AGC gain level. The signal strength is between 0 and 100.
- **AGC:** The AGC number is the DAC digital input value which controls the receiver gain control.
- **Time:** The transmit time is the total as seen from the DSP. It is the sum of: the time between the surface of the two transducers, and Tw.
- **P#:** The P number is a point between 0 and 1024 on the receive window which is a function of the FIFO size.

2.6.1.4 Diagnostics (cont.)

Plot:

Note: *To access the plot function of PanaView, first set the meter to Program mode.*

- **Plot Type:** There are 5 different plots which *PanaView* can display:

  FIFO Up - the raw upstream signal
  FIFO Down - the raw downstream signal
  Env Up - the modulated raw upstream signal
  Env Down - the modulated raw downstream signal
  Chi 2 - the Chi 2 function, which was calculated by the meter

For more detailed instructions for using the plot function, refer to the *PanaView* manual (910-211).

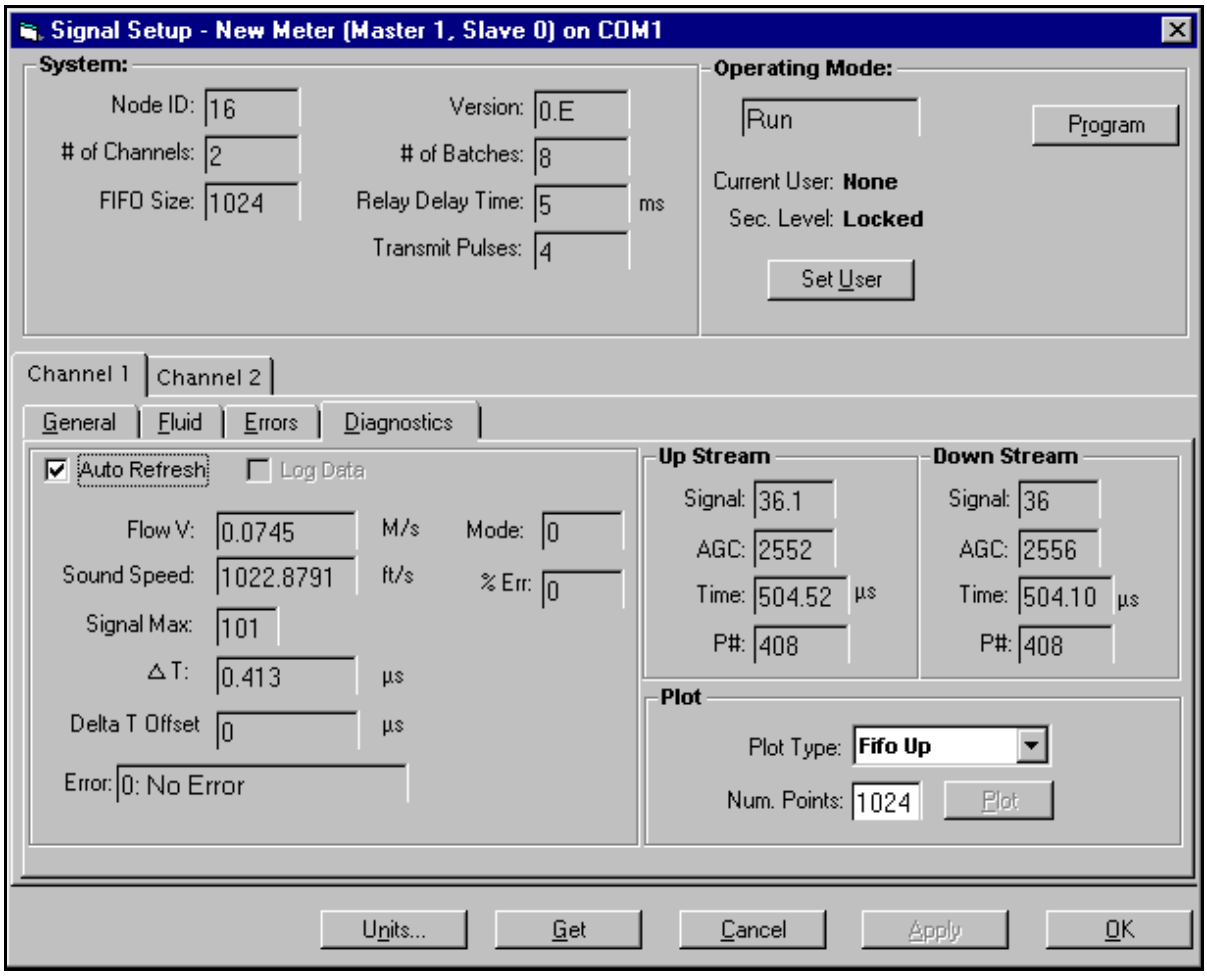


Figure 16: Diagnostics Tab Display

2.6.2 Signal Setup Buttons

2.6.2.1 Units

PanaView can display and program some parameters in different units based on user preference. The Units button allows the user to switch between the different units (see *Figure 41* below).

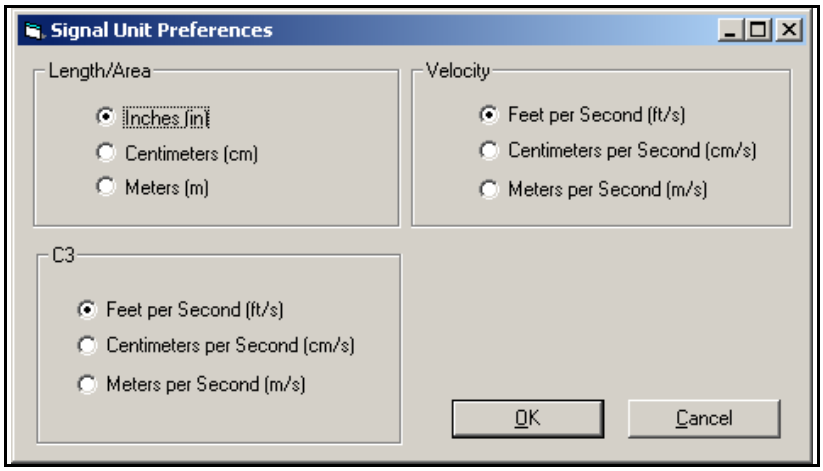


Figure 17: Signal Unit Preferences

2.6.2.2 Get

All of the programming information is stored in the meter non-destructive memory. *PanaView* displays may be updated manually by pressing the Get button.

Chapter 3. Operation

3.1 Introduction

See Chapter 1, *Installation*, and Chapter 2, *Initial Setup*, to prepare the *Sentinel Flow Measurement System* for operation. When the meter is ready to take measurements, proceed with the instructions in this chapter.

Note: *All inputs and outputs of the Sentinel are calibrated at the factory, prior to shipment. If it becomes necessary to recalibrate any of the inputs and/or outputs, contact Panametrics for assistance.*

WARNING! **To ensure the safe operation of the Sentinel Flow Measurement System, it must be installed and operated as described in this manual. In addition, be sure to follow all applicable local safety codes and regulations for the installation of electrical equipment.**

3.2 Getting Started

The purpose of this section is to give a brief description of the Sentinel user program and how to use PanaView to view and enter data.

3.2.1 Powering Up

Because the Sentinel does not have an ON/OFF switch, it will power up as soon as the connected power source is energized.

Note: *For compliance with the EU Low Voltage Directive (73/23/EEC), this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the meter.*

There are two methods for obtaining readings from the Sentinel:

- The built-in meter LCD Display, which is configured using PanaView
- The PanaView display on a computer screen

Note: *PanaView must be installed in order to obtain flow rate readings from the meter. See the* PanaView User Interface User's Manual *(910-211) for additional information.*

Immediately upon power-up both the green **PWR** light and the red FAULT light in the meter LCD Display begin to glow. About 15 seconds later the red light stops glowing and the software version display appears. Then, the meter performs a series of internal checks, which takes about 45 seconds, prior to displaying the flow rate data.

Note: *If the Sentinel fails any of the internal checks, try disconnecting the power and then repowering the unit. If the meter continues to fail any of the internal checks, contact Panametrics for assistance.*

After successfully performing the internal checks, the Sentinel begins taking measurements and the software version display is replaced by a measurement mode display.

3.2.2 Function Verification Procedures

Before continuing with function verification, the flowmeter body must be installed in the pipeline and pressurized with process gas. Also, the Sentinel's communications and outputs must be wired to the flow computer or plant computer. Temperature and pressure sensors should be connected to either the Sentinel or the flow computer. The *Sentinel* must be powered for at least one minute to allow for self-test and initialization, as follows:

1. Verify that the on-site control computer is not indicating fault condition from the Sentinel if the alarm output is connected.
2. If the alarm output is not connected, verify that the Sentinel is not reporting any errors by observing its display and fault indicator (red) light beneath the display.
3. Verify that the flow reading reported by the on-site control computer is reasonable and stable.

If none of the above procedures indicate a problem, the function verification is complete. If a problem is indicated, proceed to *"Installation Troubleshooting Procedures"* below.

3.2.3 Installation Troubleshooting Procedures

The purpose of these procedures is to troubleshoot the Sentinel installation, if a fault condition was indicated while performing the *"Function Verification Procedures"* in the previous section.

If the Sentinel failed to power on, check the wiring for the presence of power in a safe manner. If the power is wired correctly and power is present, call Panametrics for assistance.

If the Sentinel is indicating a fault condition on the display or alarm output, refer to *Error Codes*, Chapter 4, or *Diagnostics*, Chapter 5 in this manual.

If the on-site control computer is not receiving flow data and the Sentinel display is not indicating a fault, check the wiring of the outputs from the Sentinel to the on-site control computer or the flow computer, if used.

Check the programming of the flow computer, if used, and verify that its input and output wiring is correct. If you cannot resolve the problem, call Panametrics for assistance.

3.2.4 The LCD Display

The components of the LCD display are shown in *Figure 42* below, along with a typical mass flow rate readout.

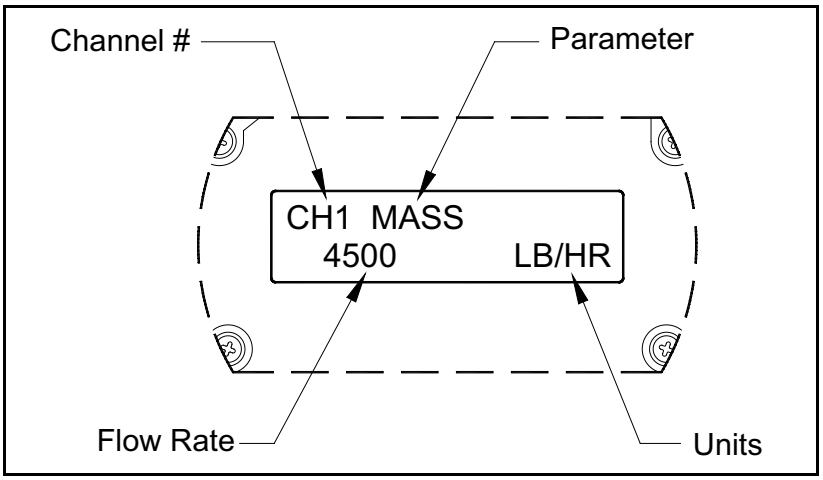


Figure 1: A Typical LCD Flow Rate Display

As shown in *Figure 42* above, the display screen includes the following information:

- Channel Number
- Flow Parameter
- Units of Measure
- Flow Rate Value

CAUTION! **If the Sentinel is being installed in a hazardous area, be sure to adjust the backlight brightness and display contrast of the meter LCD window before mounting the system (see *"Adjusting the LCD Contrast and Brightness" on page xxxiv*).**

Note: *Error code messages may appear in the lower right corner of the LCD display. For information about these error codes and how to respond to them, refer to Chapter 4,* Error Codes.

3.3 Setting Configuration Parameters

With PanaView installed on your computer (see the *PanaView Graphical Interface User's Manual*), you can enter and record the meter information in a number of different ways. The Meter Browser Menu is illustrated in *Figure 43* below.

Note: *For reference during PanaView programming, see the PanaView Menu Map in* Figure 69 on page lxxxix.

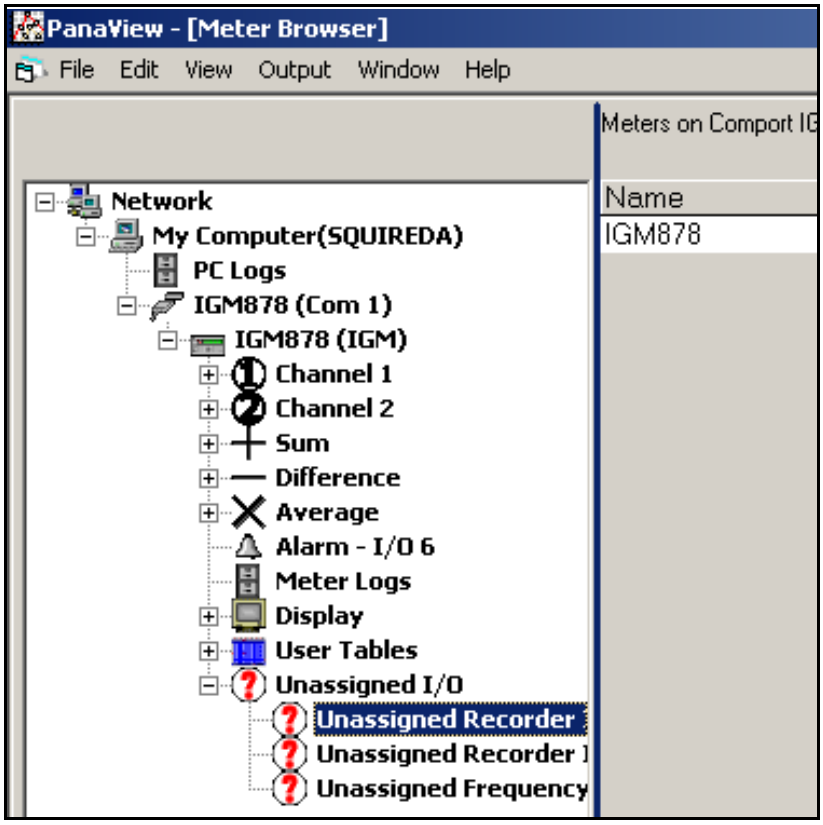


Figure 2: PanaView Meter Browser Menu

3.4 Archiving Site Configuration Files

The meter has the ability to save configuration files to the PC for archiving. The archived files can be loaded into the active configuration of the instrument as well. This functionality is available using the *PanaView* interface. To save the current configuration of the instrument, select the meter in the PanaView Meter Browser. Using the mouse, right click on the meter and select Site File (see *Figure 44* below).

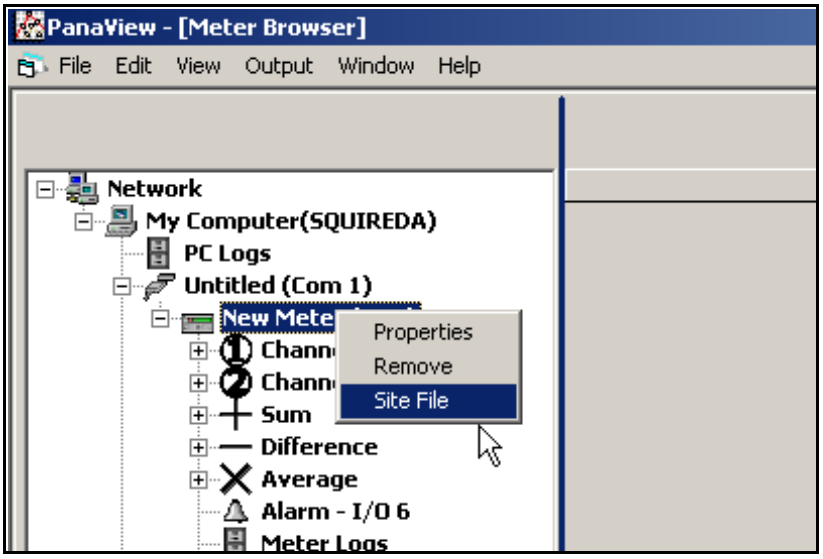


Figure 3: Selecting the Site File Icon

A dialogue box will appear (see *Figure 45* below).

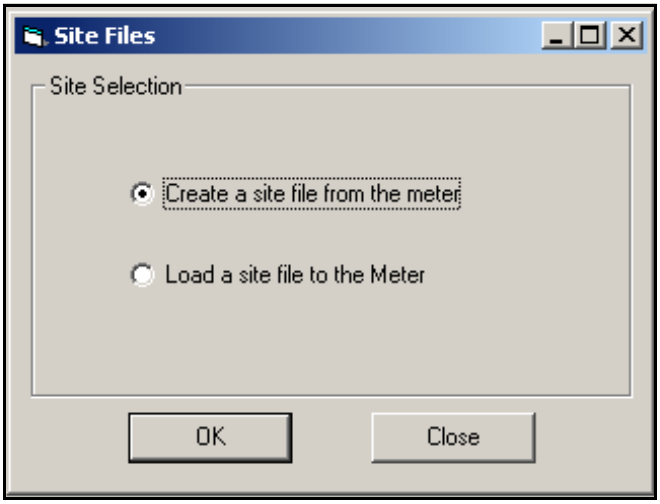


Figure 4: Site Selection Dialogue Box

3.4 Archiving Site Configuration Files (cont.)

To save the current meter configuration to the PC, select Create a site file from the meter and then click OK. You will be prompted for the location and the name of the file in the next dialog. After the file is selected, PanaView will read the current instrument parameters and write them to the site file.

To load a stored configuration into the meter, click on Load a site file to the meter and then click OK. You must then locate the file to load. After the file is selected, PanaView will read the configuration file and load the parameters into the instrument. After the process is complete, you must initialize the instrument in PanaView because its configuration parameters have changed. See Chapter 2, *Initial Setup*, for instructions.

3.5 Programming a Fault Alarm/Flow Direction Indicator

The alarm output can be programmed as a fault alarm or a flow direction indicator. Programming is available using the PanaView interface. To program the relay, expand the meter in the PanaView meter browser and double click on the Alarm icon (see *Figure 46* below).

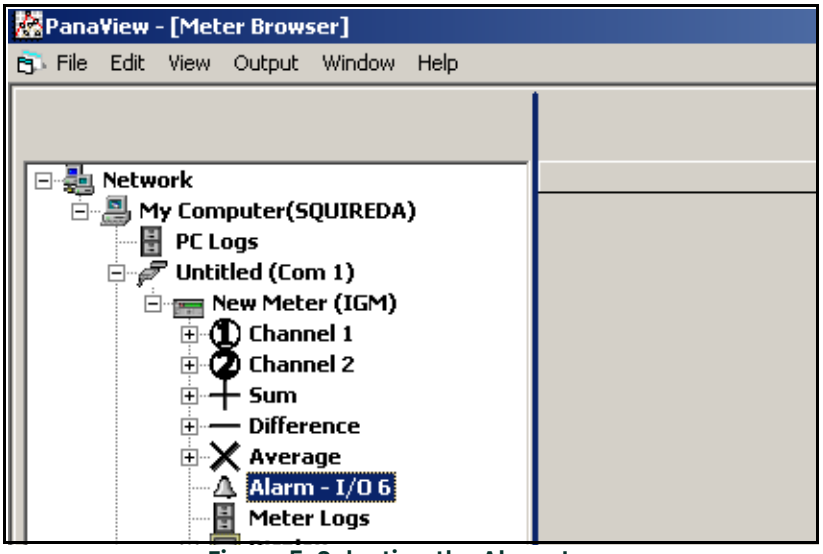


Figure 5: Selecting the Alarm Icon

A dialogue box will appear (see *Figure 47* below). Select whether the relay should be configured as a Fault Alarm or as a Flow Direction Indicator and click OK.

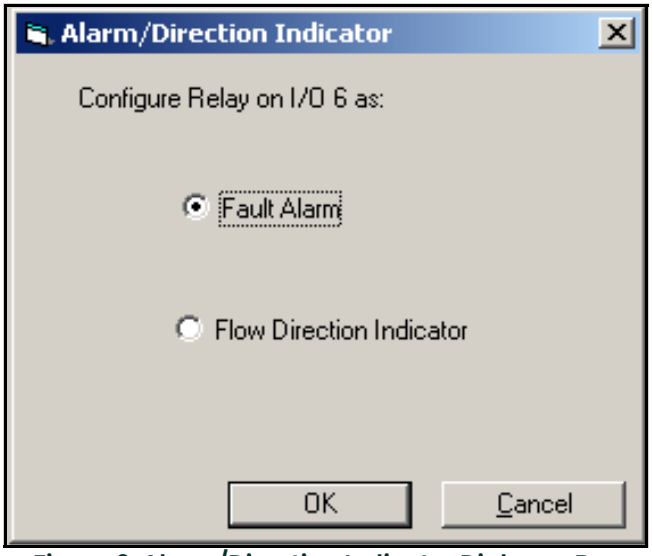


Figure 6: Alarm/Direction Indicator Dialogue Box

3.6 Configuring and Calibrating the Analog Outputs

Every Sentinel flow meter includes two built-in analog outputs (A and B) at terminal block J1. Before beginning calibration of these outputs, an ammeter must be connected to the desired analog output. Both the zero-point and the full-scale values for all of these outputs must be calibrated. After calibrating the outputs, which have a resolution of
5.0 uA (0.03% of full scale), their linearity should be tested.

Note: *The zero point of the analog output may be set to either 0 mA or 4 mA. However, the calibration always uses the 4 mA point, and the meter extrapolates this value to obtain the 0 mA point.*

3.6.1 Configuring the Analog Outputs

CAUTION! **The load on the analog output must not exceed 600 W. Do not connect the ammeter directly across the analog output terminals.**

Prepare for calibration by inserting an ammeter in series with the load on the desired output. See Figure 3-7 below to identify the OUT(+) and RTN(-) pins.

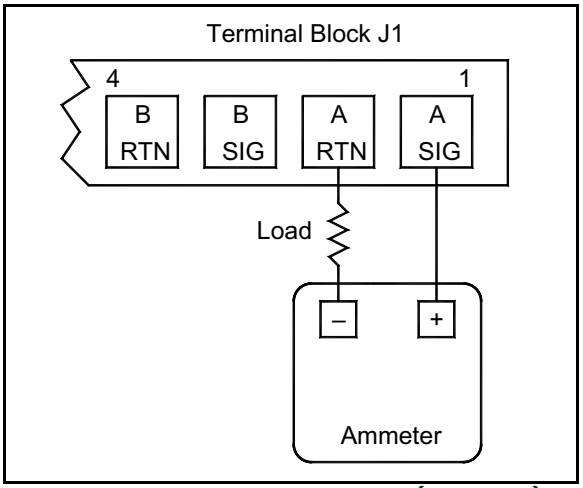


Figure 7: Ammeter Connection (Output A)

Use the PanaView Recorder Properties to calibrate an Analog Output. To access these menu options, complete the following steps:

1. Make sure the system is connected to your computer, the system and the computer are turned ON, and PanaView is up and running.
2. Under File open the New Meter Browser.
3. Expand the drop-down menus until you access the meter and its submenus. Expand the last meter submenu, Unassigned I/O.
4. Double-click on Recorder 1 or Recorder 2 to bring up the Analog Output properties window. Under the General tab, select the desired option from the Type drop-down menu (see *Figure 49 on page lxxi*).

3.6.1 Configuring the Analog Outputs (cont.)

5. Set the Zero and the Span to the desired values. In the Recorder Unit section, select the desired output for Channel, Sensor/Class and Unit. Click on Apply. The window should look similar to *Figure 49* below.

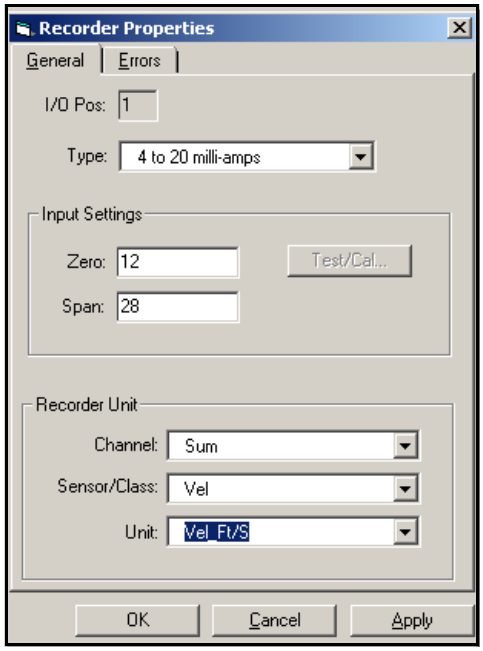


Figure 8: Recorder Properties

6. Next, click on the Errors tab and select the Error Handling schemes for the On Low Error and On High Error cases from the drop-down menus. Then click on Apply (see *Figure 50* below).

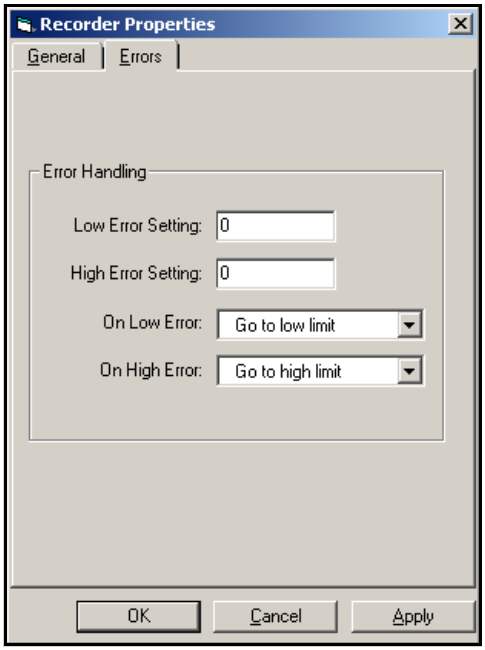


Figure 9: Recorder Errors

3.6.2 Calibrating the Analog Outputs

After the configuration in the previous section is complete, proceed as follows to calibrate the analog outputs:

1. Under the Recorder Properties General tab, click on Test.
2. A window similar to *Figure 51* below should appear, asking if you want to test the Recorder. Press Yes.

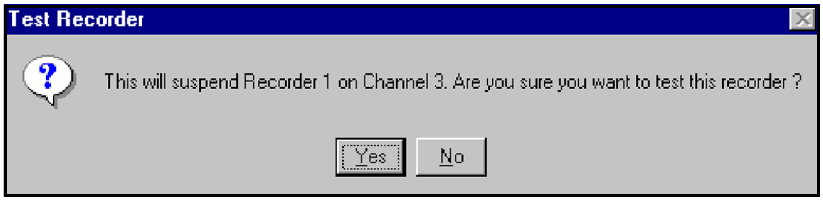


Figure 10: Test Recorder Prompt

3. The screen should now look similar to *Figure 52* below. Click on the 4 mA option in the Trim section.
4. Read the current off the digital multimeter and enter the value from the DMM into the Actual mA box for 4 mA.
5. Click on the 20 mA option in the Trim section and enter the value from the DMM into the Actual mA box for 20 mA.
6. Click on the Apply button. You may now select among the test percentages to verify mA at each percentage.

Note: *If you need to calibrate a second time, press the* Reset *button.*

7. Press OK when you are finished calibrating the analog output.

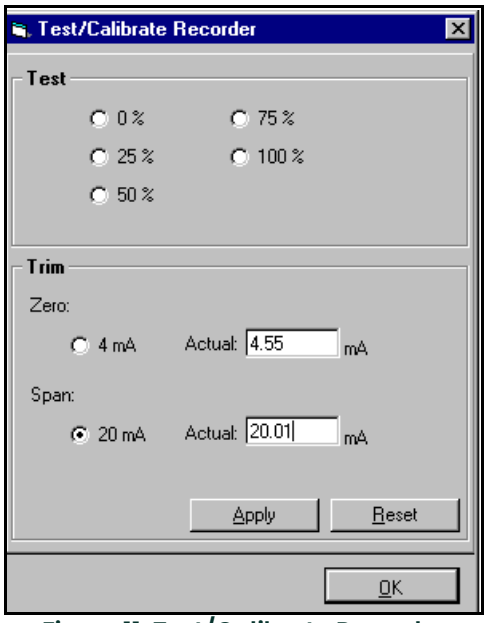


Figure 11: Test/Calibrate Recorder

3.7 Configuring and Testing the Frequency Output

Use the PanaView Unassigned Frequency on I/O menu to calibrate a *Frequency Output*. To access these menu options, complete the steps in the following section.

3.7.1 Configuring the Frequency Output

1. Make sure the system is connected to your computer, the system and the computer are turned on, and PanaView is up and running.
2. Under File open the New Meter Browser.
3. Expand the drop-down menus until you access the meter and its submenus. Expand the last meter submenu, Unassigned I/O.
4. Double click on Frequency 1 or Frequency 2, whichever is desired, then double-click on Frequency to bring up the Frequency Properties window.
5. Under the General tab, locate the Input Settings section and enter the desired values for the Min, Max, Zero and Span parameters.
6. In the Frequency Unit section, select the desired output for Channel, Sensor/Class and Unit from drop-down menus, and click on Apply. The window should look similar to *Figure 53* below.

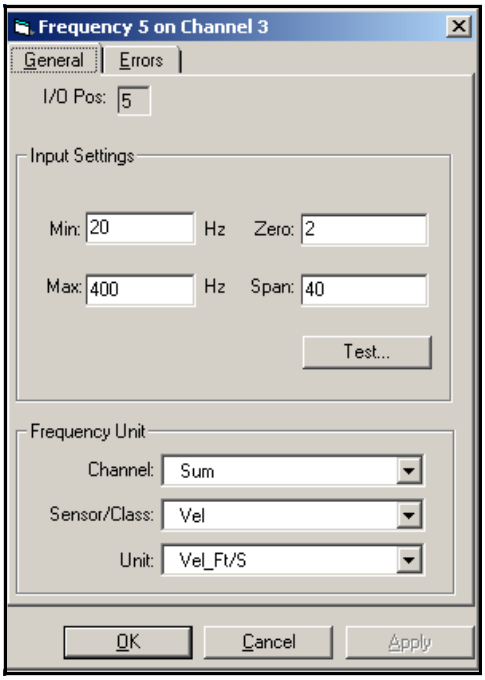


Figure 12: Frequency Properties

3.7.1 Configuring the Frequency Output (cont.)

7. Next, click on the Errors tab (see *Figure 54* below). Select the Error Handling schemes for On Low Error and On High Error cases from the drop-down menus. Then Click on Apply.

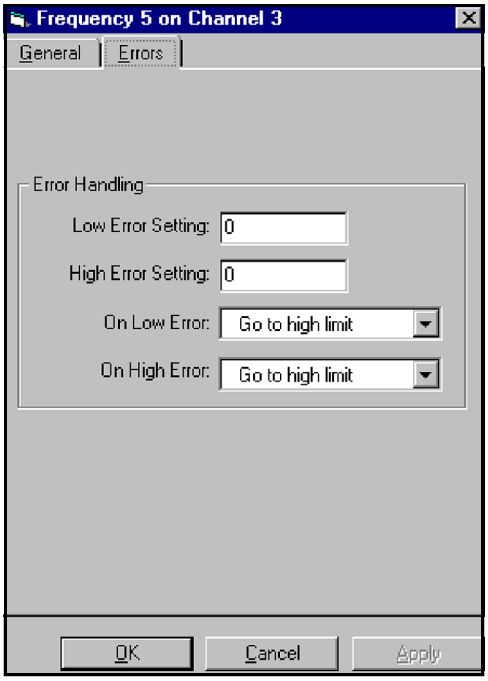


Figure 13: Frequency Errors

3.7.2 Testing the Frequency Output

1. Under the General tab, click on Test.
2. A window similar to *Figure 55* below should appear, asking if you want to test the Frequency. Click on Yes.

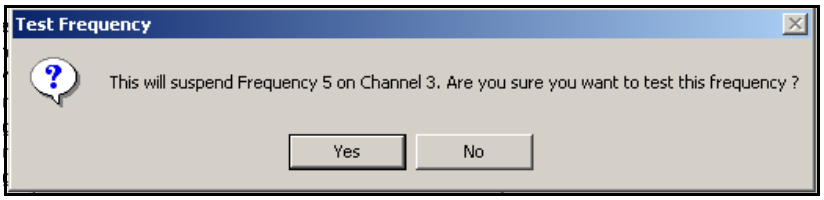


Figure 14: Test Frequency Prompt

3. The screen should now look similar to *Figure 56* below. Use the mouse to move the Test Percentage pointer to 0%. Read the frequency value on the oscilloscope. The oscilloscope should read the Zero value. Next, set the Test Percentage pointer to 100%. Read the frequency off the oscilloscope. The oscilloscope should read the Span value.
4. When you are done, press OK in the Test Frequency window and then OK in the Frequency 5 on Channel ... window.

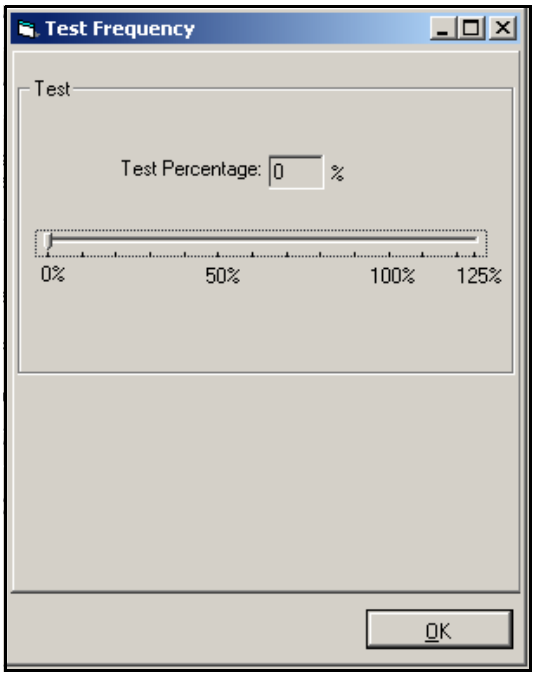


Figure 15: Test Frequency Window

3.8 Calibrating the Sensors

Use the PanaView ADC Configuration menu to calibrate a *Sensor* option card. To access these menu options, complete the following steps:

1. Make sure the system is connected to your computer, the system and computer are turned ON, and *PanaView* is up and running.
2. Under File open the New Meter Browser.
3. Click on the + sign before each level to open it.
4. Under Unassigned I/O, right click on Unassigned ADC IO 7 and select the desired configuration option (see *Figure 57* below).

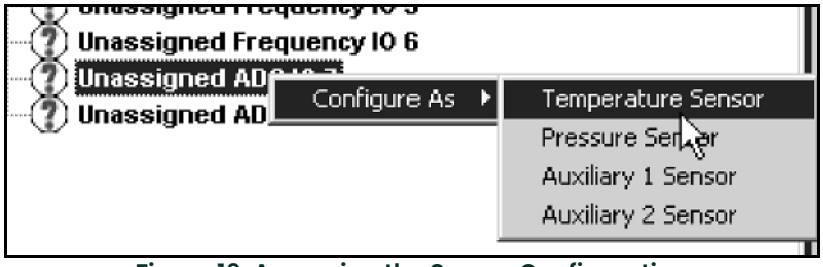


Figure 16: Accessing the Sensor Configuration

5. When a display similar to that shown in *Figure 58* below appears, make whatever selections and settings are appropriate under both displays (General and Calibration). Then, click on OK or Apply and the display returns to the list of selections.
6. To calibrate a second Sensor card, repeat the above process with the second Unassigned ADC IO option.

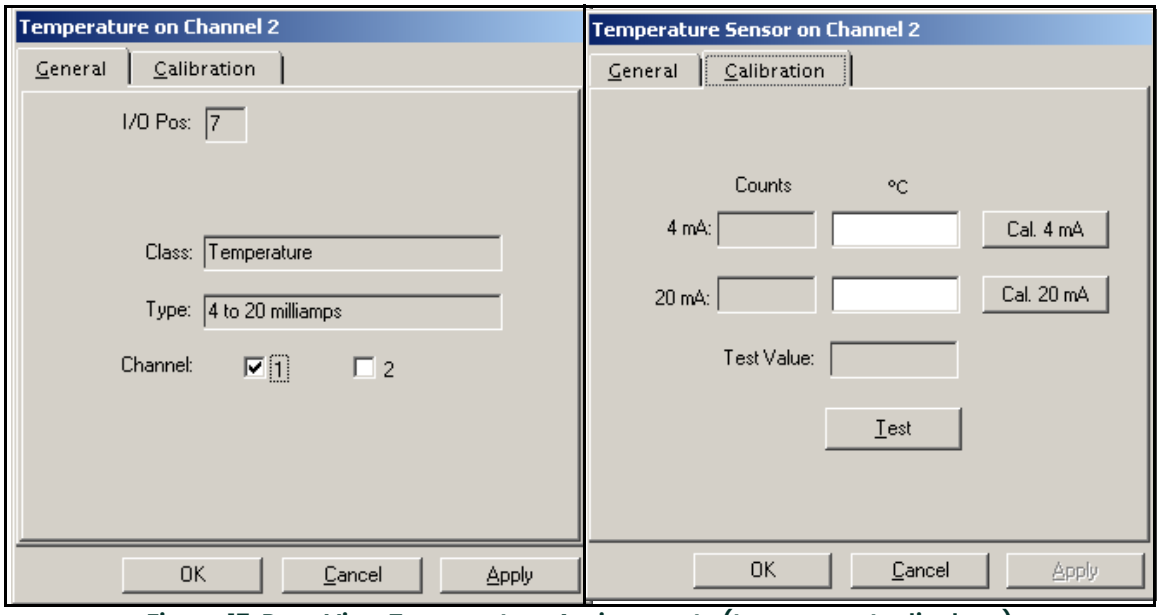


Figure 17: PanaView Temperature Assignments (two separate displays)

3.9 Entering Temperature and Pressure Constants

Use PanaView to enter fixed values for flow temperature and pressure. To accomplish this, complete the following steps:

1. Make sure the system is connected to your computer, the system and the computer are turned ON, and PanaView is up and running.
2. In the *File* menu, open the New Meter Browser.
3. To enter values for Channel 1, click on the + sign before each level to open it (see *Figure 43 on page lxvi*).
4. Double click on the Temp or Pres option and the Temperature or Pressure display appears (see *Figure 59* below).
5. Enter the desired values and click on the OK button.
6. To set up temperature and/or pressure constants for Channel 2, repeat the above process with the Channel 2, Temp or Pres option.
7. When the appropriate temperature and pressure values have been entered, proceed to *"Entering Velocity Constants" on page lxxviii*.

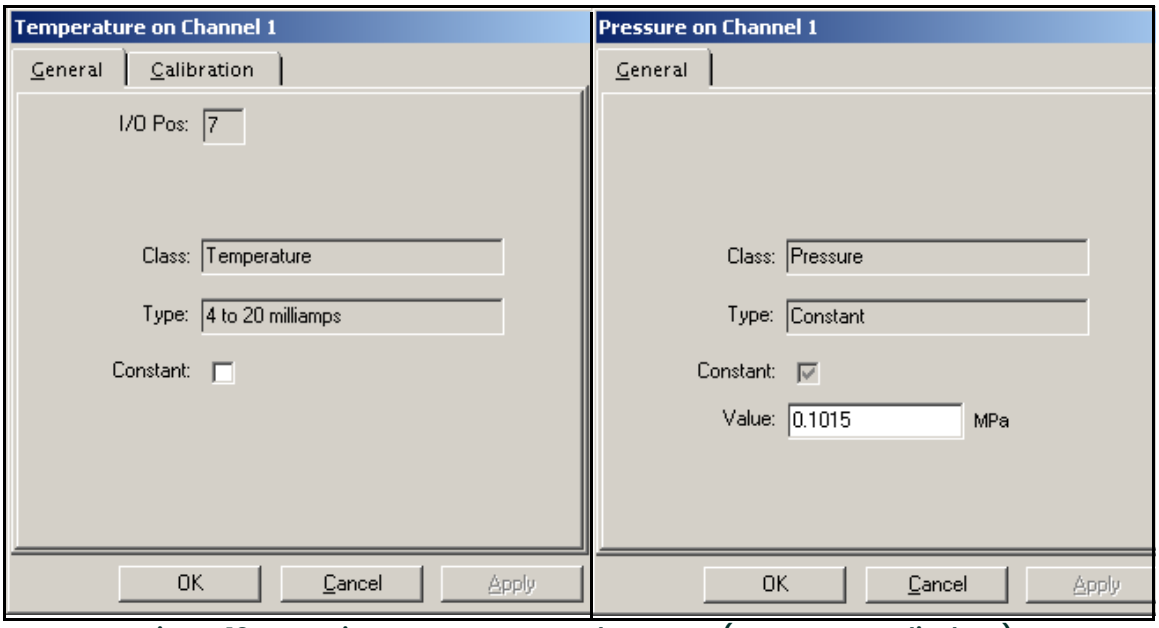


Figure 18: PanaView Temperature and Pressure (two separate displays)

3.10 Entering Velocity Constants

Use PanaView to enter fixed values for flow velocity. To accomplish this, complete the following steps:

1. Make sure the system is connected to your computer, the system and the computer are turned on, and PanaView is up and running.
2. In the *File* menu, open the New Meter Browser.
3. To enter values for Channel 1, click on the + sign before each level to open it (see *Figure 43 on page lxvi*).
4. Click twice on Vel and the Velocity display appears (see *Figure 60* below).
5. Enter the desired values and click on the OK button.

Note: *The values should be entered in ascending velocity order.*

6. To enter values for Channel 2, repeat the above procedure under the Channel 2 directory.
7. When all the appropriate values have been entered, exit the program.

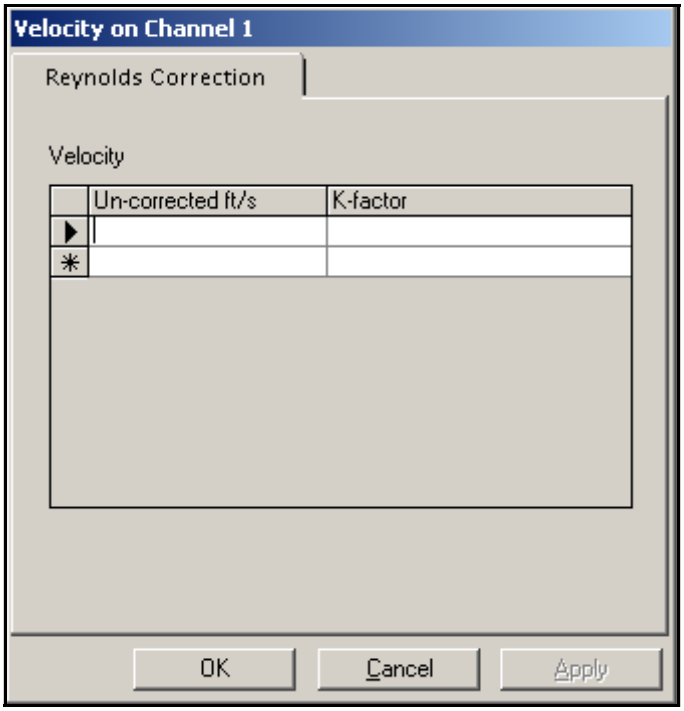


Figure 19: PanaView Velocity Correction Display

3.11 Displaying Measurements

Use PanaView to observe the sensor information on the computer screen in any combination of channels, measurement modes, and measurement units in either a text format or a graphic format.

To set up the display, complete the following steps:

1. Make sure the system is connected to your computer, the system and the computer are turned ON, and *PanaView* is up and running.
2. In the File menu, open a New Meter Browser.
3. Under Output select either Graphing/New or Text Display, whichever is desired.
4. Click on the + sign before each level to open it. See *Figure 61* below and *Table 9 on page 18* for details on the available options.

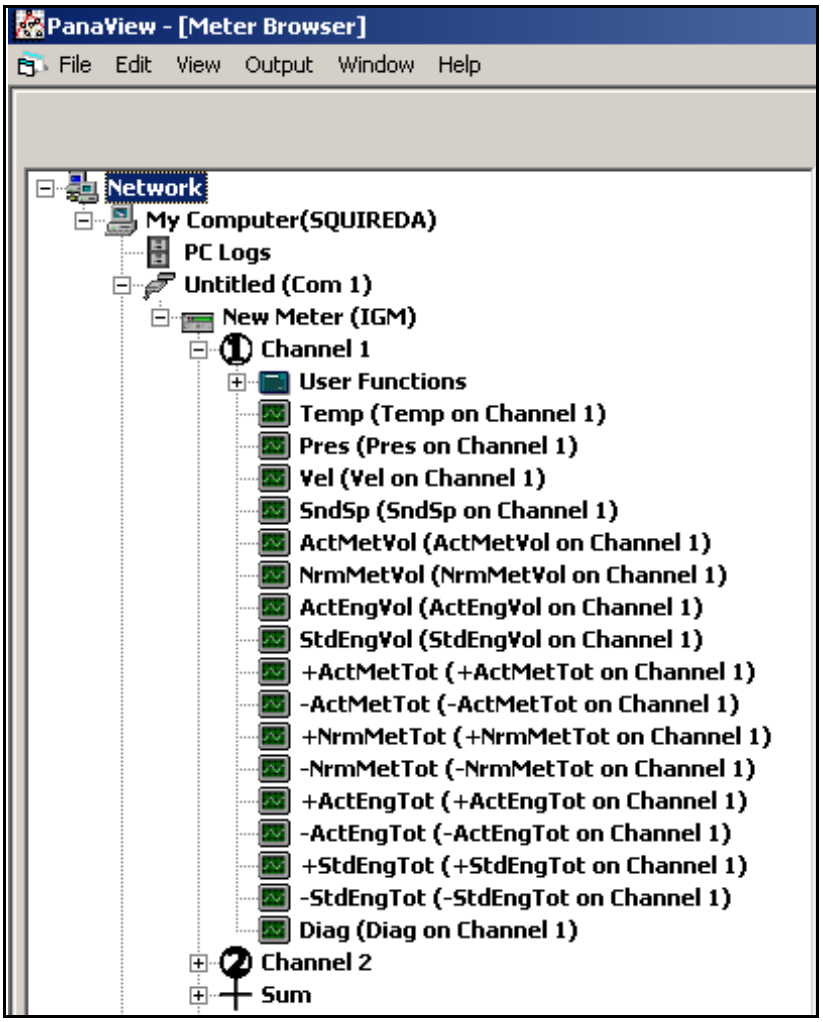


Figure 20: PanaView Output Menu

3.11 Displaying Measurements (cont.)

Selection	Description
Temp	Temperature
T_C	Degrees Celsius
T_F	Degrees Fahrenheit
T_K	Kelvin
T_DVM	Digital Voltmeter (Diagnostic Mode)
Pres	Pressure
PSIg	Pounds per square inch (general)
Bars	Bars
mbs	Millibars
mmHg	Millimeters of Mercury
Pas	Pascal, gauge
kPas	KiloPascal, gauge
PSIa	Pounds per square inch (absolute)
MPas	MegaPascal
P_DVM	Digital Voltmeter (Diagnostic Mode)
Vel	Velocity
Vinst_M/S	Instantaneous velocity in meters/sec.
Vinst_Ft/S	Instantaneous velocity in feet/second
Vel_M/S	Average velocity in meters/second
Vel_Ft/S	Average velocity in feet/second
SndSp	Soundspeed
SOS_M/S	Speed of sound in meters/second
SOS_Ft/S	Speed of sound in feet/second
ActMetVol	Actual Metric Volume
ACM/S	Actual Metric Volume per second
KACM/S	Kilo Actual Metric Volume per second
MACM/S	Mega Actual Metric Volume per second
ACM/M	Actual Metric Volume per minute
KACM/M	Kilo Actual Metric Volume per minute
MACM/M	Mega Actual Metric Volume per minute
ACM/H	Actual Metric Volume per hour
KACM/H	Kilo Actual Metric Volume per hour
MACM/H	Mega Actual Metric Volume per hour
ACM/D	Actual Metric Volume per day
KACM/D	Kilo Actual Metric Volume per day
MACM/D	Mega Actual Metric Volume per day
NrmMetVol with “NCM”	Standard Metric Volume (same as above with “NCM”)
ActEngVol with “ACF”	Actual English Volume (same as above with “ACF”)
StdEngVol with “SCF”	Standard English Volume (same as above with “SCF”)
+ActMetTot	Actual Metric Total Forward

Selection	Description
+ACM	Actual Metric Total Foward in meters
+KACM	Actual Metric Total Forward in kilometers
+MACM	Actual Metric Total Forward in megameters
-ActMetTot	Actual Metric Total Reversed
-ACM	Actual Metric Total Reversed in meters
-KACM	Actual Metric Total Reversed in kilometers
-MACM	Actual Metric Total Reversed in megameters
+NrmMetTot	Standard Metric Total Forward
+NCM	Standard Metric Total Forward in meters
+KNCM	Standard Metric Total Forward in kilometers
+MNCM	Standard Metric Total Forward in megameters
-NrmMetTot	Standard Metric Total Reversed
-NCM	Standard Metric Total Reversed in meters
-KNCM	Standard Metric Total Reversed in kilometers
-MNCM	Standard Metric Total Reversed in megameters
+ActEngTot	Actual English Total Forward
+ACF	Actual English Total Forward in feet
+KACF	Actual English Total Forward in kilofeet
+MACF	Actual English Total Forward in megafeet
-ActEngTot	Actual English Total Reversed
-ACF	Actual English Total Reversed in feet
-KACF	Actual English Total Reversed in kilofeet
-MACF	Actual English Total Reversed in megafeet
+StdEngTot	Standard English Total Forward
+SCF	Standard English Total Forward in feet
+KSCF	Standard English Total Forward in kilofeet
+MSCF	Standard English Total Forward in megafeet
-StdEngTot	Standard English Total Reversed
-SCF	Standard English Total Reversed in feet
-KSCF	Standard English Total Reversed in kilofeet
-MSCF	Standard English Total Reversed in megafeet
Comp	Composite
Cmp Vel	Composite velocity
Cmp SOS	Composite soundspeed
Diag	Diagnostic Parameters
P Num Up	Signal peaks - upstream flow
P Num Dn	Signal Peaks - downstream flow
Cmp Flow Err	Composite flow error
Cmp Comm Err	Composite common error
Percent Err	Percentage error
Meas Mode	Measuring mode

3.11 Displaying Measurements (cont.)

5. Select the channel and the category to be observed.
6. Double click on the measurement(s) desired and, depending on the number of parameters chosen and the format that was selected in Step 3, a display similar to either that shown in *Figure 62* below or *Figure 63 on page lxxxiv* will appear
7. After the parameters have been observed and recorded, exit the display and repeat the procedure for any other required programming.

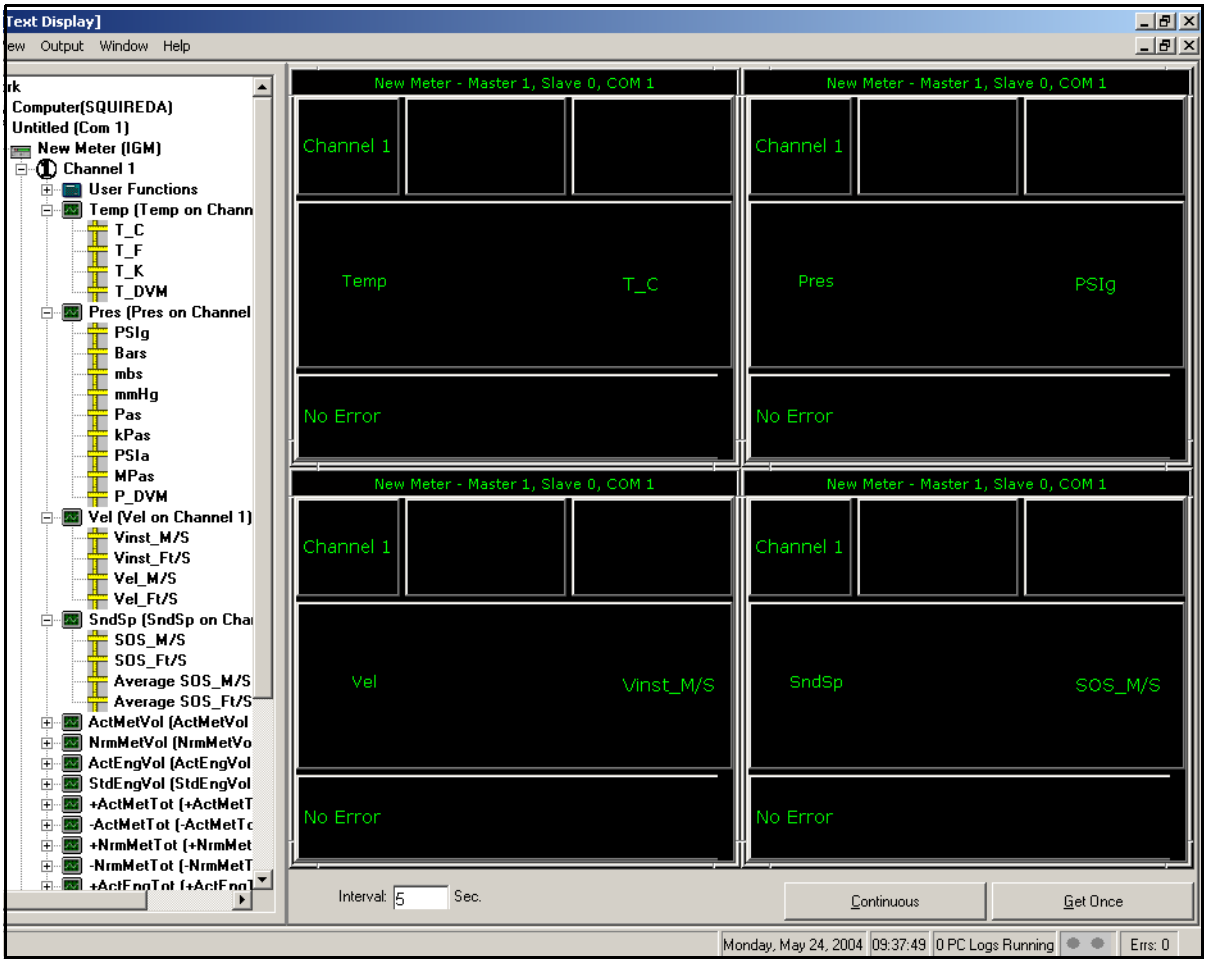


Figure 21: PanaView Measurements Display in Text Format

3.11 Displaying Measurements (cont.)

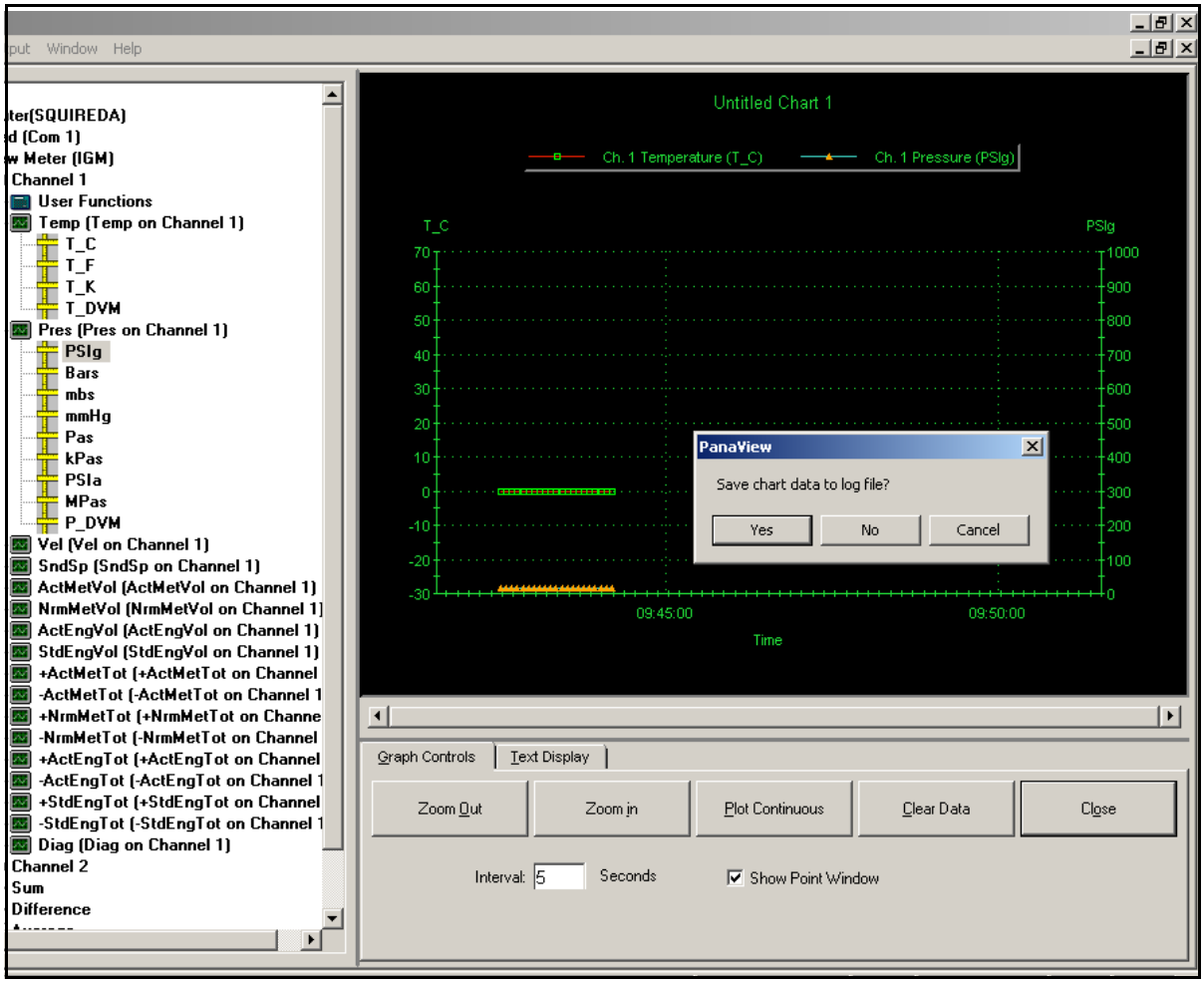


Figure 22: PanaView Measurements Display in Graph Format

Note: *Upon exiting a display in graph format, a prompt appears reading "*Save chart data to log file?*" Respond as desired and exit the display.*

For further details on collecting and displaying data see Chapter 6, *Data Handling*, in the *PanaView Manual* (910-211).

3.12 Resetting the Totalizers

Periodically, the totalizers will need to be reset to zero. To reset the totalizers, proceed to the next section.

3.12.1 Preparing the Electronics

1. Power down the electronics.
2. Break the lead and wire seal on the front cover, if one was applied for security reasons (see *Figure 64* below).
3. Unscrew the cover and set it aside.

Figure 23: Breaking the Seal

4. Identify the notch toward the top left side of the LCD display board, through which the DIP switch can be seen (see *Figure 65* below).

Figure 24: Locating the Dip Switch

3.12.1 Preparing the Electronics (cont.)

5. Use a small screwdriver to move the top (#8) switch to the *ON* (left) position (see *Figure 66* below).
6. If the system is not already connected to a PC or laptop computer, use the RS232 (or RS485) terminal on the rear of the electronics package to make the connection.
7. Power up the electronics.

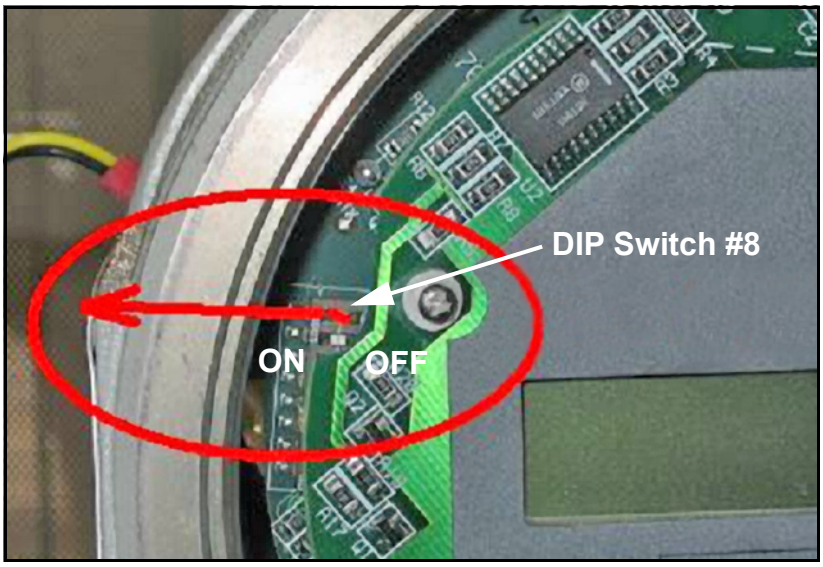


Figure 25: Moving DIP Switch #8 to ON

3.12.2 Using PanaView to Clear the Totalizers

Please be aware of the following:

- Only the PanaView *Meter Browser* window can be used to reset the totalizers (see *Figure 67 on page lxxxvii*).
- Each channel has its own totalizer:
  - Channel 1 (Path 1)
  - Channel 2 (Path 2)
  - Average (average of Paths 1 & 2)
- Totalizers are reset under the metric objects:
  - +ActMetTot
  - –ActMetTot
  - +NrmMetTot
  - –NrmMetTot
- Resetting the metric totalizers will reset the English totalizers automatically.

3.12.2 Using PanaView to Clear the Totalizers (cont.)

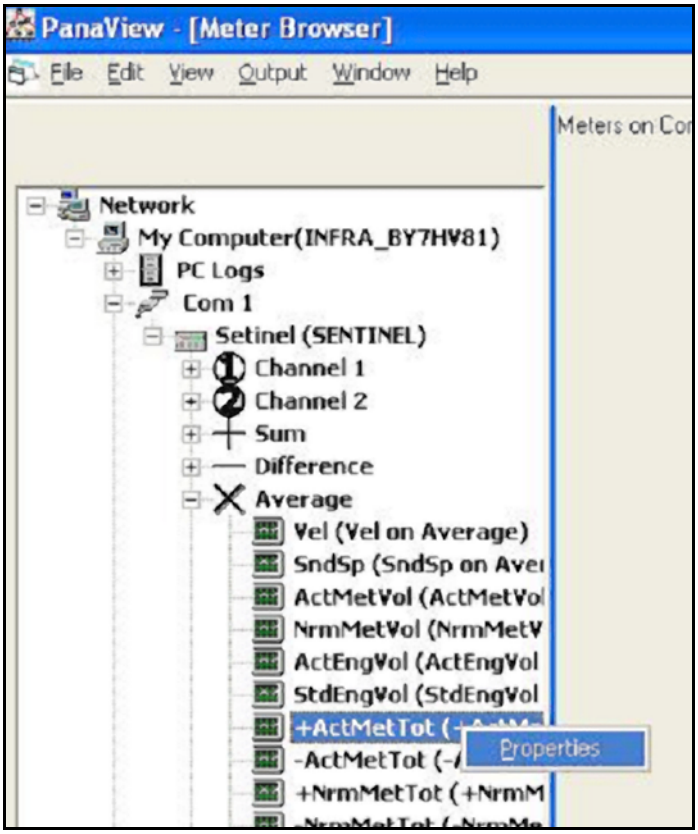


Figure 26: The Meter Browser Window

Proceed to the next page to continue.

3.12.2 Using PanaView to Clear the Totalizers (cont.)

1. Click on a totalizer to reset it (+ActMetTot in this example).
2. Right click to bring up Properties.
3. Click on Properties. The current total will be displayed (see *Figure 68* below).
4. Click the Reset button. The counter will be reset to 0.
5. Click OK.
6. Repeat the procedure for each totalizer in Channel 1, Channel 2, and Average to reset **all** totalizers.

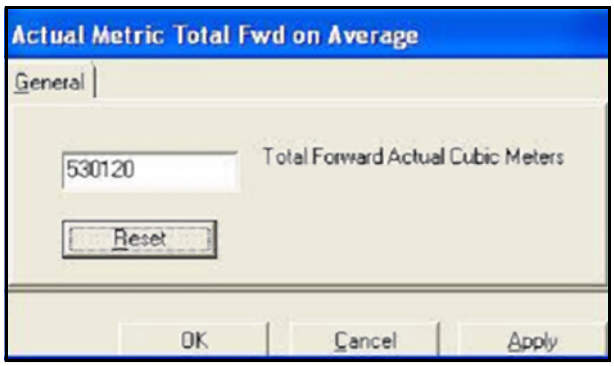


Figure 27: Actual Metric Total Fwd on Average

3.12.3 Returning to Operation

1. Verify that all totalizers have been cleared.
2. Power down the electronics.
3. Move the #8 DIP switch to the OFF (right) position.
4. Power up the electronics and verify the operations, including the display board.
5. Reapply a new lead and wire seal, if such security is needed, and reinstall the front cover.

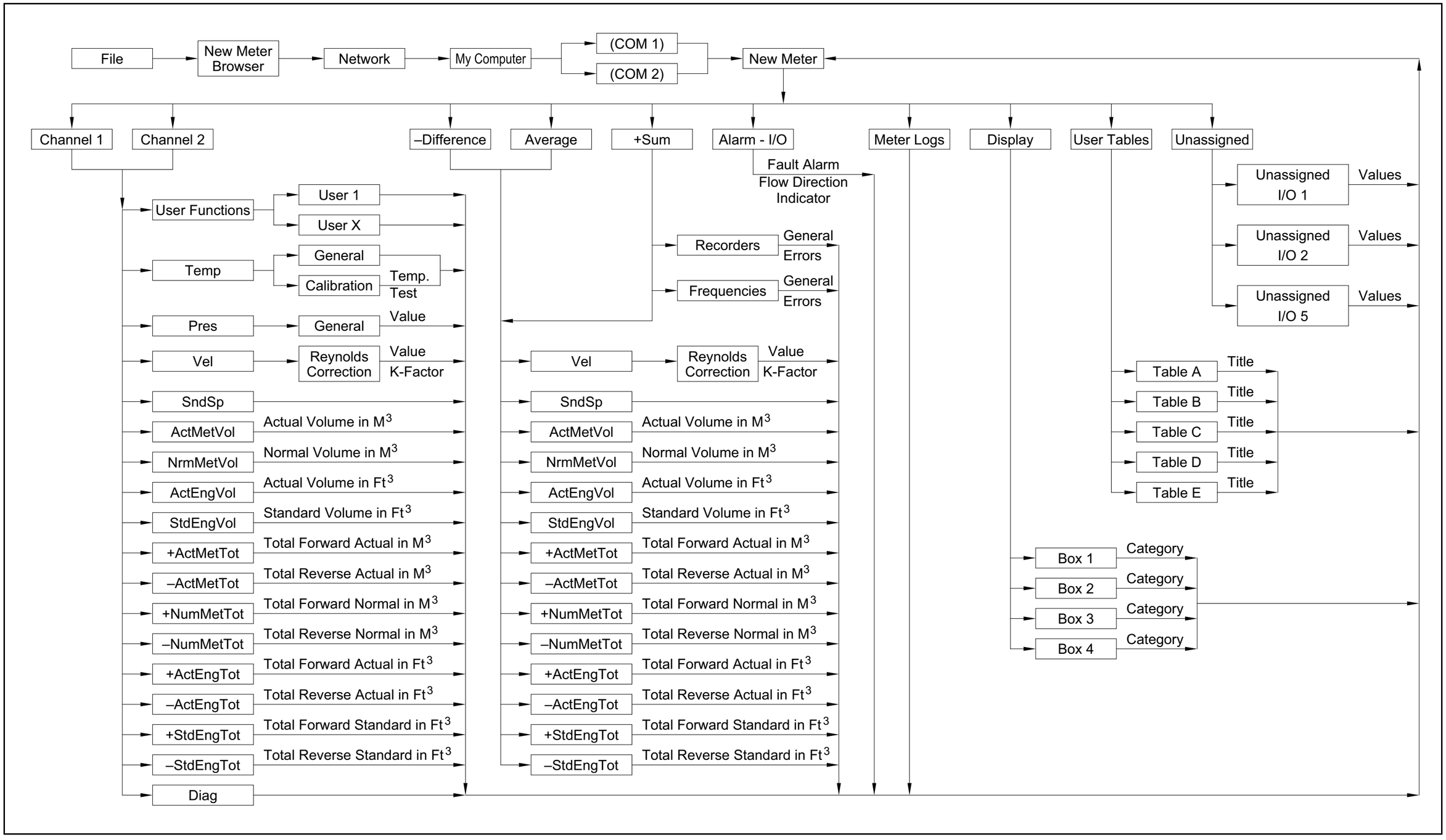


Figure 1: PanaView Meter Browser Menu Map

[no content intended for this page]

Chapter 4. Error Codes

4.1 Introduction

The ultrasonic flow transmitters are reliable, easy to maintain instruments. When the Sentinel Flow Measurement System is properly installed and operated, as described in the first three chapters of this manual, the meters provide accurate flow rate measurements with minimal user intervention. However, if a problem should arise with the electronics enclosures, the transducers or the flowcell, a built-in error code message system greatly simplifies the troubleshooting process.

Note: *For information on setting up the Sentinel to diagnose errors, see* "Errors" on page lviii.

All of the possible error code messages are discussed in this chapter, along with the possible causes and the recommended actions. When an error code is generated, it appears in the LCD display screen as shown in *Figure 70* below.

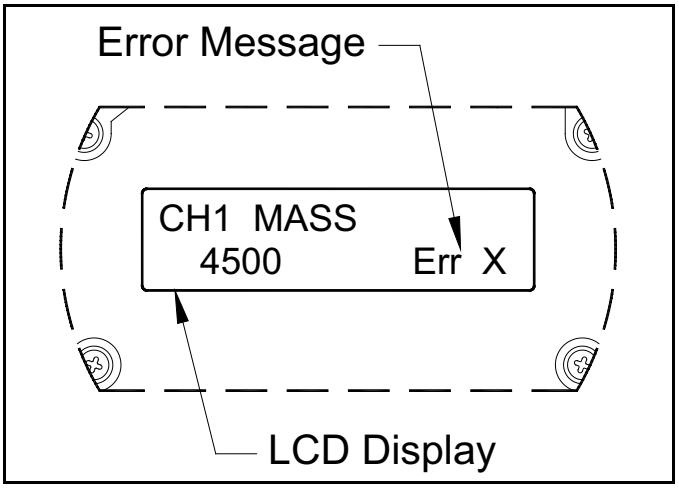


Figure 1: Error Message Location

4.2 Error Descriptions and Actions

If an error message appears on the meter display screen during operation of the Sentinel, refer to the following list of error descriptions for instructions on how to proceed.

4.2.1 Err 0: No Error

Problem: No error condition currently exists.

Cause: This message appears briefly to confirm that the response to another error message has corrected the problem.

Action: No action is required.

4.2.2 Err 1: Low Signal

Problem: Poor ultrasonic signal strength or the signal exceeds the limits entered in the New Meter Browser setup (see Chapter 2, *Initial Setup*).

Cause: Poor signal strength may be caused by a defective cable, a flowcell problem, a defective transducer or a problem in the electronics console. A signal that exceeds the programmed limits is probably caused by the entry of an improper value in the **New Meter Browser** information setup (see Chapter 2, *Initial Setup*).

Action: Using the procedures in Chapter 5, *Diagnostics*, check the components listed above. Also, check the value entered into the New Meter Browser information setup (see Chapter 2, *Initial Setup*).

4.2.3 Err 2: Soundspeed Error

Problem: The soundspeed exceeds the limits programmed in the New Meter Browser information setup (see Chapter 2, *Initial Setup*).

Cause: The error may be caused by incorrect programming, poor flow conditions or poor transducer orientation.

Action: Compare the measured soundspeed to tabulated nominal values for the fluid being used and correct any programming errors. Refer to Chapter 5, *Diagnostics*, to correct any flowcell and/or transducer problems.

4.2.4 Err 3: Velocity Range

Problem: The velocity exceeds the limits programmed in the New Meter Browser information setup (see Chapter 2, *Initial Setup*).

Cause: This error may be caused by the entry of improper programming data or by poor flow conditions and/or excessive turbulence.

Action: Make sure the actual flow rate is within the programmed limits. See Chapter 2, *Initial Setup* for details. Refer to Chapter 5, *Diagnostics*, to correct any flowcell and/or transducer problems.

4.2.5 Err 4: Signal Quality

Problem: The signal quality is outside the limits programmed in the New Meter Browser information setup (see Chapter 2, *Initial Setup*).

Cause: The peak of the upstream or downstream correlation signals has fallen below the correlation peak limit, as set in the New Meter Browser information setup. This may be caused by a flowcell or electrical problem.

Action: Check for sources of electrical interference and verify the integrity of the electronics console by temporarily substituting a test flowcell that is known to be good. Check the transducers and relocate them, if necessary. See Chapter 5, *Diagnostics*, for instructions.

4.2.6 Err 5: Amplitude Error

Problem: The signal amplitude exceeds the limits programmed in the New Meter Browser information setup (see Chapter 2, *Initial Setup*).

Cause: Solid or liquid particulates may be present in the flowcell. Poor coupling for clamp-on transducers.

Action: Refer to Chapter 5, *Diagnostics*, to correct any flowcell problems.

4.2.7 Err 6: Cycle Skip, Accel.

Problem: The acceleration exceeds the limits programmed in the New Meter Browser information setup (see Chapter 2, *Initial Setup*).

Cause: This condition is usually caused by poor flow conditions or improper transducer alignment.

Action: Refer to Chapter 5, *Diagnostics*, to correct any flowcell and/or transducer problems.

4.2.8 Err 7: DSP Signal Error

4.2.9 Err 8: Temp Input Error

Problem: This message indicates a temperature input error.

Cause: The temperature exceeds the specified limits for the analog/RTD inputs option card or no input device is connected.

Action: Check the temperature transmitter and the connecting cable. Refer to *Diagnostics* in Chapter 2, *Initial Setup*, and recalibrate the analog/RTD inputs option card.

4.2.10 Err 9: Press In Error

Problem: This message indicates a pressure input error.

Cause: The pressure exceeds the specified limits for the analog input card, or no input device is connected.

Action: Check the pressure transmitter and the connecting cable. Refer to *"Entering Temperature and Pressure Constants" on page lxxvii* and calibrate the analog input card.

4.2.11 Err 10: Totalizer Overflow

Problem: The totalizers are unable to keep up with the total accumulated flow signals.

Cause: The programmed units/pulse value is too small.

Action: Select a larger number of units/pulse value.

Chapter 5. Diagnostics

5.1 Introduction

This chapter explains how to troubleshoot the Sentinel Flow Measurement System if problems arise with the electronics enclosure, the flowcell, or the transducers. Indications of a possible problem include:

- Display of an error message on the meter LCD display screen
- Erratic flow readings
- Readings of doubtful accuracy, such as readings that are not consistent with readings from another flow measuring device connected to the same process.

If any of the above conditions occur, proceed with the instructions presented in this chapter.

5.2 Displaying Diagnostic Parameters

The PanaView Instrument Interface software has built-in *Diagnostic Parameters* to aid in the troubleshooting of flowcell, transducer and/or electrical problems. To access these parameters, refer to *Figure 71* below and *Table 9 on page 70* and complete the following steps:

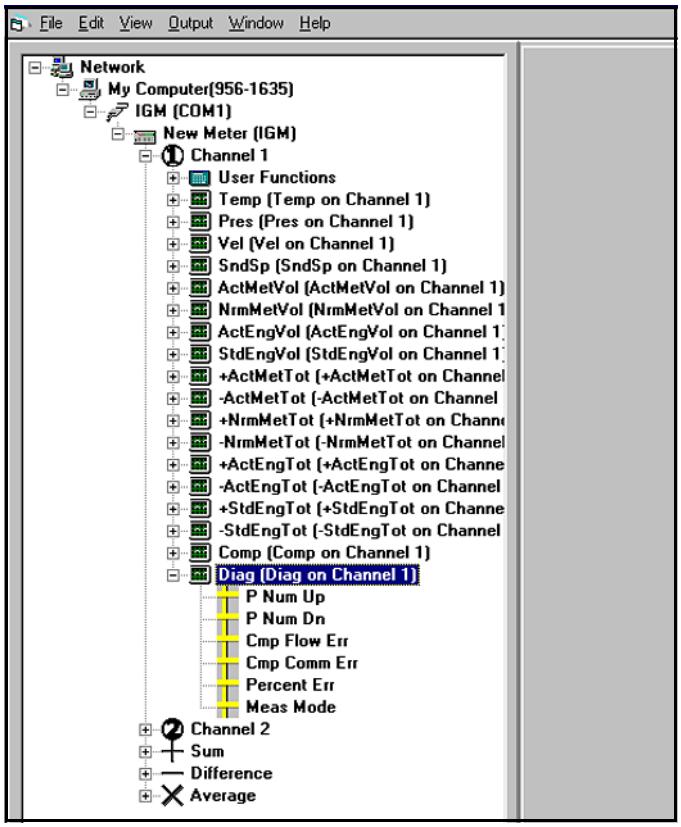


Figure 1: PanaView Meter Browser Output Menu

5.2 Displaying Diagnostic Parameters (cont.)

1. Make sure the system is connected to your computer, the system and the computer are turned ON, and *PanaView* is up and running.
2. In the File menu, open a New Meter Browser.
3. In the Output menu, select either Graphing/New or Text Display.
4. Click on the + sign before each level to 3expand it.
5. Select the desired channel, and click on the + sign before the Diag (Diag on Channel X) option.
6. Double click on one or more of the six parameters and, depending on the number of parameters chosen and the format selected in Step 3, a display similar to that shown in *Figure 72* below or *Figure 73 on page xcvii* will appear.

Note: *The* Graphing/New *selection will allow only one or two parameters per display (see* Figure 73 on page xcvii*).*

7. After the parameters have been observed and recorded, exit the display and repeat the procedure for any other information.

Note: *Upon exiting a display in graphical format, a prompt reading* "Save chart data to log file?" *appears. Respond as desired and exit the display.*

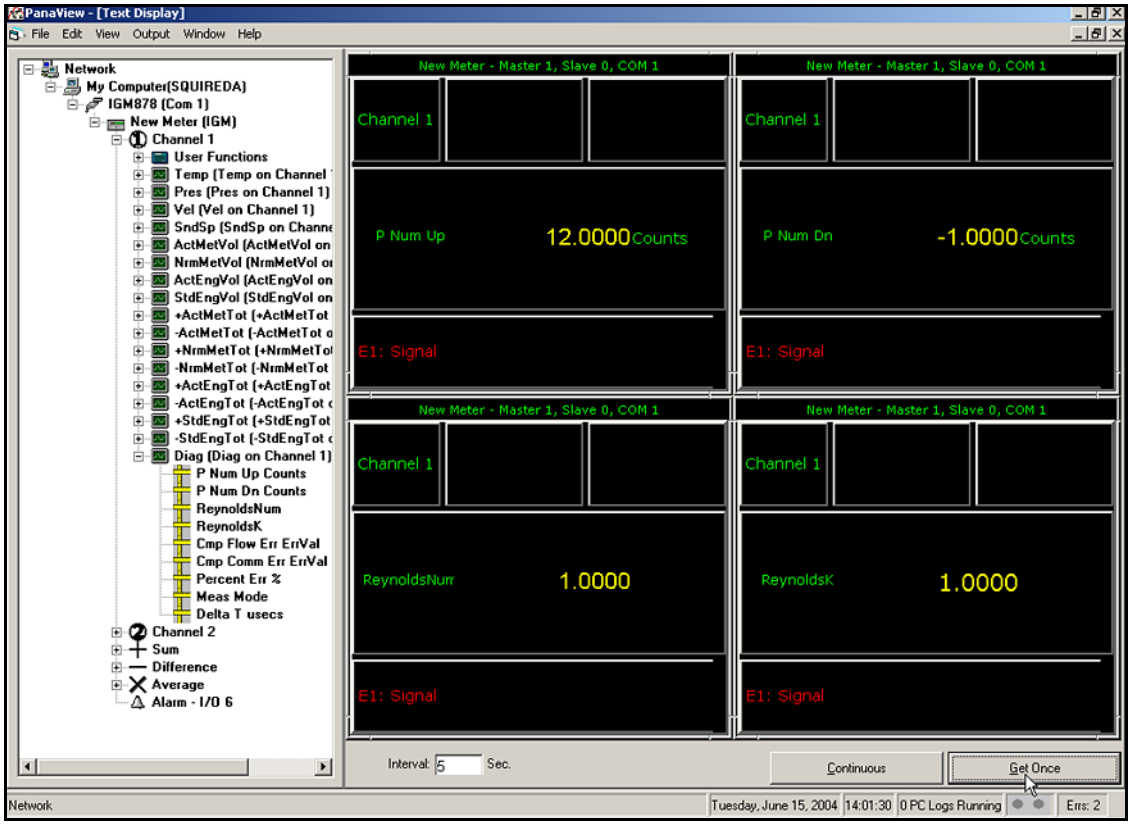


Figure 2: Diagnostic Display in Text Format

5.3 Diagnostic Record

The values for the diagnostic parameters, immediately after initial installation of the meter and verification of proper operation, should be entered in *Figure 20 on page 123*. These values can then be compared to future values to help diagnose any future malfunction of the system.

Note: *For further details on collecting and displaying data, see Chapter 6, Data Handling the PanaView Graphical User Interface manual (910-211).*

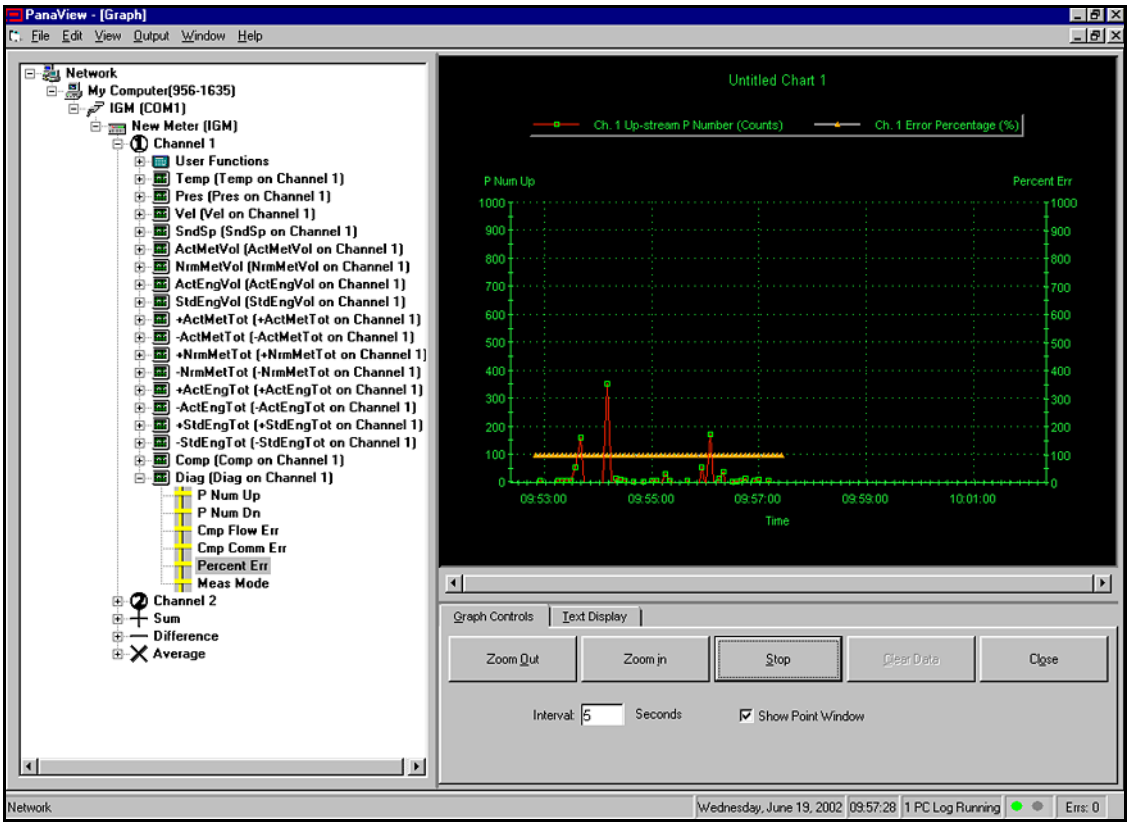


Figure 3: Diagnostic Display in Graphical Format

5.4 Flowcell Problems

If preliminary troubleshooting using the *Error Codes* in Chapter 4 and *"Displaying Diagnostic Parameters" on page xcv* indicates a possible flowcell problem, proceed with this section.

Flowcell problems fall into two general categories:

- Gas problems
- Pipe problems.

Read the following sections carefully to determine if the problem is indeed related to the flowcell. If the instructions in this section fail to resolve the problem, contact Panametrics for assistance.

5.4.1 Gas Problems

Most gas-related problems result from a failure to observe the *Sentinel Flow Measurement System* installation instructions. Refer to Chapter 1, *Installation*, to correct any installation problems.

If the physical installation of the system meets the recommended specifications, it is possible that the gas itself may be preventing accurate flow rate measurements. The gas being measured must meet the following requirements:

- ***The gas must be homogeneous, single-phase and relatively clean.***
  Although a low level of entrained particles may have little effect on the operation of the *Sentinel* system, excessive amounts of solid (smoke) or liquid (steam) particles will absorb or disperse the ultrasound signals. This interference with the ultrasound transmissions through the gas will cause inaccurate flow rate measurements. In addition, temperature gradients in the gas flow may result in erratic or inaccurate flow rate readings.
- ***The gas must not excessively attenuate ultrasound signals.***
  Some gases (e.g., high-purity carbon dioxide, hydrogen, nitrogen, etc.) readily absorb ultrasound energy. In such cases, an **E1** error code message will appear on the meter display screen to indicate that the ultrasonic signal strength is insufficient for reliable measurements.
- **The gas soundspeed must not vary excessively.**
  The Sentinel system will tolerate relatively large changes in the gas soundspeed, as may be caused by variations in gas composition or temperature. However, such changes must occur slowly. Rapid fluctuations in the gas soundspeed, to a value that is considerably different from that programmed into the *Sentinel*, will result in erratic or inaccurate flow rate readings. Refer to *"Displaying Measurements" on page lxxix*, and make sure that the appropriate soundspeed appears in the soundspeed display.

5.4.2 Pipe Problems

Pipe-related problems may result either from a failure to observe the installation instructions, as described in Chapter 1, *Installation*, or from improper programming of the flowmeter. By far, the most common pipe problems are the following:

- ***The collection of material at the transducer locations.***
  Accumulated debris at the transducer locations will interfere with transmission of the ultrasound signals. As a result, accurate flow rate measurements are not possible. Refer to Chapter 1, *Installation*, for more details on proper transducer installation.
- ***Inaccurate pipe measurements.***
  The accuracy of the flow rate measurements is no better than the accuracy of the programmed pipe dimensions. For the Sentinel system, the flowcell dimensions are programmed at the factory prior to shipment and the correct data is included in the documentation. Check the adjacent pipe for dents, eccentricity, weld deformity, straightness and other factors that may cause inaccurate readings.

5.5 Transducer Problems

Ultrasonic transducers are rugged, reliable devices. However, they are subject to physical damage from mishandling and chemical attack. The most common transducer problems are listed below:

- **Leaks:**
  Leaks may occur around the transducer and/or the flowcell fittings. Repair such leaks immediately. If the leaking gas is corrosive, carefully check the transducer and cables for damage, after the leak has been repaired.
- ***Corrosion Damage:***
  If the transducer material was not properly chosen for the intended application, the transducers may suffer corrosion damage. The damage usually occurs either at the electrical connector or on the transducer surface. Any transducer damaged in this manner must be replaced. Contact Panametrics for information on transducers in materials suitable for the application.
- ***Internal Damage:***
  An ultrasonic transducer consists of a ceramic crystal bonded to the transducer case. The bond between the crystal and the case or the crystal itself may be damaged by extreme mechanical shock and/or temperature extremes. Also, the internal wiring can be corroded or shorted if contaminants enter the transducer housing.
- ***Physical Damage:***
  Transducers may be physically damaged by dropping them onto a hard surface or striking them against another object. The transducer connector is the most fragile part and is the one most subject to damage. Minor damage may be repaired by carefully bending the connector back into shape. If the connector cannot be repaired, the transducer must be replaced.

Note: *Transducers must be replaced in pairs. Refer to Chapter 6,* Transducer Replacement*, and Chapter 2,* Initial Setup*, to program the replacement transducer data into the meter.*

If the instructions in this section fail to resolve the problem, contact Panametrics for assistance.

[no content intended for this page]

Chapter 6. Transducer Replacement

6.1 Introduction

WARNING! **Prior to performing any maintenance procedures, be sure to disconnect the main power from the unit.**

WARNING! **If the *Sentinel* is installed in a hazardous environment, the electronics enclosure must be moved to a safe area prior to removing the covers.**

Note: *For compliance with the EU Low Voltage Directive, this unit requires an external power disconnect device such as a switch or circuit breaker. The disconnect device must be marked as such, clearly visible, directly accessible, and located within 1.8 m (6 ft) of the meter.*

IMPORTANT: Keep a detailed record of all service performed on the Sentinel in Appendix B, Service Record. This service history may prove very helpful in diagnosing any future problems.

WARNING! **Installation and removal of transducers should be performed only if the area is known to be non-hazardous.**

6.2 T11 Transducer Construction

Each T11 transducer assembly (see *Figure 74* below) consists of the following components:

- A metallic body
- A flange that is an integral part of the body
- A transducer head
- A BNC style connector for use in connecting the transducer to the flowmeter
- An integral 1/2" NPT male thread on the BNC connector end for mounting the junction box.

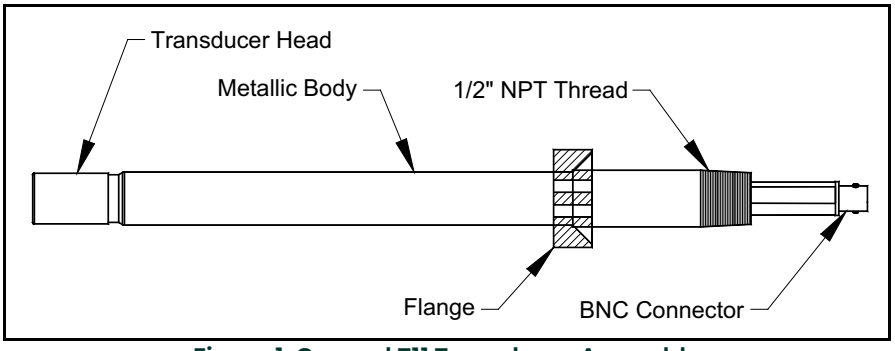


Figure 1: General T11 Transducer Assembly

6.3 Replacing T11 Transducers in a Depressurized Pipe

If T11 transducer replacement is required and the pipeline is shut down and depressurized or if the meter is removed, follow the procedure in this section.

Note: *To replace T11 transducers in a pressurized pipe, see* "Replacing T11 Transducers in a Pressurized Pipe" on page cvi.

WARNING! **Follow all applicable safety codes while performing the following procedure.**

WARNING! **Make sure the power is disconnected before performing the following steps.**

WARNING! **Make sure the process line is shut down before removing transducers according to this procedure. Serious injury or death may occur if the transducers are removed from a live process line.**

The following equipment is required to complete the removal and re-installation of T11 transducers in a depressurized pipe line:

- Torque wrench
- Spray lubricant
- Anti-seize lubricant

6.3.1 Removing the Old Transducer from a Depressurized Pipe

To remove the old transducer, complete the following steps:

1. Remove the cover from the T11 conduit box, disconnect the BNC connector from the transducer, and remove the conduit box.
2. Remove the four bolts from the transducer sensor flange with a 9/16" socket wrench.

IMPORTANT: Inspect the bolts to verify that they are not damaged. If one or more bolts need to be replaced, use only approved 3/8-16 UNC x 1.5" SAE class 8 bolts.

3. Remove the sensor flange from the transducer.
4. Remove the transducer from the holder.

6.3.2 T11 Transducer Installation Components

See *Table 1* below and *Figure 75* below for the components required to install the new transducer.

Table 1: Components at each Transducer Location

No.*	Part Number	Description	Qty.
1	577-004-00	Sensor Holder	1
2	551-1135	Sensor Flange	1
3	410-538	O-Ring, Size 210, Viton	2
4	410-539	O-Ring, Size 213, Viton	1
5	412-1032-24	Screw, Cap Hex 3/8-16 x 1-1/2	4
6	412-148	Washer, Lock Split 3/8"	4
7		O-Ring-Safe Lubricant	A/R
8		Anti-Seize Lubricant	A/R
*Component numbers correspond to item numbers in *Figure 75* below.			

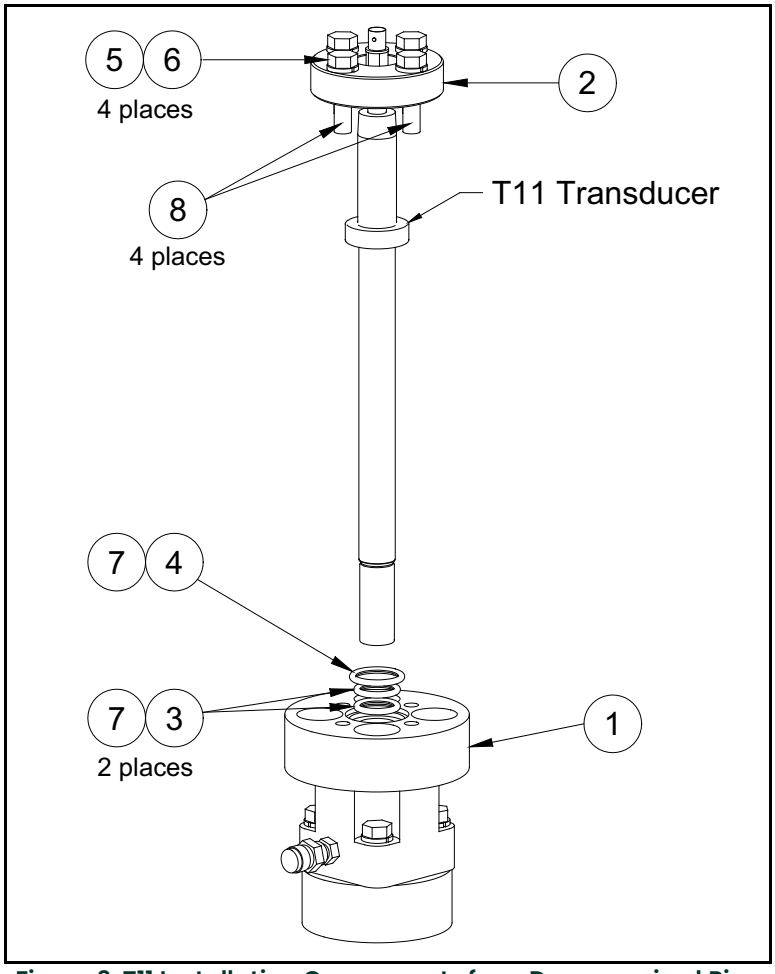


Figure 2: T11 Installation Components for a Depressurized Pipe

6.3.3 Installing a New Transducer in a Depressurized Pipe

IMPORTANT: The following procedures should be used only in situations where the process line is shut down.

IMPORTANT: Do not reuse the old o-rings. Replace them with new o-rings, as specified in Table 1 on page ciii.

Use the components described in the previous section, to install the new transducers as follows:

1. Lubricate and install three new o-rings in the T11 holder (see *Figure 76* below and *Table 1 on page ciii*).

Note: *The item numbers shown in Figure 76* below correspond to those listed in *Table 1 on page ciii.*

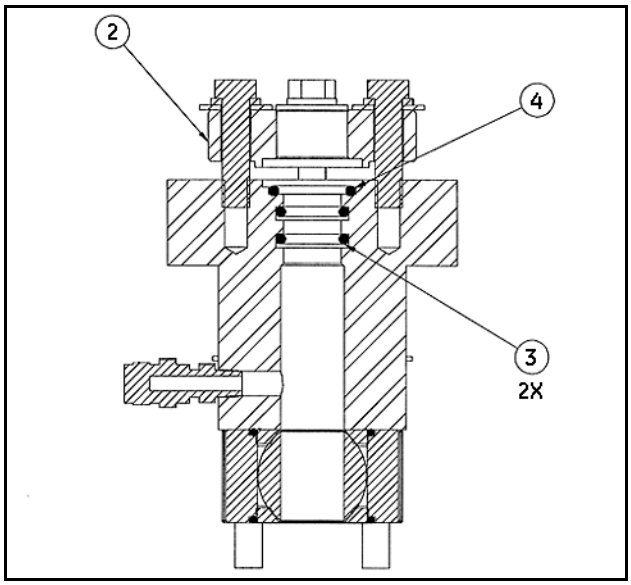


Figure 3: Holder Cross-Section - O-Ring Placement

2. Inspect the sealing surfaces of the transducer mount and the T11 transducer that is to be inserted into the meter body to insure there is no damage to either surface.
3. Lubricate the shaft of the transducer with a spray lubricant that is safe for the o-rings.
4. Carefully push the transducer into the holder until the flange contacts the face o-ring seal, being careful not to disturb the o-rings.

6.3.3 Installing a New Transducer in a Depressurized Pipe (cont.)

5. Mount the sensor flange over the top of the transducer, shoulder side down, and hand tighten the four upper bolts.
6. Using a torque wrench, tighten the four upper bolts to 15 ft-lb in the order shown in *Figure 77* below. Then, tighten the four bolts to 30 ft-lb in the same order shown in *Figure 77* below.
7. Thread the flameproof junction box onto the end of the transducer with the BNC connector. Ensure that at least five full threads are engaged.
8. Connect the cable from the meter to the transducer within the junction box and install the junction box cover.

SHOCK HAZARD! Do not contact the transducer center conductor.

9. Repeat the above steps for any additional T11 transducers that are required to complete the installation.

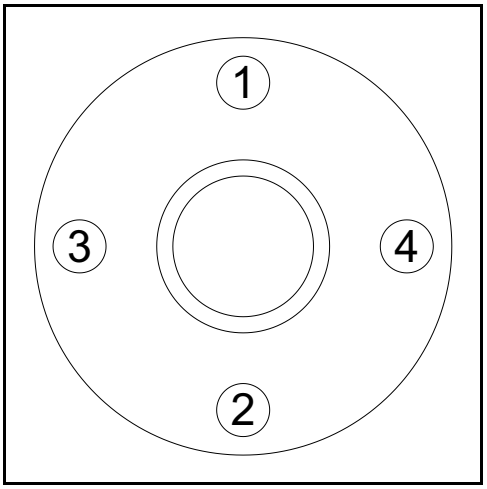


Figure 4: Holder Top View - Bolt Tightening Order

6.4 Replacing T11 Transducers in a Pressurized Pipe

If T11 transducer replacement is required and the pipeline cannot be depressurized, follow the procedure in this section.

IMPORTANT: The following procedure is used only in situations where the process line cannot be shut down.

Note: *To replace T11 transducers in a depressurized pipe, see* "Replacing T11 Transducers in a Depressurized Pipe" on page ci.

WARNING! Follow all applicable safety codes while performing the following procedure.

WARNING! Make sure the power is disconnected before performing the following steps.

WARNING! During the installation and removal of a transducer, the indicated danger zone areas are potential pinch points (see *Figure 83 on page cix*). Attention is required to ensure safe use.

WARNING! Because of the serious nature of replacing transducers in a pressurized pipe, it is recommended that the following procedures be handled by an experienced field service individual.

The following equipment is required to complete the removal and re-installation of T11 transducers in a pressurized pipe line:

- Torque wrench, with 9/16" and 5/8" sockets
- Spray lubricant
- Anti-seize lubricant
- Sentinel T11 insertion mechanism kit

IMPORTANT: Removal and re-installation must be done as a single process. Do not leave the pipeline with no transducers installed for an extended period of time.

6.4.1 Removing the Old Transducer from a Pressurized Pipe

To remove an existing transducer from a pressurized pipe, complete the following steps:

1. Remove the cover from the T11 transducer conduit box, disconnect the BNC connector from the transducer, and remove the conduit box.
2. Apply anti-seize lubricant to the transducer thread and hand-tighten the transducer pusher onto the transducer until it is firmly in place (see *Figure 78* below).

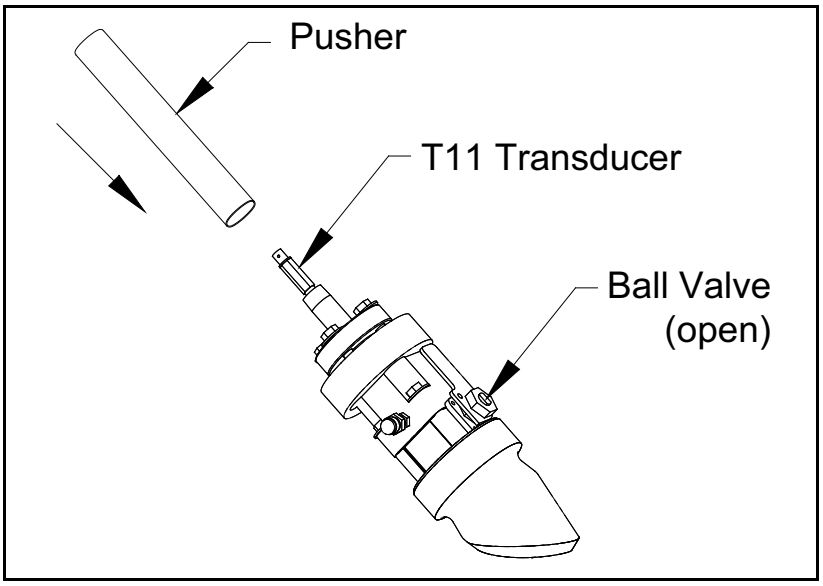


Figure 5: Transducer Pusher Installation

3. Apply anti-seize lubricant to the insertion mechanism threads (see *Figure 79* below).

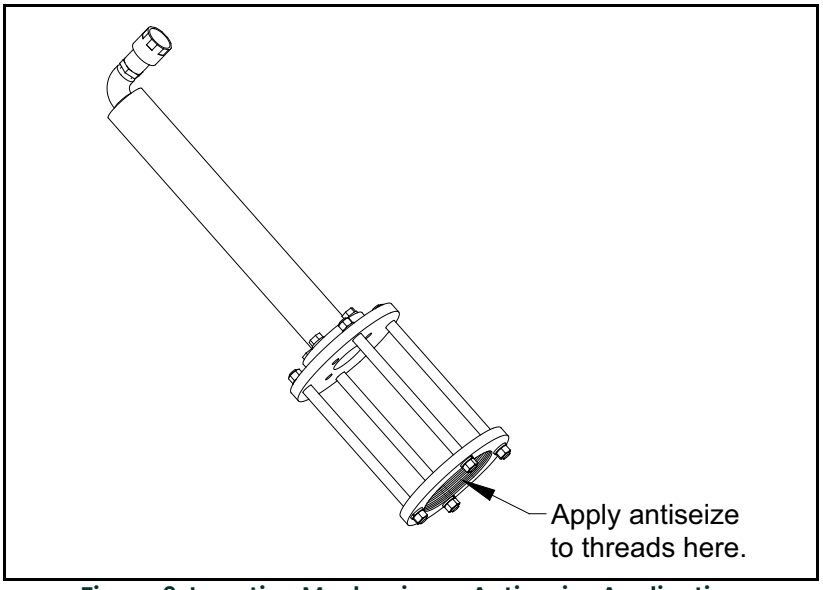


Figure 6: Insertion Mechanism - Anti-seize Application

6.4.1 Removing the Old Transducer from a Pressurized Pipe (cont.)

4. Thread the insertion mechanism onto the meter body holder, then connect a hydraulic pump to the insertion mechanism (see *Figure 80* and *Figure 81* below).

Figure 7: Installing the Insertion Mechanism

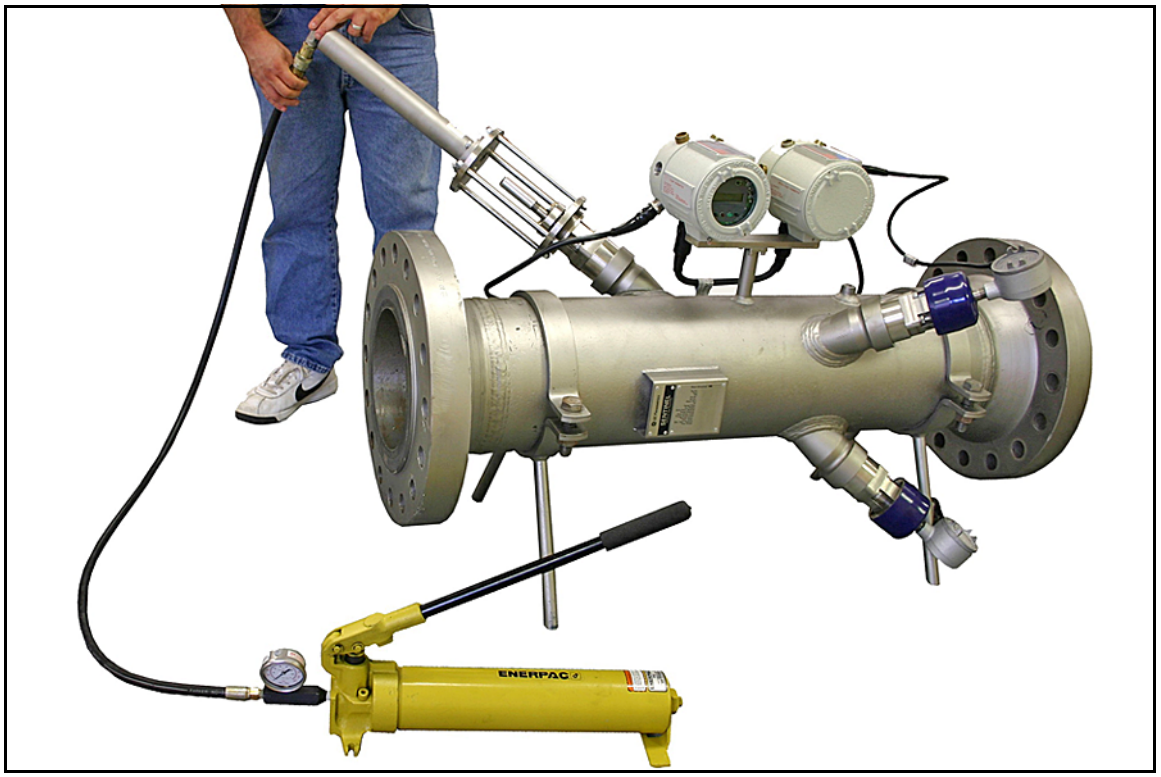


Figure 8: Connecting the Hydraulic Pump

6.4.1 Removing the Old Transducer from a Pressurized Pipe (cont.)

5. Pressurize the hydraulic pump to 1500 psi (see *Figure 82* below).

Figure 9: Pressurizing the Hydraulic Pump

6. Remove the four bolts from the transducer flange with a 9/16" socket wrench (see *Figure 83* below).

IMPORTANT: Inspect the bolts to verify that they are not damaged. If one or more bolts need to be replaced, use only approved 3/8-16 UNC x 1.5" SAE class 8 bolts.

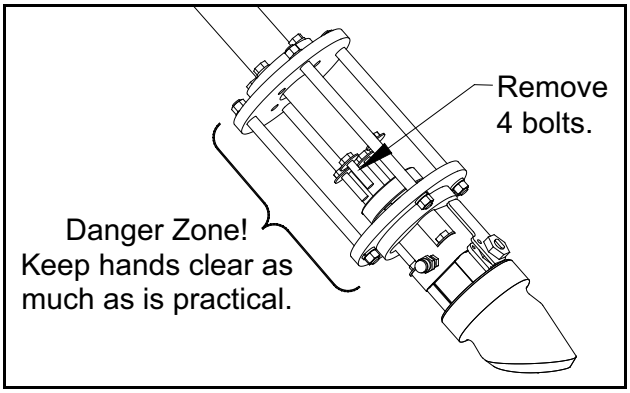


Figure 10: Transducer Flange Bolt Removal

WARNING! **During the installation and removal of a transducer, the indicated danger zone areas are potential pinch points (see *Figure 83* above). Attention is required to ensure safe use.**

6.4.1 Removing the Old Transducer from a Pressurized Pipe (cont.)

7. Using the hydraulic pump valve, slowly release pressure from the hydraulic ram until the transducer has retracted to the positive stop in the mechanism (see *Figure 84* below).

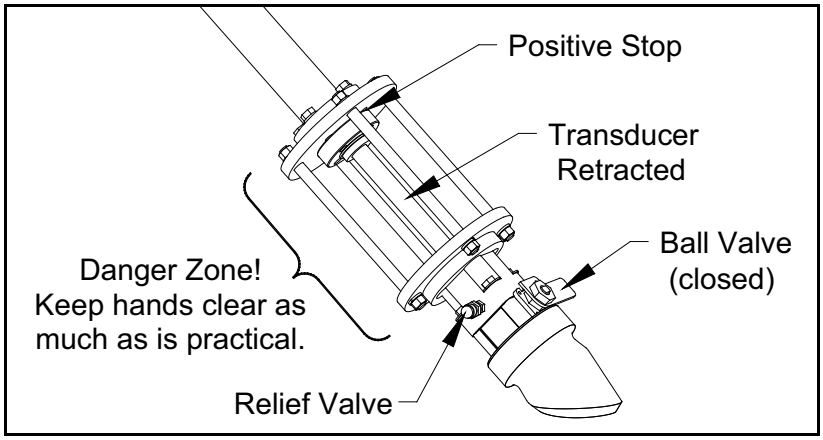


Figure 11: Transducer Retracted

8. Close the ball valve and secure it in the closed position. Lock the ball valve in place using an appropriate **LOTO** (lock-out, tag-out) device and tags.
9. Open the pressure relief valve to release the pressure of any gas trapped in the holder, then close the pressure relief valve and torque it to 15 ft-lb.
10. Disconnect the hydraulic pump and remove the insertion mechanism.
11. Remove the T11 transducer assembly from the pipe and then remove the pusher and the 4-bolt sensor flange from the transducer.

The T11 transducer removal procedure is now complete.

6.4.2 T11 Transducer Installation Components

See *Table 2* below and *Figure 85* below for the components required to install the new transducer.

Table 2: Components at each Transducer Location

No.*	Part Number	Description	Qty.
1	577-004-00	Sensor Holder	1
2	551-1135	Sensor Flange	1
3	410-538	O-Ring, size 210 Viton	2
4	410-539	O-Ring, size 213 Viton	1
5	412-1032-24	Screw, Cap Hex 3/8-16 x 1-1/2	4
6	412-148	Washer, Lock Split 3/8"	4
7		O-Ring-Safe Lubricant	A/R
8		Anti-Seize Lubricant	A/R
*Component numbers correspond to item numbers in *Figure 85* below.			

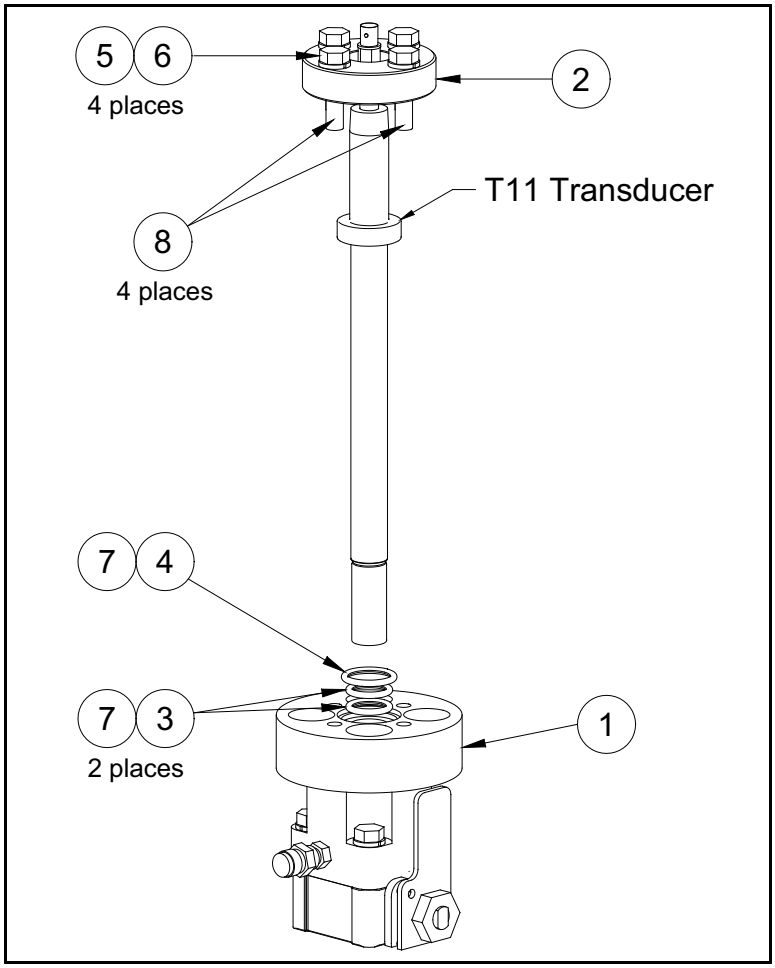


Figure 12: T11 Installation Components for a Pressurized Pipe

6.4.3 Installing a New Transducer in a Pressurized Pipe

IMPORTANT: The following procedures should be used only in situations where the process line is not shut down.

IMPORTANT: Do not reuse the old o-rings. Replace them with new o-rings, as specified in Table 2 on page cxi.

Use the components described in the previous section, to install the new transducers as follows:

1. Lubricate and install three new o-rings in the T11 holder (see *Figure 86* below and *Table 2 on page cxi*).

Note: *The item numbers shown in Figure 76* below correspond to those listed in *Table 2 on page cxi.*

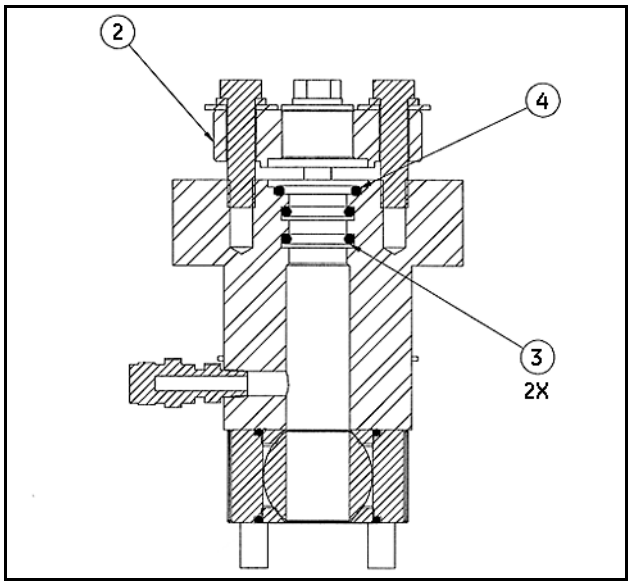


Figure 13: Holder Cross-Section - O-Ring Placement

2. Inspect the sealing surfaces of the sensor holder and the T11 transducer that is to be inserted into the meter body to verify that there is no damage to either surface.
3. Apply anti-seize lubricant to the new T11 transducer NPT threads, then assemble a T11 pusher onto the new transducer (see *Figure 87 on page cxiii*).
4. Lubricate the shaft of the transducer with spray lubricant that is safe fir the o-rings. Then, insert the transducer into the meter body holder, while carefully pressing the transducer head past the radial o-rings (see *Figure 86* above and *Figure 87 on page cxiii*).
5. While keeping the pump valve open, thread the insertion mechanism onto the holder and connect the hydraulic pump (see Figure 80 on page cviii).
6. Slide the T11 transducer back to the positive stop of the insertion mechanism (see *Figure 84 on page cx*). Verify that the pressure relief valve is closed and torqued to 15 ft-lb.

6.4.3 Installing a New Transducer in a Pressurized Pipe (cont.)

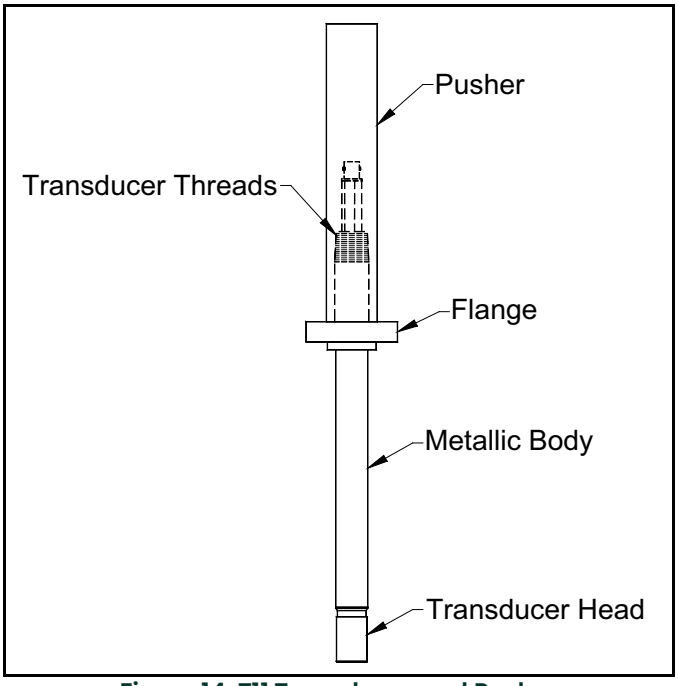


Figure 14: T11 Transducer and Pusher

7. While standing clear of the transducer, open the ball valve on the meter body holder.
8. Close the hydraulic pump valve. Pump the hydraulic ram up to 1500 psi to push the transducer into the meter body and hold it in place.
9. Align the flange holes of sensor flange with the tapped holes in the holder. Apply anti-seize lubricant to the flange bolts, install 3/8" lock washers and loosely bolt the flange to the holder. Using a torque wrench, tighten the four bolts to 15 ft-lb in the order shown in *Figure 77 on page cv*. Then, tighten the four bolts to 30 ft-lb in the same order shown in *Figure 77 on page cv*.
10. Release pressure from the hydraulic ram, remove the insertion mechanism, and remove the transducer pusher.
11. Thread the flameproof junction box onto the end of the transducer with the BNC connector. Ensure that at least five full threads are engaged.
12. Connect the cable from the meter to the transducer within the junction box and install the junction box cover.

SHOCK HAZARD! Do not contact the transducer center conductor.

13. Repeat the above steps for any additional T11 transducers that are required to complete the installation.

[no content intended for this page]

Chapter 7. Specifications

7.1 System Specifications

7.1.1 Operating Gas

Relative Density

Minimum: 0.554
Maximum: 0.87

Carbon Dioxide Level

Maximum: 10%

Pressure

Minimum: 115 psig (8 Bar)
Maximum: 1480 psig (100 Bar)

Temperature

Minimum: –22°F (–30°C)
Maximum: +140°F (+60°)C

7.1.2 Ambient Temperature

Operating

Minimum: –40°F (–40°C)
Maximum: +140°F (+60°C)

Non-Operating

Minimum: –40°F (–40°C)
Maximum: +140°F (+60°C)

7.1.3 Meter Nominal Accuracy

System Setup

Upstream - 5 diameters of straight pipe
Downstream - 5 diameters of straight pipe

Maximum Error (without flow calibration)

±0.5% between 0.1 Qmax and Qmax
±1.0% between Qmin and 0.1 Qmax

7.1.3 Meter Nominal Accuracy (cont.)

Repeatability

±0.2% between 0.1 Qmax and Qmax
±0.4% between Qmin and 0.1 Qmax

Resolution

0.003 ft/s (0.001 m/s)

Velocity Sampling Interval

0.2 sec

Maximum Peak-to-Peak Error

0.4% between 0.1Qmax and Qmax

Zero-Flow Reading

< 0.007 ft/s (2.13 mm/s) for each acoustic path
< 0.01 ft/s (3.05 mm/s) composite for all paths

Error due to upstream disturbances

±0.3% in addition to nominal error

Note: *Accuracy can be improved with High Pressure NG flow calibration*

7.1.4 Flow Velocity Range

For pipe size 4" to 10" (15 cm to 25 cm)

Maximum actual measurable velocity: ±118 ft/s (±36 m/s)
Minimum actual measurable velocity: ±2.4 ft/s (±0.72 m/s)
Transitional flow velocity: 11.8 ft/s (3.6 m/s)

For pipe size 12" to 24" (30 cm to 61 cm)

Maximum actual measurable velocity: ±88.6 ft/s (±27 m/s)
Minimum actual measurable velocity: ±1.48 ft/s (±0.45 m/s)
Transitional flow velocity: 8.86 ft/s (2.7 m/s)

7.2 Electronics Specifications

Approvals

FM/CSA Class I, Div. 1, Groups B, C & D
II 2 G EEx d IIC T6 (Flameproof)
CE Mark Compliance
Compliance with AGA Report No. 9

Enclosure

Epoxy-Coated Aluminum (Standard, NEMA 7/4X)

Power

AC Voltage: 95 – 240VAC ±10%, 50 – 60Hz ±2%
DC Voltage: 24VDC ±20% (use only Class 2 rated power supplies)
Maximum Power Consumption: 20W

Display

2 Lines, 16 Character Backlit Display

Communications

Bidirectional RS485 or RS232 Link to PanaView Software
Two 0/4 to 20mA isolated outputs, 600Ω maximum load
One frequency (HF) output, optically isolated, from DC to 10 kHz maximum
One hermetically sealed Form C alarm relay that can be applied to indicate flow direction or fault
Two isolated 4 to 20mA inputs and 24V loop power for pressure and temperature
Optional two HF outputs and two alarm outputs or one HF output and 4 to 20mA inputs
One RS485 Modbus digital output correspond to the following map (see *Modbus Map* on page 7-4)

7.2 Electronics Specifications (cont.)

Modbus Map

The IGM878 Flow Transmitter, when equipped with the optional Modbus output card, can transmit flow data and diagnostic information to a flow computer or SCADA, serially, using a Gould-type RTU protocol. For security and audit-trail purposes, the unit must be programmed through the PanaView interface. This means that only the Modbus function command 3 (read multiple registers), is valid.

Communication parameters: 9600, n, 8, 1
The format for the data exchange is as follows:

- The ***send*** command (initiated by host flow computer or controller) is of the form:

  <time delimiter> <Addr> <3> <First Register MSB>
  <First Register LSB> <Register Count MSB>
  <Register Count LSB> <CRC Low> <CRC High> <time delimiter>

- The ***response*** (initiated by host flow computer or controller) is of the form:
  [time delimiter] <Addr> <3> <Byte count> < Data ..... >
  <CRC Low> <CRC High> <time delimiter>

The format for the returned data types is as follows:

Integer	Integer (I)	1 Register
Floating Point	Single Precision (FP)	2 Registers
Double Precision	Double Precision (DP)	4 Registers

Table 13 on page 109 is the data map for the IGM878 and Sentinel. The refresh rate indicates how often the central controller updates the memory map, available using the ModBus port. The most time-critical information is stored at the top of the register. This limits how deep the user has to go into the resister stack to gather the real-time information. All values are IEEE format MSB first (big-endian).

7.2 Electronics Specifications (cont.)

Modbus Map (cont.)

1	Actual Volumetric Flow	FP	0	am^3/hr	1s
3	Soundspeed	FP	0	m/s	1s
5	Measurement Status	I	0		1s
6	Area Average Velocity	FP	0	m/s	1s
8	Normal Volumetric Flow	FP	0	sm^3/hr	1s
10	Actual Volume Forward Total	DP	0	am^3	2s
14	Actual Volume Reverse Total	DP	0	am^3	2s
18	Normal Volume Forward Total	DP	0	sm^3	2s
22	Normal Volume Reverse Total	DP	0	sm^3	2s
26	Mass Flow	FP	0	kg/hr	2s*
28	Forward Mass Total	FP	0	kg	2s*
30	Reverse Mass Total	FP	0	kg	2s*
32	Energy Flow	FP	0	J/hr	5s*
34	Forward Energy Total	FP	0	J	5s*
36	Reverse Energy Total	FP	0	J	5s*
38	Pressure	FP	10^5	Pa	10s/Fixed
40	Temperature	FP	20	C	10s/Fixed
42	Super Compressibility Factor x 1000	I	1000		10s/Fixed
43	Density x 1000	I	1000	lb/ft^3	10s/Fixed
44	Kinematic Viscosity x 10^8	I	1000	m^2/s	10s/Fixed*
45	Heating Value	I	25000	kJ/m^3	10s/Fixed*
46	Path A Velocity	I	0	m/s x 1000	10s
47	Path A Sound Speed	I	0	m/s x 10	10s
48	Path A % Readings in Error	I	0		10s
49	Path A Last Error	I	0		10s*
50	Path B Velocity	I	0	m/s x 1000	10s
51	Path B Sound Speed	I	0	m/s x 10	10s
52	Path B % Readings in Error	I	0		10s
53	Path B Last Error	I	0		10s*
54	Path C Velocity	I	0	m/s x 1000	10s
55	Path C Sound Speed	I	0	m/s x 10	10s
56	Path C % Readings in Error	I	0		10s
57	Path C Last Error	I	0		10s*
58	Path D Velocity	I	0	m/s x 1000	10s
59	Path D Soundspeed	I	0	m/s x 10	10s
60	Path D % Readings in Error	I	0		10s

61	Path D Last Error	I	0		10s*
62	Path E Velocity	I	0	m/s x 1000	10s
63	Path E Sound Speed	I	0	m/s x 10	10s
64	Path E % Readings in Error	I	0		10s
65	Path E Last Error	I	0		10s*
66	Path F Velocity	I	0	m/s x 1000	10s
67	Path F Sound Speed	I	0	m/s x 10	10s
68	Path F % Readings in Error	I	0		10s
69	Path F Last Error	I	0		10s*
70	Internal Update Rate	I	10	Hz	On Init.
71	Sound Speed Low Limit	I	300	m/s	On Init.
72	Sound Speed High Limit	I	500	m/s	On Init.
73	Velocity High Limit	I	40	m/s	On Init.
74	Velocity Low Limit	I	–40	m/s	On Init.
75	Signal Strength High Limit	I	100	dB	On Init.
76	Signal Strength Low Limit	I	20	dB	On Init.
77	Amplitude High Limit	I	95		On Init.
78	Amplitude Low Limit	I	35		On Init.
79	Number in Average	I	32		On Init.
80	Software Version	I	(2 ASCII)		On Init.
81	Checksum	I			On Init.
82	Number of Paths	I	4		On Init.
83	Modbus Address	I	32		On Init.
*Not available at this time.					

7.3 Environmental Specifications

7.3.1 Operating Temperature

Minimum
−40°F (−40°C)

Maximum
+140°F (+60°C)

7.3.2 Random Vibration

Frequency Range
10-150 Hz

Total RMS Level
5.25 ft/s^2 (1.6 m/s^2)

ASD Level 10-20Hz
0.157 ft/s^2 (0.048 m/s^2)

ASD Level 20-150Hz
-3dB/octave

Number of Axes
3

Duration
2 minutes or longer per axis

7.3.3 Sinusoidal Vibration

Frequency Range
10-150 Hz

Total RMS Level
6.56 ft/s^2 (2 m/s^2)

Number of Axes
3

Duration
20 cycles per axis

7.3.4 Mechanical Shock

Free Fall Height

1 inch (25.4 mm)

7.3.5 Power Voltage Variation

Mains Voltage

Nominal mains voltage = 10%
Mains Frequency (AC version)
50 Hz or 60 Hz ±2%

7.3.6 Short Time Power Reduction

Reduction

100% during 10ms
50% during 20ms

Repeated

10 times

Interval

10 seconds

7.3.7 Bursts (Transients)

Spike Characteristics

Double exponential waveform

Peak Value

500 V

Rise Time

5 ns

Half Amplitude Duration

50 ns

Burst Length

15 ms

Burst Period (Repetition Time Interval)

300 ms

7.3.8 Electrostatic Discharge

Exposure
10 times

Time Interval
10 seconds

Test Voltage direct contact
6 kV

Test Voltage Spark
8 kV

7.3.9 Electromagnetic Susceptibility

Frequency Range
0.1 to 500 MHz

Field Strength
3.05 Volts/ft (10 Volts/m)

7.4 T11 Transducer Specifications

Frequency
100kHz ±20% or 200kHz ±20%

Bandwidth
15% (100 kHz) or 25% (200 kHz)

Ambient Temperature
–22°F to 140°F (–30°C to 60°C)

Chemical Exposure
Continuous natural gas

HiPot Test
2121 VDC ("+" to "–", "+" to case and "–" to case)

Transducer Length
12 inches (30.5 cm)

Critical Dimension
9 inches (22.9 cm)

Connector
Isolated straight BNC

Pressure
115 to 2175 psi (8 to 150 bar)

Depressurization Concern
Not applicable

Corrosion Resistance
Non-corrosive metal face

Construction
All Titanium

Certifications
II 26 EEx d IIC T6 (Flameproof)
CSA/CUS Class I, Div.1, Groups B, C & D

7.5 Spoolpiece Specifications

Body Design Code

U.S. Dept. of Transportation Regulation 49 C.F.R. Part 192, *Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards*

MSS SP-97 *Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded and Butt Welding Ends* –(Burst Test Guidelines)

ASME B36.10M *Welded and Seamless Wrought Steel Pipe*

Flange Design Code

ASME B16.5 *Pipe Flanges and Flanged Fittings*

Design Temperature

–22°F to 140°F (–30°C to 60°C) for meter body only

Operating Pressure

740 psig or 50 Bar for ANSI 300
1480 psig or 100 Bar for ANSI 600

Exterior Coating System

Sandblast per SPCC Spec SP10
Inorganic zinc silicate primer (3 mils DFT)
Epoxy High-Build (4-6 mils DFT)

System Safety Analysis

REAP 10 Panametrics Power Systems Product Safety (PHA and Ha2Op)

Internal Coating

Water Soluble Rust Preventative

7.5 Spoolpiece Specifications (cont.)

6″	300 lb (112 kg)	45″ (1143mm)	40	6.065″
	600 lb (224 kg)		80	5.761″
8″	300 lb (112) kg	48″ (1219mm)	40	7.981″
	600 lb (224 kg)		80	7.625″
10″	300 lb (112 kg)	52″ (1321mm)	40	10.020″
	600 lb (224 kg)		80	9.562″
12″	300 lb (112) kg	56″ (1422mm)	40	11.938″
	600 lb (224 kg)		80	11.374″
14″	300 lb (112 kg)	58″ (1473mm)	40	13.124″
	600 lb (224 kg)		80	12.500″
16″	300 lb (112) kg	60″ (1524mm)	40	15.000″
	600 lb (224 kg)		80	14.312″
18″	300 lb (112 kg)	63″ (1600mm)	40	16.876″
	600 lb (224 kg)		80	16.124″
20″	300 lb (112) kg	67″ (1702mm)	40	18.812″
	600 lb (224 kg)		80	17.938″
24″	300 lb (112 kg)	74″ (1880mm)	40	22.624″
	600 lb (224 kg)		80	21.562″

Pipe Flanges and Fittings	Carbon Steel (A105 or A350 LF2*)
Pipe Sections	Carbon Steel (A106 Gr. B or A333 Gr. 6*)
Transducer Holder Components	Stainless Steel 316/316L (A276)
T11 Transducer	Titanium CP Gr. 2 (B348/B381)
*A350 LF2 and A333 Gr. 6 are used for low temperature service and are specified by the customer.	

7.6 Sentinel Ordering Information

Table 16 below and *Table 17 on page 14* show how the *Sentinel Flow Measurement System* part numbers are configured from the options specified.

7.6.1 Spoolpiece Ordering Information

The information below shows how the ***Spoolpiece*** part number is configured from the options specified.

A		B		C		D		E		F		G		H		I
Sentinel	-		-		-		-		-		-	1	-		-	

LTR	CATEGORY	OPTIONS
B	Nominal Pipe Size	**6** = 6.0″ (152.4) ID x 45.0″ (1143.0) long* **8** = 8.0″ (203.2) ID x 48.0″ (1219.2) long* **10** = 10.0″ (254.0) ID x 52.0″ (1320.8) long* **12** = 12.0″ (304.8) ID x 56.0″ (1422.4) long* **14** = 14.0″ (355.6) ID x 58.0″ (1473.2) long* **16** = 16.0″ (406.4) ID x 60.0″ (1524.0) long* **18** = 18.0″ (457.2) ID x 63.0″ (1600.2) long* **20** = 20.0″ (508.0) ID x 67.0″ (1701.8) long* **24** = 24.0″ (609.6) ID x 74.0″ (1879.6) long*
C	Uni/Bi-Directional	**0** = No Upstream Pipe **1** = One Upstream Pipe **2** = Two Upstream Pipes
D	Flange Class and Pipe Bore	**30** = 300 Class Sch. 40 **60** = 600 Class Sch. 80
E	Materials	**1** = Pipe: ASTM A106 GR.B; Flange and Fitting: ASTM A105 **2** = Pipe: ASTM A333 GR.6; Flange and Fitting: ASTM A350 LF2
F	Valve	**0** = None **1** = Single Valve
G	Transducer Type	**1** = T11
H	Transducer Material	**1** = Titanium CP GR.2 **2** = 316SS
I	Transducer Frequency	**1** = 100 kHz **2** = 200 kHz
* Spoolpiece body length equals raised face to raised face.		

7.6.2 Electronics Ordering Information

The information in *Table 17* below shows how the ***Electronics*** part number is configured from the options specified.

A		B	C	D
IGM878	-			

LTR	CATEGORY	OPTIONS
B	Power	**1** = 85 – 264 VAC **2** = 18 – 35 VDC
C	Comm	**1** = RS232 **2** = RS485
D	Frequency	**1** = Broadband (100 kHz – 200 kHz) **2** = 100 kHz Narrow Band **3** = 200 kHz Narrow Band

7.6.3 Standard Options

Channels

Dual

Display

16 x 2

I/O

one Frequency output
one Alarm output
two 4–20mA inputs

Package

Epoxy-Coated Aluminum

Additional Comm

Modbus

Appendix A. CE Mark Compliance

A.1 Introduction

For CE Mark compliance, the *Sentinel Flow Measurement System* must be wired in accordance with the instructions in this appendix.

IMPORTANT: *CE Mark compliance is required for all units intended for use in EU countries.*

A.2 Wiring

The Sentinel must be wired with the recommended cable, and all connections must be properly shielded and grounded. Refer to *Table 3* below for the specific requirements.

Table 1: Wiring Modifications

Connection	Cable Type	Termination Modification
Input/Output	22 AWG shielded (e.g., Baystate #78-1197)	Terminate shield to chassis ground.
	Armored conduit	None - grounded using a conduit fitting.
Power	14 AWG, 3 conductor, shielded (e.g., Belden #19364)	Terminate shield to chassis ground.
	Armored Conduit	None - grounded using a conduit fitting.

Note: *If the Sentinel is wired as described in this appendix, the system will comply with the EMC Directive.*

[no content intended for this page]

Appendix B. Data Records

B.1 Service Record

Whenever any service procedure is performed on the *Sentinel Flow Measurement System*, the details of the service should be recorded in this appendix. An accurate service history of the system can prove very helpful in troubleshooting any future problems.

Record complete and detailed service data for the Sentinel in *Table 19* below. Make additional copies of the table as needed.

Date	Description of Service	Performed By

Date	Description of Service	Performed By

B.2 Diagnostic Parameters

After a successful initial installation of the Sentinel system and whenever any system malfunction is noticed, the values for the diagnostic parameters should be entered in *Table 20* below. For a definition of terms see *Table 9 on page 70*.

Parameter	Initial	Current	Current	Current	Current
P Num Up					
P Num Dn					
Cmp Flow Err					
Cmp Comm Err					
Percent Err					
Meas Mode					

B.3 Option Cards Installed

Whenever an option card is installed or changed in the flow transmitter, record the type of card and any additional setup information in the appropriate row of *Table 21* below.

Slot #	Type of Card	Additional Setup Information
1		
2		

Appendix C. Brazilian INMETRO Approval

Serviço Público Federal

MINISTÉRIO DO DESENVOLVIMENTO, INDÚSTRIA E COMÉRCIO EXTERIOR
INSTITUTO NACIONAL DE METROLOGIA, NORMALIZAÇÃO E QUALIDADE INDUSTRIAL
INMETRO

Portaria INMETRO/DIMEL/Nº 278 , de 27 de dezembro de 2006.

O Diretor de Metrologia Legal do Instituto Nacional de Metrologia, Normalização e Qualidade Industrial - INMETRO, no exercício da delegação de competência outorgada pelo Senhor Presidente do INMETRO, através da Portaria nº 257, de 12.11.91, conferindo-lhe as atribuições dispostas no item 4.1, alínea "g", da Regulamentação Metrológica aprovada pela Resolução nº 11, de 12 de outubro de 1988, do CONMETRO, resolve:

Considerando o contido na Portaria INMETRO n° 083 de 01/06/1990, Art.3°;

Considerando o contido na Portaria INMETRO n° 210 de 04/11/1994, Art.1°, atendida mediante a apresentação do relatório de ensaios número CVN-509654-01 e declaração número CVN-509654-02, emitidos pelo Netherlands Meetinstituut – NMi da Holanda, conforme as exigências estabelecidas na recomendação OIML R32 e D11, resolve:

Aprovar, em caráter provisório, o modelo *SENTINEL* do medidor de vazão de gás ultra-sônico, marca GE SENSING, bem como as instruções que deverão ser observadas quando da realização do controle metrológico legal.

1. CARACTERÍSTICOS DO MODELO:

1.1 Fabricante: GE Sensing Inc.
Endereço: 1100 Technology Park Drive – Billerica (MA) – United States of America
1.2 Representante: DRUCK BRASIL LTDA. (GE Sensing Brasil)
Endereço: Rua Alexandre Marcondes Filho, 115 – São Bernardo do Campo – São Paulo – Brasil.
1.3 Descrição: Medidor de vazão do tipo ultra-sônico, com 02 (dois) canais para medição de gases.
1.4: Marca: GE Sensing.
1.5: Modelo: SENTINEL.
1.6: Dispositivo Indicador: Em conformidade com as exigências constantes da OIML R32.

Dimel/Divol
Rflazari
GE SENSING – 52600.050.690/2006-86

INMETRO
Diretoria de Metrologia Legal - DIMEL
Divisão de Instrumentos de Medição de Volume - DIVOL
Endereço: Av. Nossa Senhora das Graças, 50 - Xerém - Duque de Caxias - RJ CEP 25250-020
Telefone: (0XX21) 2679-9132 – Fax: (0XX21) 2679-9470

(Fls. 02 da Portaria INMETRO/DIMEL/Nº 273 , de 27 de dezembro de 2006.)

1.7: Prescrições Técnicas e Metrológicas:

Diâmetro nominal (DN)	Vazão mínima Qmin (m^3/h)	Vazão máxima Qmáx (m^3/h)	Faixa de medição	Valor do pulso (pulsos / m^3)
DN 100	34	1064	1:30	30743
DN 150	44	2416	1:50	13549
DN 200	76	4183	1:50	7824
DN 250	120	6593	1:50	4963
DN 300	106	7019	1:60	4662
DN 350	128	8483	1:70	3858
DN 400	168	11082	1:70	2953
DN 450	213	14027	1:70	2333
DN 500	264	17430	1:70	1877
DN 600	382	25209	1:70	1298

2. ESPECIFICAÇÕES:

2.1 Temperatura máxima: + 80 ° C

2.2 Temperatura mínima : - 30 ° C

2.3 Intervalo de pressão de serviço: 0 a 15 Mpa

2.4 Velocidade máxima de operação: 36 m/s

3. FORMA, DIMENSÕES E QUALIDADE DOS MATERIAIS:

3.1 Conforme memorial descritivo e desenhos constante do Processo n.º 52600 050690/06-86.

4. CONTROLE METROLÓGICO:

4.1 O sistema de medição deverá ser submetido à avaliação pelo INMETRO, visando sua aprovação provisória nos termos desta Portaria, apresentando os seguintes dados:

a) empresa que adquiriu o instrumento de medição;

b) local de instalação do instrumento de medição;

c) certificado de verificação do instrumento de medição;

d) esquema de instalação do sistema de medição ao qual o instrumento de medição será incorporado.

4.2 Na verificação serão realizados os seguintes procedimentos:

a) exame visual para verificar se o instrumento de medição está de acordo com as características apresentadas no certificado de verificação;

b) exame metrológico quanto ao atendimento aos erros máximos admissíveis estabelecidos para o sistema de medição, conforme Recomendação Internacional OIML R32;

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Divisão de Instrumentos de Medição de Volume - DIVOL
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Telefone: (0XX21) 2679-9132 – Fax: (0XX21) 2679-9470

(Fls. 03 da Portaria INMETRO/DIMEL/Nº 279 , de 27 de dezembro de 2006.)

c) outros que se fizerem necessários, a serem estabelecidos com os segmentos envolvidos no processo de medição e controle metrológico;

d) inspeção quanto ao atendimento às exigências na Portaria conjunta ANP/INMETRO nº 1 de 19/06/2000, em função da sua utilização.

4.3 O proprietário do sistema de medição deverá disponibilizar os meios necessários e adequados para viabilizar a execução do controle metrológico quanto ao atendimento do mesmo aos preceitos estabelecidos na Recomendação Internacional OIML R32.

4.4 Erros Máximos admissíveis:

Vazão Q M^3/h	Erros Máximos Admissíveis	
	em verificação inicial	em serviço
$Q_{min} \leq Q < Q_t$	± 2%	± 2%
$Q_t \leq Q \leq Q_{máx}$	± 1%	± 1%

Q = vazão, Q_t = vazão de transição, Q_{min} = vazão mínima

4.5 Periodicidade da verificação: As verificações metrológicas serão realizadas anualmente.

4.6: A utilização do referido medidor nas medições fiscais, apropriação e transferência de custódia, está condicionada ao atendimento dos requisitos constantes da Portaria Conjunta ANP/INMETRO nº 01, de 19 de junho de 2000, ou regulamento que vier a substituí-lo.

5 MARCAS DE APROVAÇÃO E SELAGEM:

5.1 Será aposta em placa fixada no corpo do medidor a marca relativa à aprovação de modelo na forma:

5.2 A marca de selagem do instrumento de medição obedecerá ao plano de localização constante do desenho anexo a portaria.

5.3 Será aposta em local a ser definido pelo INMETRO a marca relativa ao controle metrológico no sistema de medição ao qual o instrumento de medição será incorporado.

5.4 O instrumento de medição deve possuir uma placa de identificação, na qual deverá constar as seguintes inscrições:

a) número da portaria da aprovação de modelo;

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Divisão de Instrumentos de Medição de Volume - DIVOL
Endereço: Av. Nossa Senhora das Graças, 50 - Xerém - Duque de Caxias - RJ CEP 25250-020
Telefone: (0XX21) 2679-9132 – Fax: (0XX21) 2679-9470

(Fls. 04 da Portaria INMETRO/DIMEL/Nº 278 , de 27 de dezembro de 2006.)

b) símbolo ou marca do fabricante;
c) número de série;
d) ano de fabricação;
e) vazão máxima: ($Q_{máx}$) em m^3/h;
f) vazão mínima: (Q_{min}) em m^3/h;
g) pressão máxima de trabalho ($P_{máx}$) em Pa;
h) país de origem;
i) a faixa das condições de operação na qual o medidor deve trabalhar dos erros máximos admissíveis, expresso na forma:

t_m = ...-... °C;

p_m = ...-...Pa (ou KPa ou MPa);

j) se o requerido, uma designação comercial do medidor de gás, um número de série especial, o nome do distribuidor de gás, o nome do reparador e o ano de reparo.

6. DESENHOS ANEXOS À PRESENTE PORTARIA:

6.1 Vista Geral do Medidor de Vazão;
6.2 Vista e Dimensões do Medidor DN 100 mm;
6.3 Vista e Dimensões dos Medidores DN 150 mm a 600 mm;
6.4 Legenda dos Componentes do Medidor de Vazão;
6.5 Detalhes de Instalação Típica do Sistema de Comunicação;
6.6 Condicionador de Fluxo;
6.7 Arranjo de Instalação de Medidores em Fluxo Uni-direcional e Bi-direcional;
6.8 Pontos de selagem.

7. ENTRADA EM VIGOR:

7.1 Esta Portaria entra em vigor na data de sua assinatura.

MAURÍCIO MARTINELLI RECHE
Diretor Substituto de Metrologia Legal

Dimel/Divol
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INMETRO
Diretoria de Metrologia Legal - DIMEL
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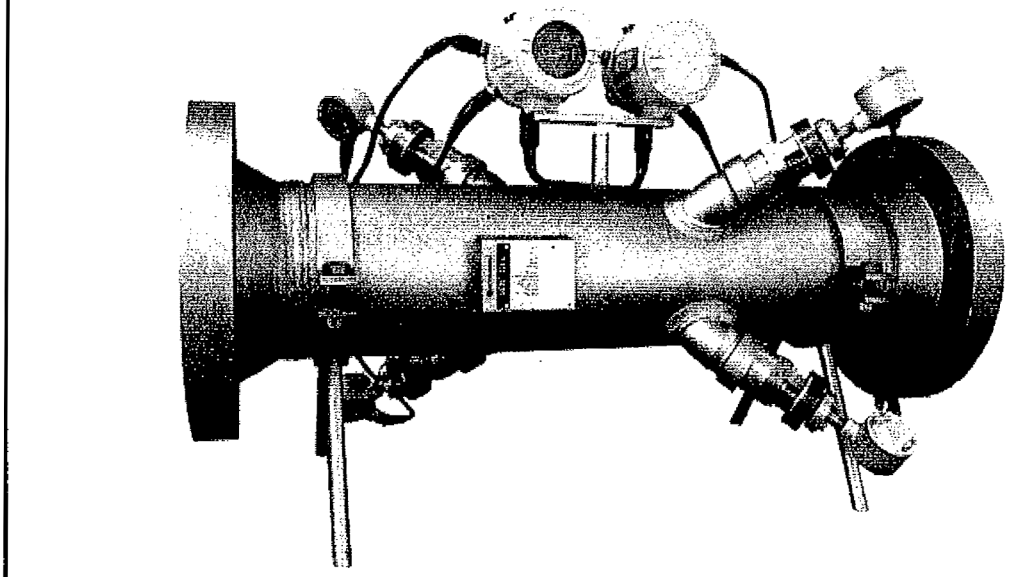
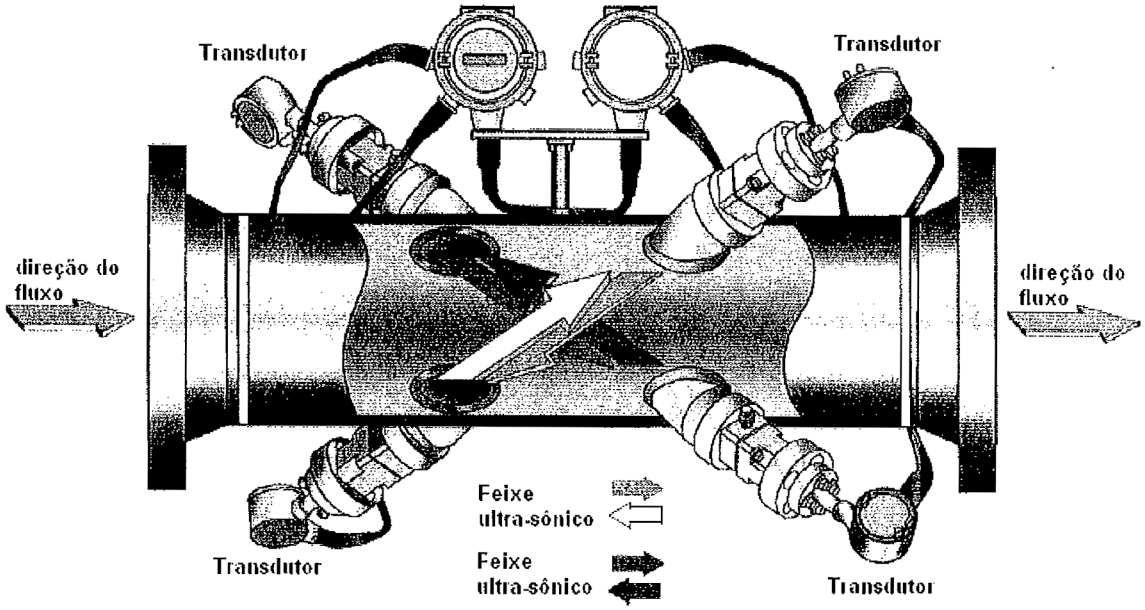
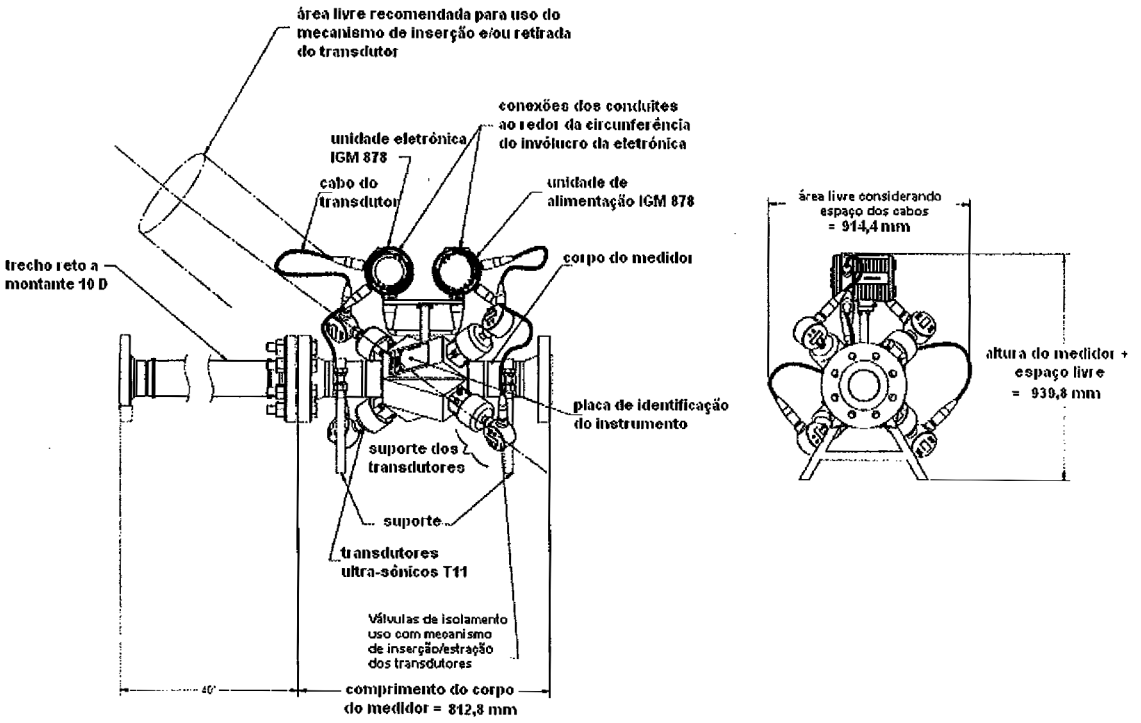
Telefone: (0XX21) 2679-9132 – Fax: (0XX21) 2679-9470





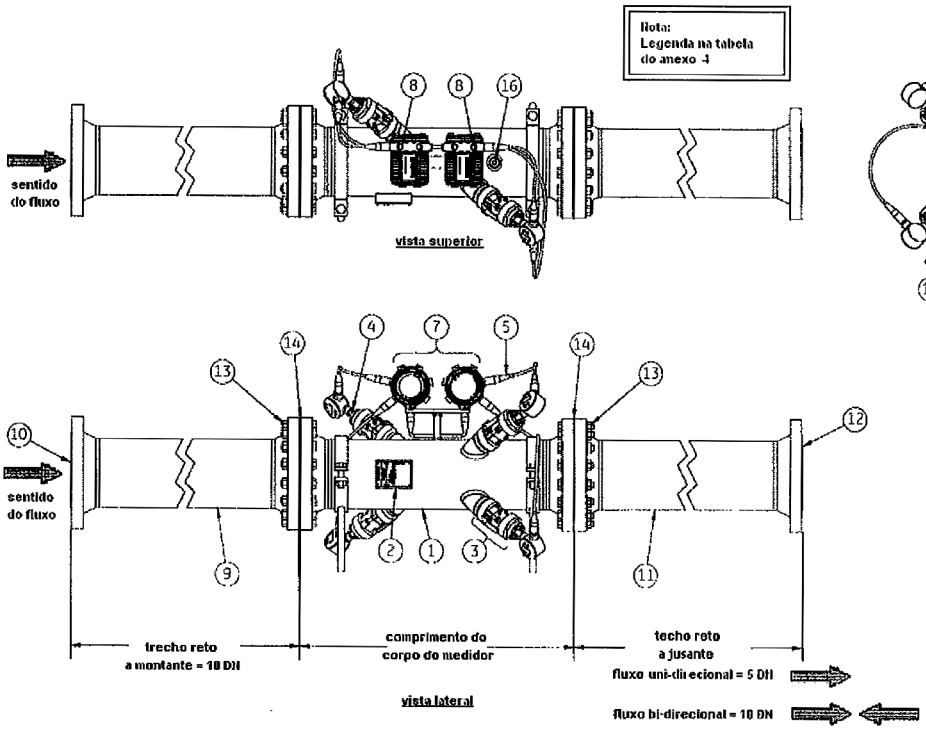
DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.

INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	VISTA GERAL DO MEDIDOR DE VAZÃO	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 01

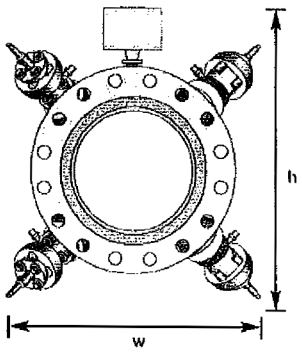


DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.

INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA (GE Sensing Brasil)	COTAS EM: N/D
	VISTA E DIMENSÕES DO MEDIDOR DN 100 mm	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 02



DIÂMETRO NOMINAL	PESO FLANGE ANSI B16.5 300 # e 600 #		DISTÂNCIA FACE-A-FACE	ALTURA (h)	COMPRIMENTO (w)
pol (mm)	300 lb (135 kg)	600 lb (270 kg)	pol (mm)	pol (mm)	pol (mm)
6 (152)	212 lb (95 kg)	320 lb (144 kg)	45 (1143)	37 (940)	36 (914)
8 (203)	297 lb (134 kg)	440 lb (198 kg)	48 (1219)	39 (991)	38 (965)
10 (254)	390 lb (175 kg)	665 lb (299 kg)	52 (1321)	42 (1067)	40 (1016)
12 (305)	558 lb (251 kg)	843 lb (379 kg)	56 (1422)	44 (1118)	42 (1067)
14 (356)	684 lb (308 kg)	1028 lb (463 kg)	58 (1473)	46 (1168)	44 (1118)
16 (406)	900 lb (405 kg)	1396 lb (628 kg)	60 (1524)	48 (1219)	46 (1168)
18 (457)	1118 lb (503 kg)	1702 lb (766 kg)	63 (1600)	50 (1270)	48 (1219)
20 (508)	1421 lb (639 kg)	2188 lb (985 kg)	67 (1702)	53 (1346)	50 (1270)
24 (610)	2088 lb (940 kg)	3028 lb (1363 kg)	74 (1880)	57 (1448)	54 (1372)



DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.

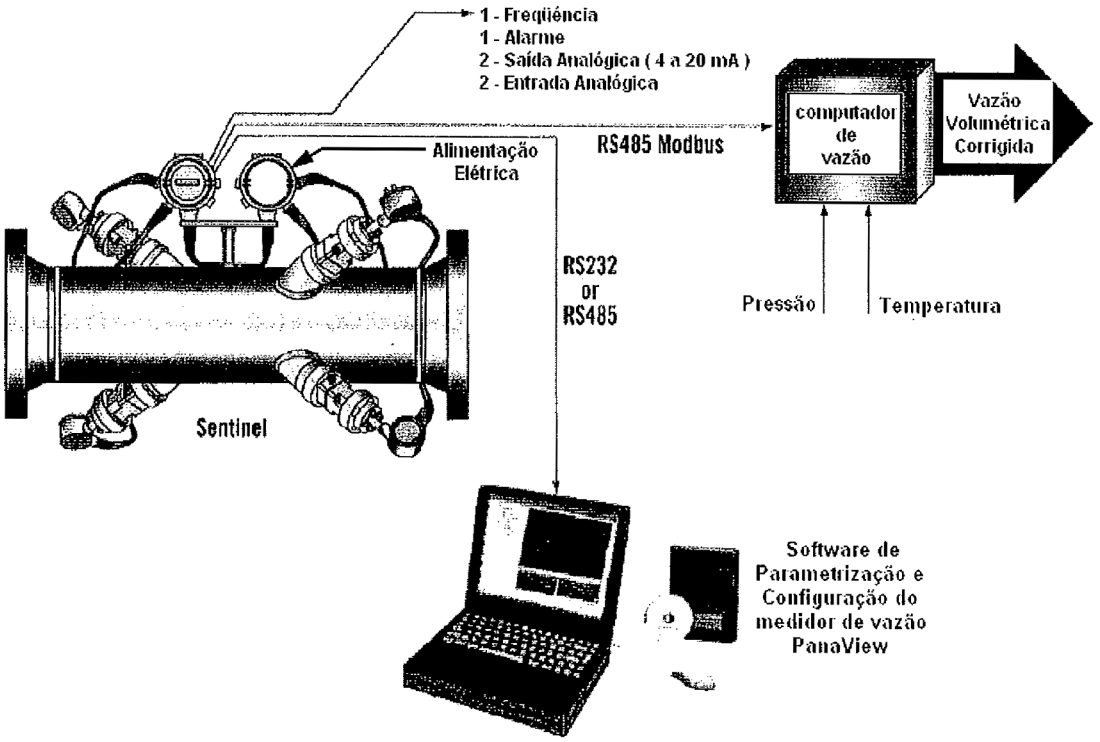
INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	VISTA E DIMENSÕES DOS MEDIDORES DN 150 mm a 600 mm	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 03

TABELA 1 - LEGENDA DOS COMPONENTES

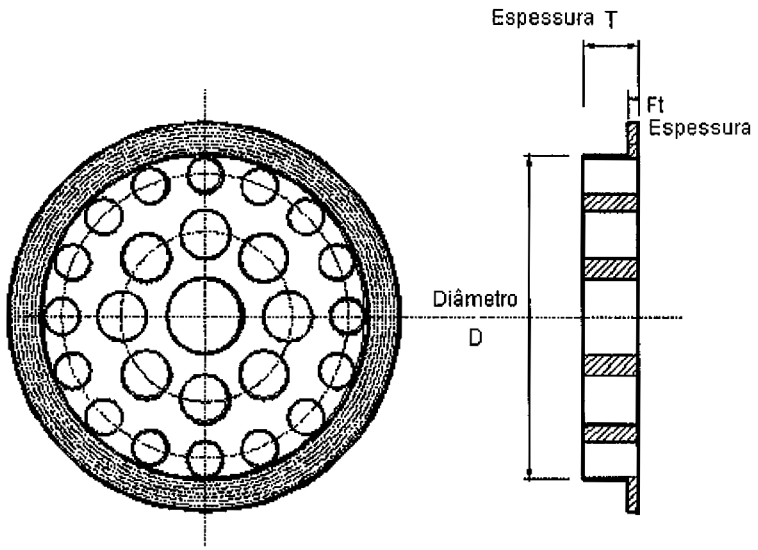
No.	Componente
1	corpo do medidor
2	placa de identificação
3	suporte do transdutor
4	transdutor T11
5	invólucro do cabo do transdutor
6	caixa de junção à prova de explosão
7	unidade eletrônica
8	conectores externos conduites
9	trecho reto à montante
10	condicionador de fluxo
11	trecho reto a jusante
12	condicionador de fluxo (em fluxo di-direcional)
13	parafusos
14	vedações e gaxetas
15	suporte do medidor (removido após instalação)
16	tomada para sensor de pressão

DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.

INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	LEGENDA DOS COMPONENTES DO MEDIDOR DE VAZÃO	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 04



DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.		
INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	DETALHES DE INSTALAÇÃO TÍPICA DO SISTEMA DE COMUNICAÇÃO	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 05

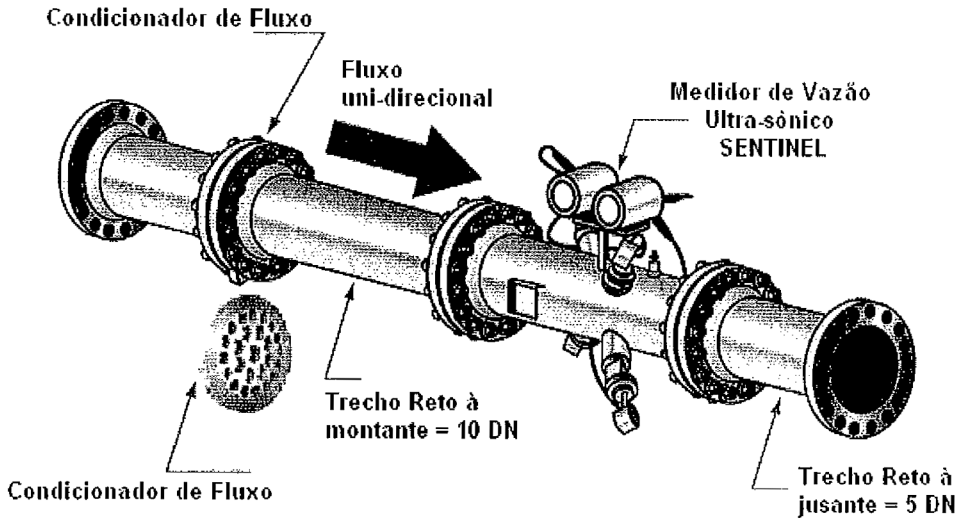


DN (pol / mm)	D – Diâmetro Schedule 40/80		T – Espessura Schedule 40/80		Ft – Flange Espessura
4 / 100	4.026	3.826	0.600	0.574	0.250
6 / 150	6.065	5.761	0.900	0.864	0.250
8 / 200	7.981	7.625	1.190	1.144	0.250
10 / 250	10.020	9.562	1.500	1.434	0.250
12 / 300	11.938	11.374	1.790	1.700	0.250
16 / 400	15.000	14.312	2.250	2.147	0.250
20 / 500	18.812	17.938	2.820	2.690	0.375
24 / 600	22.624	21.562	3.390	3.230	0.500

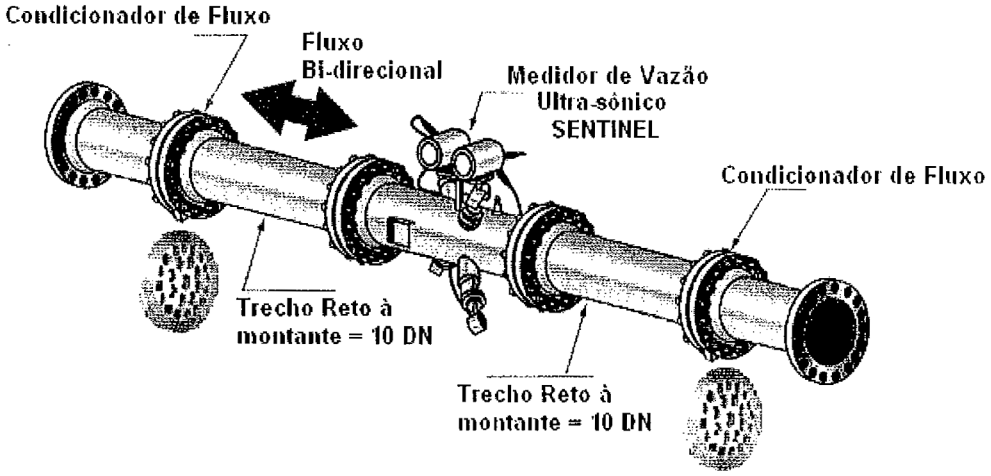
DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.

INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	CONDICIONADOR DE FLUXO	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 06

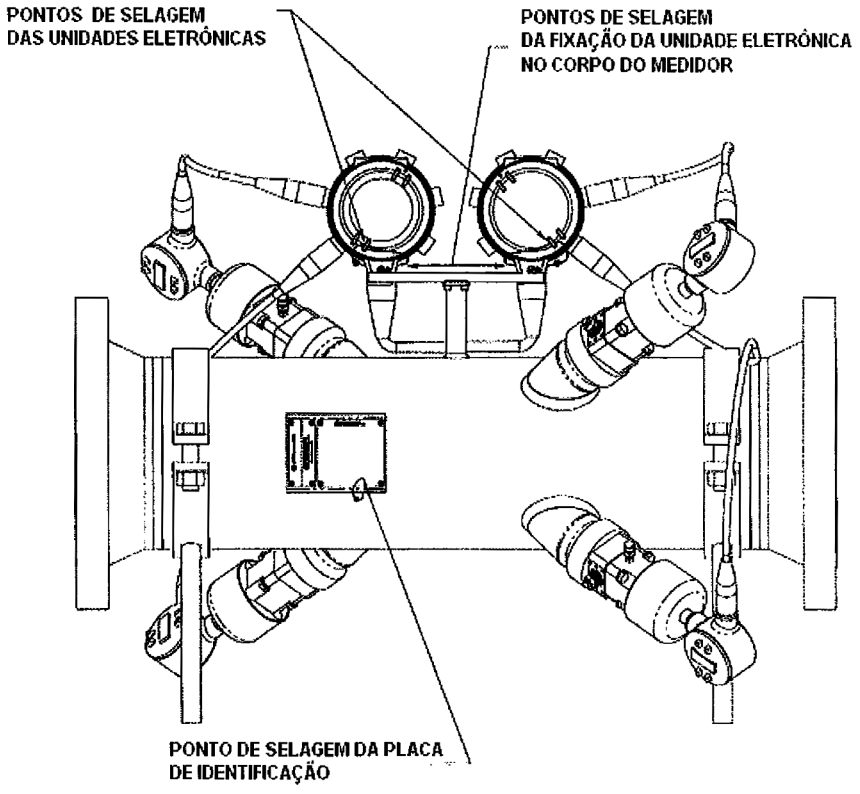
FLUXO UNI-DIRECIONAL



FLUXO BI-DIRECIONAL



DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 273 DE 27 DE dezembro DE 2006.		
INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	ARRANJO DE INSTALAÇÃO DE MEDIDORES EM FLUXO UNI-DIRECIONAL E BI-DIRECIONAL	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 07



DESENHO ANEXO À PORTARIA INMETRO/DIMEL Nº 278 DE 27 DE dezembro DE 2006.

INMETRO	FABRICANTE: GE SENSING REPRESENTANTE: DRUCK BRASIL LTDA. (GE Sensing Brasil)	COTAS EM: N/D
	PONTOS DE SELAGEM	ESCALA: N/D
	MODELO: SENTINEL – GE SENSING	ANEXO: 08

Appendix D. NMI Nederlands Meetinstituut Approval

Nederlands Meetinstituut

DECLARATION

Number CVN-509654-02 Rev. A
Page 1 of 1
Projectnr. 509654

Applicant: GE Infrastructure Sensing
Zuiderinslag 4a
3871 MR Hoevelaken
The Netherlands

Submitted: Ultrasonic gasmeters
Manufacturer : GE-Sensing Panametrics
Model : Sentinel

Scope of investigation: Evaluation of the gas meter, model Sentinel, for compliance with the "essential requirements for ultrasonic gas meters" in The Netherlands, to be used for custody transfer purposes.

Tests: The following tests are performed by NMi for judgement:
- determinations of the error curve;
- temperature tests, dry heat and cold;
- a damp heat, steady state test;
- a damp heat, cyclic test;
- vibration tests;
- distortion tests of the power supply;
- electrostatic discharges;
- electromagnetic susceptibility tests;
- functionality-, security- and validity-tests.

The results are presented in test report no. CVN-509654-01.

Result: Based on the results of the above mentioned performed tests NMi will give a positive advice to the Ministry of Economic Affairs in The Netherlands to allow the use of the ultrasonic gas meter, manufactured by GE-Sensing Panametrics, model Sentinel, from 4" up to 18" for custody transfer purposes, for the measuring ranges as stated in annex 1 belonging to this Declaration.
Meter sizes bigger then 18" have to be validated first by performing a high pressure calibration. If those meter sizes fulfill the requirements as mentioned in the essential requirements for ultrasonic gas meters, also a positive advice for those versions will be given to the Ministry of Economic Affairs in the Netherlands.

Dordrecht, 10 April 2006
NMi Certin B.V.

Ing. C. Oosterman
manager Product Certification

NMi Certin B.V.
Hugo de Grootplein 1,
3314 EG Dordrecht
P.O. Box 394, 3300 AJ Dordrecht,
NL
phone +31 78 6332 332
fax +31 78 6332 309
certin@nmi.nl
www.nmi.nl

Parties concerned can lodge objection against this decision, within six weeks after the date of submission, to the general manager of NMi B.V. (see "Regulation objection and appeal against decisions of NMi B.V.")

NMi B.V., chamber of comm. no. 27.228.701
NMi Certin B.V., chamber o.c. nr. 27.233.418

Nederlands Meetinstituut

Number CVN-509654-02 Rev. A
Annex 1
Page 1 of 1

Measuring range

In the table below for the several designs and constructions the measuring range is stated.

Meter type	Q_{min} [m^3/h] (see remark A)	Q_{max} [m^3/h] (see remark B)
4"	34	1.100
6"	40	2.450
8"	70	4.200
10"	120	6.600
12"	100	7.100
14"	120	8.500
16"	160	11.200
18"	200	14.000

remark A : instead of Q_{min} a higher value may be chosen
remark B : instead of Q_{max} a lower value may be chosen

Appendix E. Romanian Bureau of Legal Metrology Approval

BIROUL ROMÂN DE METROLOGIE LEGALĂ
ROMANIAN BUREAU OF LEGAL METROLOGY
Şos. Vitan Bârzeşti 11 ⏲ Sector 4 ⏲ 042122 Bucureşti România
Tel. +4021 332 09 54 ⏲ Fax +4021 332 06 15 ⏲ office@brml.ro

CERTIFICAT
APROBARE DE MODEL
Nr. 181 / 05.12.2006

AUTORITATEA EMITENTĂ: **BIROUL ROMÂN DE METROLOGIE LEGALĂ**

În conformitate cu prevederile Ordonanței Guvernului României nr.20/1992, modificată şi aprobată prin Legea nr.11/1994, cu modificările ulterioare, se eliberează prezentul certificat:

Pentru mijlocul de măsurare: **Contor / traductor de debit de gaz, cu ultrasunete, tip SENTINEL**

produse de : **GE Infrastructure SENSING**
Bay 148,Shannon Industrial Estate,Shannon,Co.Clare-Ireland
Tel. +31-332536444; Fax. +31-332537269

Poziția din Lista Oficială L .O. 2004 : **L 33-3; L37-8**

Solicitantul aprobării: **S.C. SMARTECH CONSULT S.R.L.**
Str.Ciugureanu Daniel Nr.12,sect.1-Bucureşti
Tel/Fax. 2248040

Acest certificat atestă conformitatea modelelor cu seriile 061599-1, 061600-1 și 1848, cu cerințele prevăzute în NML 004-05 «Contoare de gaz și dispozitive de conversie a volumului», conferă *drepturi* și impune *obligații* care decurg din actele normative în vigoare. Conformitatea a fost stabilită prin încercările descrise în raportul nr. 181/2006.

INSCRIPȚIONAREA MARCAJULUI APROBĂRII DE MODEL:
Marcajul se aplică de către producător sau reprezentantul autorizat al acestuia pe plăcuța de identificare a fiecărui mijloc de măsurare livrat și are reprezentarea grafică alăturată .

RO
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VALABILITATEA:
Prezenta aprobare de model este valabilă până la data de 05.12.2011.
Documentația parafată de Biroul Român de Metrologie Legală se păstrează la solicitant până la 05.12.2016. Caracteristicile principale ale mijloacelor de măsurare sunt indicate în Anexa 1 (4 pagini), parte integrantă din prezentul certificat.

DIRECTOR GENERAL
Prof.univ.dr.ing. **Fănel Iacobescu**

ANEXA 1 pag. 1/4
la Certificatul aprobării de model nr.181/05.12.2006

DESCRIEREA MODELULUI

Contor / Traductor de debit de gaz, cu ultrasunete, tip SENTINEL

Producător: GE Infrastructure SENSING - Irlanda
Solicitant: S.C. SMARTECH CONSULT S.R.L.

1. Domeniu de utilizare

Contorul/traductorul de gaz cu ultrasunete tip SENTINEL este destinat pentru echiparea sistemelor de măsurare din instalații de distribuție/colectare a gazelor, prin conducte sub presiune. Acest mijloc de măsurare este utilizat în domenii de interes public în care se realizează măsurări privind corectitudinea tranzacțiilor comerciale sau măsurări privind perceperea taxelor și impozitelor, în conformitate cu prevederile art. 4, lit. e din Lista oficială în vigoare, în condițiile prezentate la cap.4.

2. Descriere

Contorul/traductorul de gaz cu ultrasunete tip SENTINEL este realizat având la bază un senzor de debit ce funcționează pe principiul măsurării interferențiale a vitezei de deplasare a fluxului de gaz printr-un tronson de măsurare calibrat (DN). Corpul senzorului de debit constituie segmentul central al tronsonului de măsurare calibrat, acesta fiind prevăzut cu locașuri și elemente de poziționare controlată a senzorilor ultrasonici de detectare a vitezei de deplasare a fluxului de gaz. Pentru măsurarea vitezei de deplasare a gazului, aparatul este prevăzut cu 2 căi independente de detectare a acesteia, pentru fiecare fiind alocată câte o pereche de senzori ultrasonici. La fiecare pereche de senzori, impulsul ultrasonic este transmis alternativ de un senzor și recepționat de către celălalt.

Principalele părți componente ale aparatului sunt:

- corpul senzorului de debit. Este prevăzut cu 4 proeminențe (înclinate la 60^0 față de axa de curgere) prevăzute cu locașuri de amplasare a senzorilor ultrasonici, o priză de presiune, un suport de fixare a unităților de procesare SPU, un suport pentru plăcuța de identificare, flanșe de cuplare la tronsoanele calibrate amonte-aval ale conductei de măsurare;
- 2 perechi de senzori ultrasonici (fiecare pereche constituind câte o cale independentă de măsurare a vitezei fluxului), montați încliat la 60^o față de axa conductei de măsurare. Sunt prvăzuți cu cabluri de semnal cu conenxiune la unitatea de procesare (SPU) asociată;
- un bloc electronic constituit din două unități tip SPU de procesare a semnalului ultrasonic (câte una pentru fiecare din perechile de senzorii ultrasonici conectați). Unitățile SPU sunt dispozitive electronice cu funcție principală de adaptor a semnalului ultrasonic, fiecare dintre acestea fiind prevăzute cu dispozitive auxiliare (o unitate SPU este echipată cu un dispozitiv de calcul-afișare a volumului de gaz măsurat în condiții de lucru iar cealaltă unitate SPU este echipată cu module pentru semnale de ieșire și interfețe de comunicare exterioară). Unitățile SPU sunt montate pe un suportul special prevăzut la carcasa senzorului de debit.

Aparatul poate realiza, simultan sau independent, funcțiile de "contor" de volum (cu indicare locală) și/sau de "traductor de debit de volum", valorile mărimilor măsurate și afișate/transmise fiind determinate în condiții de lucru.

Notă: pentru măsurarea de cantități convertite la condiții de bază este necesară asocierea aparatului cu mijloace de măsurare exterioare (calculator de debit,traductoare de presiune și de temperatură,etc.), compatibile.

Aparatul este realizat în variantele dimensionale prezentate în tabelul 1, fiecare dintre acestea putând fi configurată pentru măsurarea într-un singur sens sau în ambele sensuri de curgere ale gazului.

În fig. 1...5 sunt prezentate imaginile de recunoaștere ale aparatului, plăcuța de identificare, schemele de instalare (funcție de sensul de curgere al aplicației configurate) și schema de sigilare.

2. Caracteristici principale

Tabel 1

DN	Dimensiune funcțională echivalentă G	Debit de lucru* (m^3/h)		viteză gaz măsurat Min/Max (m/s)	DN	Dimensiune funcțională echivalentă G	Debit de lucru (m^3/h)		viteză gaz măsurat Min/Max (m/s)
		Qmin	Qmax				Qmin	Qmax	
100 (4")	650	34	1064	0,72 / 36	350 (14")	6500	128	8483	0,45 / 27
150 (6")	1600	44	2416	0,72 / 36	400 (16")	6500	168	11082	0,45 / 27
200 (8")	2500	76	4183	0,72 / 36	450 (18")	10000	213	14027	0,45 / 27
250 (10")	4000	120	6593	0,72 / 36	500 (20")	10000	264	17430	0,45 / 27
300 (12")	4000	106	7019	0,45 / 27	600 (24")	16000	382	25209	0,45 / 27

*** NOTĂ: Conform prevederilor Listei Oficiale LO-2004, prezentul certificat acoperă contoarele de gaz la care debitul maxim (Qmax) ≤ 2500 m^3/h.**
Limitele «Qmin» , «Qmax» pentru debitul de lucru și valoarea debitului de tranziție «Qt» se stabilesc la calibrarea inițială a fiecărui aparat cu respectarea următoarelor relații : Qmax/Qmin > 20 ; Qmax/Qt > 5

număr de căi de măsurare	2 (sens de curgere opțional: unic sau bidirecțional)
fluid de lucru	gaz natural
viteza gazului	conf.Tabel 1
presiune de măsurare	(0...51) bar ; (0...103) bar ; (0...153) bar ;
temperatura gazului rumăsurat	(-40...60) °C
temperatură mediu ambiant	(-25...70) °C
erori tolerate	clasa de exactitate a contorului = 1 (conf. NML 004-05)
alimentare	220 V_{CA} ; 17...32 V_{CC}
semnale de intrare/ieșire și comunicări	2 intrări izolate (4...20 mA ; buclă de putere 24V), pentru presiune și tempeatură 1 sau 2 ieșiri în frecvență, izolate optic (HF = 1 sau 2 Hz; LF = 10 kHz); 2 ieșiri analogice: (4...20)mA; 1 ieșire de releu (semnal alarmă); opțional 2 ieșiri alarme (una HF și una 4...20 mA) interfețe: o comunicare bidirecțională (RS 232 sau RS 485/PanaView Software) o ieșire digitală RS 485/ Modbus
Condiții de instalare : conf. fig.4 și 5	

4.Exigențe în utilizare

Pentru utilizarea contorului/traductorului de debit de gaz cu ultrasunete tip SENTINEL pentru măsurări în domenii de interes public în care se realizează măsurări privind corectitudinea tranzacțiilor comerciale sau măsurări privind perceperea taxelor și impozitelor, trebuie respectate cel puțin următoarele condiții:

- să fie integrat într-un sistem de măsurare cu aprobare de model proprie sau să funcționeze în asociere cu mijloace de măsurare (calculator de debit cu dispozitiv de conversie și traductoare de presiune și de temperatură, etc), compatibile și cu aprobare de model proprie;
- instalarea și întreținerea în timpul exploatării să fie făcute conform specificațiilor tehnice ale producătorului;
- să funcționeze în interacțiune cu dispozitivele automate ale instalației de tranzit aferentă tronsonului de măsurare, prevăzute să reacționeze la apariția evenimentelor neconforme (cum ar fi depășirea valorilor limită ale parametrilor de lucru „debit, temperatură, presiune" depășirea pragurilor de eroare prestabilite, defecțiuni constructive sau funcționale ale componentelor contorului, etc.).

Marcare-sigilare:

Marcajul aprobării de model se aplică pe plăcuța de identificare (fig.3), fixată pe carcasa senzorului de debit.

Marcajul de verificare metrologică se aplică astfel :

- la verificarea metrologică inițială : în toate punctele de sigilare (S1.....S7) ;
- la verificarea metrologică periodică în punctul de sigilare S2 .

Punctele de sigilare sunt:

S1 - sigilarea elementelor de fixare ale fiecărui senzor ultrasonic, la carcasa senzorului de debit;
S2 - sigilarea elementelor de fixare ale capacelor de închidere a cutiei de conexiuni ale fiecăruia din senzorii ultrasonici;
S3 - sigilarea elementelor de fixare în poziție închisă a capacului frontal al primei unități de procesare SPU (prevăzută cu dispozitiv de afișare);
S4– sigilarea elementelor de fixare în poziție închisă a capacului de spate al primei unități de procesare SPU (prevăzută cu dispozitiv de afișare);
S5– sigilarea elementelor de fixare în poziție închisă a capacului frontal al celei de a doua unități de procesare SPU (fără dispozitiv de afișare);
S6– sigilarea elementelor de fixare în poziție închisă a capacului de spate al celei de a doua unități de procesare SPU (fără dispozitiv de afișare);
S7– sigilarea plăcuței de identificare la corpul senzorului de debit.

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Fig.1

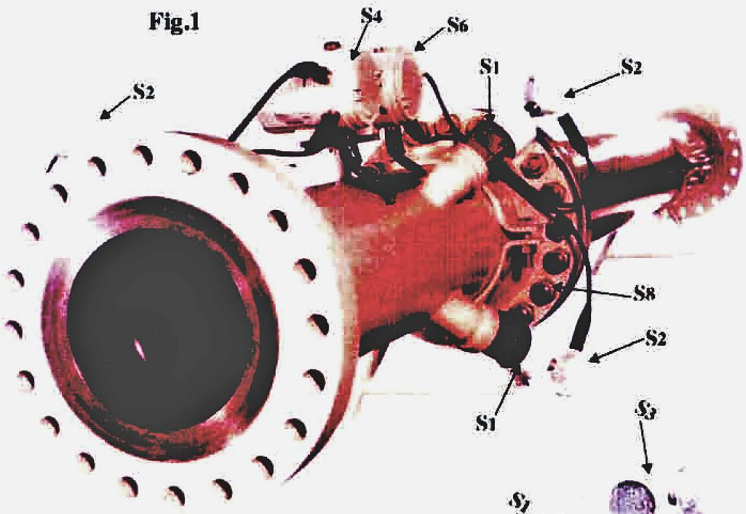


Fig.2

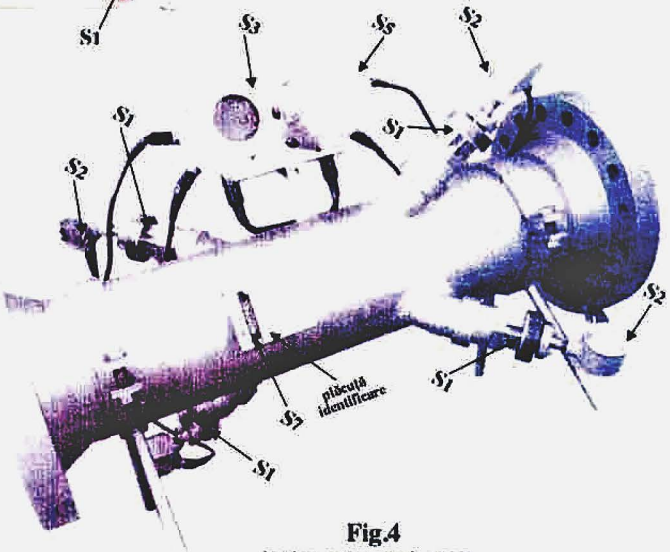


Fig.3

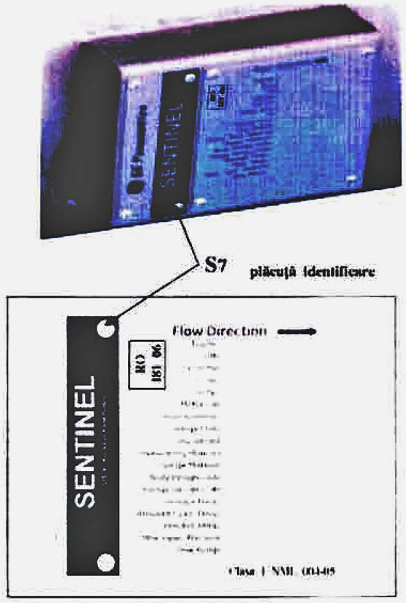
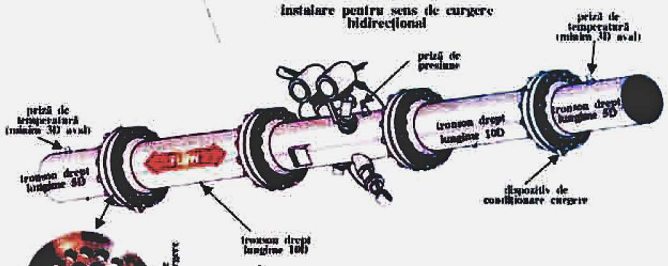


Fig.4
instalare pentru sens de curgere bidirecțional



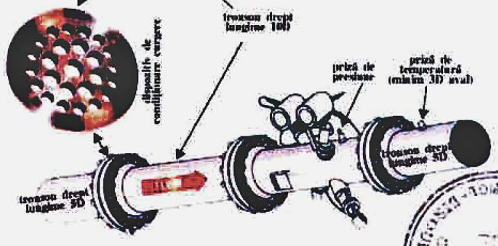


Fig.5
instalare pentru sens de curgere unidirecțional

U

V

W

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Warranty

Each instrument manufactured by Panametrics Sensing is warranted to be free from defects in material and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the instrument, at the sole discretion of Panametrics Sensing. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If Panametrics Sensing determines that the equipment was defective, the warranty period is:

- one year from delivery for electronic or mechanical failures
- one year from delivery for sensor shelf life

If Panametrics Sensing determines that the equipment was damaged by misuse, improper installation, the use of unauthorized replacement parts, or operating conditions outside the guidelines specified by Panametrics Sensing, the repairs are not covered under this warranty.

The warranties set forth herein are exclusive and are in lieu of all other warranties whether statutory, express or implied (including warranties or merchantability and fitness for a particular purpose, and warranties arising from course of dealing or usage or trade).

Return Policy

If a Panametrics Sensing instrument malfunctions within the warranty period, the following procedure must be completed:

1. Notify Panametrics Sensing, giving full details of the problem, and provide the model number and serial number of the instrument. If the nature of the problem indicates the need for factory service, Panametrics Sensing will issue a RETURN AUTHORIZATION NUMBER (RAN), and shipping instructions for the return of the instrument to a service center will be provided.
2. If Panametrics Sensing instructs you to send your instrument to a service center, it must be shipped prepaid to the authorized repair station indicated in the shipping instructions.
3. Upon receipt, Panametrics Sensing will evaluate the instrument to determine the cause of the malfunction.

Then, one of the following courses of action will then be taken:

- If the damage is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.
- If Panametrics Sensing determines that the damage is not covered under the terms of the warranty, or if the warranty has expired, an estimate for the cost of the repairs at standard rates will be provided. Upon receipt of the owner's approval to proceed, the instrument will be repaired and returned.

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Customer Support Centers

U.S.A.
The Boston Center
1100 Technology Park Drive
Billerica, MA 01821
U.S.A.

Tel: 800 833 9438 (toll-free)
978 437 1000

E-mail: panametricstechsupport@bakerhughes.com

Ireland
Sensing House
Shannon Free Zone East
Shannon, County Clare
Ireland

Tel: +353 (0)61 470291
E-mail: panametricstechsupport@bakerhughes.com

BH038C11 EN E (05/2023)

Baker Hughes