

PanaFlow™ MV80 & MV82

Vortex Volumetric and Mass Flowmeters

User's Manual



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CUSTOMER NOTICE FOR OXYGEN SERVICE! Unless you have specifically ordered optional O₂ cleaning, this flow meter may not be fit for oxygen service. Some models can only be properly cleaned during the manufacturing process. GE Measurement & Control is not liable for any damage or personal injury, whatsoever, resulting from the use of the MV80 or MV 82 standard mass flow meters for oxygen gas.

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. The safety of any system incorporating the equipment is the responsibility of the assembler of the system.

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.

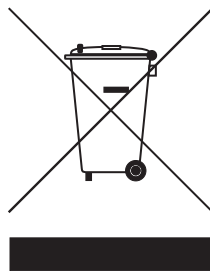
Unauthorized Operation

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

Environmental Compliance

Waste Electrical and Electronic Equipment (WEEE) Directive

GE Measurement & Control 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.

Visit www.gemeasurement.com/environmental-health-safety-ehs for take-back instructions and more information about this initiative.

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Appendix D. Glossary

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Chapter 1. Introduction

1.1 Multi-Parameter Vortex Mass Flowmeters

The GE PanaFlow™ MV80 & MV82 Vortex Flowmeters provide a reliable solution for process flow measurement. From a single entry point in the pipeline, MV80 & MV82 meters offer precise measurements of mass or volumetric flow rates.

1.1.1 Multi-Parameter Mass Flowmeters

Mass flowmeters utilize three primary sensing elements: a vortex shedding velocity sensor, an RTD temperature sensor and a solid state pressure sensor to measure the mass flow rate of gases, liquids, and steam.

Meters are available as loop powered devices or with up to three 4-20 mA analog output signals for monitoring your choice of the five process variables (mass flow, volumetric flow, temperature, pressure and fluid density). The Energy Monitoring option permits real-time calculation of energy consumption for a facility or process.

1.1.2 Volumetric Flowmeters

The primary sensing element of a volumetric flowmeter is a vortex shedding velocity sensor. The analog 4-20 mA output signal offers your choice of volumetric or mass flow rate. Mass flow rate is based on a constant value for fluid density stored in the instrument's memory.

Both the mass and volumetric flowmeters can be ordered with a local keypad/display which provides instantaneous flow rate, total, and process parameters in engineering units. A pulse output signal for remote totalization and MODBUS, BACNET or HART communications are also available. PanaFlow digital electronics allows for easy reconfiguration for most gases, liquids and steam. The PanaFlow MV80 & MV82 Meters' simple installation combines with an easy-to-use interface that provides quick set up, long term reliability and accurate mass flow measurement over a wide range of flows, pressures and temperatures.

1.1.3 Using This Manual

This manual discusses how to install and operate both the MV80 In-Line and MV82 Insertion Flow Meters:

- Chapter 1 includes an introduction and product description
- Chapter 2 provides information needed for installation
- Chapter 3 describes system operation and programming
- Chapter 4 provides information on HART and MODBUS protocols
- Chapter 5 covers troubleshooting and repair
- Appendix A lists the product specifications
- Appendix B shows current agency approvals
- Appendix C Discusses flow meter calculations
- Appendix D lists a glossary of terms

1.2 How the PanaFlow Vortex Mass Flowmeter Operates

PanaFlow MV80 and MV82 Mass Flowmeters (see *Figure 1* below) use a unique sensor head to monitor mass flow rate by directly measuring three variables—fluid velocity, temperature and pressure. The built-in flow computer calculates the mass flow rate and volumetric flow rate based on these three direct measurements. The velocity, temperature and pressure sensing head is built into the vortex meter's flow body. To measure fluid velocity, the flowmeter incorporates a bluff body (shedder bar) in the flow stream and measures the frequency of vortices created by the shedder bar. Temperature is measured using a platinum resistance temperature detector (PRTD). Pressure measurement is achieved using a solid-state pressure transducer. All three elements are combined into an integrated sensor head assembly located downstream of the shedder bar within the flow body.

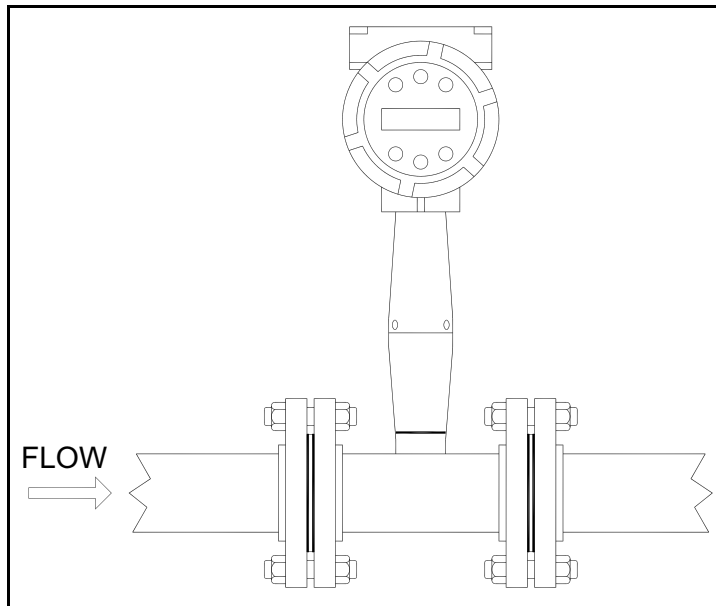


Figure 1: In-Line Vortex Multi-Parameter Mass Flowmeter

1.3 Velocity Measurement

The PanaFlow vortex velocity sensor is a patented mechanical design that minimizes the effects of pipeline vibration and pump noise, both of which are common error sources in flow measurement with vortex flowmeters. The velocity measurement is based on the well-known Von Karman vortex shedding phenomenon. Vortices are shed from a shedder bar, and the vortex velocity sensor located downstream of the shedder bar senses the passage of these vortices. This method of velocity measurement has many advantages including inherent linearity, high turndown, reliability and simplicity.

1.3.1 Vortex Shedding Frequency

Von Karman vortices form downstream of a shedder bar into two distinct wakes. The vortices of one wake rotate clockwise while those of the other wake rotate counterclockwise. Vortices generate one at a time, alternating from the left side to the right side of the shedder bar. Vortices interact with their surrounding space by over-powering every other nearby swirl on the verge of development. Close to the shedder bar, the distance (or wave length) between vortices is always constant and measurable. Therefore, the volume encompassed by each vortex remains constant, as shown in *Figure 2* below. By sensing the number of vortices passing by the velocity sensor, the PanaFlow™ Flowmeter computes the total fluid volume.

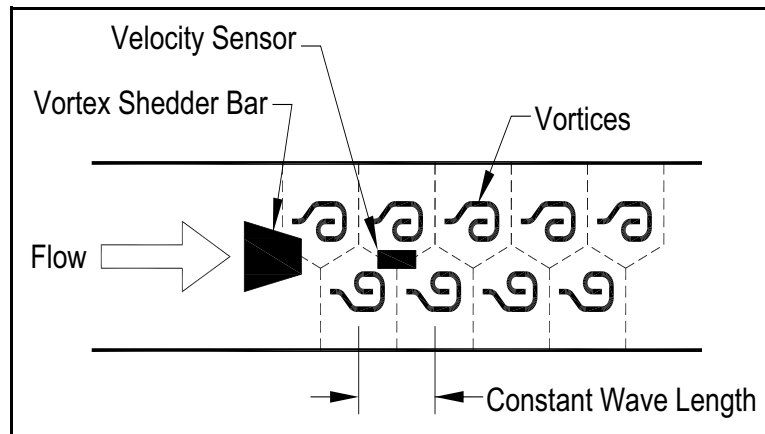


Figure 2: Measurement Principle of Vortex Flowmeters

1.3.2 Vortex Frequency Sensing

The velocity sensor incorporates a piezoelectric element that senses the vortex frequency. This element detects the alternating lift forces produced by the Von Karman vortices flowing downstream of the vortex shedder bar. The alternating electric charge generated by the piezoelectric element is processed by the transmitter's electronic circuit to obtain the vortex shedding frequency. The piezoelectric element is highly sensitive and operates over a wide range of flows, pressures and temperatures.

1.3.3 Flow Velocity Range

To ensure trouble-free operation, vortex flowmeters must be correctly sized so that the flow velocity range through the meter lies within the measurable velocity range (with acceptable pressure drop) and the linear range.

The measurable range is defined by the minimum and maximum velocity using *Table 1* below.

Table 1: Measurable Ranges

Parameter	Gas	Liquid	Units for ρ
V_{\min}	$\sqrt{\frac{25 \text{ ft/s}}{\rho}}$	1 ft/s	English ρ (lb/ft ³)
V_{\max}	300 ft/s	30 ft/s	
V_{\min}	$\sqrt{\frac{37 \text{ m/s}}{\rho}}$	0.3 m/s	Metric ρ (kg/m ³)
V_{\max}	91 m/s	9.1 m/s	

The pressure drop for series MV82 insertion meters is negligible. The pressure drop for series MV80 in-line meters is defined as:

$$\Delta P = .00024 \rho V^2 \quad \text{English units } (\Delta P \text{ in psi, } \rho \text{ in lb/ft}^3, V \text{ in ft/sec)}$$

$$\Delta P = .000011 \rho V^2 \quad \text{Metric units } (\Delta P \text{ in bar, } \rho \text{ in kg/m}^3, V \text{ in m/sec)}$$

The linear range is defined by the Reynolds number. The Reynolds number is the ratio of the inertial forces to the viscous forces in a flowing fluid and is defined as:

$$Re = \frac{\rho V D}{\mu}$$

Where,
 Re = Reynolds Number
 ρ = mass density of the fluid being measured
 V = velocity of the fluid being measured
 D = internal diameter of the flow channel
 μ = viscosity of the fluid being measured

The Strouhal number is the other dimensionless number that quantifies the vortex phenomenon. The Strouhal number is defined as:

$$St = \frac{f d}{V}$$

Where,
 St = Strouhal Number
 f = frequency of vortex shedding
 d = Shedder bar width
 V = fluid velocity

1.3.3 Flow Velocity Range (cont.)

As shown in *Figure 3* below, PanaFlow meters exhibit a constant Strouhal number across a large range of Reynolds numbers, indicating a consistent linear output over a wide range of flows and fluid types. Below this linear range, the intelligent electronics in PanaFlow automatically corrects for the variation in the Strouhal number with the Reynolds number. The meter's smart electronics corrects for this non-linearity via its simultaneous measurements of the process fluid temperature and pressure. This data is then used to calculate the Reynolds number in real time. PanaFlow meters automatically correct down to a Reynolds number of 5,000.

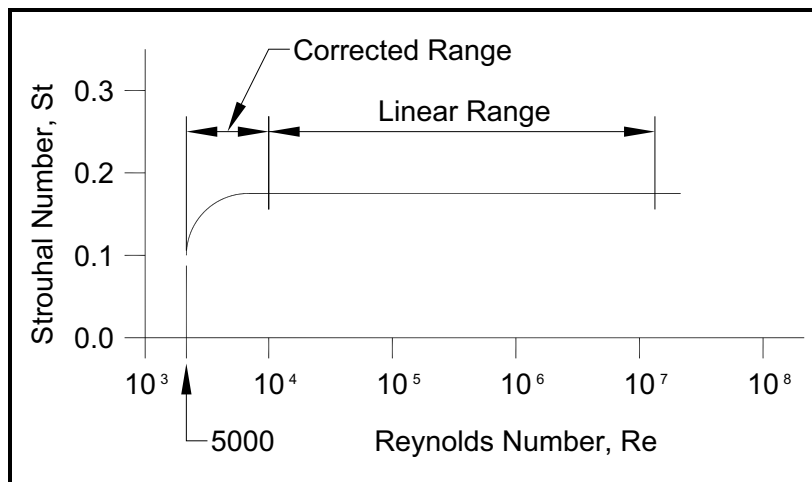


Figure 3: Reynolds Number Range for the PanaFlow MV

1.4 Temperature Measurement

PanaFlow Flowmeters use a 1000 ohm platinum resistance temperature detector (PRTD) to measure fluid temperature.

1.5 Pressure Measurement

PanaFlow Flowmeters incorporate a solid-state pressure transducer isolated by a 316 stainless steel diaphragm. The transducer itself is micro-machined silicon, fabricated using integrated circuit processing technology. A nine-point pressure/temperature calibration is performed on every sensor. Digital compensation allows these transducers to operate within a 0.3% of full scale accuracy band within the entire ambient temperature range of -40°F to 140°F (-40 to 60°C). Thermal isolation of the pressure transducer ensures the same accuracy across the allowable process fluid temperature range of -330°F to 750°F (-200 to 400°C).

1.6 Flowmeter Configurations

PanaFlow Vortex Mass Flowmeters are available in two model configurations:

- Series MV80 in-line flowmeter (replaces a section of the pipeline)
- Series MV82 insertion flowmeter (requires a “cold” tap or a “hot” tap into an existing pipeline)

Both the in-line and insertion configurations are similar in that they both use identical electronics and have similar sensor heads. Besides installation differences, the main difference between an in-line flowmeter and an insertion flowmeter is their method of measurement.

For an in-line vortex flowmeter, the shedder bar is located across the entire diameter of the flow body. Thus, the entire pipeline flow is included in the vortex formation and measurement. The sensing head, which directly measures velocity, temperature and pressure is located just downstream of the shedder bar.

Insertion vortex flowmeters have a shedder bar located across the diameter of a short tube. The velocity, temperature and pressure sensor are located within this tube just downstream of a built-in shedder bar. This entire assembly is called the insertion sensing head. It fits through any entry port with a 1.875 inch minimum internal diameter.

The sensing head of an insertion vortex flowmeter directly monitors the velocity at a point in the cross-sectional area of a pipe, duct, or stack (referred to as “channels”). The velocity at a point in the pipe varies as a function of the Reynolds number. The insertion vortex flowmeter computes the Reynolds number and then computes the total flow rate in the channel. The output signal of insertion meters is the total flow rate in the channel. The accuracy of the total flow rate computation depends on adherence to the piping installation requirements given in *Chapter 2*. If adherence to those guidelines cannot be met, contact GE for specific installation advice.

1.6.1 Multivariable Options

The MV80 or MV82 models are available with the following options:

- **V** = volumetric flowmeter
- **VT** = velocity and temperature sensors
- **VTP** = velocity, temperature, and pressure sensors
- **VT-EM** = energy output options
- **VTP-EM** = energy options with pressure
- **VT-EP** = external pressure transmitter input.

1.6.2 Line Size, Process Connections and Materials

The MV80 In-line model is built for line sizes ½ through 4 inch wafer or ½ through 8 inch flanged design using ANSI 150, 300, 600, PN16, 40, or 64 class flanges.

The MV82 Insertion model can be used in line sizes 2 inch and greater and is built with a compression fitting or packing gland design using 2 inch NPT, or 2 inch flanged connections (ANSI 150, 300, 600, PN16, 40, or 64 class flanges). The packing gland design can be ordered with a permanent or removable retractor.

The MV80 In-line model can be built with A105 carbon steel, 316L stainless steel, or Hastelloy C-276. The MV82 Insertion model can be built with 316L stainless steel or Hastelloy C-276.

1.6.3 Flowmeter Electronics

PanaFlow flowmeter electronics are available mounted directly to the flow body, or remotely mounted. The electronics housing may be used indoors or outdoors, including wet environments. Available input power options are: DC loop powered (2-wire), DC powered or AC powered. Three analog output signals are available for your choice of three of the five process variables: mass flow rate, volumetric flow rate, temperature, pressure or fluid density. A pulse output signal for remote totalization and MODBUS or HART communications are also available.

PanaFlow flowmeters include a local 2 x16 character LCD display housed within the enclosure. Local operation and reconfiguration is accomplished using six push buttons operated via finger touch. For hazardous locations, the six buttons can be operated with the electronics enclosure sealed using a hand-held magnet, thereby not compromising the integrity of the hazardous location certification.

The electronics include nonvolatile memory that stores all configuration information. The nonvolatile memory allows the flowmeter to function immediately upon power up, or after an interruption in power. All flowmeters are calibrated and configured for the customer's flow application.

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Chapter 2. Installation

2.1 Installation Overview

PanaFlow Vortex Flowmeter installations are simple and straightforward. Both the Series MV80 In-Line and Series MV82 Insertion type flowmeter installations are covered in this chapter. After reviewing the installation requirements given below, see page 11 for Series MV80 installation instructions. See “*Series MV82 Insertion Flowmeter Installation*” on page 15 for Series MV82 installation instructions. Wiring instructions begin in “*Loop Power Flowmeter Wiring Connections*” on page 32.

2.1.1 Flowmeter Installation Requirements



WARNING! Consult the flowmeter nameplate for specific flowmeter approvals before any hazardous location installation.

Before installing the flowmeter, verify that the installation site allows for these considerations:

1. Line pressure and temperature will not exceed the flowmeter rating.
2. The location meets the required minimum number of pipe diameters upstream and downstream of the sensor head as illustrated in *Figure 4 on page 10*.
3. Safe and convenient access with adequate overhead clearance for maintenance purposes.
4. Verify that the cable entry into the instrument meets the specific standard required for hazardous area installations.
5. For remote installations, verify the supplied cable length is sufficient to connect the flowmeter sensor to the remote electronics.

Also, before installation, check your flow system for anomalies such as:

- Leaks
- Valves or restrictions in the flow path which could create disturbances in the flow profile that might cause unexpected flow rate indications

2.1.2 Unobstructed Flow Requirements

Select an installation site that will minimize possible distortion in the flow profile. Valves, elbows, control valves and other piping components may cause flow disturbances. Check your specific piping condition against the examples shown in *Figure 4* below. In order to achieve accurate and repeatable performance install the flowmeter using the recommended number of straight run pipe diameters upstream and downstream of the sensor.

Note: For liquid applications in vertical pipes, avoid installing with flow in the downward direction because the pipe may not be full at all points. Choose to install the meter with flow in the upward direction if possible.

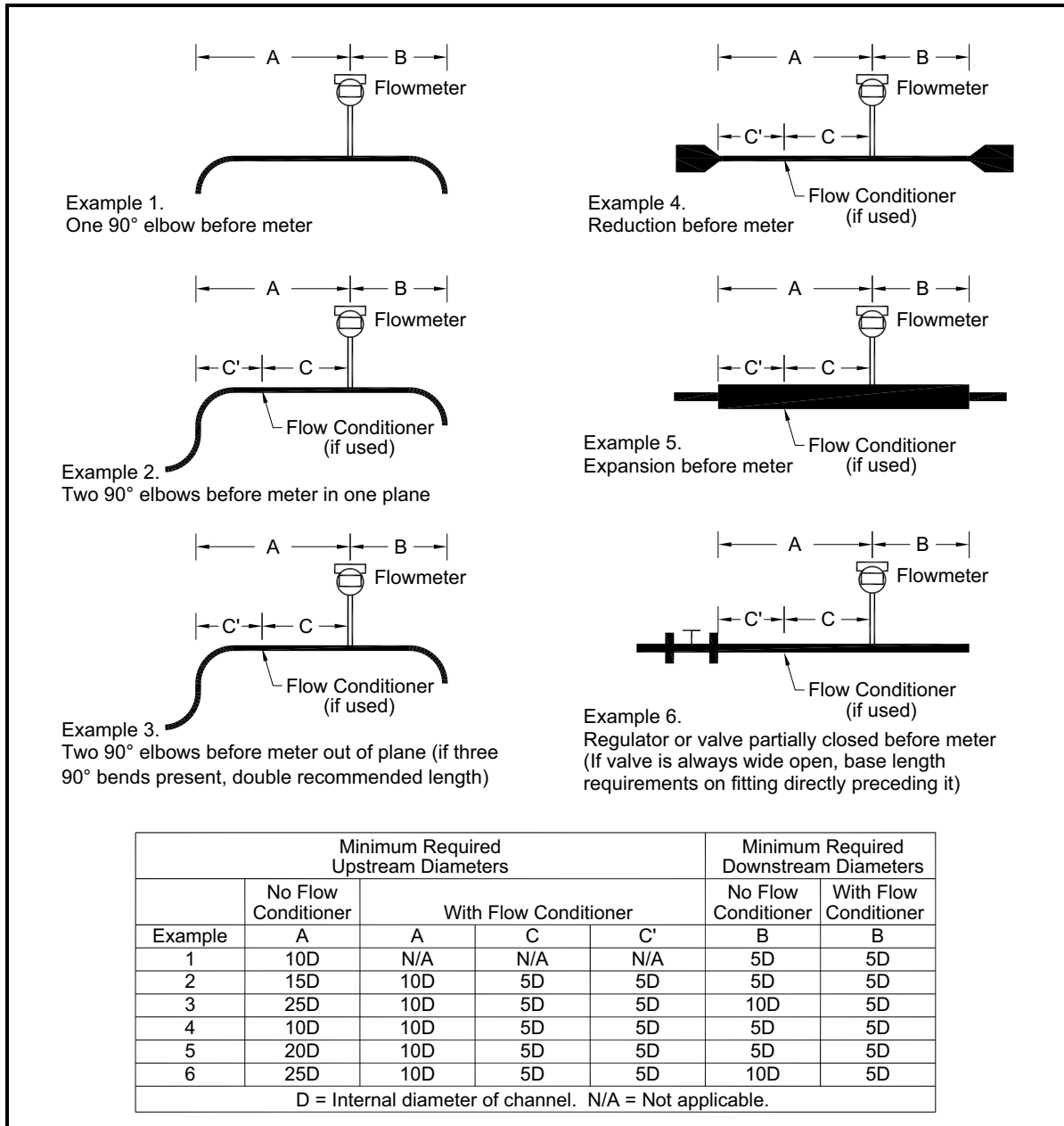


Figure 4: Recommended Pipe Length Requirements for Installation of Series MV80 & MV82

2.2 Series MV80 In-Line Flowmeter Installation

Install the Series MV80 In-Line Flowmeter between two conventional pipe flanges as shown in *Figure 6 on page 12* and *Figure 7 on page 14*. *Table 2* below provides the recommended minimum stud bolt lengths for wafer-style meter body size and different flange ratings.

The meter inside diameter is equal to the same size nominal pipe ID in schedule 80. For example, a 2" meter has an ID of 1.939" (2" schedule 80). Do not install the meter in a pipe with an inside diameter smaller than the inside diameter of the meter. For schedule 160 and higher pipe, a special meter is required. Consult GE before purchasing the meter.

Series MV80 Meters require customer-supplied gaskets. When selecting gasket material make sure that it is compatible with the process fluid and pressure ratings of the specific installation. Verify that the inside diameter of the gasket is larger than the inside diameter of the flowmeter and adjacent piping. If the gasket material extends into the flow stream, it will disturb the flow and cause inaccurate measurements.

2.2.1 Flange Bolt Specifications

Table 2: Minimum Recommended Stud Bolt Lengths for Wafer Meters

Stud Bolt Lengths for Each Flange Rating (inches)			
Line Size	Class 150 and PN16	Class 300 and PN40	Class 600 and PN64
1 inch	6.00	7.00	7.50
1.5 inch	6.25	8.50	9.00
2 inch	8.50	8.75	9.50
3 inch	9.00	10.00	10.50
4 inch	9.50	10.75	12.25

The required bolt load for sealing the gasket joint is affected by several application-dependent factors. Therefore the required torque for each application may be different. Refer to the ASME Pressure Vessel Code guidelines for bolt tightening standards and refer to *Figure 5* below for the proper bolt tightening sequence.

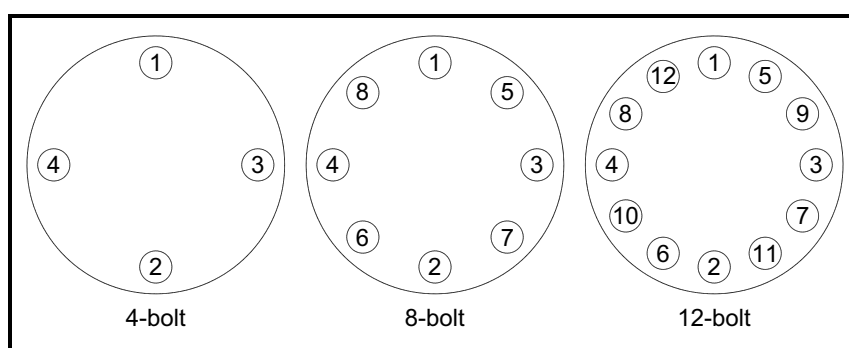


Figure 5: Flange Bolt Torquing Sequence

2.2.2 Installing Wafer-Style Flowmeters

Install the wafer-style meter between two conventional pipe flanges of the same nominal size as the flowmeter (see *Figure 6* below). If the process fluid is a liquid, make sure the meter is located where the pipe is always full. This may require locating the meter at a low point in the piping system.

Note: *Vortex flowmeters are not suitable for two-phase flows, such as liquid and gas mixtures.*

For horizontal pipelines having a process temperature above 300° F, mount the meter at a 45 or 90-degree angle to avoid overheating the electronics enclosure. To adjust the viewing angle of the enclosure or display/keypad, see “*Display/Keypad Adjustment (All Meters)*” on page 30 and “*Enclosure Adjustment (Series MV80 Only)*” on page 31.

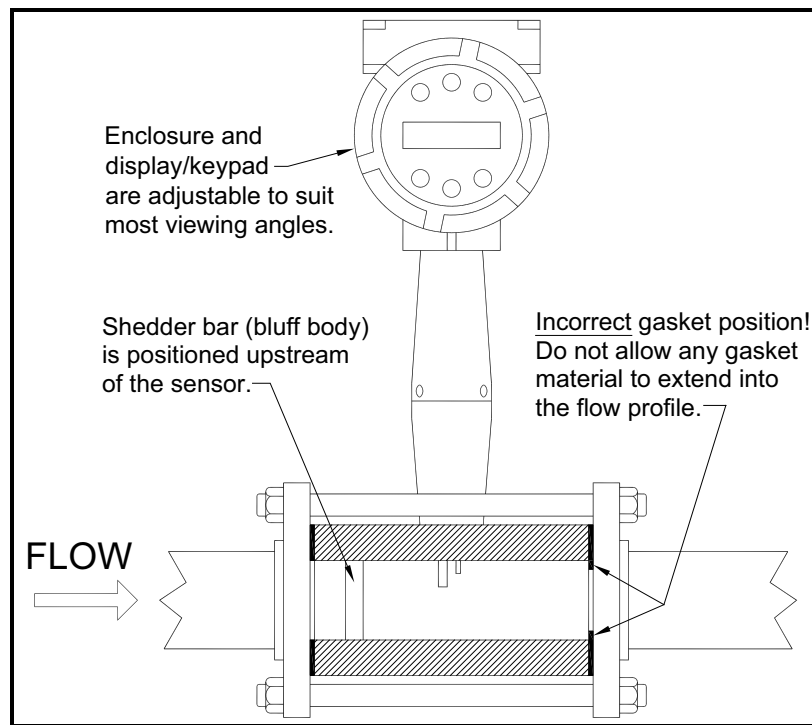


Figure 6: Wafer-Style Flowmeter Installation



CAUTION! When using toxic or corrosive gases, purge the line with inert gas for a minimum of four hours at full gas flow before installing the flowmeter.

When installing the meter make sure the section marked with a flow arrow is positioned upstream of the outlet, with the arrow head pointing in the direction of flow. (The mark is on the wafer adjacent to the enclosure mounting neck.) This ensures that the sensor head is positioned downstream of the vortex shedder bar and is correctly aligned to the flow. Installing the meter opposite this direction will result in completely inaccurate flow measurement.

2.2.2 Installing Wafer-Style Flowmeters (cont.)

To install the meter, complete the following steps:

1. Turn off the flow of process gas, liquid or steam. Verify that the line is not pressurized. Confirm that the installation site meets the required minimum upstream and downstream pipe diameters.
2. Insert the studs for the bottom side of the meter body between the pipe flanges. Place the wafer-style meter body between the flanges with the end stamped with a flow arrow on the upstream side, with the arrow head pointing in the direction of flow. Center the meter body inside the diameter with respect to the inside diameter of the adjoining piping.
3. Position the gasket material between the mating surfaces. Make sure both gaskets are smooth and even with no gasket material extending into the flow profile. Obstructions in the pipeline will disturb the flow and cause inaccurate measurements.
4. Place the remaining studs between the pipe flanges. Tighten the nuts in the sequence shown in *Figure 5 on page 11*. Check for leaks after tightening the flange bolts.

2.2.3 Installing Flange-Style Flowmeters

Install the flange-style meter between two conventional pipe flanges of the same nominal size as the flowmeter (see *Figure 7* below). If the process fluid is a liquid, make sure the meter is located where the pipe is always full. This may require locating the meter at a low point in the piping system.

Note: *Vortex flowmeters are not suitable for two-phase flows, such as liquid and gas mixtures.*

For horizontal pipelines having a process temperature above 300° F, mount the meter at a 45 or 90-degree angle to avoid overheating the electronics enclosure. To adjust the viewing angle of the enclosure or display/keypad, see “*Display/Keypad Adjustment (All Meters)*” on page 30 and “*Enclosure Adjustment (Series MV80 Only)*” on page 31.

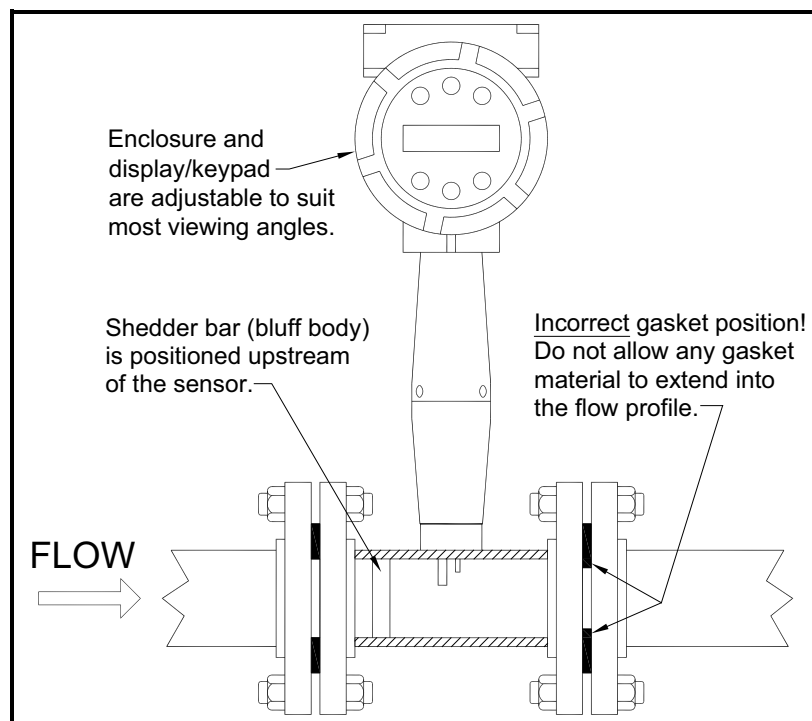


Figure 7: Flange-Style Flowmeter Installation



CAUTION! When using toxic or corrosive gases, purge the line with inert gas for a minimum of four hours at full gas flow before installing the flowmeter.

When installing the meter make sure the flange marked with a flow arrow is positioned upstream of the outlet flange, with the arrow head pointing in the direction of flow. The mark is on the flange adjacent to the enclosure mounting neck. This ensures that the sensor head is positioned downstream of the vortex shedder bar and is correctly aligned to the flow. Installing the meter opposite this direction will result in completely inaccurate flow measurement.

2.2.3 Installing Flange-Style Flowmeters (cont.)

To install the meter, complete the following steps:

1. Turn off the flow of process gas, liquid or steam. Verify that the line is not pressurized. Confirm that the installation site meets the required minimum upstream and downstream pipe diameters.
2. Seat the meter level and square on the mating connections with the flange stamped with a flow arrow on the upstream side, with the arrow head pointing in the direction of flow. Position a gasket in place for each side. Make sure both gaskets are smooth and even with no gasket material extending into the flow profile. Obstructions in the pipeline will disturb the flow and cause inaccurate measurements.
3. Install bolts in both process connections. Tighten the nuts in the sequence shown in *Figure 5 on page 11*. Check for leaks after tightening the flange bolts.

2.3 Series MV82 Insertion Flowmeter Installation

2.3.1 General Installation Guidelines

Prepare the pipeline for installation using either a cold tap or hot tap method described in this section. Refer to a standard code for all pipe tapping operations. The following tapping instructions are general in nature and intended for guideline purposes only. Before installing the meter, review the mounting position and isolation valve requirements given in the following sub-sections.

2.3.1a Electronics Enclosure Clearance

Allow clearance between the electronics enclosure top and any obstruction when the meter is fully retracted.

2.3.1b Isolation Valve Selection

An isolation valve is available as an option with Series MV82 meters. If you supply the isolation valve, refer to *Figure 8* below and verify that it meets the following requirements:

1. A minimum valve bore diameter of 1.875 inches is required, and the valve's body size should be two inches. Normally, gate valves are used.
2. Verify that the valve's body and flange rating are within the flowmeter's maximum operating pressure and temperature.
3. Choose an isolation valve with at least a two inch distance between the flange face and the gate portion of the valve. This ensures that the flowmeter's sensor head will not interfere with the operation of the isolation valve.

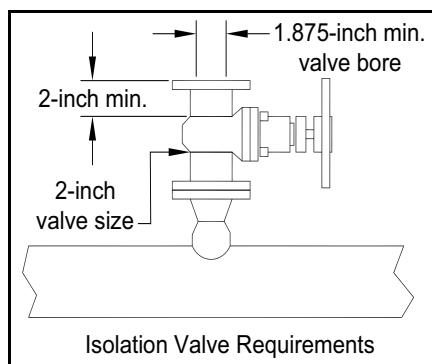


Figure 8: Isolation Valve Dimensions

2.3.1c Cold Tap Guidelines

Refer to a standard code for all pipe tapping operations. The following tapping instructions are general in nature and intended for guideline purposes only. Proceed as follows:



CAUTION! When using toxic or corrosive gases, purge the line with inert gas for a minimum of four hours at full gas flow before installing the flowmeter.

1. Turn off the flow of process gas, liquid or steam. Verify that the line is not pressurized.
2. Confirm that the installation site meets the minimum upstream and downstream pipe diameter requirements. See *Figure 4 on page 10*.
3. Use a cutting torch or sharp cutting tool to tap into the pipe. The pipe opening must be at least 1.875 inches in diameter. (Do not attempt to insert the sensor probe through a smaller hole.)
4. Remove all burrs from the tap. Rough edges may cause flow profile distortions that could affect flowmeter accuracy. Also, obstructions could damage the sensor assembly when inserting into the pipe.



WARNING! All flowmeter connections, isolation valves and fittings for cold tapping must have the same or higher pressure rating as the main pipeline.

5. After cutting, measure the thickness of the cut-out and record this number for calculating the insertion depth.
6. Weld the flowmeter pipe connection on the pipe. Make sure this connection is within $\pm 5^\circ$ perpendicular to the pipe centerline (see *Figure 9* below).

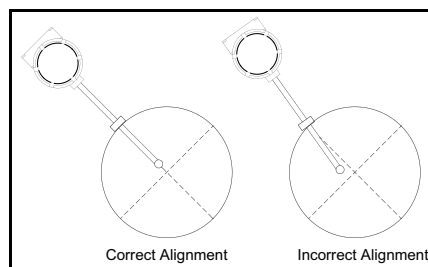


Figure 9: Connection Alignment

7. Install the isolation valve (if used).
8. When welding is complete and all fittings are installed, close the isolation valve or cap the line. Run a static pressure check on the welds. If pressure loss or leaks are detected, repair the joint and retest.
9. Connect the meter to the pipe process connection.
10. Calculate the sensor probe insertion depth and insert the sensor probe into the pipe as described on the following pages.

2.3.1d Hot Tap Guidelines



WARNING! Hot tapping must be performed by a trained professional. US. regulations often require a hot tap permit. The manufacturer of the hot tap equipment and/or the contractor performing the hot tap is responsible for providing proof of such a permit.



WARNING! All flowmeter connections, isolation valves, and fittings for hot tapping must have the same pressure rating as the main pipeline or higher.

Refer to a standard code for all pipe tapping operations. The following tapping instructions and *Figure 10* below are general in nature and are intended for guideline purposes only.

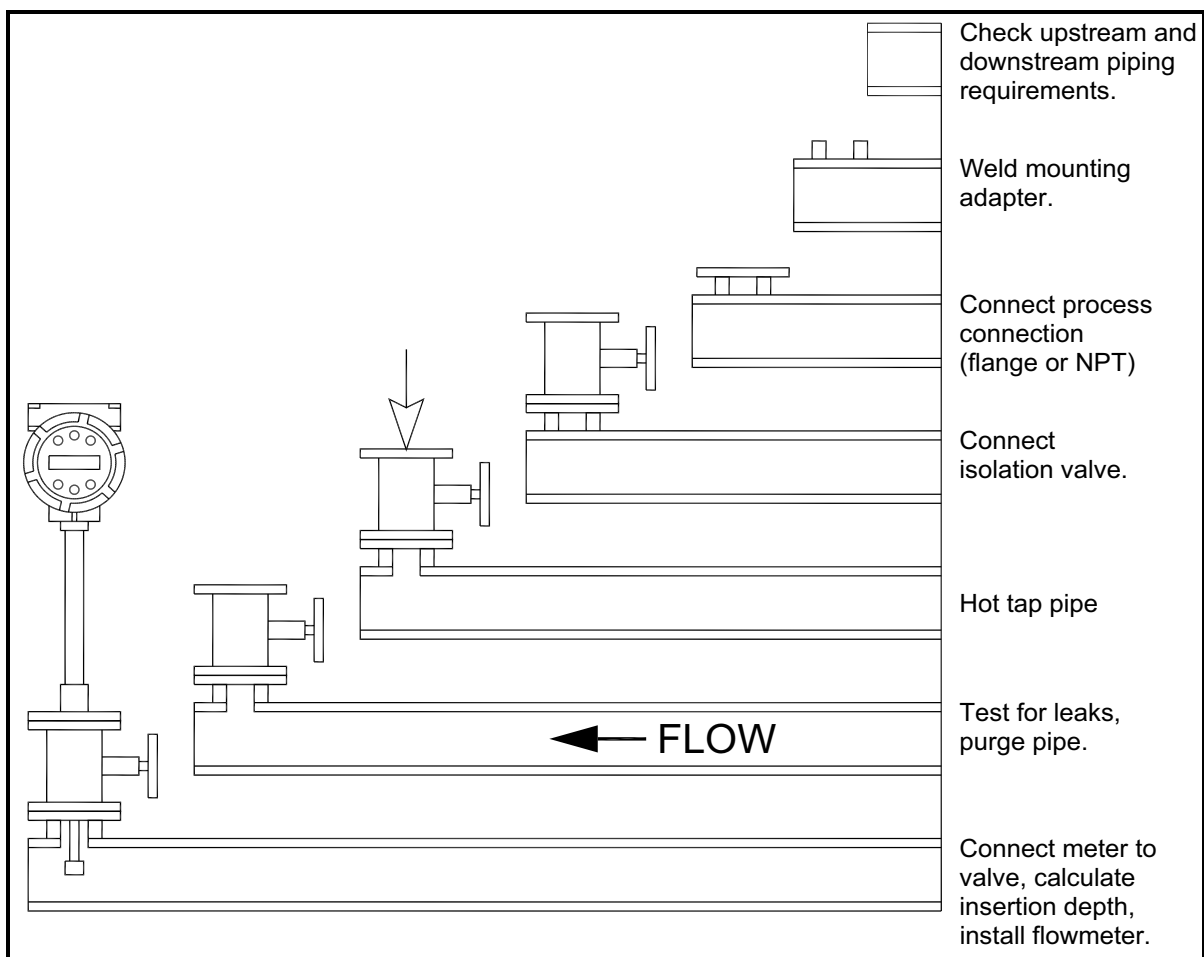


Figure 10: Hot Tap Sequence

2.3.1d Hot Tap Guidelines (cont.)

Proceed as follows:

1. Confirm that the installation site meets the minimum upstream and downstream pipe diameter requirements.
2. Weld a two inch mounting adapter on the pipe. Make sure the mounting adapter is within $\pm 5^\circ$ perpendicular to the pipe centerline (see *Figure 9 on page 16*). The pipe opening must be at least 1.875 inches in diameter.
3. Connect a two inch process connection on the mounting adapter.
4. Connect an isolation valve on the process connection. The valve's full open bore must be at least 1.875 inches in diameter.
5. Run a static pressure check on the welds. If pressure loss or leaks are detected, repair the joint and re-test.
6. Connect the hot tapping equipment to the isolation valve, open the isolation valve and drill at least a 1.875 inch diameter hole.
7. Retract the drill, close the isolation valve, and remove the hot tapping equipment.
8. Connect the flowmeter to the isolation valve and open the isolation valve.
9. Calculate the sensor probe insertion depth and insert the sensor probe into the pipe as described on the following pages.

2.3.1e Insertion Guidelines

The sensor head must be properly positioned in the pipe. For this reason, it is important that insertion length calculations are carefully followed. A sensor probe inserted at the wrong depth in the pipe will result in inaccurate readings.

Insertion flowmeters are applicable to pipes 2 inch and larger. For pipe sizes ten inches and smaller, the centerline of the meter's sensing head is located at the pipe's centerline. For pipe sizes larger than ten inches, the centerline of the sensing head is located in the pipe's cross section five inches from the inner wall of the pipe. That is, its “wetted” depth from the wall to the centerline of the sensing head is five inches.

Insertion flowmeters are available in three probe lengths:

- *Standard Probe* configuration is used with most flowmeter process connections. The length (**S**) of the stem is 29.47 inches.
- *Compact Probe* configuration is used with compression fitting process connections. The length (**S**) of the stem is 13.1 inches.
- *12-Inch Extended Probe* configuration is used with exceptionally lengthy flowmeter process connections. The length (**S**) of the stem is 41.47 inches.

2.3.1f Selecting the Correct Insertion Formula



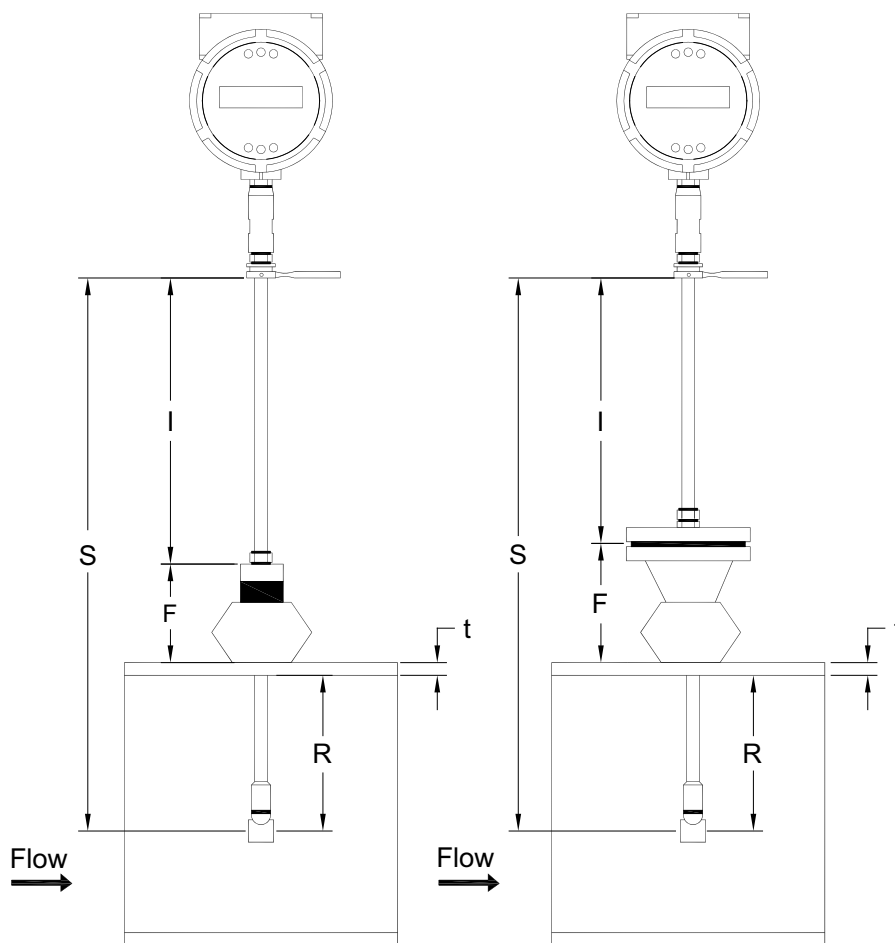
WARNING! An insertion tool must be used for any installation where a flowmeter is inserted under pressure greater than 50 psig.

Depending on your flowmeter's process connection, use the applicable insertion length formula and installation procedure as follows:

- For flowmeters with a compression type connection (NPT or flanged), follow the instructions beginning in “*Installing Flowmeters with a Compression Connection*” on page 20.
- For flowmeters with a packing gland type connection (NPT or flanged), configured with an insertion tool, follow the instructions in “*Installing Flowmeters with a Packing Gland Connection*” on page 23.
- For flowmeters with a packing gland type connection (NPT or flanged), configured without an insertion tool, follow the instructions in “*Installing Flowmeters with a Packing Gland Connection (No Insertion Tool)*” on page 28.

2.3.2 Installing Flowmeters with a Compression Connection

Refer to *Figure 11* below, and use the formula shown to determine insertion length for flowmeters (NPT and flanged) with a compression process connection.



Insertion Length Formula

$$I = S - F - R - t$$

Where:

I = Insertion Length.

S = Stem length - the distance from the center of the sensor head to the base of the enclosure adapter
(S = 29.47" for standard probes; S = 13.1" for compact; S = 41.47" for 12-inch extended).

F = Distance from the raised face of the flange or top of NPT stem housing to the outside of the pipe wall.

R = Pipe inside diameter + 2 for pipes ten inches and smaller.

R = Five inches for pipe diameters larger than ten inches

t = Thickness of the pipe wall. (Measure the disk cut-out from the tapping procedure or check a piping handbook for thickness.)

Figure 11: Insertion Calculation (Compression Type)

2.3.2 Installing Flowmeters with a Compression Connection (cont.)

Example:

To install a Series MV82 meter with a standard probe ($S = 29.47$ inches) into a 14 inch schedule 40 pipe, the following measurements (in inches) are taken:

- $F = 3$ inches
- $R = 5$ inches
- $t = 0.438$ inches

Then, using the formula given in *Figure 11 on page 20*, the insertion length for this example is 21.03 inches. Insert the stem through the fitting until an insertion length of 21.03 inches is measured with a ruler.

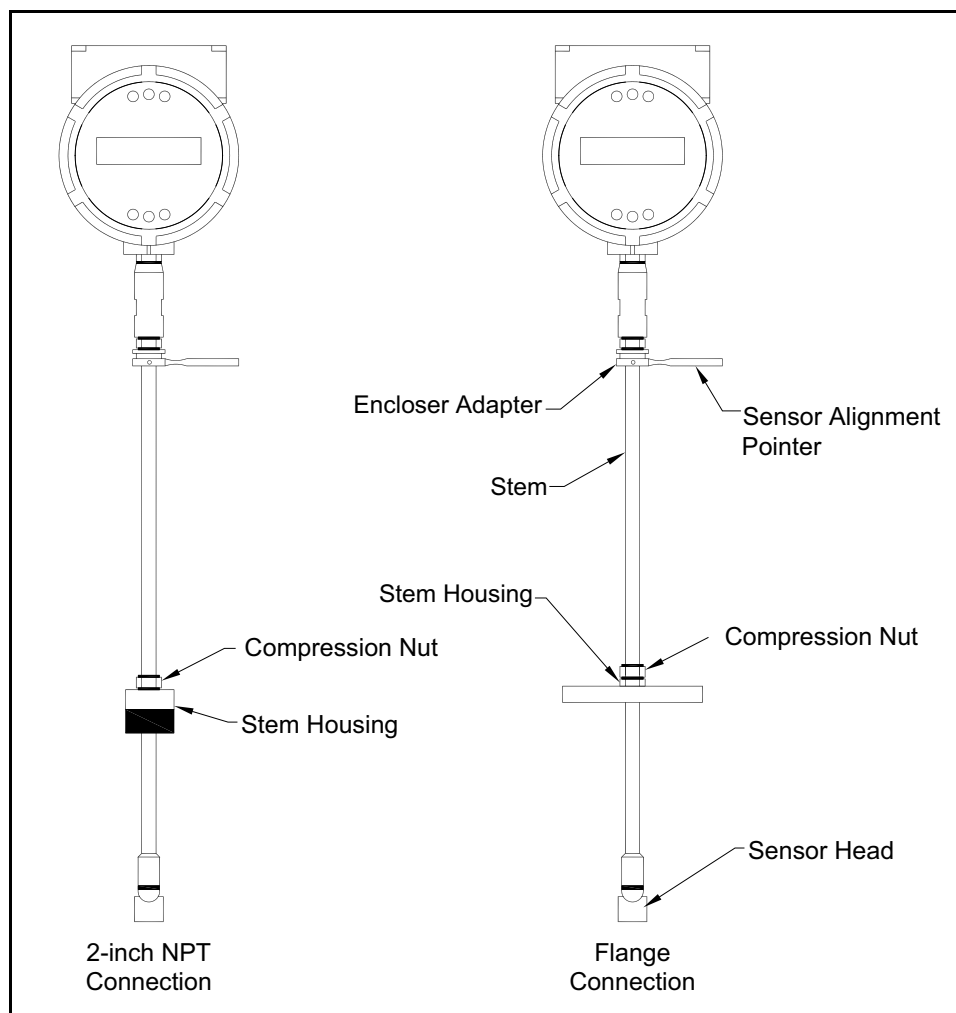


Figure 12: Flowmeter with a Compression Type Fitting

2.3.2 Installing Flowmeters with a Compression Connection (cont.)



CAUTION! The sensor alignment pointer must point downstream, in the direction of flow.



WARNING! To avoid serious injury, DO NOT loosen the compression fitting under pressure.

Refer to *Figure 12 on page 21* and complete the following steps:

1. Refer to *Figure 11 on page 20* and calculate the required sensor probe insertion length for your system.
2. Fully retract the stem until the sensor head is touching the bottom of the stem housing. Slightly tighten the compression nut to prevent slippage.
3. Bolt or screw the flowmeter assembly into the process connection. Use PTFE tape or pipe sealant to improve the seal and prevent seizing on NPT styles.
4. Hold the meter securely while loosening the compression fitting. Insert the sensor into the pipe until the calculated insertion length (I) is measured between the base of the enclosure adapter and the top of the stem housing, or to the raised face of the flanged version. Do not force the stem into the pipe.
5. Align the sensor head using the sensor alignment pointer. Adjust the alignment pointer parallel to the pipe and pointing downstream.
6. Tighten the compression fitting to lock the stem in position.

IMPORTANT: *After the compression fitting is tightened, the position is permanent.*

2.3.3 Installing Flowmeters with a Packing Gland Connection

Use the formula in *Figure 13* below to determine the insertion depth for flowmeters (NPT and flanged) equipped with an insertion tool. To install, see “*Insertion Procedure for Flowmeters with Permanent Insertion Tool*” on page 24 for instructions for meters with a permanent insertion tool. For meters with a removable insertion tool, see “*Insertion Procedure for Flowmeters with Removable Insertion Tool*” on page 26.

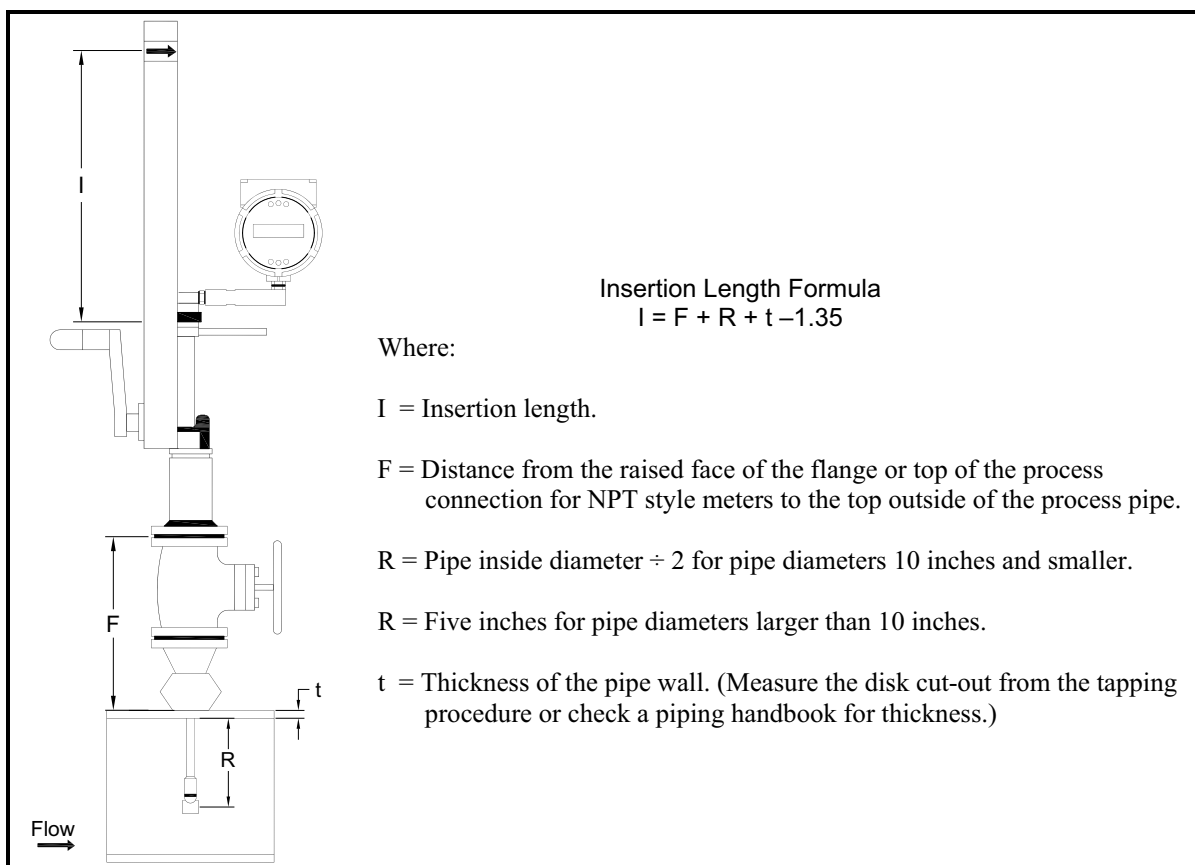


Figure 13: Insertion Length Calculation for Meters with an Insertion Tool

Example 1 - Flange Style Meters:

To install a Series MV82 Flowmeter into a 14 inch schedule 40 pipe, the following measurements are taken:

- F = 12 inches
- R = 5 inches
- t = 0.438 inches

Then, using the formula given in *Figure 13* above, the insertion length for this example is 16.09 inches.

2.3.3 Installing Flowmeters with a Packing Gland Connection (cont.)

Example 2 - NPT Style Meters:

In this example, the length of thread engagement on the NPT style meters must also be subtracted in the equation shown in *Figure 13 on page 23*. The length of the threaded portion of the NPT meter is 1.18 inches. Measure the threaded portion still visible after the installation and subtract that amount from 1.18 inches. This gives you the thread engagement length. If this cannot be measured, use 0.55 inch for this amount.

- $F = 12$ inches
- $R = 5$ inches
- $t = 0.438$ inches
- thread engagement = 1.18 inches - visible thread length (or 0.55 inches nominal value)

For this example, the equation yields an insertion length of 15.54 inches.

2.3.4 Insertion Procedure for Flowmeters with Permanent Insertion Tool

Refer to *Figure 14* below, and follow the instructions on the next page.

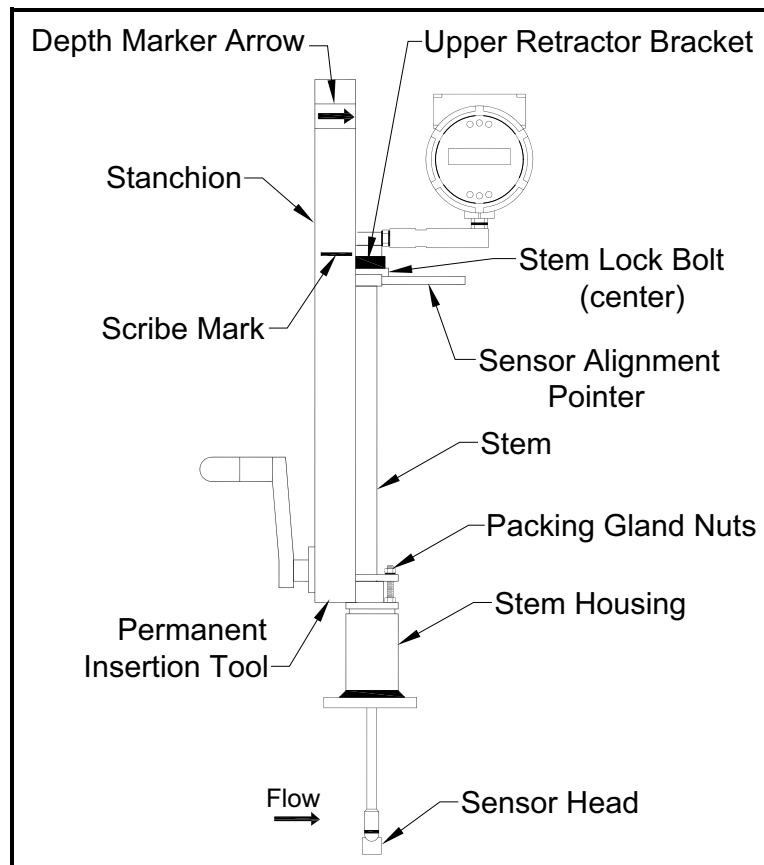


Figure 14: Flowmeter with Permanent Insertion Tool

2.3.4 Insertion Procedure for Flowmeters with Permanent Insertion Tool (cont.)



CAUTION! The sensor alignment pointer must point downstream, in the direction of flow.

Note: *If line pressure is above 500 psig, it could require up to 25 ft-lb of torque to insert the flowmeter. Do not confuse this with possible interference in the pipe.*

1. Calculate the required sensor probe insertion length (see **Example 1** on *page 23*). Measure from the depth marker arrow down the stanchion and scribe a mark at the calculated insertion depth.
2. Fully retract the flowmeter until the sensor head is touching the bottom of the stem housing. Attach the meter assembly to the two inch full-port isolation valve, if used. Use PTFE tape or pipe sealant to improve the seal and prevent seizing on NPT style meters.
3. Loosen the two packing gland nuts on the stem housing of the meter. Loosen the stem lock bolt adjacent to the sensor alignment pointer. Align the sensor head using the sensor alignment pointer. Adjust the alignment pointer parallel to the pipe and pointing downstream. Tighten the stem lock bolt to secure the sensor position.
4. Slowly open the isolation valve to the full open position. If necessary, slightly tighten the two packing gland nuts to reduce the leakage around the stem.
5. Turn the insertion tool handle clockwise to insert the sensor head into the pipe. Continue until the top of the upper retractor bracket aligns with the insertion length position scribed on the stanchion. Do not force the stem into the pipe.
6. Tighten the packing gland nuts to stop leakage around the stem. Do not use a torque over 20 ft-lb.

2.3.5 Insertion Procedure for Flowmeters with Removable Insertion Tool

Refer to *Figure 15* below, and follow the instructions on the next page.

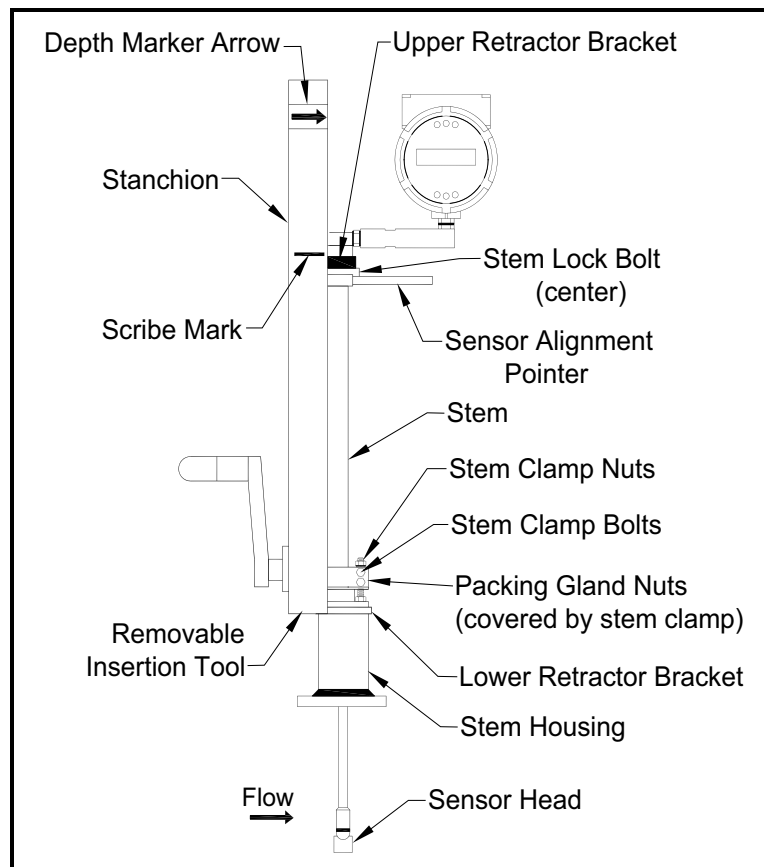


Figure 15: Flowmeter with Removable Insertion Tool

2.3.5 Insertion Procedure for Flowmeters with Removable Insertion Tool (cont.)



CAUTION! The sensor alignment pointer must point downstream, in the direction of flow.

Note: *If line pressure is above 500 psig, it could require up to 25 ft-lb of torque to insert the flowmeter. Do not confuse this with possible interference in the pipe.*

1. Calculate the required sensor probe insertion length. Measure from the depth marker arrow down the stanchion and scribe a mark at the calculated insertion depth.
2. Fully retract the flowmeter until the sensor head is touching the bottom of the stem housing. Attach the meter assembly to the two inch full-port isolation valve, if used. Use PTFE tape or pipe sealant to improve the seal and prevent seizing on NPT style meters.
3. Remove the two top stem clamp nuts and loosen two stem clamp bolts. Slide the stem clamp away to expose the packing gland nuts.
4. Loosen the two packing gland nuts. Loosen the stem lock bolt adjacent to the sensor alignment pointer. Align the sensor head using the sensor alignment pointer. Adjust the alignment pointer parallel to the pipe and pointing downstream. Tighten the stem lock bolt to secure the sensor position.
5. Slowly open the isolation valve to the full open position. If necessary, slightly tighten the two packing gland nuts to reduce the leakage around the stem.
6. Turn the insertion tool handle clockwise to insert the stem into the pipe. Continue until the top of the upper retractor bracket lines up with the insertion length mark scribed on the stanchion. Do not force the stem into the pipe.
7. Tighten the packing gland nuts to stop leakage around the stem. Do not use a torque over 20 ft-lb.
8. Slide the stem clamp back into position, and torque stem clamp bolts to 15 ft-lb. Replace the stem clamp nuts and torque them to 10-15 ft-lb.
9. To separate the insertion tool from the flowmeter, remove the four socket head cap bolts securing the upper and lower retractor brackets. Then, remove the insertion tool.

2.3.6 Installing Flowmeters with a Packing Gland Connection (No Insertion Tool)

Use the formula in *Figure 16* below to determine the insertion depth for meters with a packing gland connection (NPT and flanged) without an insertion tool.

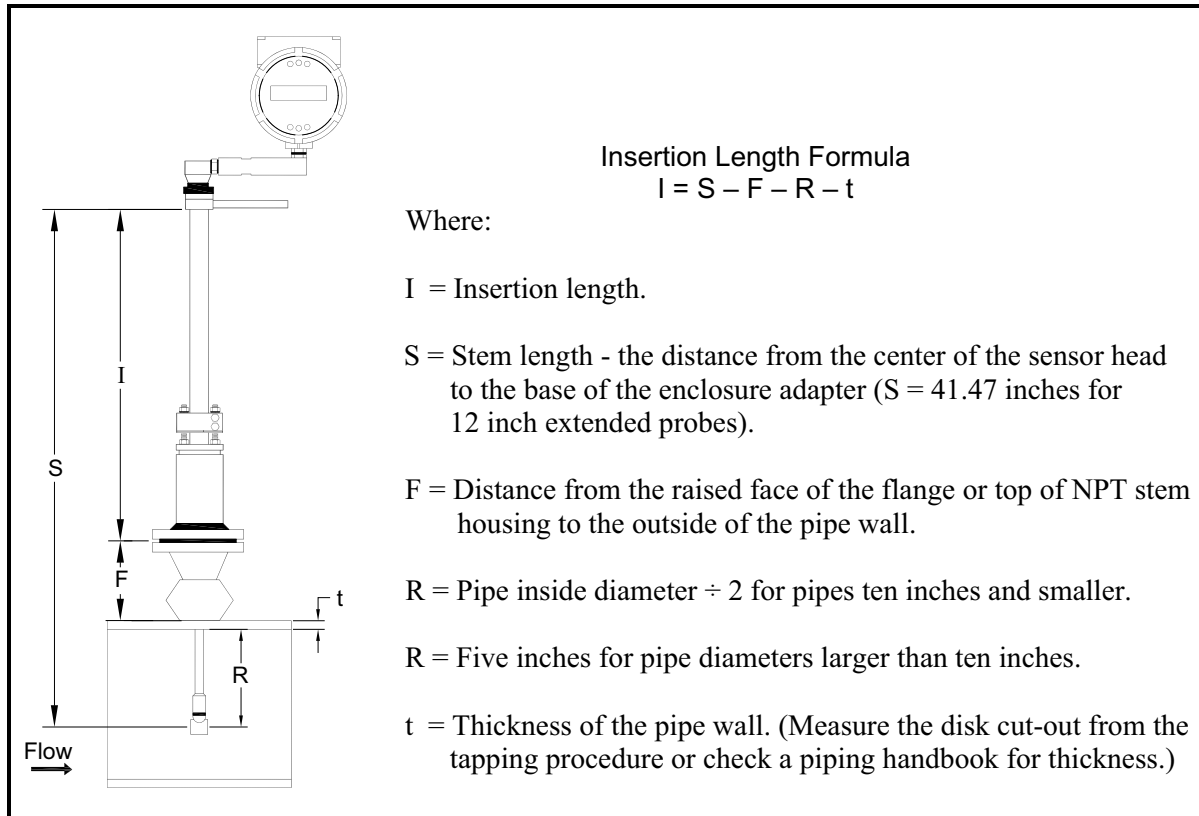


Figure 16: Insertion Calculation for Meters Without an Insertion Tool)

Example:

To install a Series MV82 Flowmeter with a standard probe ($S = 29.47$) into a 14 inch schedule 40 pipe, the following measurements are taken:

- $F = 3$ inches
- $R = 5$ inches
- $t = 0.438$ inches

For this example, the calculated insertion length is 21.03 inches.

2.3.6 Installing Flowmeters with a Packing Gland Connection (No Insertion Tool) (cont.)



WARNING! The line pressure must be less than 50 psig for installation.

To install the meter, complete the following steps:

1. Calculate the required sensor probe insertion length.
2. Fully retract the stem until the sensor head is touching the bottom of the stem housing. Remove the two top stem clamp nuts and loosen two stem clamp bolts. Slide the stem clamp away to expose the packing gland nuts. Loosen the two packing gland nuts.



CAUTION! The sensor alignment pointer must point downstream, in the direction of flow.

3. Align the sensor head using the sensor alignment pointer. Adjust the alignment pointer parallel to the pipe and pointing downstream.
4. Insert the sensor head into the pipe until the correct insertion length (I) is achieved. Do not force the stem into the pipe.
5. Tighten the packing gland nuts to stop leakage around the stem. Do not use a torque over 20 ft-lb.
6. Slide the stem clamp back into position, and torque the stem clamp bolts to 15 ft-lb. Replace the stem clamp nuts and torque them to 10-15 ft-lb.

2.4 Adjusting the Meter Orientation

Depending on installation requirements, you may need to adjust the meter orientation. There are two adjustments available. The first rotates the position of the LCD display/keypad and is available on both in-line and insertion meters. The second rotates the enclosure position. This adjustment is allowed only on Series MV80 in-line meters. Proceed to the next page for instructions

2.4.1 Display/Keypad Adjustment (All Meters)

To adjust the display/keypad position, refer to *Figure 17* below and complete the following steps:

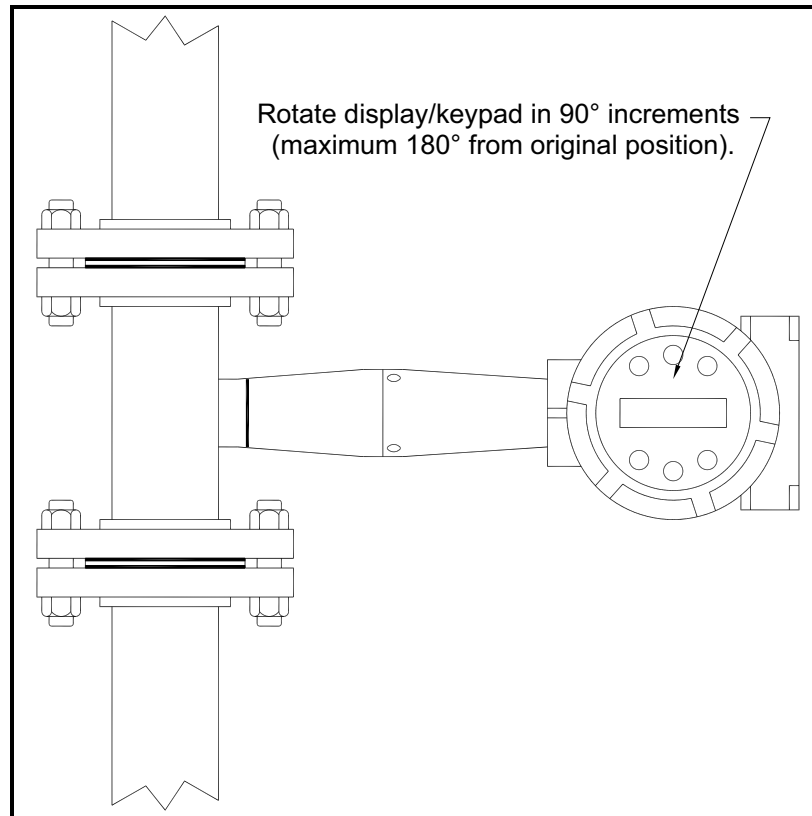


Figure 17: Display/Keypad Viewing Adjustment



CAUTION! The electronics boards are electrostatically sensitive. Wear a grounding wrist strap and make sure to observe proper handling precautions required for static-sensitive components.

1. Disconnect the power from the flowmeter.
2. Loosen the small set screw which secures the electronics enclosure cover. Unscrew and remove the cover.
3. Loosen the 4 captive screws.
4. Carefully pull the display/microprocessor circuit board away from the meter standoffs. Make sure not to damage the connected ribbon cable.
5. Rotate the display/microprocessor circuit board to the desired position. The maximum allowable rotation is two positions left or two positions right (180°).
6. Align the circuit board with the captive screws, and check that the ribbon cable is folded neatly behind the board with no twists or crimps.
7. Tighten the screws. Replace the cover and set screw, and restore power to the meter.

2.4.2 Enclosure Adjustment (Series MV80 Only)

To adjust the enclosure position, refer to *Figure 18* below and complete the following steps:

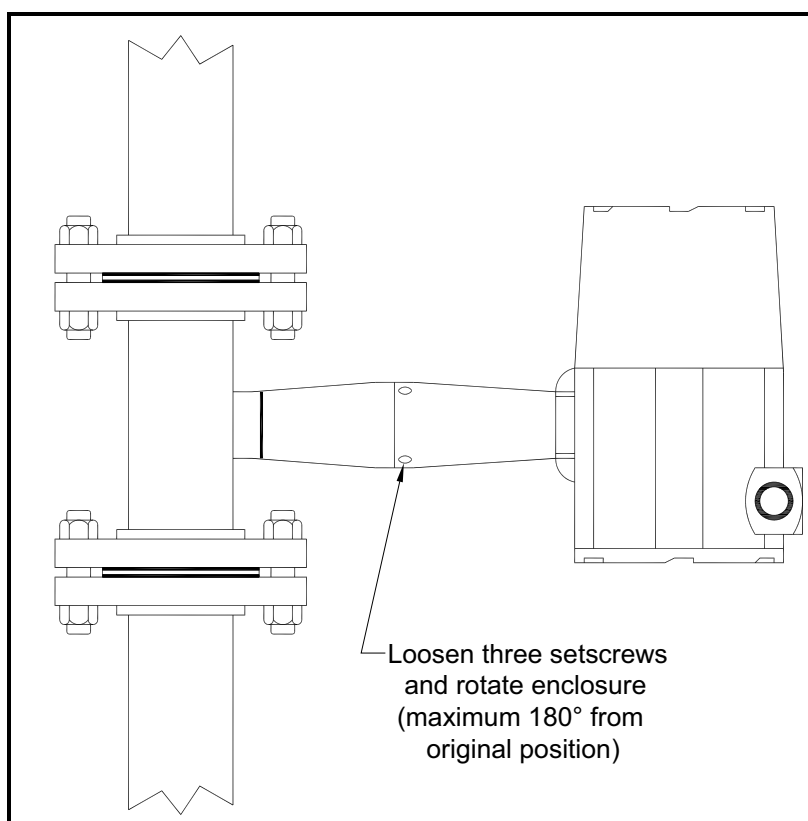


Figure 18: Enclosure Viewing Adjustment



CAUTION! To avoid damage to the sensor wires, do not rotate the enclosure beyond 180° from the original position.

1. Disconnect the power from the flowmeter.
2. Loosen the three set screws shown in *Figure 18* above, and rotate the display to the desired position. The maximum allowable rotation is 180°.
3. Tighten the three set screws, and restore power to the meter.

2.5 Loop Power Flowmeter Wiring Connections



WARNING! To avoid potential electric shock, follow National Electric Code safety practices or your local code when wiring this unit to a power source and to peripheral devices. Failure to do so could result in injury or death. All wiring procedures must be performed with the power off.

The Type 4X enclosure contains an integral wiring compartment with one dual strip terminal block located in the smaller end of the enclosure (see *Figure 19* below). Two 3/4-inch female NPT conduit entries are available for separate power and signal wiring. For all hazardous area installations, make sure to use an agency-approved fitting at each conduit entry. If conduit seals are used, they must be installed within 18 inches (457 mm) of the enclosure.

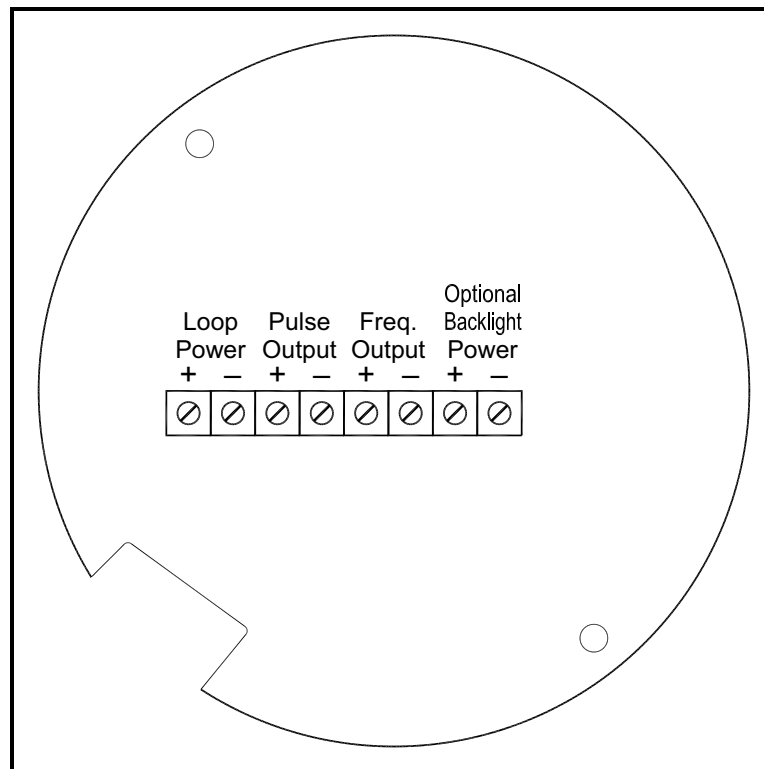


Figure 19: Loop Power Wiring Terminals

2.5.1 DC Input Power Connections

To access the wiring terminal blocks, locate and loosen the small set screw which locks the small enclosure cover in place. Then, unscrew the cover to expose the terminal block.

Connect 4-20 mA loop power (12 to 36 VDC at 25 mA, 1W max.) to the +PWR and -PWR terminals on the terminal block (see *Figure 20* below). Torque all connections to 4.43 to 5.31 in-lb (0.5 to 0.6 Nm). The DC power wire size must be 10 to 20 AWG with 1/4 inch (7 mm) of insulation stripped from each conductor.

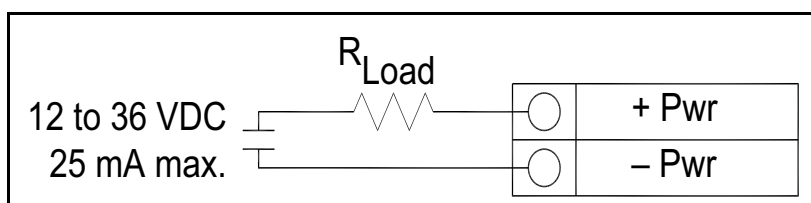


Figure 20: DC Power Connections

2.5.2 4-20 mA Output Connections

The standard PanaFlow meter has a single 4-20 mA loop, with the loop current is controlled by the meter electronics. The electronics must be wired in series with the sensor resistor or current meter (see *Figure 20* above). The current control electronics requires 12 volts at the input terminals to operate correctly.

The maximum loop resistance (load) for the current loop output is dependent upon the supply voltage and is given in *Figure 21* below. The 4-20 mA loop is optically isolated from the flowmeter electronics.

R_{load} is the total resistance in the loop, including the wiring resistance. That is, $R_{load} = R_{wire} + R_{sense}$. To calculate the maximum load resistance for the loop, subtract the minimum terminal voltage from the supply voltage and divide by the maximum loop current of 20 mA, as shown in the following equation:

$$R_{\max \text{ load}} = \frac{V_{\text{supply}} - 12V}{0.020A}$$

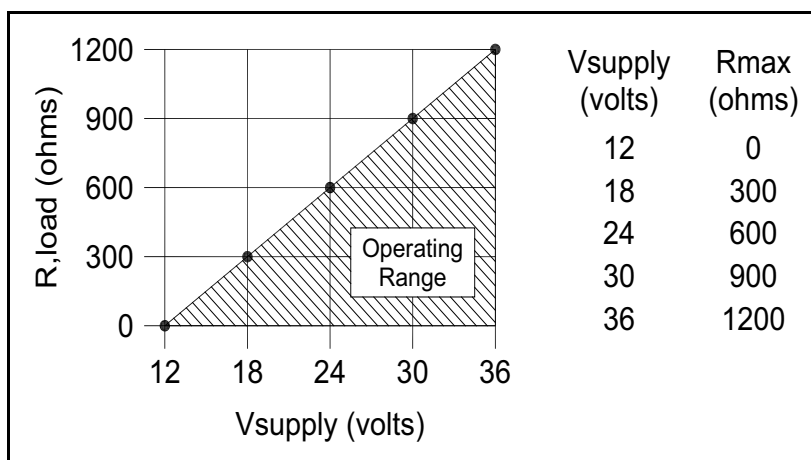


Figure 21: Load Resistance Versus Input Voltage

2.5.3 Pulse Output Connections

The pulse output is used for a remote counter. When the preset volume or mass, as defined in the totalizer settings (see “The Totalizer #1 Menu” on page 60) has passed through the meter, the output provides a 50 millisecond square pulse.

The pulse output requires a separate 5 to 36 VDC power supply connected to the normally-open, single-pole pulse output optical relay (see Figure 22 or Figure 23 below). The relay has a nominal 200 volt/160 ohm rating (i.e., it has a nominal on-resistance of 160 ohms, and the largest voltage it can withstand across the output terminals is 200 volts). However, there are current and power specifications that must be observed. The relay can conduct a current up to 40 mA and it can dissipate up to 320 mW of power. The relay output is isolated from the meter electronics and power supply.

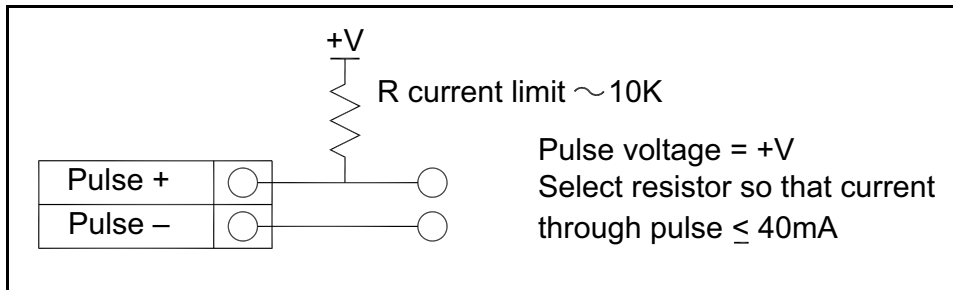


Figure 22: Isolated Pulse Output Using External Power Supply

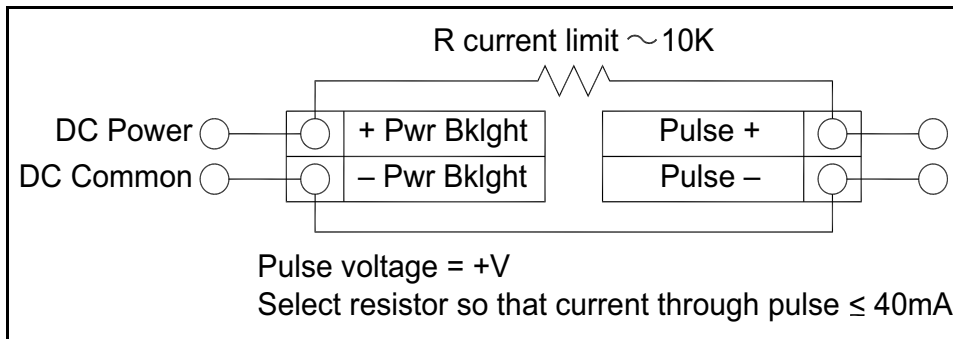


Figure 23: Non-Isolated Pulse Output Using External Power Supply

2.5.4 Frequency Output Connections

The frequency output is used for a remote counter. It can be scaled to output a 1 to 10 kHz signal proportional to mass or volume flow, temperature, pressure or density.

The frequency output requires a separate 5 to 36 VDC power supply (see *Figure 24* or *Figure 25* below). In addition, there are current and power specifications that must be observed. The output can conduct a current up to 40 mA and it can dissipate up to 200 mW of power. The output is isolated from the meter electronics and power supply.

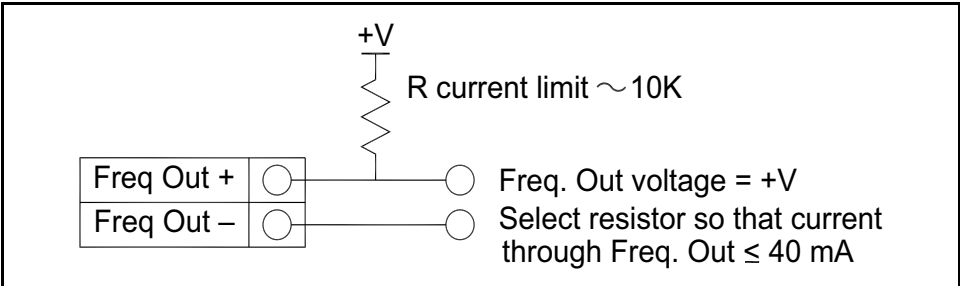


Figure 24: Isolated Frequency Output Using External Power Supply

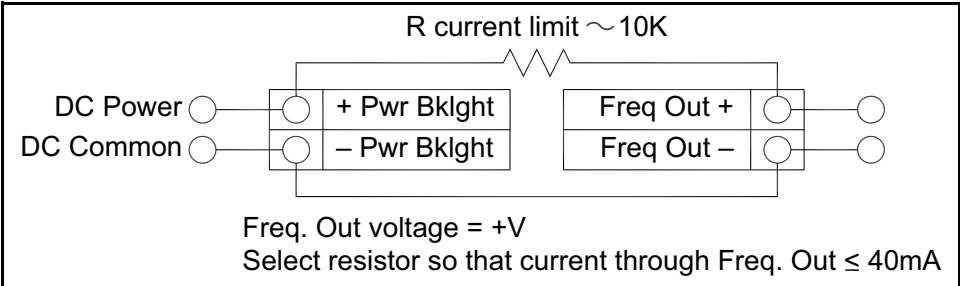


Figure 25: Non-Isolated Frequency Output Using External Power Supply

2.5.5 Optional Backlight Connection

The loop power meter has an optional backlight connection provided. It is intended to be powered by either a separate 12 to 36 VDC @ 35 mA maximum power supply or by the same power supply used for the pulse output. Both options are shown in *Figure 26* below.

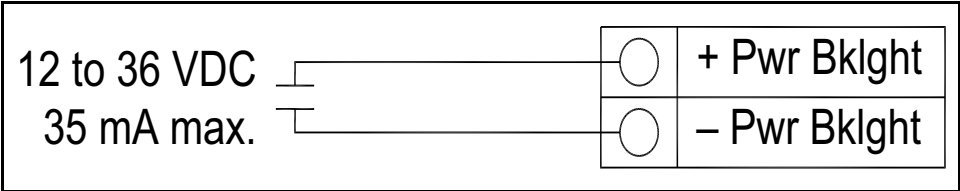


Figure 26: Backlight Using External Power Supply

2.5.6 Remote Electronics Wiring

The remote electronics enclosure should be mounted in a convenient, easy-to-reach location. For hazardous location installations, make sure to observe agency requirements for installation. Allow some slack in the interface cable between the junction box and the remote electronics enclosure. To prevent damage to the wiring connections, do not put stress on the wiring connections at any time.

The meter is shipped with temporary strain relief glands at each end of the cable. Refer to *Figure 27* below, and disconnect the cable from the meter's terminal block inside the junction box only. Do not disconnect the cable from the remote electronics enclosure. Remove both strain relief glands and install appropriate conduit entry glands and conduit. After the installation is complete, re-connect each labeled wire to the corresponding terminal position on the junction box terminal block.

IMPORTANT: *Make sure to connect the shield for each wire pair.*

Note: *Incorrect connections will cause the meter to malfunction.*

Note: *The numeric code in the junction box label matches the wire labels.*

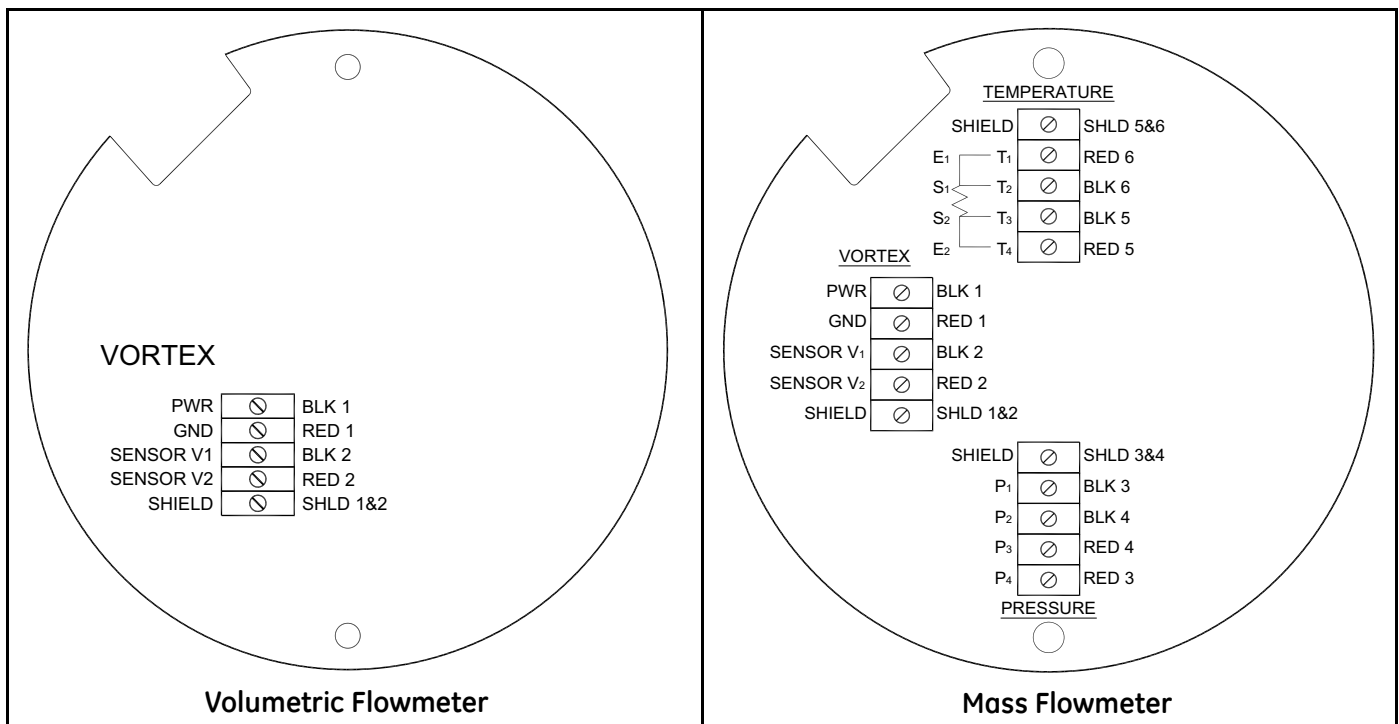


Figure 27: Loop Power Flowmeter Junction Box Sensor Connections

2.6 Line Power Meter Wiring Connections



WARNING! To avoid potential electric shock, follow National Electric Code safety practices or your local code when wiring this unit to a power source and to peripheral devices. Failure to do so could result in injury or death. All AC power connections must be in accordance with published CE directives. All wiring procedures must be performed with the power off.

The Type 4X enclosure contains an integral wiring compartment with one dual strip terminal block located in the smaller end of the enclosure (see *Figure 28* below). Two 3/4-inch female NPT conduit entries are available for separate power and signal wiring. For all hazardous area installations, make sure to use an agency-approved fitting at each conduit entry. If conduit seals are used, they must be installed within 18 inches (457 mm) of the enclosure.

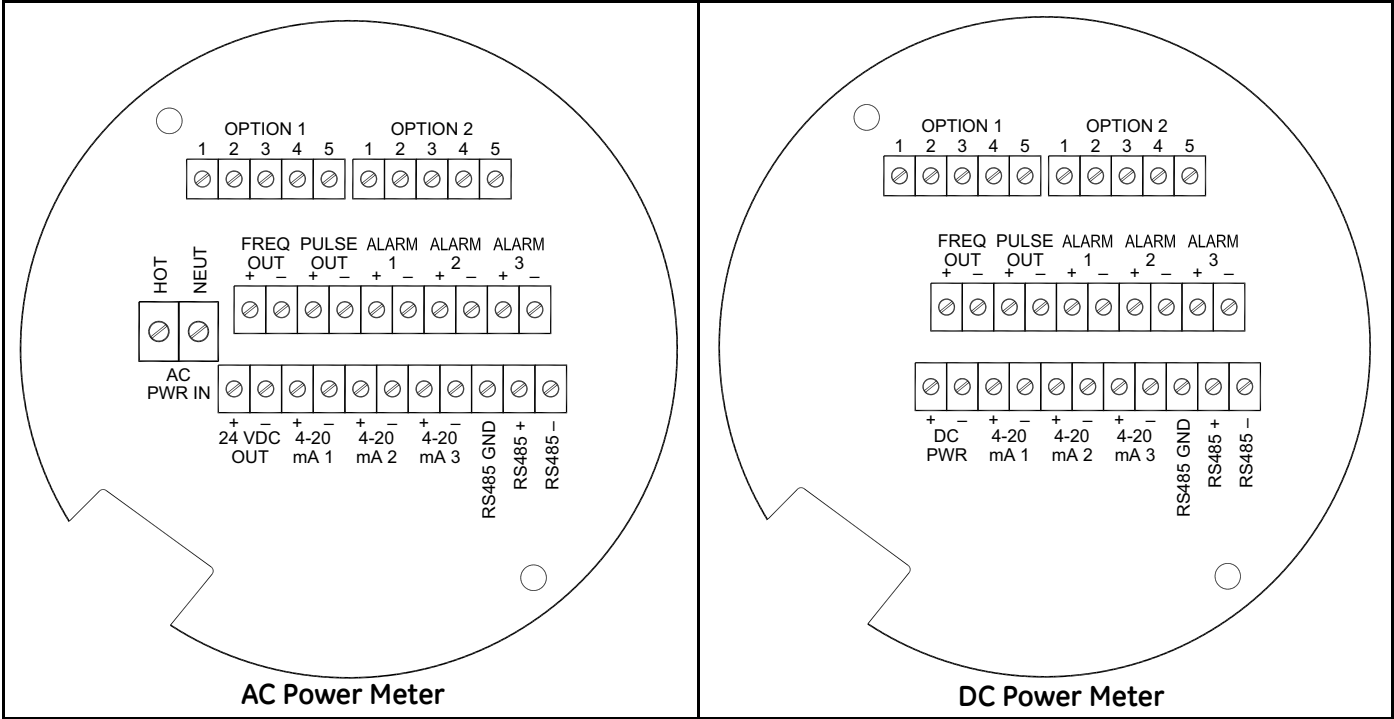


Figure 28: Line Power Wiring Terminals

2.6.1 Input Power Connections

To access the wiring terminal blocks, locate and loosen the small set screw which locks the small enclosure cover in place. Unscrew the cover to expose the terminal block.

2.6.1a AC Power Wiring



CAUTION! The AC wire insulation temperature rating must meet or exceed 85°C (185°F).

The AC power wire size must be 10 to 20 AWG with 1/4 inch (7 mm) of insulation stripped from each conductor. The wire insulation temperature must meet or exceed 85°C (185°F). Connect 100 to 240 VAC (5 W maximum) to the **Hot** and **Neut** terminals on the terminal block (see *Figure 29* below), and connect the ground wire to the safety ground lug (⊕). Torque all connections to 4.43 to 5.31 in-lb (0.5 to 0.6 Nm). Use a separate conduit entry for signal lines to reduce the possibility of AC noise interference.

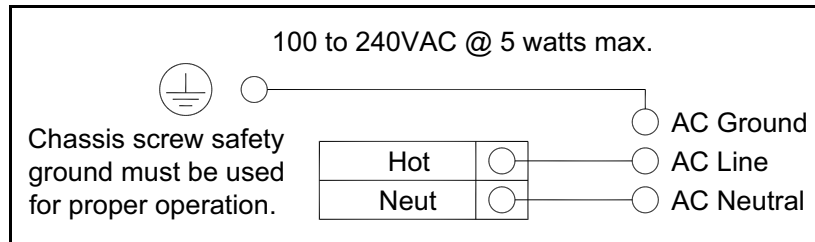


Figure 29: AC Power Connections

2.6.1b DC Power Wiring



CAUTION! The DC wire insulation temperature rating must meet or exceed 85°C (185°F).

The DC power wire size must be 10 to 20 AWG with 1/4 inch (7 mm) of insulation stripped from each conductor. The wire insulation temperature must meet or exceed 85°C (185°F). Connect 18 to 36 VDC (300 mA, 9 W maximum) to the **+DC Pwr** and **-DC Pwr** terminals on the terminal block (see *Figure 30* below). Torque all connections to 4.43 to 5.31 in-lb (0.5 to 0.6 Nm).

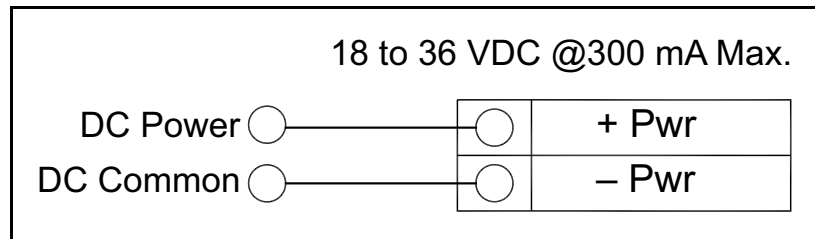


Figure 30: DC Power Connections

2.6.2 4-20 mA Output Connections

The standard PanaFlow meter has a single 4-20 mA loop. Two additional loops are available on the optional communication board. The 4-20 mA loop current is controlled by the meter electronics. The electronics must be wired in series with the sensor resistor or current meter (see *Figure 31*, *Figure 32* or *Figure 33* below). The current control electronics requires 12 volts at the input terminals to operate correctly.

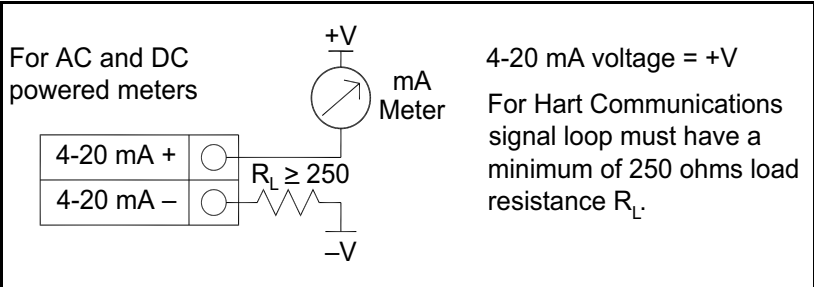


Figure 31: Isolated 4-20 mA Output with External Power Supply

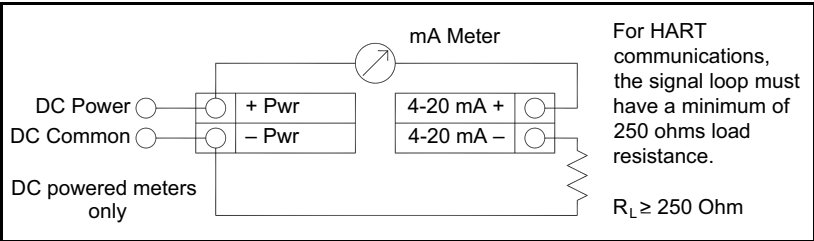


Figure 32: Non-Isolated 4-20 mA Output Using Meter Input Power Supply

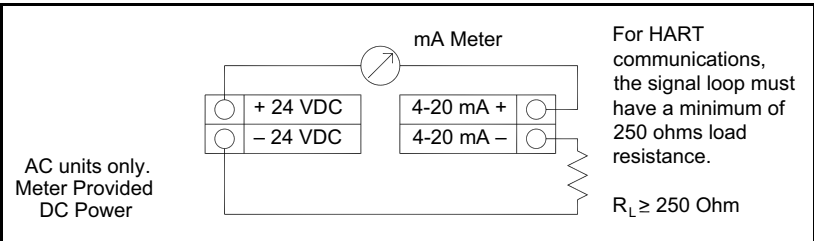


Figure 33: Isolated 4-20 mA Output Using Meter Provided Power Supply

2.6.2 4-20 mA Output Connections (cont.)

The maximum loop resistance (load) for the current loop output is dependent upon the supply voltage and is given in *Figure 34* below. The 4-20 mA loop is optically isolated from the flowmeter electronics.

R_{load} is the total resistance in the loop, including the wiring resistance. That is, $R_{load} = R_{wire} + R_{sense}$. To calculate the maximum load resistance for the loop, subtract the minimum terminal voltage from the supply voltage and divide by the maximum loop current of 20 mA, as shown in the following equation:

$$R_{max\ load} = \frac{V_{supply} - 12V}{0.020A}$$

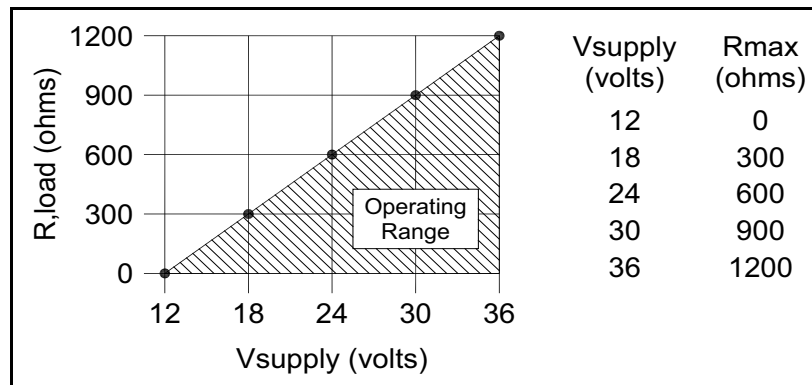


Figure 34: Load Resistance Versus Input Voltage

2.6.3 Frequency Output Connections

The frequency output is used for a remote counter. It can be scaled to output a 1 to 10 kHz signal proportional to mass or volume flow, temperature, pressure or density.

The frequency output requires a separate 5 to 36 VDC power supply. However, there are current and power specifications that must be observed. The output can conduct a current up to 40 mA and can dissipate up to 200 mW of power. The output is isolated from the meter electronics and power supply.

There are three connection options for the frequency output:

- For AC or DC powered meters, use a separate 5 to 36 VDC power supply (see *Figure 35 on page 41*). Use this option if a specific voltage is needed for the frequency output.
- For DC powered meters only, use the flow meter power supply (see *Figure 36 on page 41*). Use this option if the voltage at the flow meter power supply is an acceptable driver voltage for the connected load, taking into account that the current used by the frequency load comes from the meter's power supply.
- For AC powered meters only, use the internal 24 VDC power supply (see *Figure 37 on page 41*). Use this option if the voltage of the frequency output is the same as the voltage supplied to the circuit.

2.6.3 Frequency Output Connections (cont.)

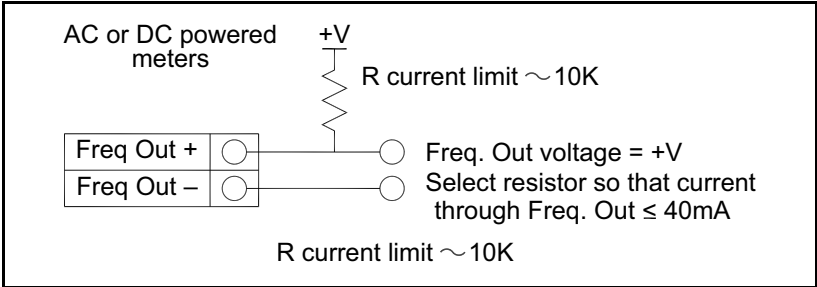


Figure 35: Isolated Frequency Output Using External Power Supply

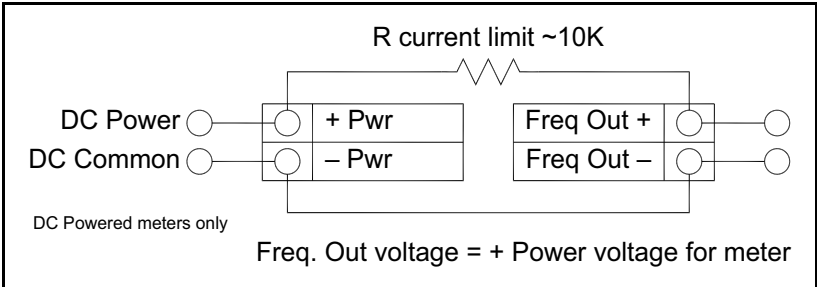


Figure 36: Non-Isolated Frequency Output Using Input Power Supply

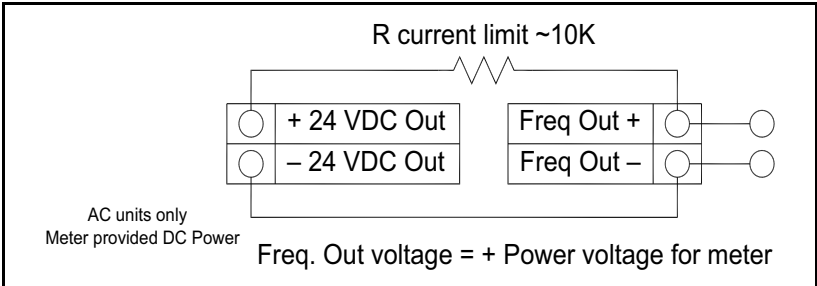


Figure 37: Isolated Frequency Output Using Meter-Provided Power Supply

2.6.4 Pulse Output Connections

The pulse output is used for a remote counter. When the preset volume or mass, as defined in the totalizer settings (see “*The Totalizer #1 Menu*” on page 60) has passed through the meter, the output provides a 50 millisecond square pulse.

The pulse output is a normally-open, single-pole pulse output optical relay with a nominal 200 volt/160 ohm rating (i.e., it has a nominal on-resistance of 160 ohms, and the largest voltage it can withstand across the output terminals is 200 volts). However, there are current and power specifications that must be observed. The relay can conduct a current up to 40 mA and it can dissipate up to 320 mW of power. The relay output is isolated from the meter electronics and power supply.

There are three connection options for the pulse output:

- For AC or DC powered meters, use a separate 5 to 36 VDC power supply (see *Figure 38 on page 43*). Use this option if a specific voltage is needed for the pulse output.
- For DC powered meters only, use the flow meter power supply (see *Figure 39 on page 43*). Use this option if the voltage at the flow meter power supply is an acceptable driver voltage for the connected load, taking into account that the current used by the pulse load comes from the meter’s power supply.
- For AC powered meters only, use the internal 24 VDC power supply (see *Figure 40 on page 43*). Use this option if the voltage of the pulse output is the same as the voltage supplied to the circuit.

2.6.4 Pulse Output Connections (cont.)

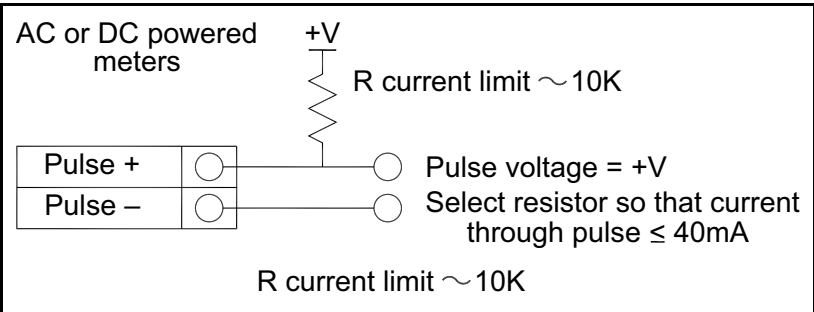


Figure 38: Isolated Pulse Output with External Power Supply

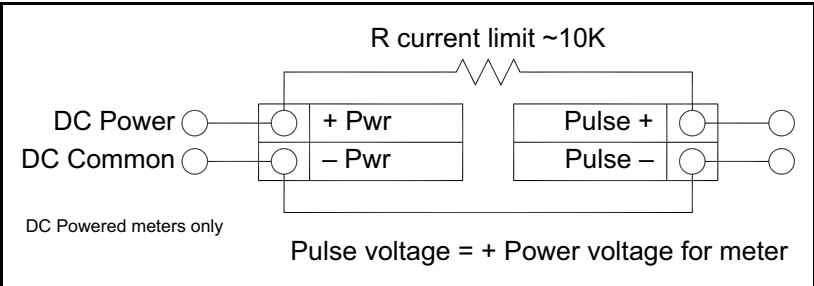


Figure 39: Non-Isolated Pulse Output Using Input Power Supply

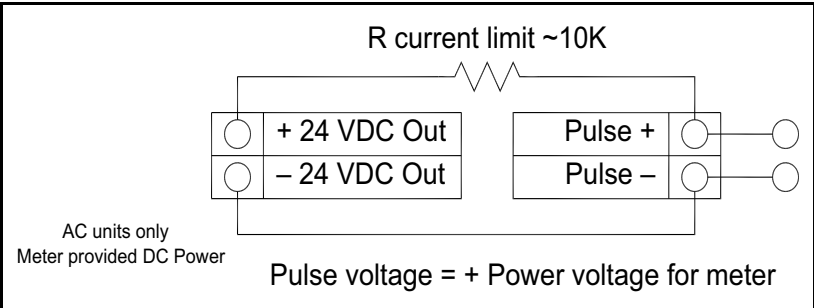


Figure 40: Isolated Pulse Output Using Provided Power Supply

2.6.5 Alarm Output Connections

One alarm output (**Alarm 1**) is included on the standard PanaFlow meter. Two or more alarms (**Alarm 2** and **Alarm 3**) are included on the optional communication board. The alarm output is used for transmitting high or low process conditions, as defined in the alarm settings (see “*The Alarms Menu*” on page 58).

The alarm output optical relays are normally-open, single-pole relays, which have a nominal 200 volt/160 ohm rating (i.e., a nominal on-resistance of 160 ohms and a maximum voltage of 200 volts across the output terminals). However, there are current and power specifications that must be observed. The relay can conduct a current up to 40 mA and can dissipate up to 320 mW of power. The relay output is isolated from the meter electronics and the power supply. When the alarm relay is closed, the current draw is constant. Make sure to size R_{load} appropriately.

There are three connection options for the alarm output:

- For AC or DC powered meters, use a separate 5 to 36 VDC power supply (see *Figure 41 on page 45*). Use this option if a specific voltage is needed for the alarm output.
- For DC powered meters only, use the flow meter power supply (see *Figure 42 on page 45*). Use this option if the voltage at the flow meter power supply is an acceptable driver voltage for the connected load, taking into account that the current used by the alarm load comes from the meter’s power supply.
- For AC powered meters only, use the internal 24 VDC power supply (see *Figure 43 on page 45*). Use this option if the voltage of the alarm output is the same as the voltage supplied to the circuit.

2.6.5 Alarm Output Connections (cont.)

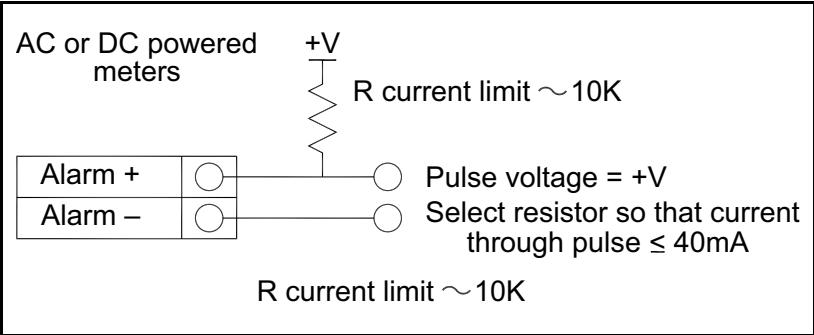


Figure 41: Isolated Alarm Output with External Power Supply

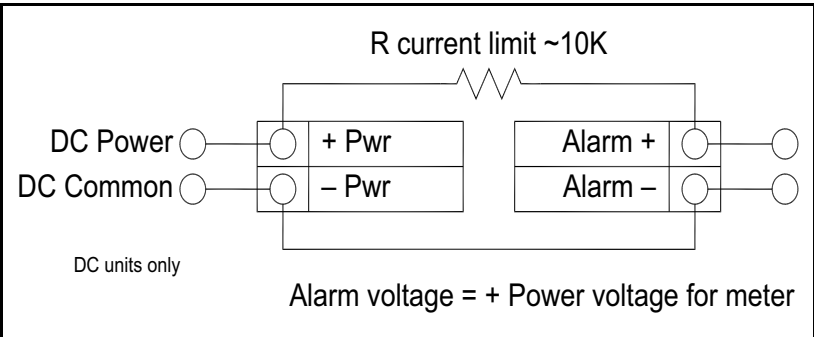


Figure 42: Non-Isolated Alarm Output Using Internal Power Supply

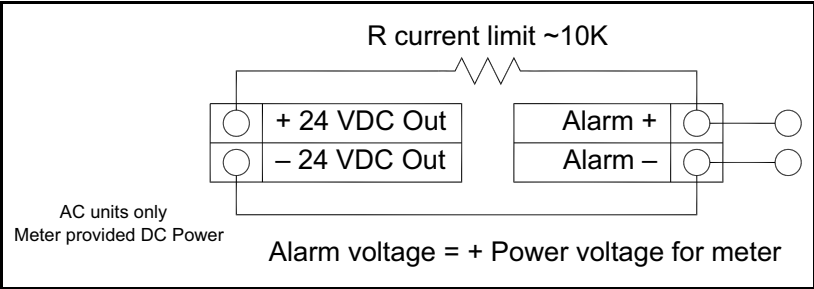


Figure 43: Isolated Alarm Output Using Meter Provided Power Supply

2.6.6 Remote Electronics Wiring

The remote electronics enclosure should be mounted in a convenient, easy to reach location. For hazardous location installations, make sure to observe agency requirements for installation. Allow some slack in the interface cable between the junction box and the remote electronics enclosure. To prevent damage to the wiring connections, do not put stress on the wire connections at any time.

The meter is shipped with temporary strain relief glands at each end of the cable. Disconnect the cable from the meter's terminal block inside the junction box only (see *Figure 44* below). Do not disconnect the cable from the remote electronics enclosure. Remove both strain relief glands and install appropriate conduit entry glands and conduit. After the installation is complete, re-connect each labeled wire to the corresponding terminal position on the junction box terminal block. Make sure to connect the shield for each wire pair shield.

Note: *Incorrect connections will cause the meter to malfunction.*

Note: *The numeric code in the junction box label matches the wire labels.*

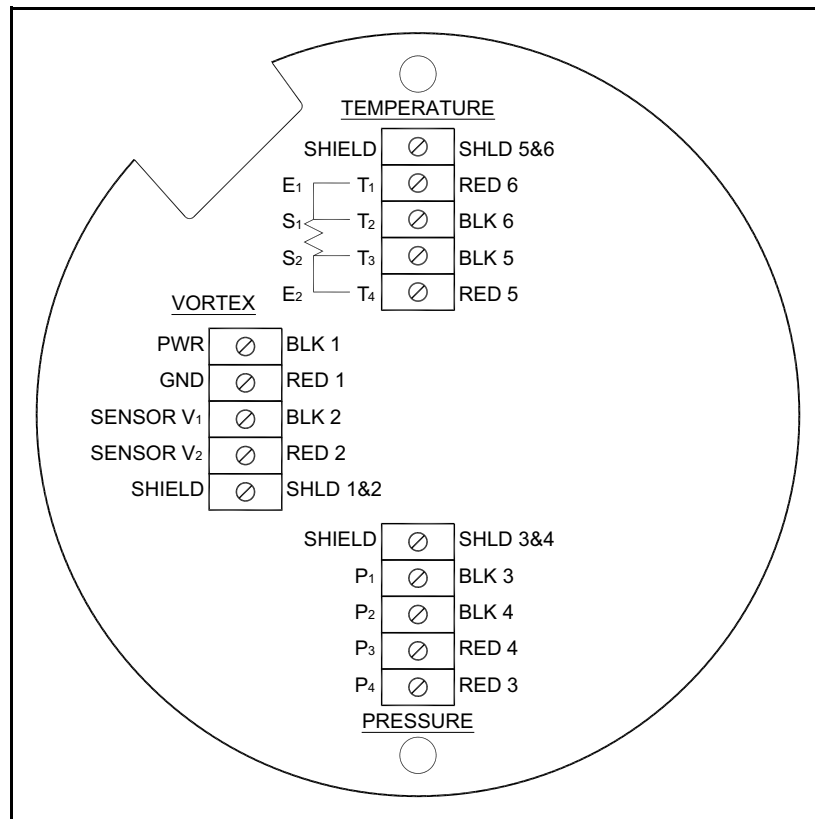


Figure 44: High Power Flowmeter Junction Box Sensor Connections

2.6.7 Optional Input Wiring

The meter has two optional input wiring terminals. These can be used to input a *Remote* or *Second RTD* input in situations such as: an *Energy Monitoring* meter, the input of a *Remote Pressure Transducer*, to pass a *Contact Closure*, for a *Remote Density* measurement, etc. The wiring diagram (see *Figure 45* below) will be included with the meter if any of these types of options are specified. Otherwise, the optional terminal blocks will be left blank and non-functional.

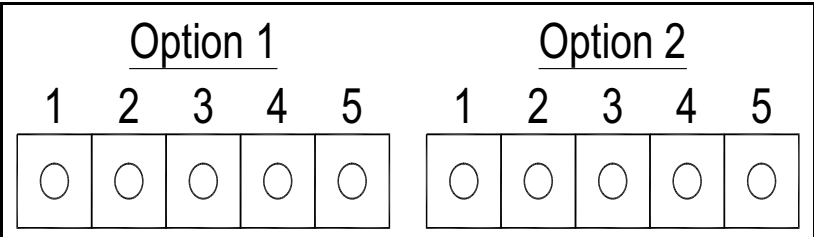


Figure 45: Optional Input Electronics Wiring

2.6.7a Optional Energy EMS RTD Input Wiring

The recommended customer-supplied second RTD is a Class A, 1000 ohm, 4-wire, platinum RTD. If a second RTD is not being used, then the factory-supplied 1000 ohm resistor needs to be installed in its place. Refer to *Figure 46* below for wiring details.

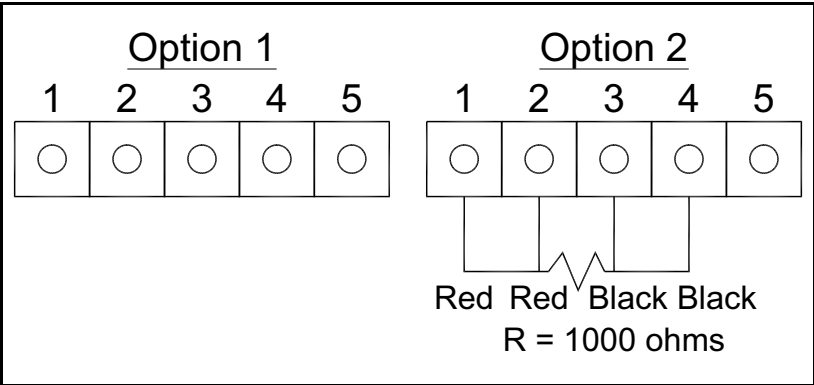


Figure 46: Optional Energy EMS RTD Input Wiring

2.6.7b Optional External 4-20 mA Input Wiring

The meter is set to have *Option 1* used for the external input. Programming menus that pertain to the optional 4-20 mA input are located in “*Hidden Diagnostics Menus*” on page 109.

Refer to *Figure 47* below to wire the external 4-20 mA input into the flowmeter using an external power supply.

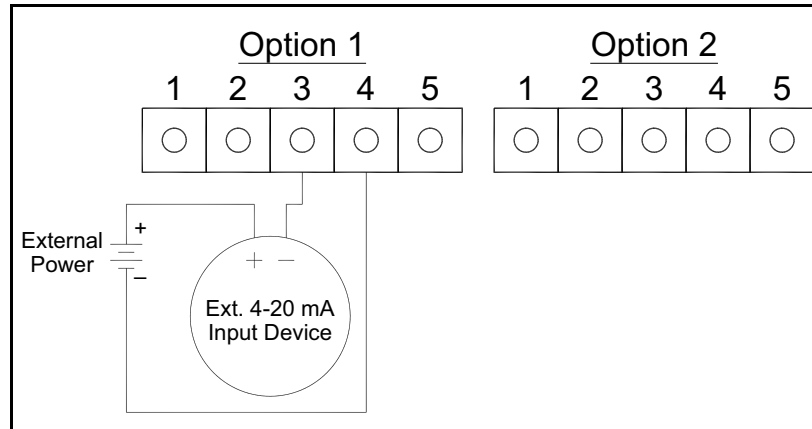


Figure 47: External 4-20 mA Input Wiring - External Power Supply

Refer to *Figure 48* below to wire the external 4-20 mA input into the flowmeter using power supplied to the input of a DC powered meter.

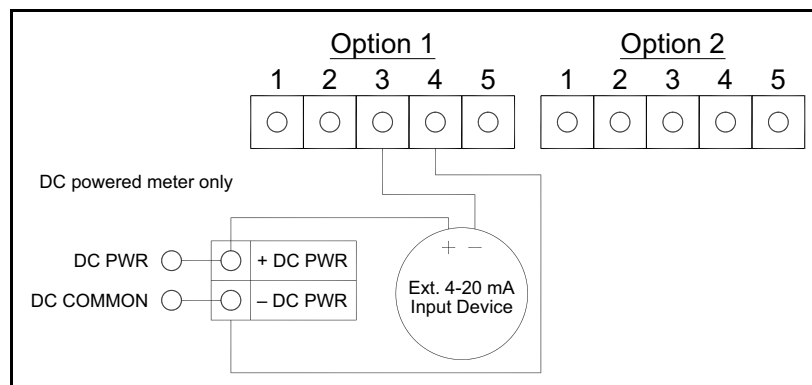


Figure 48: External 4-20 mA Input Wiring - DC Powered Meter

2.6.7b *Optional External 4-20 mA Input Wiring (cont.)*

Refer to *Figure 49* below to wire the external 4-20 mA input into the flowmeter using power from the 24 VDC output of an AC powered meter.

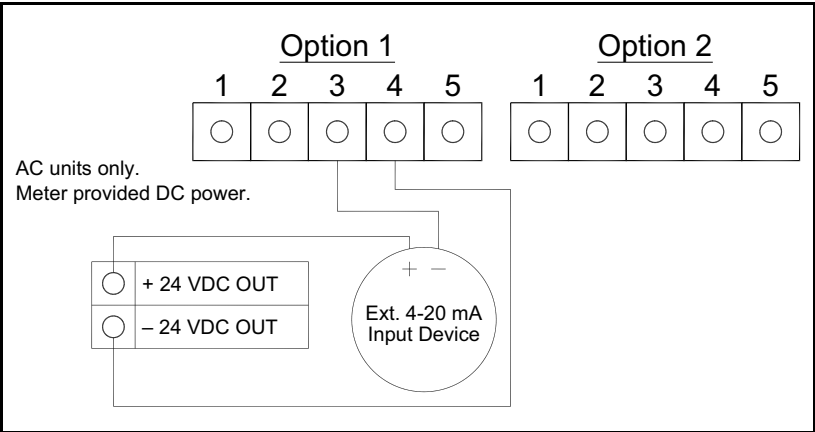


Figure 49: External 4-20 mA Input Wiring - AC Powered Meter

2.6.7c *Optional Contact Closure Input Wiring*

Refer to *Figure 50* below to wire an external switch input into the flowmeter. The meter is configured to have *Option 1* used for the external input. If the above switch is used to remotely reset the totalizer, a pushbutton switch with a momentary contact closure is recommended.

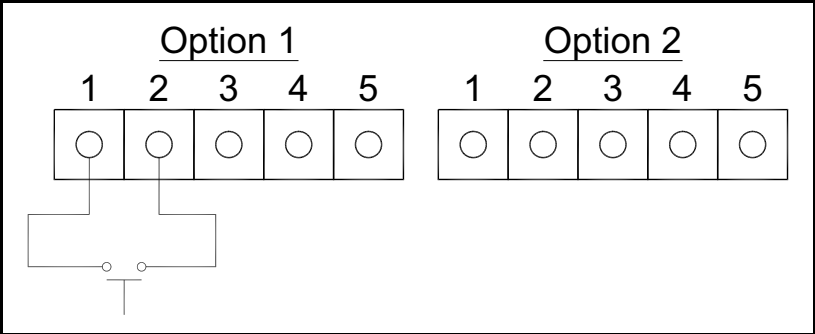


Figure 50: Optional Contact Closure Input Wiring

[no content intended for this page]

Chapter 3. Operating Instructions

After installing the PanaFlow Vortex Flowmeter per the instructions in the previous chapter, you are ready to begin operation. The sections in this chapter explain the display/keypad commands and meter start-up and programming. The meter is ready to operate at start up without any special programming. To enter parameters and system settings unique to your operation, see the following pages for instructions on using the setup menus.

3.1 Flowmeter Display/Keypad

The flowmeter digital electronics enable you to set, adjust and monitor system parameters and performance. A full range of commands are available through the display/keypad. The LCD display provides 2 x 16 characters for flow monitoring and programming. The six push-buttons can be operated in non-hazardous environments with the enclosure cover removed, In hazardous environments, the explosion-proof cover must remain in place and the keypad operated with a hand-held magnet positioned at the side of the enclosure (see *Figure 51* below).

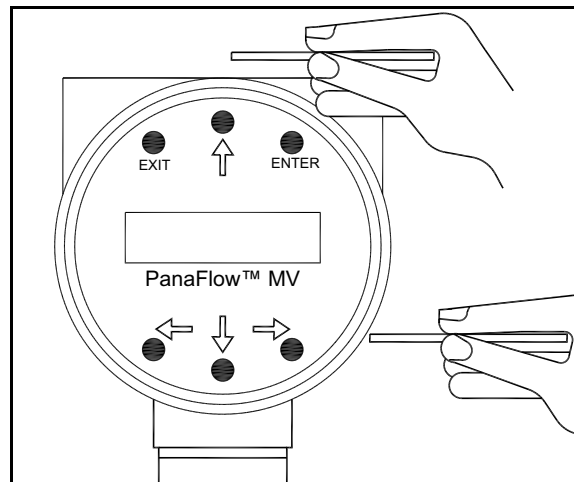


Figure 51: Magnetic Keypad Operation

3.1 Flowmeter Display/Keypad (cont.)

Figure 52 below shows a picture of the display/keypad. From Run Mode, the ENTER key enables access to the Setup Menus through a password screen. Within the Setup Menus, pressing ENTER activates the current field. To set new parameters, press the ENTER key until an underline cursor appears. Use the \uparrow \downarrow \leftarrow \rightarrow keys to select new parameters. The \uparrow \downarrow \leftarrow \rightarrow keys advance through each screen of the current menu. When changing a system parameter, all \uparrow \downarrow \leftarrow \rightarrow keys are available to enter new parameters. Press ENTER to continue.

Note: *All outputs are disabled when using the Setup Menus. If changes are not allowed, ENTER has no effect.*

The EXIT key is active within the *Setup Menus*. When using a Setup Menu, EXIT returns you to the Run Mode. If you are changing a parameter and make a mistake, EXIT enables you to start over.



Figure 52: Flowmeter Display/Keypad

3.2 Start-Up

To begin flowmeter operation:

1. Verify that the flowmeter is installed and wired as described in *Chapter 2*.
2. Apply power to the meter. At start up, the unit runs a series of self-tests that check the RAM, ROM, EPROM and all flow sensing components. After completing the self-test sequence, the *Run Mode* screens appear.

Note: *Starting the flowmeter or pressing EXIT will always display the Run Mode screens.*

3. Run Mode displays flow information based on system settings. As a result, some of the screens shown in *Figure 53* below may not be displayed. Press the **↑ ↓** arrow keys to view the Run Mode screens.
4. Press the ENTER key from any Run Mode screen to access the Setup Menus. Use the Setup Menus to configure the meter's multi-parameter features to fit your application.

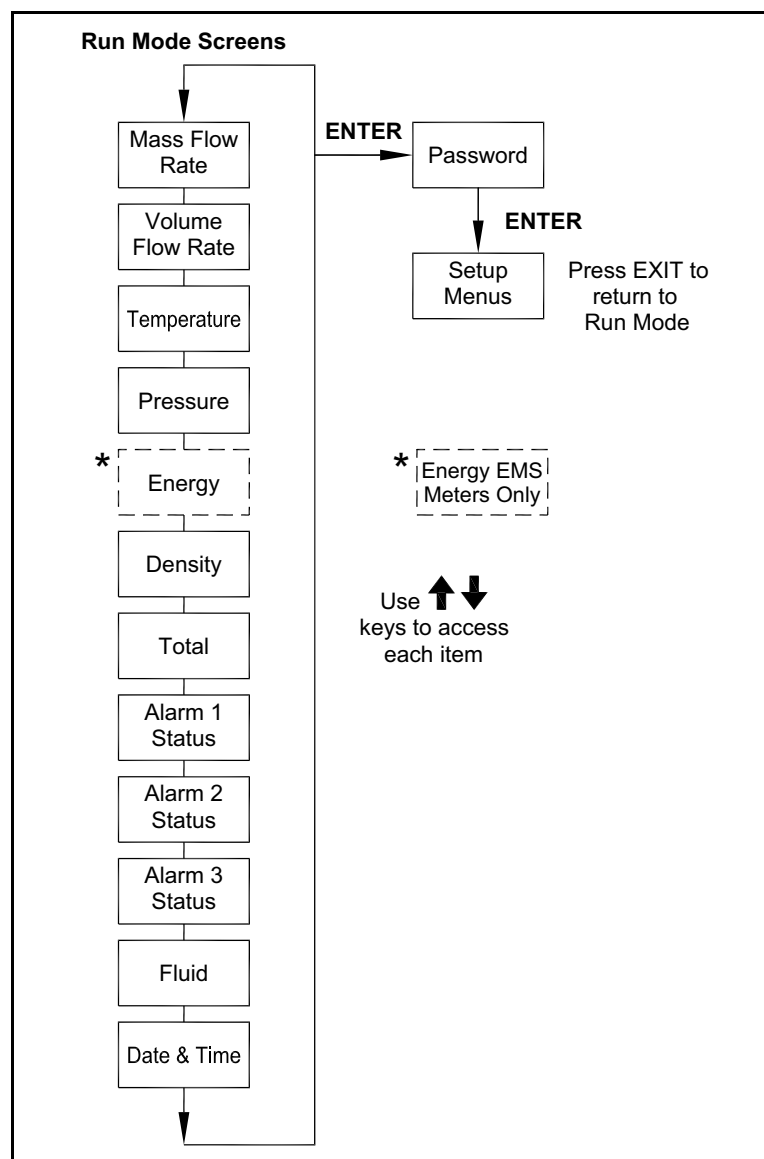


Figure 53: Run Mode Screens

3.3 Using the Setup Menus

3.3.1 A Menu Map

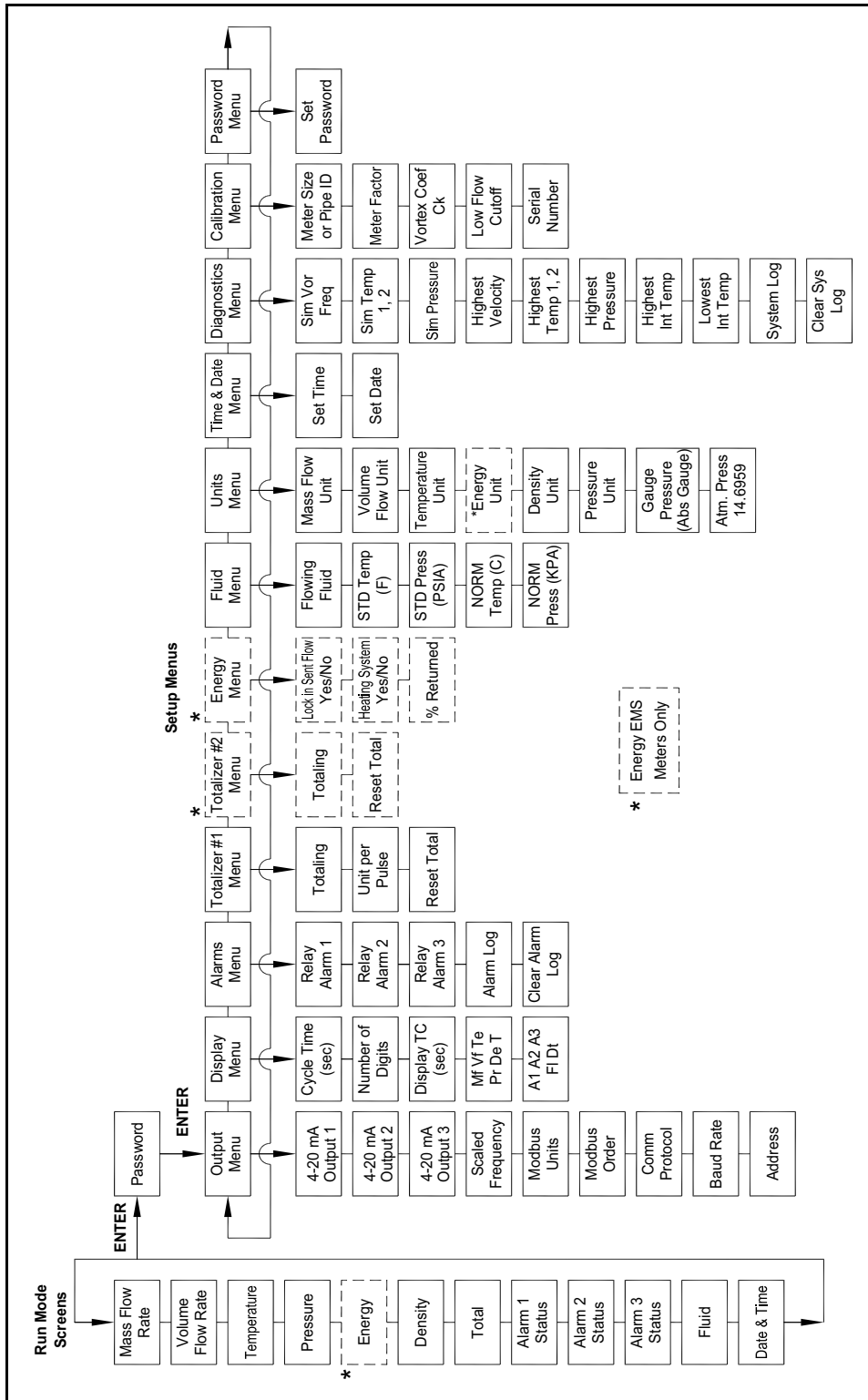


Figure 54: Complete Map of Setup Menus

3.3.2 Programming the Flowmeter

1. Enter the Setup Menu by pressing the ENTER key until prompted for a password.

Note: *All outputs are disabled while using the Setup Menus.*

2. Use the \uparrow \downarrow \leftarrow \rightarrow keys to select the new password characters (1234 is the factory-set password). When the password is correctly displayed, press ENTER to continue.
3. Use the Setup Menus described on the following pages to customize the multi-parameter features of your PanaFlow meter. The entire lower display line is available for entering parameters. Some menus in *Figure 54* below may not be displayed, based on flowmeter configuration settings
4. To activate a parameter, press ENTER. Use the \uparrow \downarrow \leftarrow \rightarrow keys to make selections. Press ENTER to continue. Press EXIT to save or discard changes and return to Run Mode.
5. Program the UNITS menu first because later menus will be based on the units selected.

3.3.3 The Output Menu

As an example of how to set an output, refer to *Figure 55 on page 56*. This example shows how to set Output 1 to measure mass flow with 4 mA = 0 lb/hr and 20 mA = 100 lb/hr with a time constant of 5 seconds.

Note: *All outputs are disabled while using the Setup Menus.*

First, set the desired units of measurement:

1. Use the \leftarrow \rightarrow keys to move to the Units Menu (see “*The Units Menu*” on page 67).
2. Press the \downarrow key until Mass Flow Unit appears. Press ENTER.
3. Press the \downarrow key until lb appears in the numerator. Press the \rightarrow key to move the underline cursor to the denominator. Press the \downarrow key until hr appears in the denominator. Press ENTER to select.
4. Press the \uparrow key until Units Menu appears.

Second, set the analog output:

1. Use the \leftarrow \rightarrow keys to move to the Output Menu.
2. Press the \downarrow key until 4-20 mA Output 1 appears.
3. Press the \rightarrow key to access Measure selections. Press ENTER and press the \downarrow key to select Mass. Press ENTER.
4. Press the \rightarrow key to set the 4 mA point in the units you have selected for mass of lb/hr. Press ENTER and use the \uparrow \downarrow \leftarrow \rightarrow keys to set 0 or 0.0. Press ENTER.
5. Press the \rightarrow key to set the 20 mA point. Press ENTER and use the \uparrow \downarrow \leftarrow \rightarrow keys to set 100 or 100.0. Press ENTER.
6. Press the \rightarrow key to select the Time Constant. Press ENTER and use the \uparrow \downarrow \leftarrow \rightarrow keys to select 5. Press ENTER.
7. Press the EXIT key and answer YES to permanently save your changes.

3.3.3 The Output Menu (cont.)

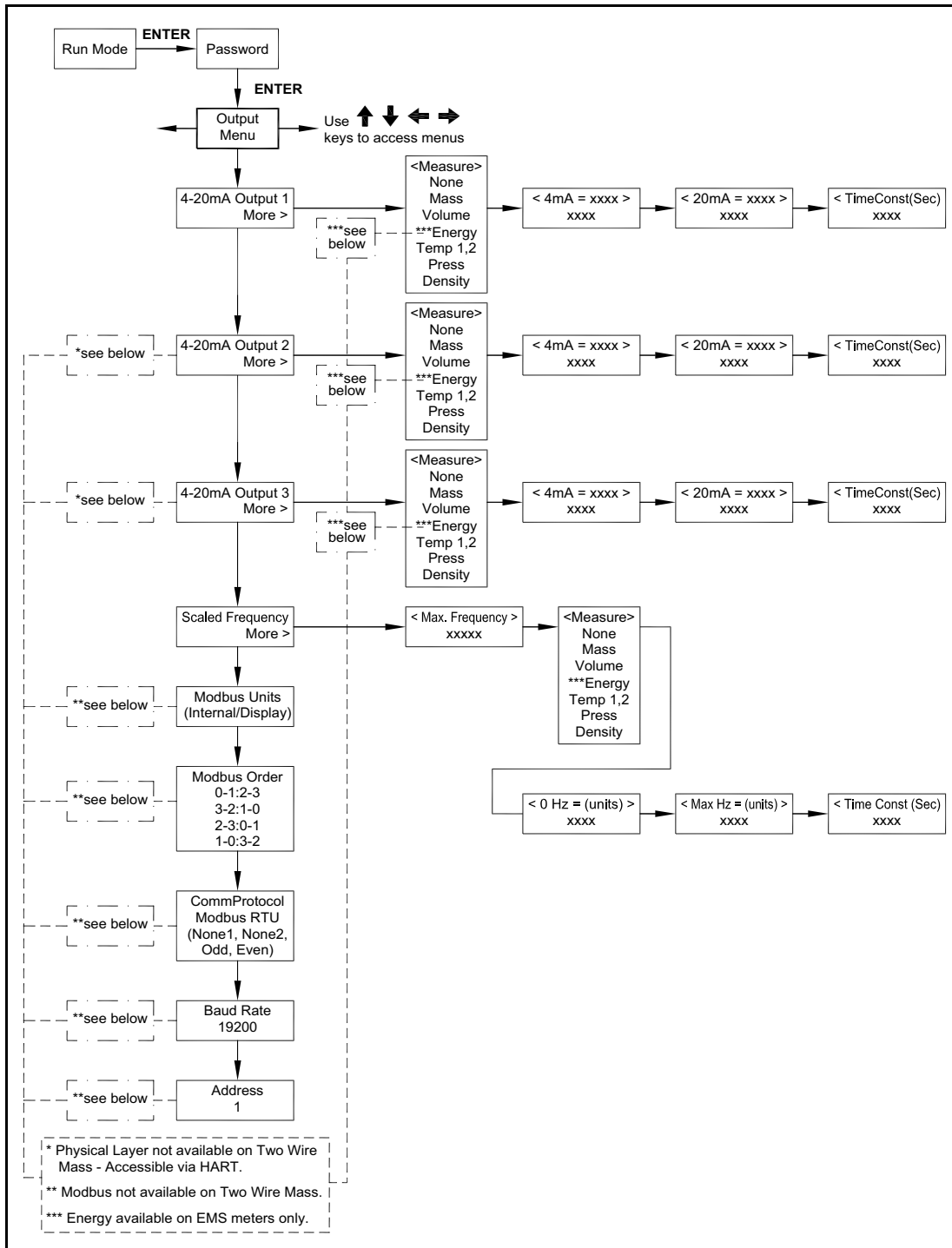


Figure 55: Output Menu Map

3.3.4 The Display Menu

Use the *Display Menu* shown in *Figure 56* below to set the cycle time for automatic screen sequencing used in Run Mode, change the precision of displayed values, smooth the values or enable or disable each item displayed in the Run Mode screens.

As an example of how to change a Run Mode display item, refer to *Figure 56* below. This example shows how to remove the temperature screen from the Run Mode screens.

Note: *All outputs are disabled while using the Setup Menus.*

1. Use the ←→ keys to move to the Display Menu.
2. Press the ↓ key until Mf Vf Pr Te De T appears.
3. Press ENTER to select. Press the → key until the cursor is positioned below Te.
4. Press the ↓ key until N appears. Press ENTER to select.
5. Press EXIT and then ENTER to save changes and return to the Run Mode.

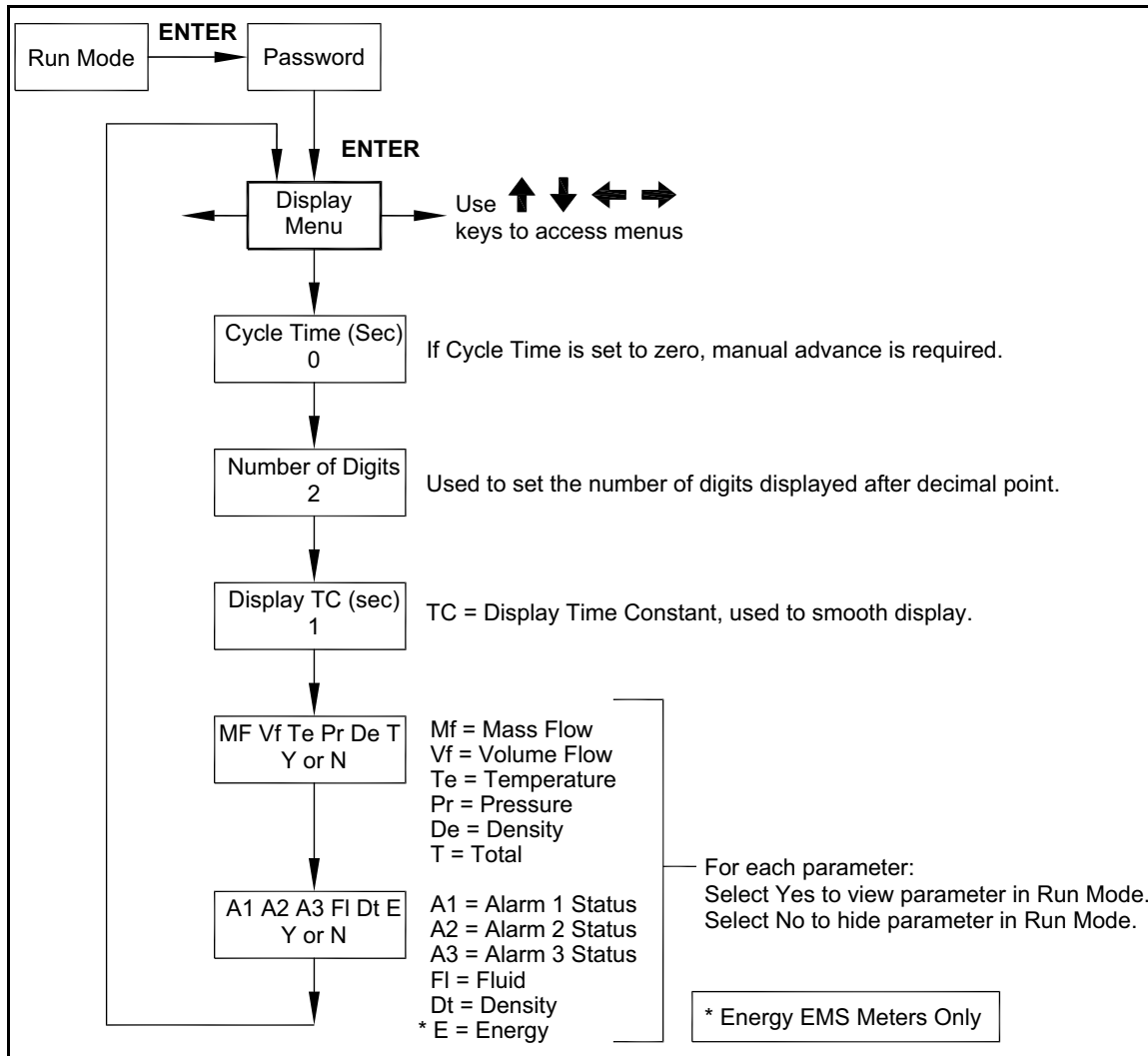


Figure 56: The Display Menu

3.3.5 The Alarms Menu

As an example of how to set an output, refer to *Figure 57 on page 59*. This example shows how to set *Relay Alarm 1* to activate if the mass flow rate is greater than 100 lb/hr. You can check the alarm configuration in Run Mode by pressing the $\uparrow \downarrow$ keys until Alarm [1] appears. The lower line displays the mass flow rate at which the alarm activates.

Note: *All outputs are disabled while using the Setup Menus.*

First, set the desired units of measurement:

1. Use $\leftarrow \rightarrow$ keys to move to the Units Menu (see “*The Units Menu*” on page 67).
2. Press the \downarrow key until Mass Flow Unit appears. Press ENTER.
3. Press the \downarrow key until lb appears in the numerator. Press the \rightarrow key to move the underline cursor to the denominator. Press the \downarrow key until hr appears in the denominator. Press ENTER to select.
4. Press the \uparrow key until Units Menu appears.

Second, set the alarm:

1. Use $\leftarrow \rightarrow$ keys to move to the Alarms Menu.
2. Press the \downarrow key until Relay Alarm 1 appears.
3. Press the \rightarrow key to access Measure selections. Press ENTER and use the \downarrow key to select Mass. Press ENTER.
4. Press the \rightarrow key to select the alarm Mode. Press ENTER and use \downarrow key to select HIGH Alarm. Press ENTER.
5. Press the \rightarrow key to select the value that must be exceeded before the alarm activates. Press ENTER and use $\uparrow \downarrow$ $\leftarrow \rightarrow$ keys to set 100 or 100.0. Press ENTER.
6. Press the EXIT key to save your changes. Alarm changes are always permanently saved, and up to three relay alarm outputs are available depending on meter configuration.

3.3.5 The Alarms Menu (cont.)

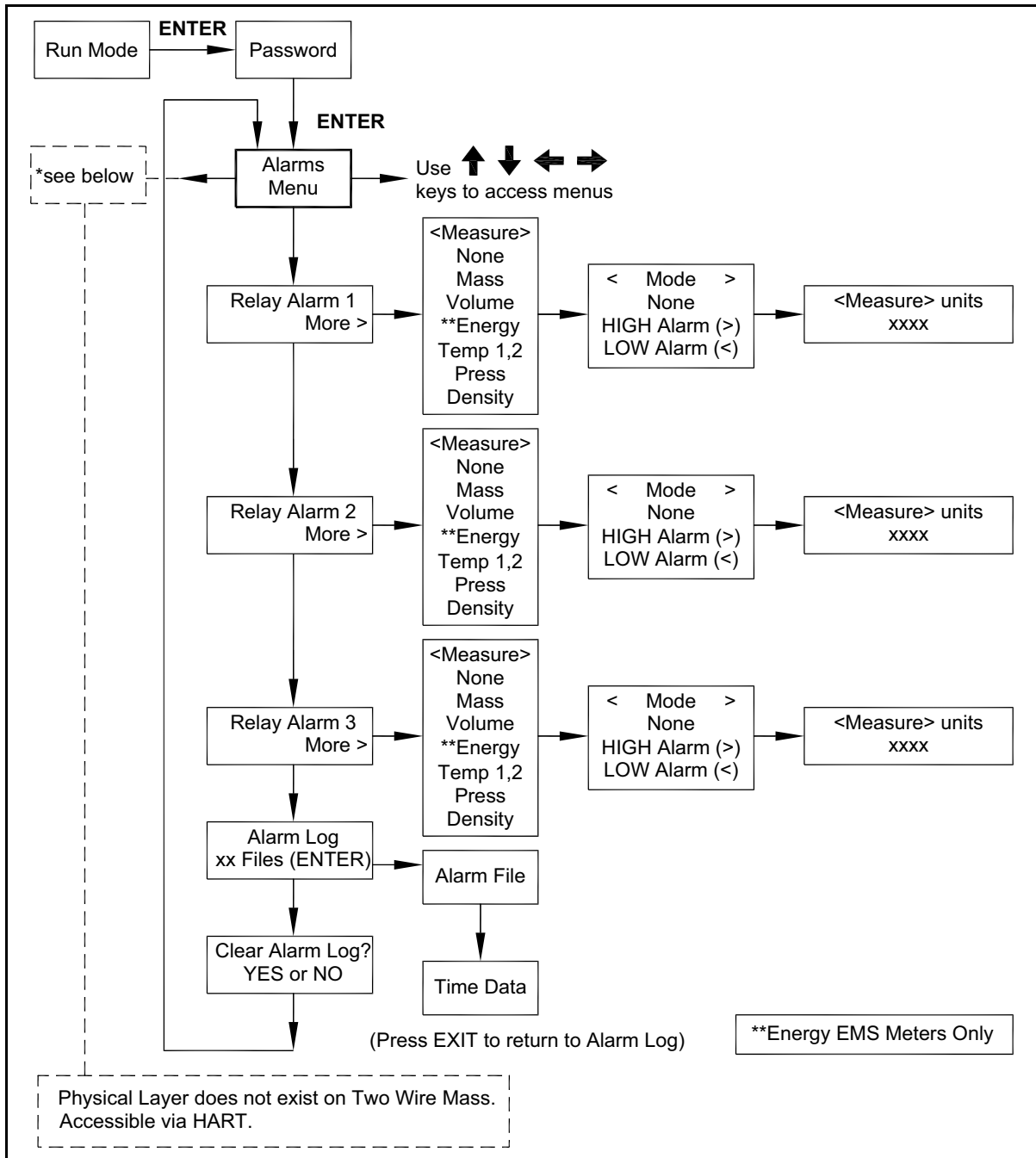


Figure 57: The Alarms Menu

3.3.6 The Totalizer #1 Menu

Use the Totalizer Menu to configure and monitor the totalizer. The totalizer output is a 50 millisecond (.05 second) positive pulse (relay closed for 50 milliseconds). The totalizer cannot operate faster than one pulse every 100 millisecond (.1 second). A good rule to follow is to set the unit per pulse value equal to the maximum flow in the same units per second. This will limit the pulse to no faster than one pulse every second.

As an example of how to set an output, refer to *Figure 58 on page 61*. This example shows how to set the totalizer to track mass flow in kg/sec.

Note: *All outputs are disabled while using the Setup Menus.*

First, set the desired units of measurement:

1. Use **←→** keys to move to the Units Menu (see to “*The Units Menu*” on page 67).
2. Press the **↓** key until Mass Flow Unit appears. Press ENTER.
3. Press the **↓** key until kg appears in the numerator. Press the **→** key to move the underline cursor to the denominator. Press the **↓** key until sec appears in the denominator. Press ENTER to select.
4. Press the **↑** key until Units Menu appears.

Second, set the pulse output:

1. Use **←→** keys to move to the Totalizer Menu.
2. Press the **↓** key until Totaling appears.
3. Press ENTER and press the **↓** key to select Mass. Press ENTER.
4. Press the **↓** key to set the pulse output in the units you have selected for mass flow of kg/sec. Press ENTER and use **↑ ↓ ←→** keys to set the pulse value equal to the maximum flow in the same units per second. Press ENTER.
5. To reset the totalizer, press the **↓** key until Reset Total? appears. Press ENTER and the **↓** key to reset the totalizer if desired. Press ENTER.
6. Press the EXIT key and answer YES to permanently save your changes.

3.3.6 The Totalizer #1 Menu (cont.)

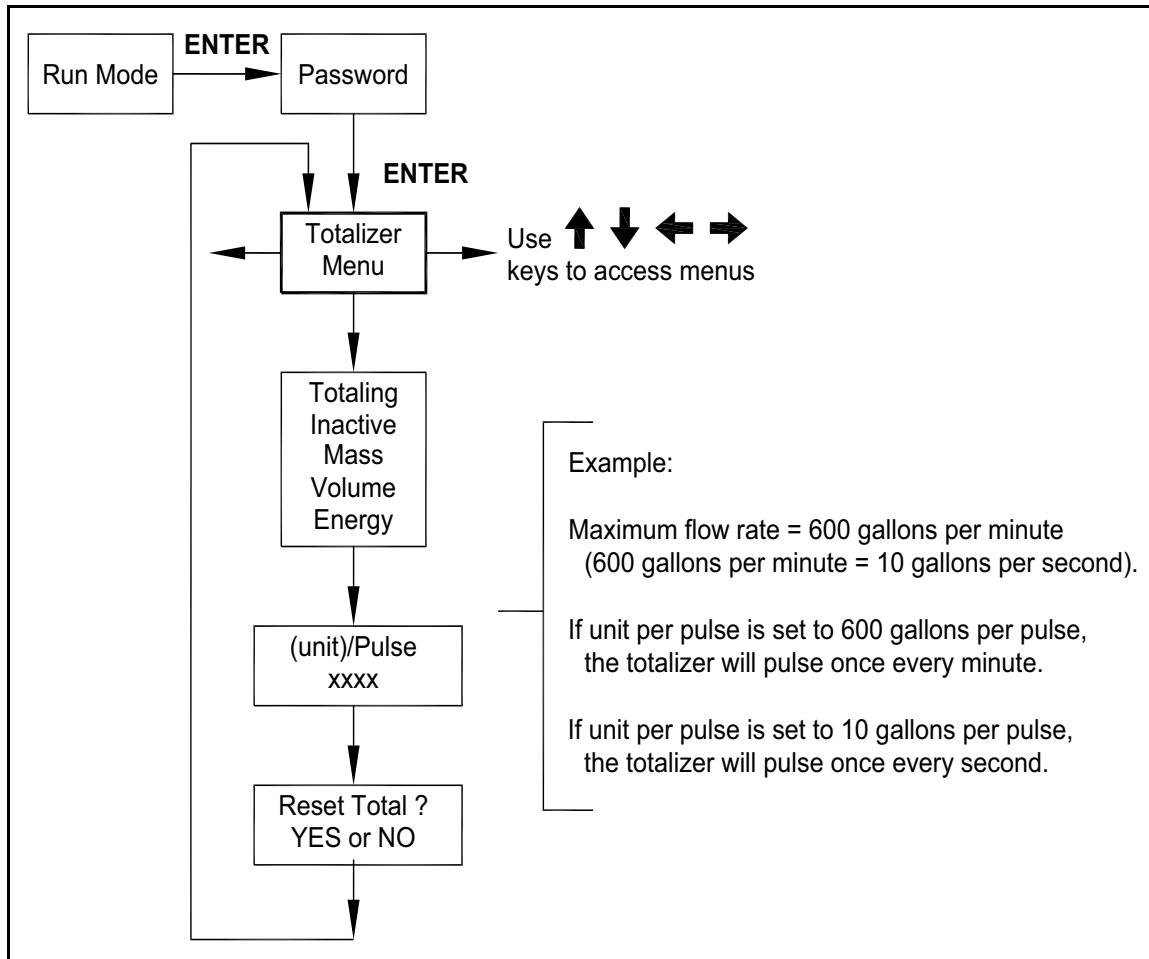


Figure 58: The Totalizer #1 Menu

3.3.7 The Totalizer #2 Menu

Refer to *Figure 59* below, and use Totalizer #2 to Monitor Flow or Energy.

Note: *Totalizer #2 does not operate a relay - it is for monitoring only.*

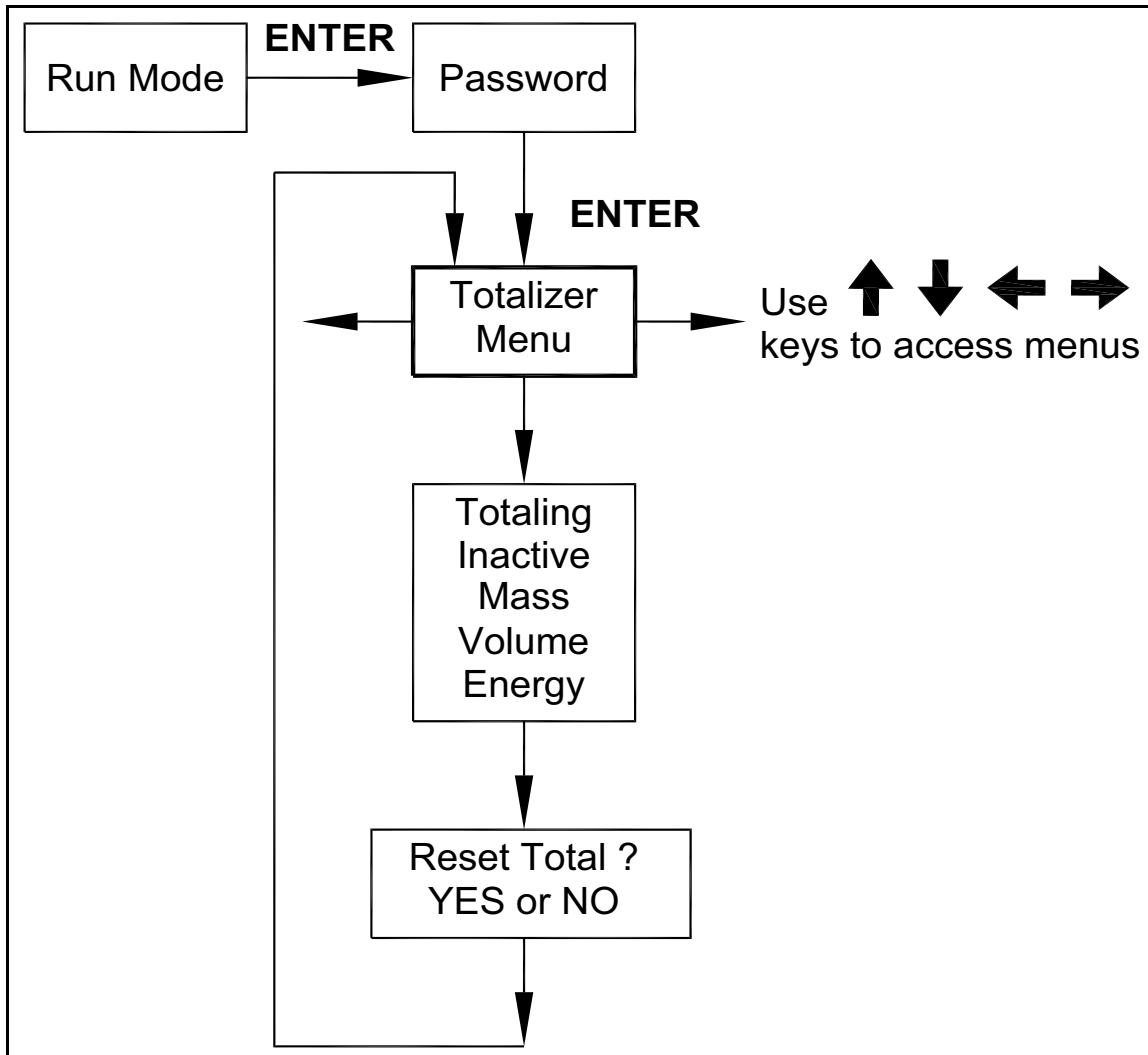


Figure 59: The Totalizer #2 Menu

3.3.8 The Energy Menu for EMS Energy Meters Only

There are several possibilities regarding the measurement of water or steam energy, given the location of the meter and the use of a second RTD. *Table 3* below summarizes the possibilities:

Table 3: Configuration Options

Fluid	Meter Location	Second RTD	Measurement
Water	“Sent” Flow Line	“Return” Flow Line	Change in Energy
Water	“Return” Flow Line	“Sent” Flow Line	Change in Energy
Water	“Sent” Flow Line	None	Outgoing Energy
Steam	“Sent” Flow Line	“Return” Flow Line (condensate)	Change in Energy
Steam	“Sent” Flow Line	None	Outgoing Energy

To use the above options, you must properly configure the meter in the *Energy Menu* (see *Figure 60 on page 64*) by completing these steps:

- 1. Loc in Sent Flow?** Select **Yes** or **No** based on where the meter is located. Refer to *Table 3* above.
- 2. Heating System?** Select **Yes** for a hot water system used for heating. Select **No** for a chilled water system used for cooling. Always select **Yes** for a steam system.
- 3. % Returned.** Select a number between **0% and 100%**. Estimate the amount of water that returns. It is usually 100%, or can be less than 100% if historical data shows the amount of makeup water used. If a second RTD is not used, set to 0%. When 0% is selected, the energy calculation represents the outgoing energy only (no return energy is subtracted).

Note: *The meter ships from the factory assuming 0% return and has a 1000 ohm resistor installed in the RTD #2 wiring location. This needs to be removed if the meter is to be used in a manner other than with 0% return and with the customer-supplied RTD in its place.*

3.3.8 The Energy Menu for EMS Energy Meters Only (cont.)

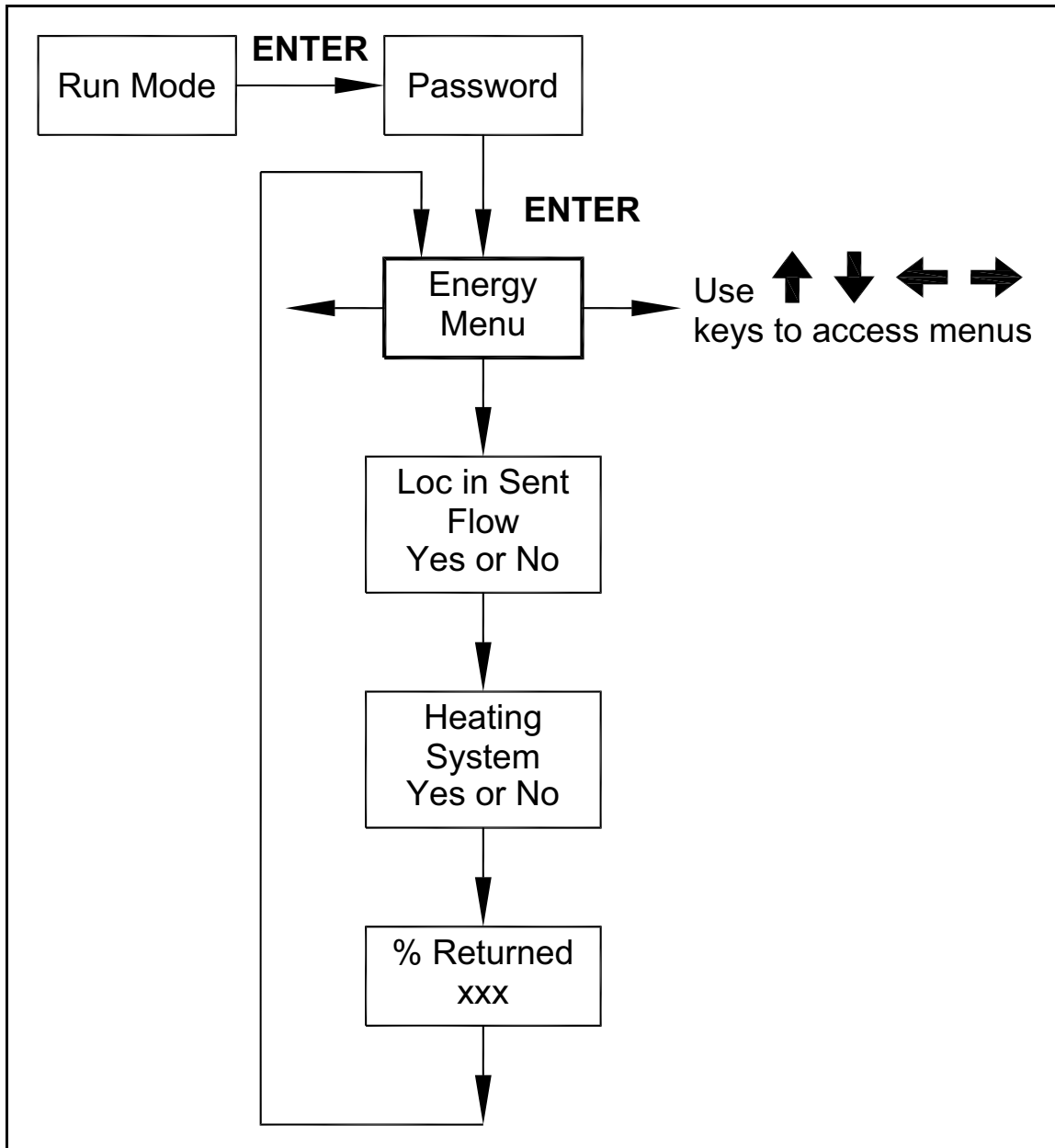


Figure 60: The Energy Menu for EMS Energy Meters Only

3.3.9 The Fluid Menu

Use the Fluid Menu (see *Figure 61 on page 66*) to configure the flowmeter for use with common gases, liquids and steam. Your flowmeter is pre-programmed at the factory for your application's process fluid.

Reference Richard W. Miller, *Flow Measurement Engineering Handbook* (Third Edition, 1996), page 2-75 for definition and use of the *Goyal-Doraiswamy* equation and page 2-76 for the definition and use of the *API 2540* equation. Also, see Appendix C for Fluid Calculation equations.

The units of measurement used in the Fluid Menu are preset and are as follows:

- Mole Weight = $\text{lb}_m/(\text{lb}_m \cdot \text{mol})$
- CRIT PRESS = psia
- CRIT TEMP = °R
- Density = Kg/m^3
- Viscosity = cP (centipoise).

3.3.10 The Units Menu

Use the Units Menu (see *Figure 62* below) to configure the flowmeter with the desired units of measurement. These are global settings and determine what appears on all screens.

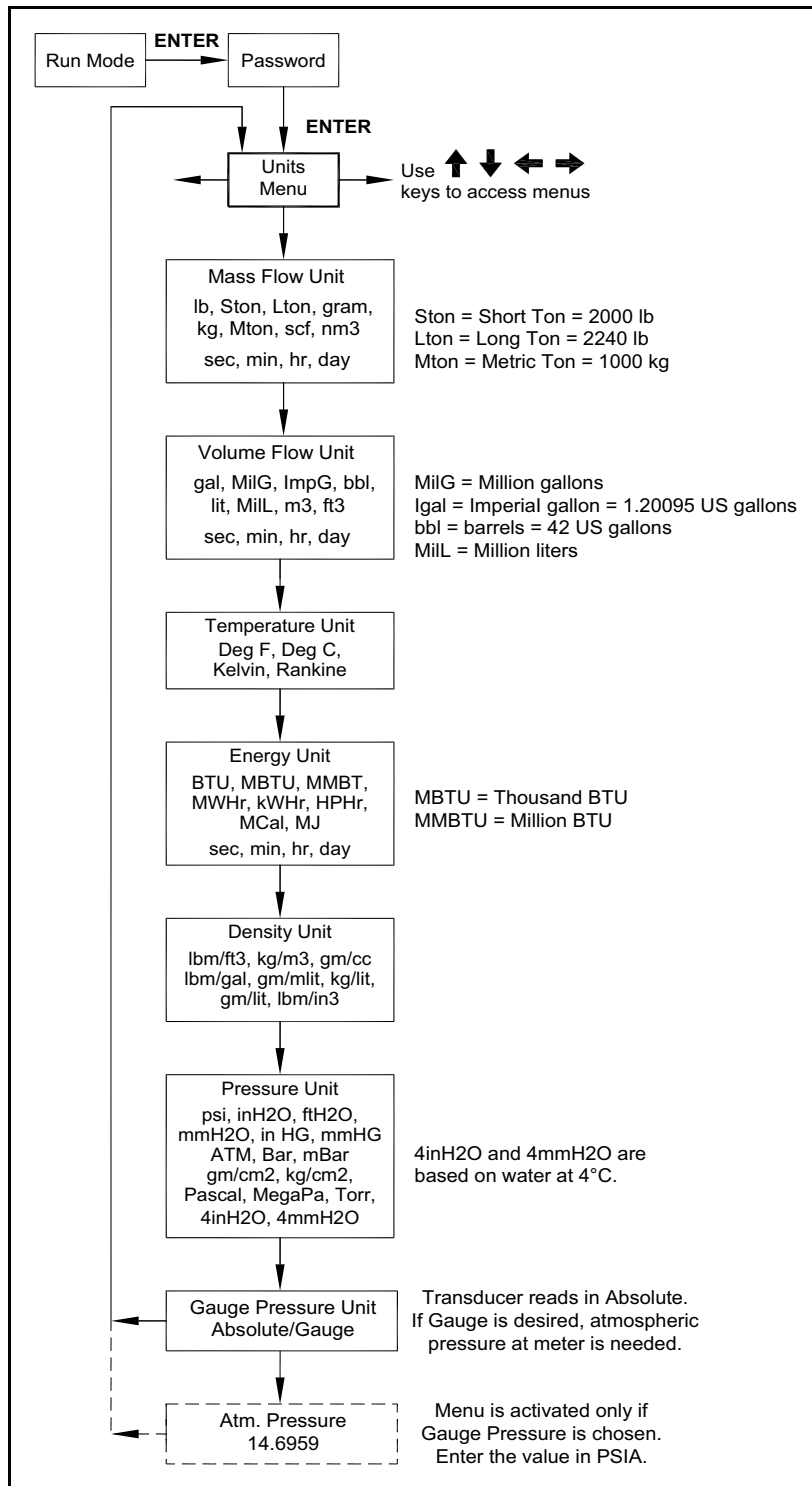


Figure 62: The Units Menu

3.3.11 The Time & Date Menu

Use the Time and Date Menu (see *Figure 63* below) to enter the correct time and date into the flowmeter's memory. The parameters are used in the Run Mode and the alarm and system log files.

Note: *Time is displayed in AM/PM format, but military format is used to set the time. For example, 1:00 PM is entered as 13:00:00 in the Set Time menu.*

This example shows how to set the time to 12:00:00. You can check the time in Run Mode by pressing the $\uparrow \downarrow$ keys until the Time & Date screen appears.

Note: *All outputs are disabled while using the Setup Menus.*

1. Use $\leftarrow \rightarrow$ keys to move to the Time and Date Menu.
2. Press the \downarrow key until Set Time appears. Press ENTER.
3. Press the \downarrow key until 1 appears. Press the \rightarrow key to move the underline cursor to the next digit. Press the \downarrow key until 2 appears. Continue sequence until all desired parameters are entered. Press ENTER to return to the Time and Date Menu.
4. Press EXIT to return to Run Mode.

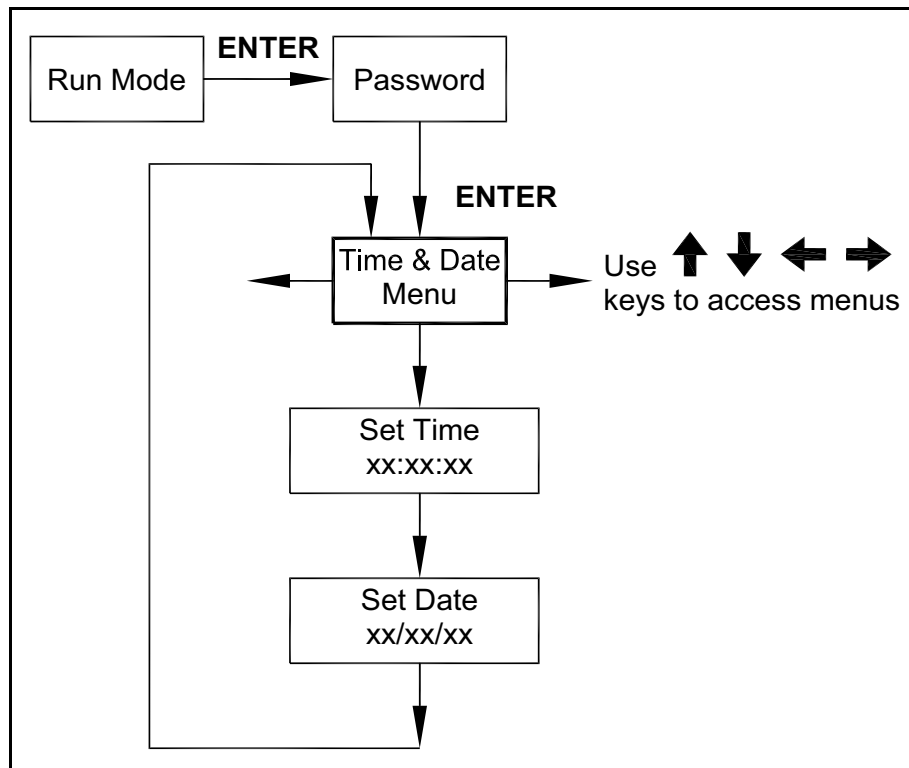


Figure 63: The Time & Date Menu

3.3.12 The Diagnostics Menu

Use the Diagnostics Menu (see *Figure 64 on page 70*) to simulate operation and review the system files. The system log files contain time/date stamped messages including: power on, power off, programming time outs, parameter faults, incorrect password entry and other various information relative to system operation and programming.

The simulated inputs are for testing the meter to verify that the programming is correct. They are also used to enter nominal operating temperature and pressure for the V only model. Simulated vortex frequency allows you to enter any value for the sensor input in Hz. The meter will calculate a flow rate based on the corresponding value and update all analog outputs (**the totalizer display and output is not affected by a simulated frequency**). The simulated pressure and temperature settings work the same way. The meter will output these new values and will use them to calculate a new density for mass flow measurement.

Note: *When your diagnostic work is complete, make sure to return the values to zero to allow the electronics to use the actual transducer values. For the V only model, keep the temperature and pressure at nominal operating conditions.*

If the meter display indicates a temperature or pressure fault, a substitute value can be entered to allow flow calculations to continue at a fixed value until the source of the fault is identified and corrected. **The units of measure of the displayed values are the same as the units configured for the flowmeter.**

3.3.12 The Diagnostics Menu (cont.)

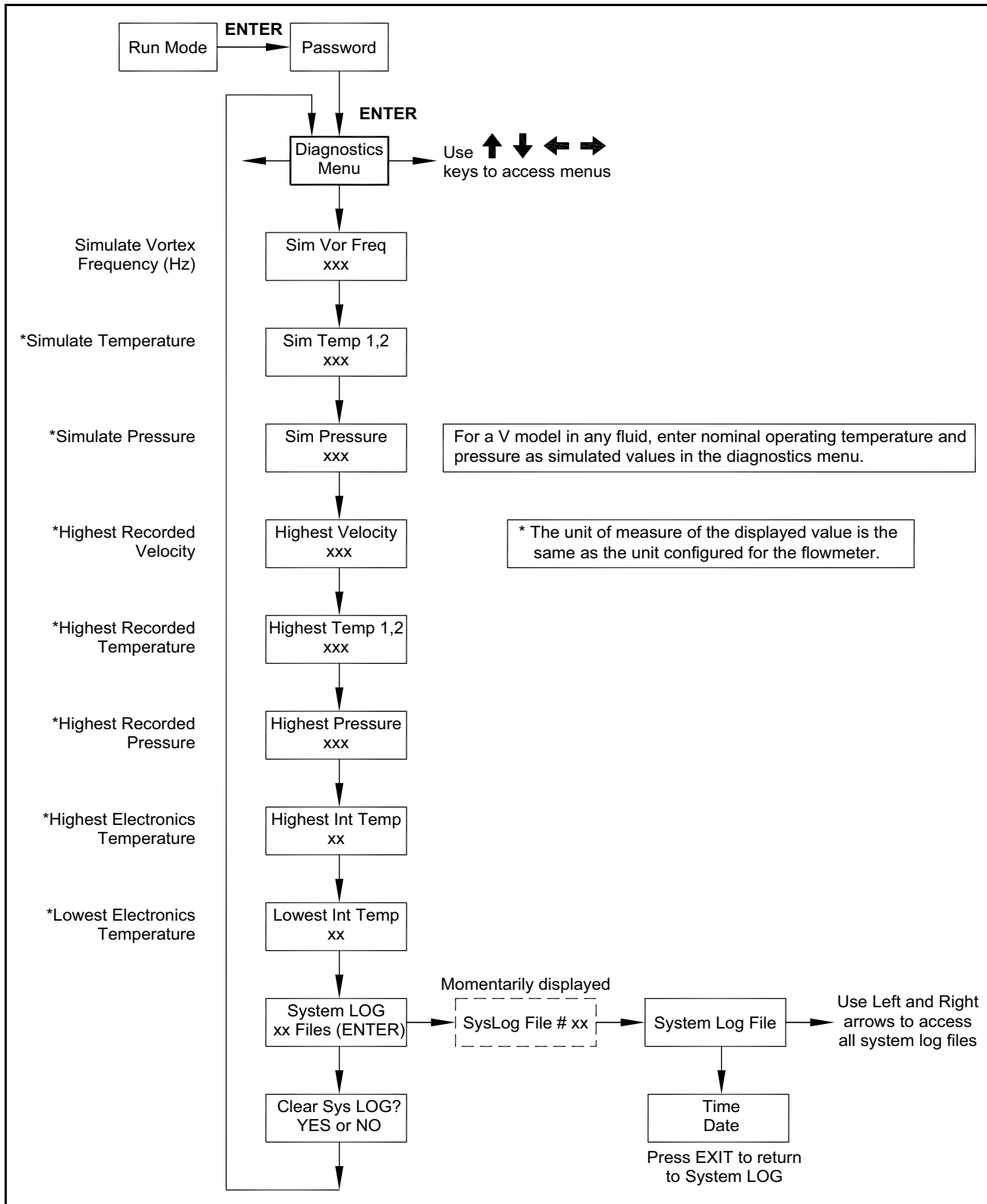


Figure 64: The Diagnostics Menu

3.3.13 The Calibration Menu

The Calibration Menu (see *Figure 65* below) contains the calibration coefficients for the flowmeter. These values should be changed only by properly trained personnel. The **Vortex Coef Ck** and **Low Flow Cutoff** are set at the factory. Consult GE for help with these settings if the meter is showing erratic flow rate readings.

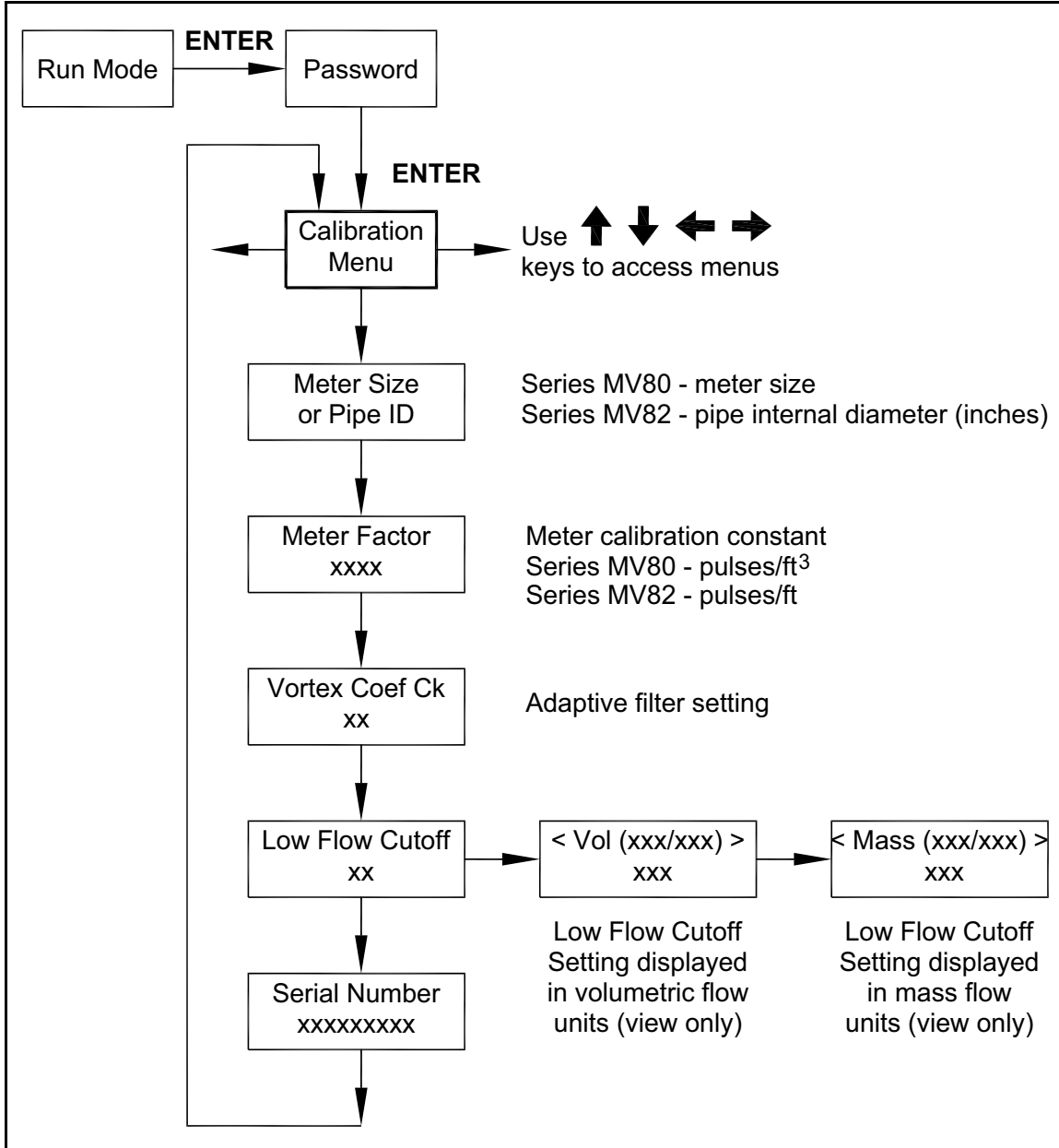


Figure 65: The Calibration Menu

3.3.14 The Password Menu

Use the Password Menu (see *Figure 66* below) to set or change the system password. The factory-set password is **1234**.

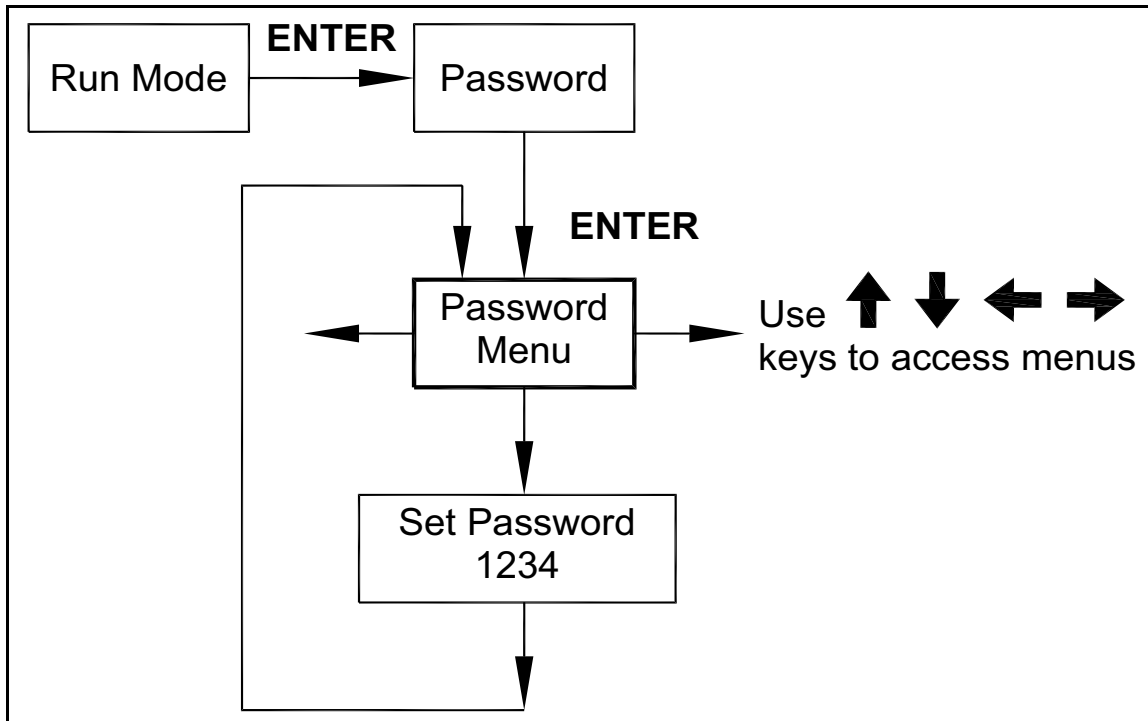


Figure 66: The Password Menu

Chapter 4. Serial Communications

4.1 HART Communications

The HART Communications Protocol (Highway Addressable Remote Transducer Protocol) is a bidirectional digital serial communications protocol. The HART signal is based on the Bell 202 standard and is superimposed on the 4-20 mA Output 1. Peer-to-peer (analog/digital) and multi-drop (digital only) modes are supported.

4.1.1 Wiring



WARNING! Place the controls in manual mode when making configuration changes to the vortex meter.

The following diagrams show the proper connections required for HART communications:

4.1.1a HART Loop Powered Meter Wiring

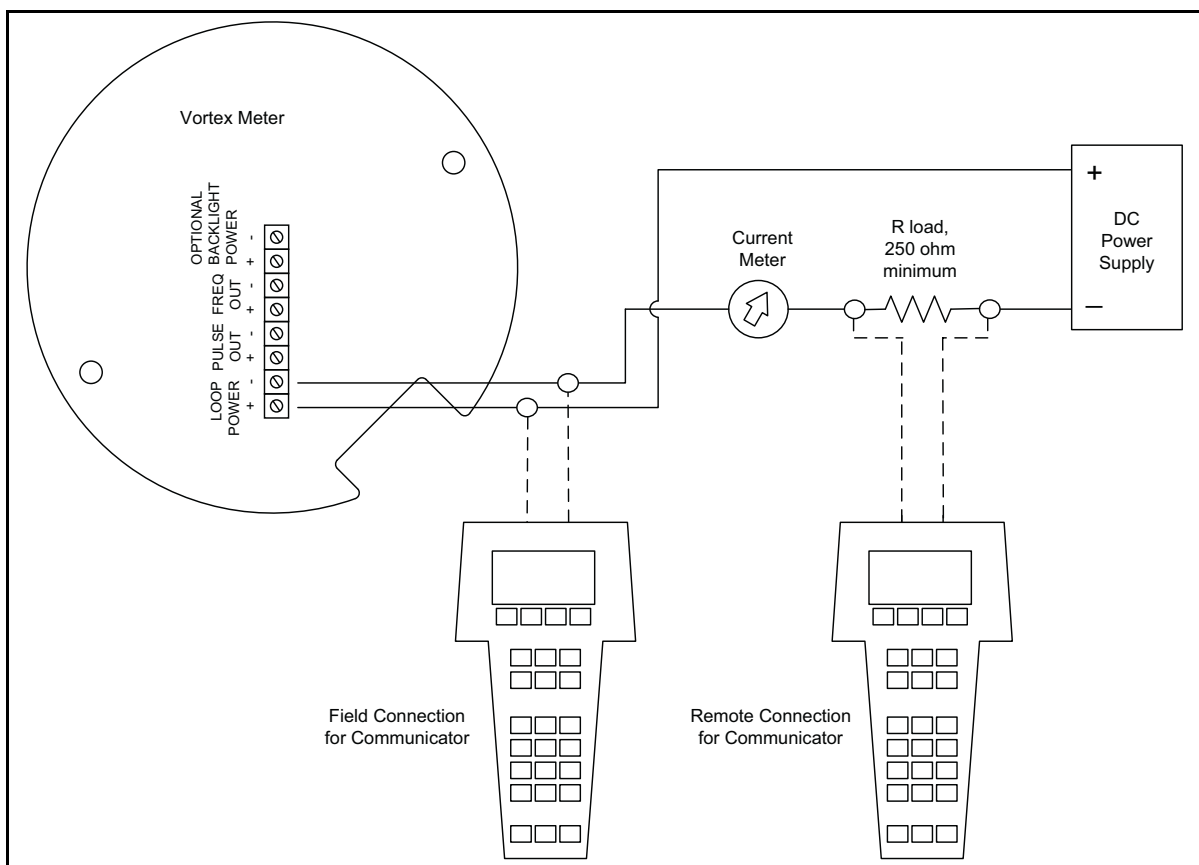


Figure 67: HART Loop Powered Meter Wiring

4.1.1b HART DC Powered Meter Wiring

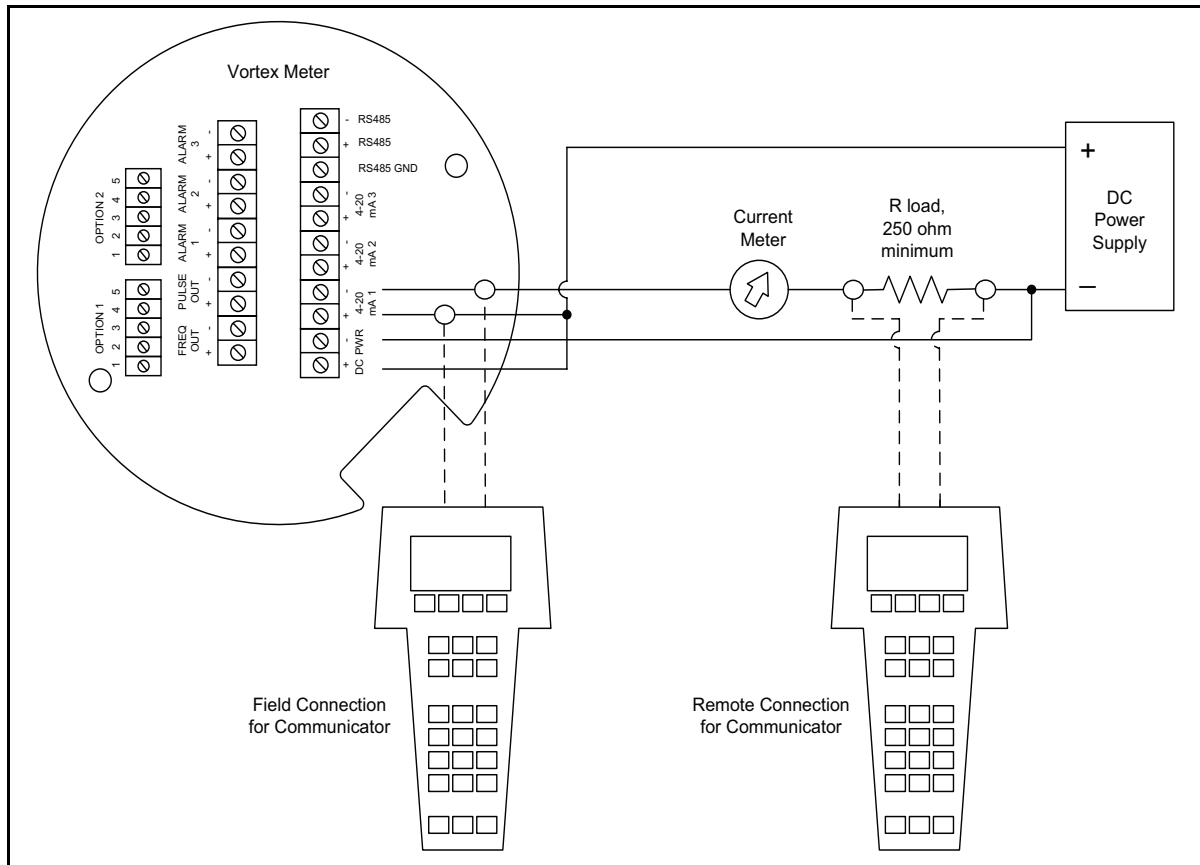


Figure 68: HART DC Powered Meter Wiring

4.1.1c HART AC Powered Meter Wiring

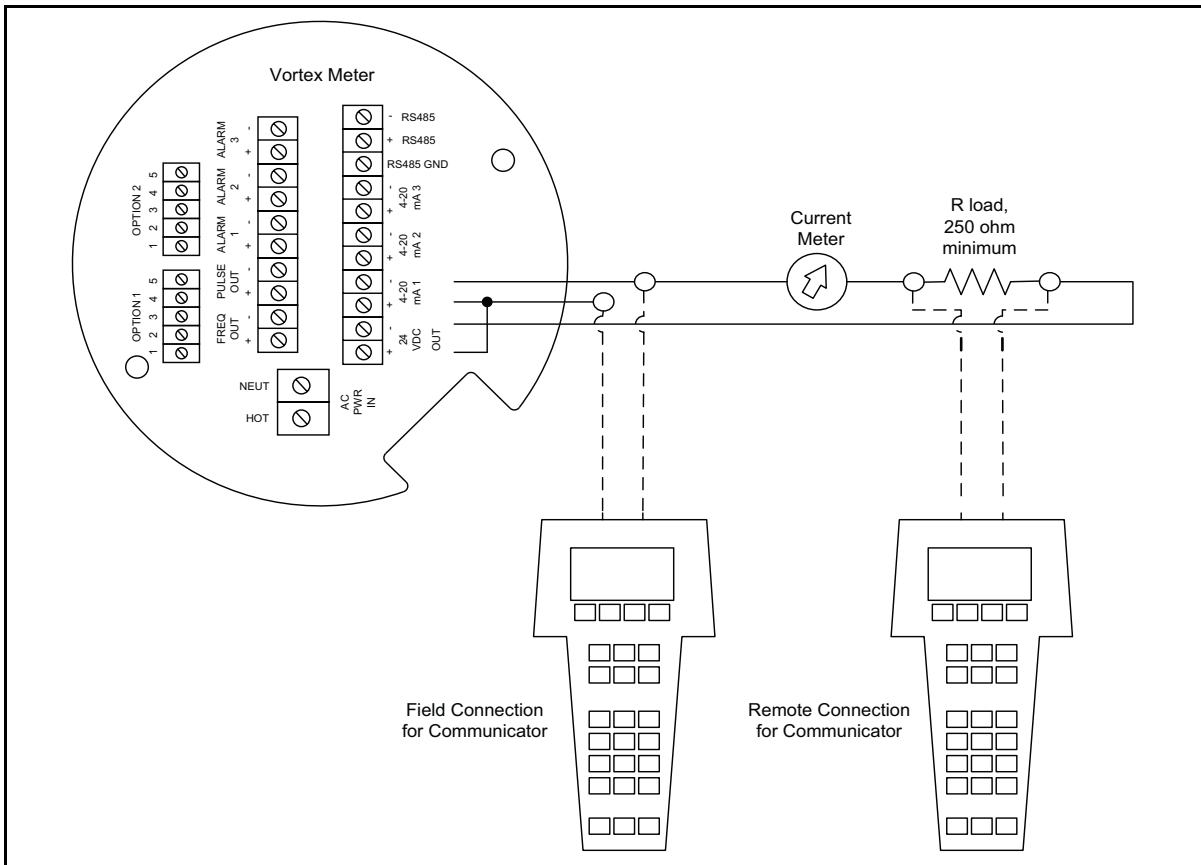


Figure 69: HART AC Powered Meter Wiring

4.1.2 HART Commands with the Digital Display Menu

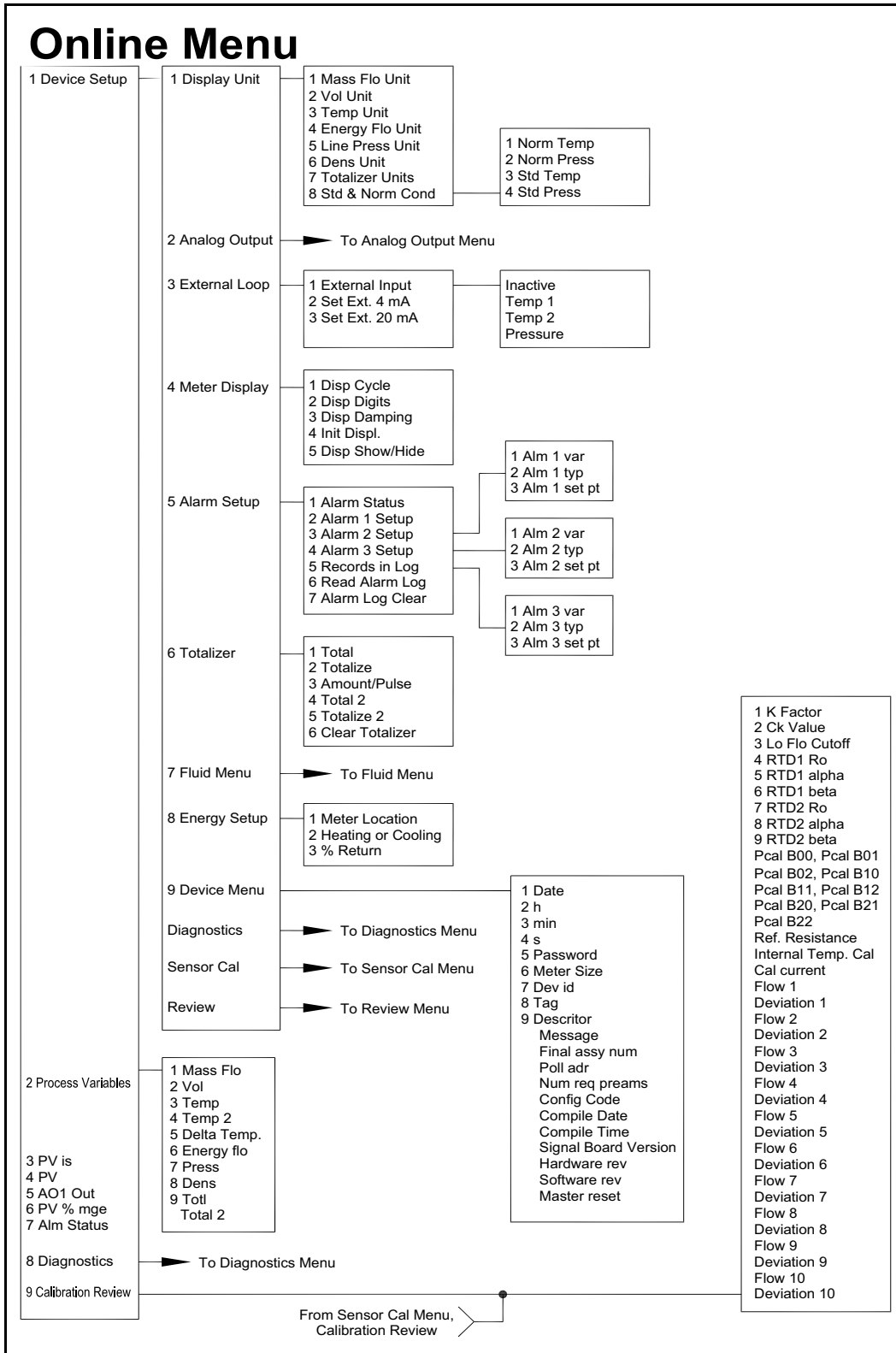


Figure 70: HART Commands with the Online Menu

4.1.2 HART Commands with the Digital Display Menu (cont.)

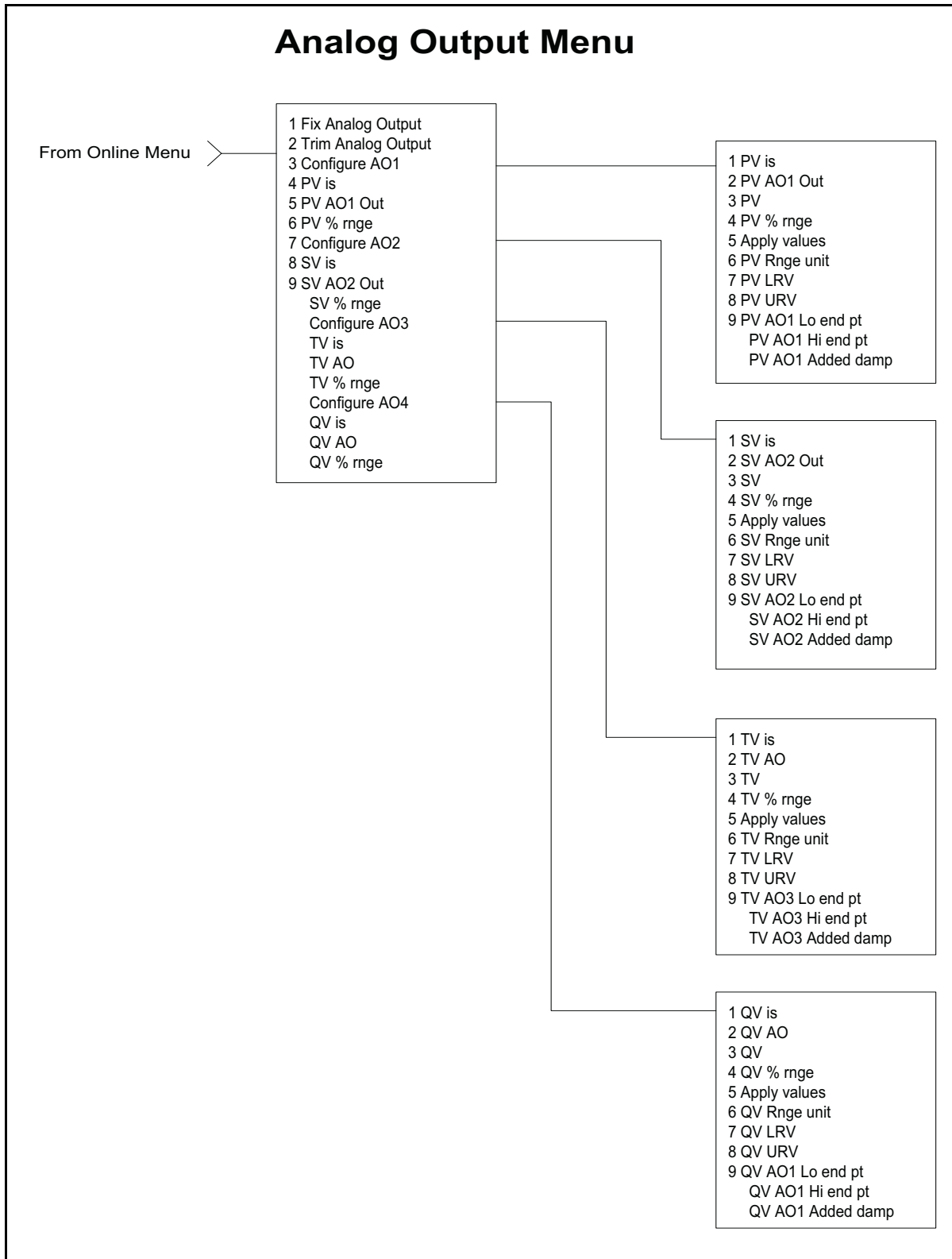


Figure 71: HART Commands with the Analog Output Menu

4.1.2 HART Commands with the Digital Display Menu (cont.)

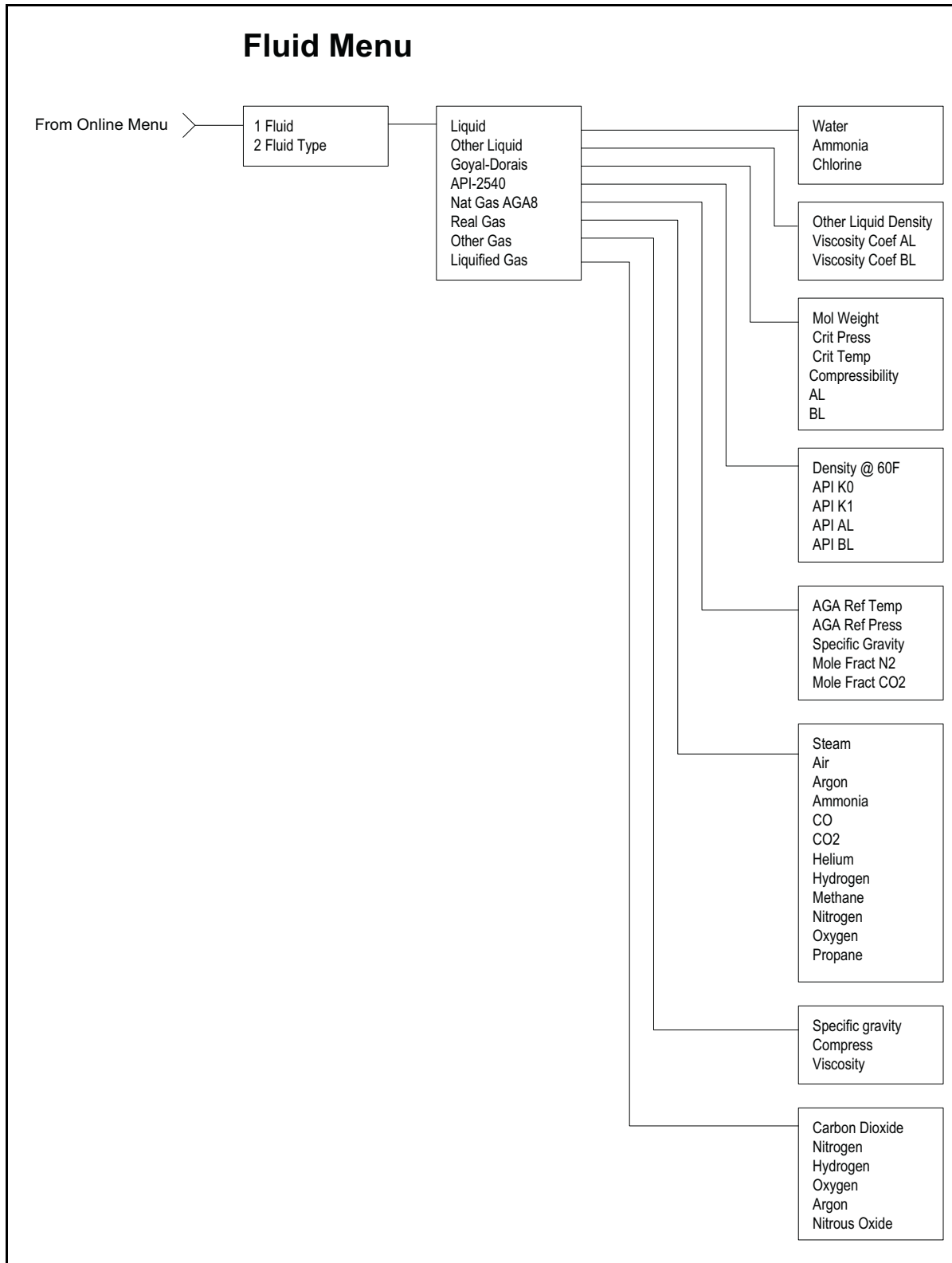


Figure 72: HART Commands with the Fluid Menu

4.1.2 HART Commands with the Digital Display Menu (cont.)

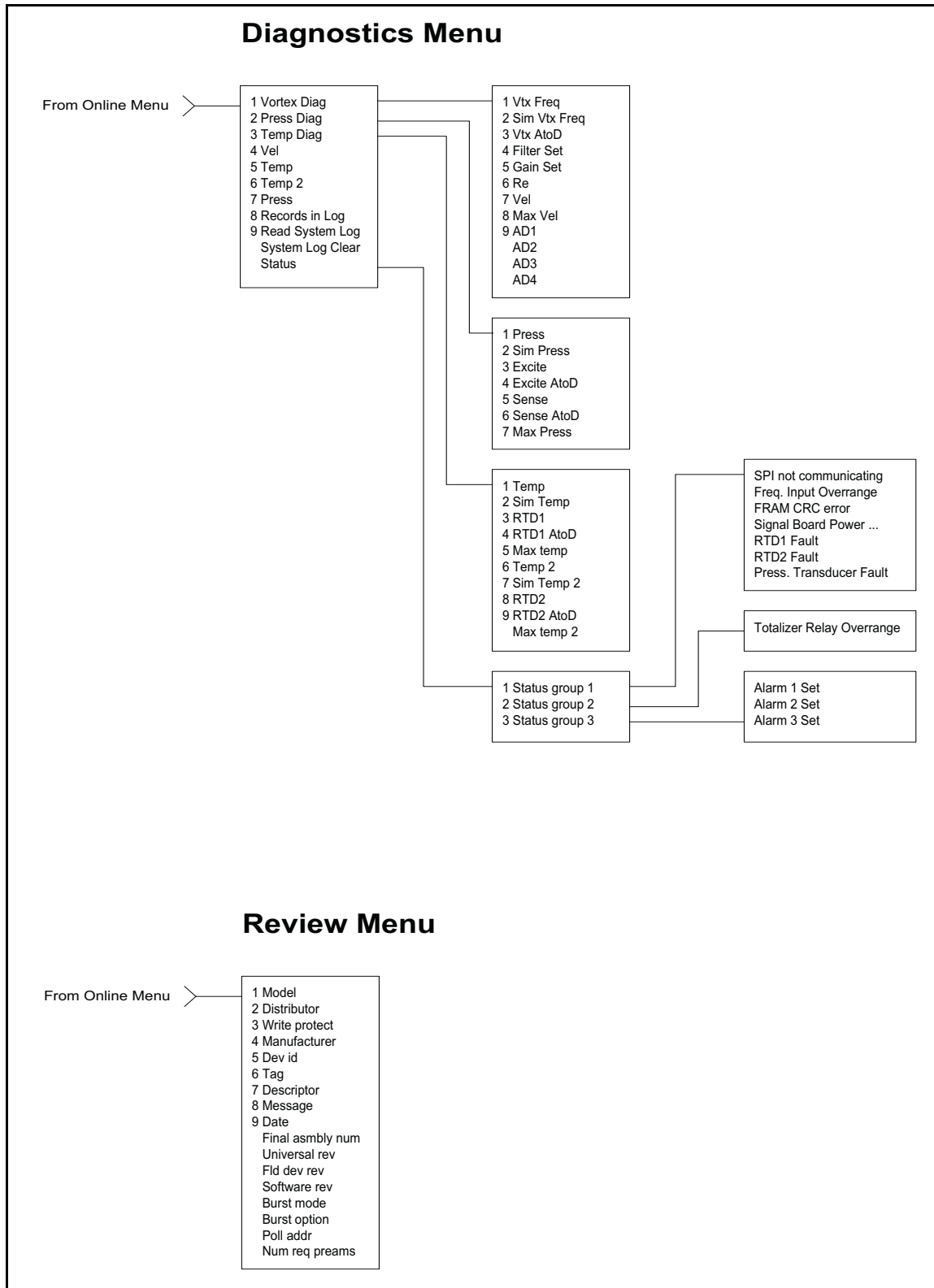


Figure 73: HART Commands with the Diagnostics Menu

4.1.2 HART Commands with the Digital Display Menu (cont.)

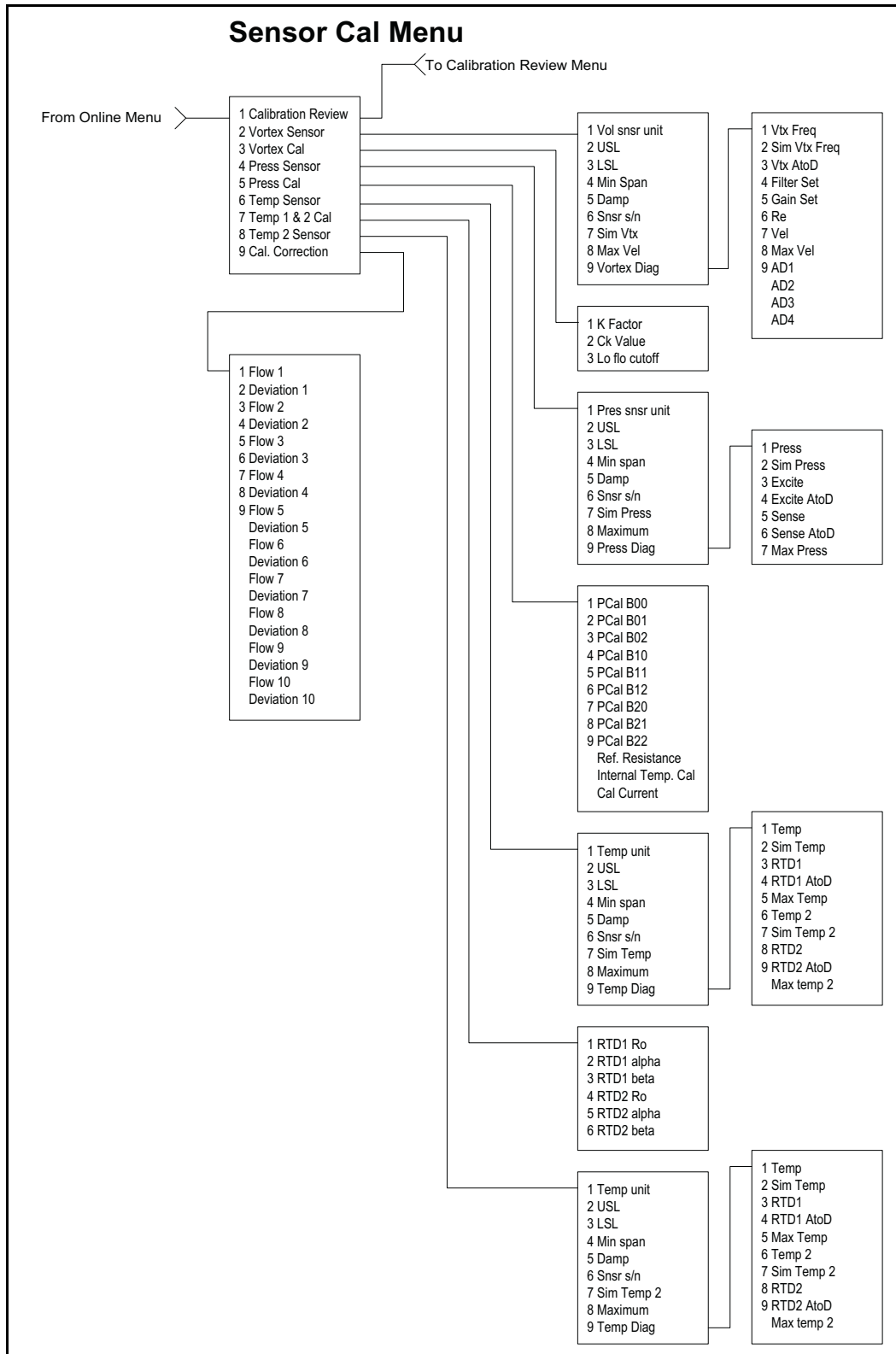


Figure 74: HART Commands with the Sensor Cal Menu

4.1.3 HART Commands with the Generic Digital Display Menu

Note: Use password 16363.

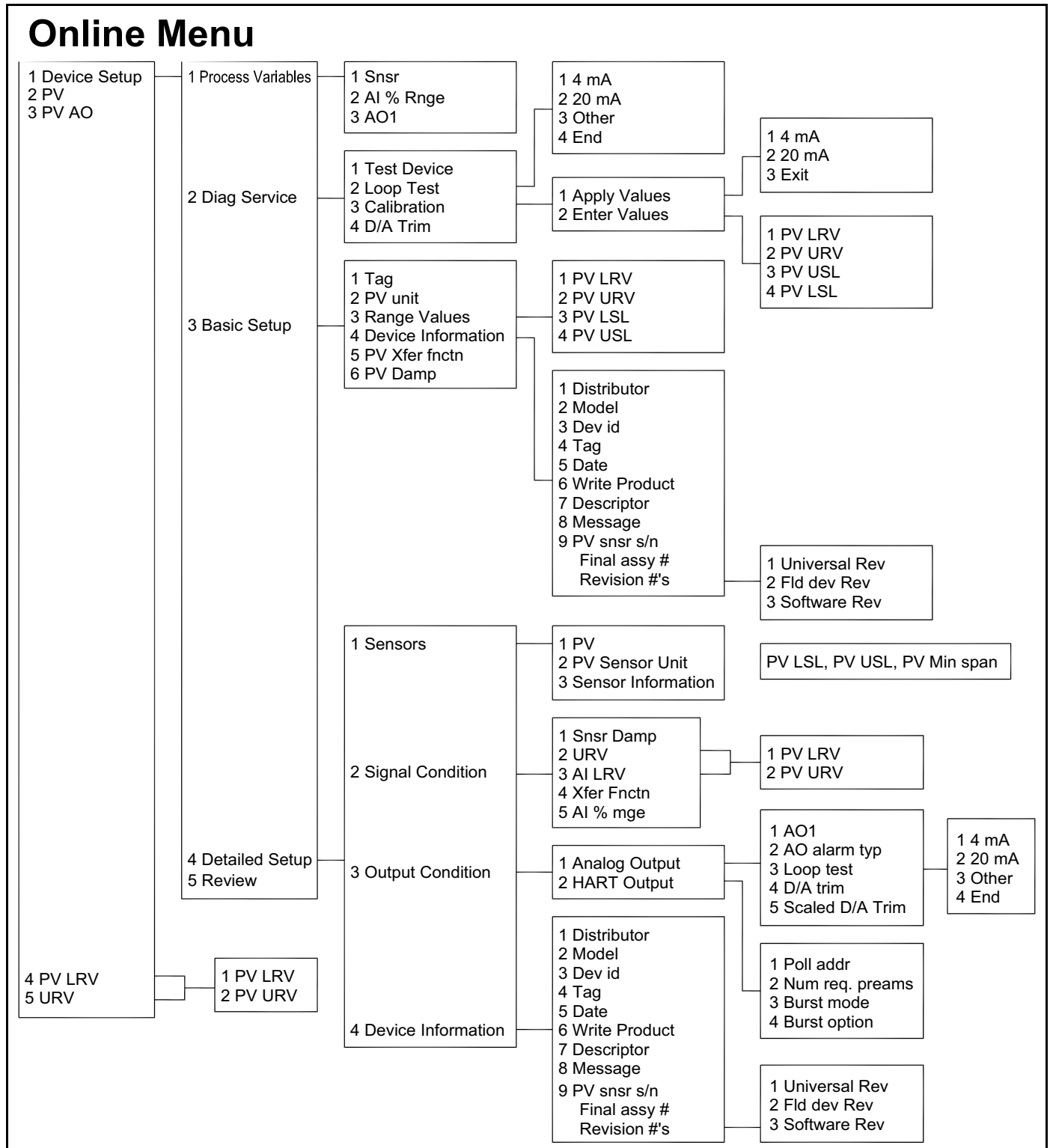


Figure 75: HART Commands with the Generic Online Menu

4.1.4 Fast Key Sequence

Note: Use password 16363.

Table 4: Fast Key Sequence

Sequence	Description	Access	Notes
1,1,1	Snsr	View	Primary variable value
1,1,2	AI % Rnge	View	Analog output % range
1,1,3	AOI	View	Analog output, mA
1,2,1	Test Device	N/A	Not used
1,2,2,1	4 mA	View	Loop test, fix analog output at 4 mA
1,2,2,2	20 mA	View	Loop test, fix analog output at 20 mA
1,2,2,3	Other	Edit	Loop test, fix analog output at mA value entered
1,2,2,4	End		Exit loop test
1,2,3,1,1	4 mA	N/A	Not used, apply values
1,2,3,1,2	20 mA	N/A	Not used, apply values
1,2,3,1,3	Exit		Exit apply values
1,2,3,2,1	PV LRV	Edit	Primary variable lower range value
1,2,3,2,2	PV URV	Edit	Primary variable upper range value
1,2,3,2,3	PV USL	View	Primary variable upper sensor limit
1,2,3,2,4	PV LSL	View	Primary variable lower sensor limit
1,2,4	D/A Trim	Edit	Calibrate electronics 4mA and 20mA values
1,3,1	Tag	Edit	Tag
1,3,2	PV unit	Edit	Primary variable units
1,3,3,1	PV LRV	Edit	Primary variable lower range value
1,3,3,2	PV URV	Edit	Primary variable upper range value
1,3,3,3	PV LSL	View	Primary variable upper sensor limit
1,3,3,4	PV USL	View	Primary variable lower sensor limit
1,3,4,1	Distributor	N/A	Not used
1,3,4,2	Model	N/A	Not used
1,3,4,3	Dev id	View	Device identification
1,3,4,4	Tag	Edit	Tag
1,3,4,5	Date	Edit	Date
1,3,4,6	Write Protect	View	Write protect
1,3,4,7	Descriptor	Edit	Vortex flowmeter
1,3,4,8	Message	Edit	32 character alphanumeric message
1,3,4,9	PV snsr s/n	View	Primary variable sensor serial number
1,3,4,menu	Final assy #	Edit	Final assembly number
1,3,4,menu,1	Universal Rev	View	Universal revision
1,3,4,menu,2	Fld dev Rev	View	Field device revision
1,3,4,menu,3	Software Rev	view	Software revision
1,3,5	PV Xfer fnctn	View	Linear
1,3,6	PV Damp	Edit	Primary variable damping (time constant) in seconds
1,4,1,1	PV	View	Primary variable value

Table 4: Fast Key Sequence (cont.)

Sequence	Description	Access	Notes
1,4,1,2	PV Sensor Unit	Edit	Primary variable units
1,4,1,3	Sensor Information	View	PV LSL, PV USL, PV Min span
1,4,2,1	Snsr Damp	Edit	Primary variable damping (time constant) in seconds
1,4,2,2,1	PV LRV	Edit	Primary variable low range value
1,4,2,2,2	PV URV	Edit	Primary variable upper range value
1,4,2,3,1	PV LRV	Edit	Primary variable low range value
1,4,2,3,2	PV URV	Edit	Primary variable upper range value
1,4,2,4	Xfer Fnctn	View	Linear
1,4,2,5	AI % mge	View	Analog output % range
1,4,3,1,1	AO1	View	Analog output, mA
1,4,3,1,2	AO alarm typ	N/A	Not used
1,4,3,1,3,1	4 mA	View	Loop test, fix analog output at 4 mA
1,4,3,1,3,2	20 mA	View	Loop test, fix analog output at 20 mA
1,4,3,1,3,3	Other	Edit	Loop test, fix analog output at mA value entered
1,4,3,1,3,4	End		Exit loop test
1,4,3,1,4	D/A trim	Edit	Calibrate electronics 4mA and 20mA values
1,4,3,1,5	Scaled D/A trim	N/A	Not used
1,4,3,2,1	Poll addr	Edit	Poll address
1,4,3,2,2	Num req. preams	View	Number of required preambles
1,4,3,2,3	Burst mode	N/A	Not used
1,4,3,2,4	Burst option	N/A	Not used
1,4,4,1	Distributor	N/A	Not used
1,4,4,2	Model	N/A	Not used
1,4,4,3	Dev id	View	Device identification
1,4,4,4	Tag	Edit	Tag
1,4,4,5	Date	Edit	Date
1,4,4,6	Write Protect	View	Write protect
1,4,4,7	Descriptor	Edit	Vortex flowmeter
1,4,4,8	Message	Edit	32 character alphanumeric message
1,4,4,9	PV snsr s/n	View	Primary variable sensor serial number
1,4,4,menu	Final assy #	Edit	Final assembly number
1,4,4,menu,1	Universal Rev	View	Universal revision
1,4,4,menu,2	Fld dev Rev	View	Field device revision
1,4,4,menu,3	Software Rev	View	Software revision
1,5	Review	N/A	Not used
2	PV	View	Primary variable value
3	PV AO	View	Analog output, mA
4,1	PV LRV	Edit	Primary variable lower range value
4,2	PV URV	Edit	Primary variable upper range value
5,1	PV LRV	Edit	Primary variable lower range value
5,2	PV URV	Edit	Primary variable upper range value

4.2 Modbus Communications



WARNING! Place the controls in manual mode when making configuration changes to the vortex meter.

4.2.1 Applicable Flowmeter Models

PanaFlow Mass Flowmeters, Models MV80 and MV82 with Modbus communication protocol and firmware version 4.00.58 and above are capable of Modbus communications.

4.2.2 Overview

This section describes the preliminary implementation of the Modbus communication protocol for use in monitoring common process variables in the PanaFlow Vortex Flowmeter. The physical layer utilizes the half-duplex RS-485 port and the Modbus protocol.

4.2.3 Reference Documents

The following technical documents are available online from www.modbus.org:

- Modbus Application Protocol Specification V1.1
- Modbus Over Serial Line Specification & Implementation Guide V1.0
- Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. J

4.2.4 Wiring

An RS485 daisy chained network configuration, as shown in *Figure 76* below, is recommended. Do not use a star, ring, or cluster arrangement.

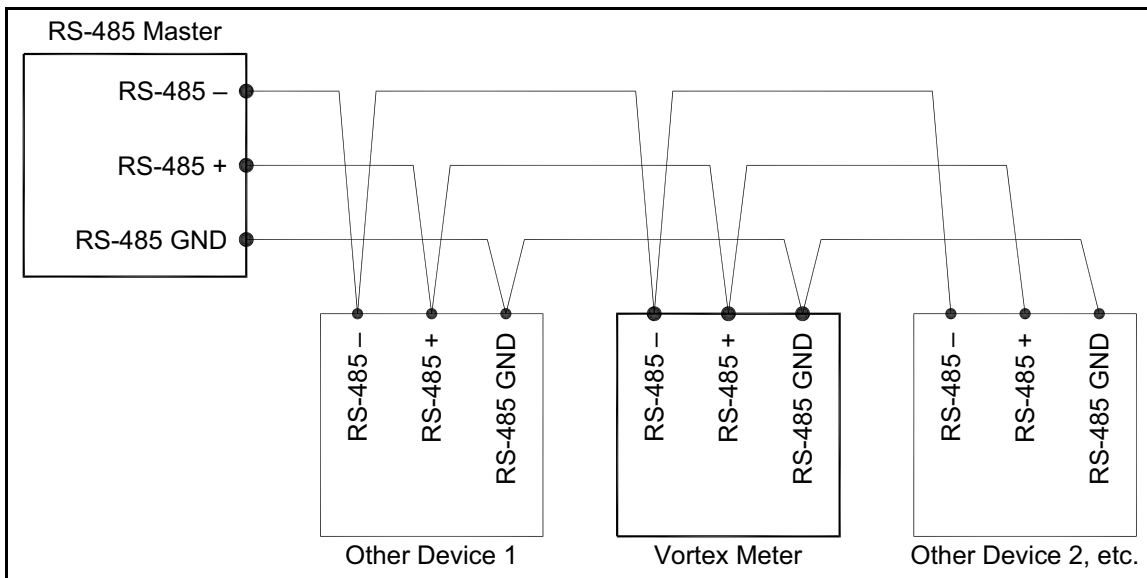


Figure 76: RS-485 Modbus Wiring

4.2.5 Pin Labeling Among Devices

- RS-485 - = "A" = "TxD-/RxD-" = "Inverting pin"
- RS-485 + = "B" = "TxD+/RxD+" = "Non-Inverting pin"
- RS-485 GND = "GND" = "G" = "SC" = "Reference"

4.2.6 Menu Items

The following menu items are in the *Output Menu* and allow selection and control of the Modbus communication protocol.

4.2.6a Address

When the Modbus protocol is selected, the Modbus address is equal to the user programmable device address if it is in the range 1...247, in accordance with the Modbus specification. If the device address is zero or is greater than 247, then the Modbus address is internally set to 1.

4.2.6b Comm Protocol

The Comm Protocol menu allows selection of “Modbus RTU Even,” “Modbus RTU Odd,” “Modbus RTU None2” or “Modbus RTU None1” (non-standard Modbus) with Even, Odd and None referring to the parity selection. When even or odd parity is selected, the unit is configured for 8 data bits, 1 parity bit and 1 stop bit; with no parity, the number of stop bits is 1 (non-standard) or 2. When changing the protocol, the change is made as soon as the ENTER key is pressed.

4.2.6c Modbus Units

The Modbus Units menu is used to control the display units, where applicable, for the meter's variables. The internal base units of the meter are: °F, psia, lbm/sec, ft³/sec, Btu/sec, lbm/ft³. The display variables are displayed in the user selected display units.

4.2.6d Modbus Order

The byte order within registers and the order in which multiple registers containing floating point or long integer data are transmitted may be changed with this menu item. According to the Modbus specification, the most significant byte of a register is transmitted first, followed by the least significant byte. The Modbus specification does not prescribe the order in which registers are transmitted when multiple registers represent values longer than 16 bits. Using this menu item, the order in which registers representing floating point or long integer data and/or the byte order within the registers may be reversed for compatibility with some PLCs and PC software.

Table 5 below lists the four selections are available in this menu. When selecting an item, the protocol is changed immediately without having to press the ENTER key.

Table 5: Modbus Order Options

Order	Description
0-1:2-3	Most significant register first, most significant byte first (default)
2-3:0-1	Least significant register first, most significant byte first
1-0:3-2	Most significant register first, least significant byte first
3-2:1-0	Least significant register first, least significant byte first

All of the registers are affected by the byte order, including strings and registers representing 16-bit integers. The register order affects only the order of those registers representing 32-bit floating point and long integer data, but does not affect single 16-bit integers or strings.

4.2.6e Modbus Protocol

The Modbus RTU protocol is supported in this implementation. Supported baud rates are 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200. The default baud rate is 19200 baud. Depending upon the Modbus protocol selected, data is transmitted in 8-bit data frames with even or odd parity and 1 stop bit, or no parity and 2 or 1 (non-standard) stop bits.

The current Modbus protocol specification does not define register usage. However, there is an informal obsolete register numbering convention (see *Table 6* below) which is derived from the original Modicon Modbus protocol specification. This convention is used by many vendors of Modbus capable products.

Table 6: Register Numbering Convention

Registers	Usage	Valid Function Codes
00001-09999	Read/write bits (“coils”)	01 (read coils) 05 (write single coil) 15 (write multiple coils)
10001-19999	Read-only bits (“discrete inputs”)	02 (read discrete inputs)
30001-39999	Read-only 16 bit registers (“input registers”), IEEE 754 floating point register pairs, arbitrary length strings encoded as two ASCII characters per 16-bit register	03 (read holding registers) 04 (read input registers)
40001-49999	Read/write 16-bit registers (“holding registers”, IEEE 754 floating point register pairs, arbitrary length strings encoded as two ASCII characters per 16-bit register	03 (read holding registers) 06 (write single register) 16 (write multiple registers)

Each range of register numbers maps to a unique range of addresses that are determined by the function code and the register number. The address is equal to the least significant four digits of the register number minus one, as shown in *Table 7* below.

Table 7: Register Number Range Mapping

Registers	Function Codes	Data Type and Address Range
00001-09999	01, 05, 15	Read/write bits 0000-9998
10001-19999	02	Read-only bits 0000-9999
30001-39999	03, 04	Read-only 16-bit registers 0000-9998
40001-49999	03, 06, 16	Read/write 16-bit registers 0000-9998

4.2.6f Register Definitions

The meter serial number and those variables that are commonly monitored (mass, volume and energy flow rates, total, pressure, temperature, density, viscosity, Reynolds number, and diagnostic variables such as frequency, velocity, gain, amplitude and filter setting) are accessible via the Modbus protocol. Long integer and floating point numbers are accessed as pairs of 16-bit registers in the register order selected in the Modbus Order menu. Floating point numbers are formatted as single precision IEEE 754 floating point values.

The flow rate, temperature, pressure, and density variables may be accessed as either the flowmeter internal base units or in the user-programmed display units, which is determined by the programming of the Output Menu “Modbus Units” item. The display units strings (see *Table 8* below) may be examined by accessing their associated registers. Each of these units string registers contain 2 characters of the string, and the strings may be 2 to 12 characters in length with unused characters set to zero. Note that the byte order affects the order in which the strings are transmitted. If the Modbus Order menu (see “*Modbus Order*” on page 86) is set to 0-1:2-3 or 2-3:0-1, then the characters are transmitted in the correct order; if it is set to 1-0:3-2 or 3-2:1-0, then each pair of characters will be transmitted in reverse order

Table 8: Display Units Strings

Registers	Variable	Data Type	Units	Function Code	Addresses
65100-65101	Serial number	unsigned long	--	03, 04	
30525-30526	Totalizer	unsigned long	display units*	03, 04	524-525
32037-32042	Totalizer units	string	--	03, 04	2036-2041
30009-30010	Mass flow	float	display units*	03, 04	8-9
30007-30008	Volume flow	float	display units*	03, 04	6-7
30005-30006	Pressure	float	display units*	03, 04	4-5
30001-30002	Temperature	float	display units*	03, 04	0-1
30029-30030	Velocity	float	ft/sec	03, 04	28-29
30015-30016	Density	float	display units*	03, 04	14-15
30013-30014	Viscosity	float	cP	03, 04	12-13
30031-30032	Reynolds number	float	--	03, 04	30-31
30025-30026	Vortex frequency	float	Hz	03, 04	24-25
34532	Gain	char	--	03, 04	4531
30085-30086	Vortex amplitude	float	Vrms	03, 04	84-85
30027-30028	Filter setting	float	Hz	03, 04	26-27

4.2.6f Register Definitions (cont.)

Table 9 below shows the registers that are available with the energy meter firmware.

Table 9: Energy Firmware Registers

Registers	Variable	Data Type	Units	Function Code	Addresses
30527-30528	Totalizer #2	unsigned long	display units*	03, 04	526-527
32043-32048	Totalizer #2 units	string	--	03, 04	2042-2047
30003-30004	Temperature #2	float	display units*	03, 04	2-3
30011-30012	Energy flow	float	display units*	03, 04	10-11

Table 10 below shows the registers that contain the display units strings:

Table 10: Display Unit Strings Registers

Registers	Variable	Data Type	Units	Function Code	Addresses
32007-30012	Volume Flow units	string	--	03, 04	2006-2011
32001-32006	Mass flow units	string	--	03, 04	2000-2005
32025-32030	Temperature units	string	--	03, 04	2024-2029
32019-32024	Pressure units	string	--	03, 04	2018-2023
32031-32036	Density units	string	--	03, 04	2030-2035
32013-32017	Energy flow units	string	--	03, 04	2012-2017

Function codes 03 (read holding registers) and 04 (read input registers) are the only codes supported for reading these registers, and function codes for writing holding registers are not implemented. We recommend that the floating point and long integer registers be read in a single operation with the number of registers being a multiple of two. If this data is read in two separate operations, with each reading being a single 16-bit register, then the value will likely be invalid.

The floating point registers with values in display units are scaled to the same units currently displayed, but they are instantaneous values that are not smoothed. If display smoothing is enabled (non-zero value entered in the Display TC item in the Display Menu), then the register values will not agree exactly with the displayed values.

4.2.6g Exception Status Definitions

The Read Exception Status command (function code 07) returns the exception status byte, which is defined as shown in *Table 11* below. This byte may be cleared by setting “coil” register #00003 (function code 5, address 2, data = 0xff00).

Table 11: Exception Status Bits

Bit(s)	Definition
0-1	Byte order (see Modbus Order on “ <i>Modbus Order</i> ” on page 86) <ul style="list-style-type: none"> • 0 = 3-2:1-0 1 = 2-3:0-1 • 2 = 1-0:3-2 3 = 0-1:2-3
2	Temperature sensor fault
3	Pressure sensor fault
4	A/D converter fault
5	Period overflow
6	Pulse overflow
7	Configuration changed

4.2.6h Discrete Input Definitions

The status of the three alarms may be monitored via the Modbus Read Discrete Input command (function code 02), as shown in *Table 12* below. The value returned indicates the state of the alarm, and will be 1 only if the alarm is enabled and active. A zero value is transmitted for alarms that are either disabled or inactive.

Table 12: Alarm Status Registers

Registers	Variable	Function Code	Address
10001	Alarm #1 state	02	0
10002	Alarm #2 state	02	1
10003	Alarm #3 state	02	2

4.2.6i Control Register Definitions

The only writable registers in this implementation are the Reset Exception Status, Reset Meter and Reset Totalizer functions, which are implemented as “coils” which may be written with the Write Single Coil command (function code 05) to address 8 through 10, respectively, (register #00009 through #00011). The value sent with this command must be either 0x0000 or 0xff00, or the meter will respond with an error message; the totalizer will be reset or exception status cleared only with a value of 0xff00.

4.2.6j Error Responses

If an error is detected in the message received by the unit, the function code in the response is the received function code with the most significant bit set, and the data field will contain the exception code byte (see *Table 13* below).

Table 13: Exception Codes

Exception Code	Description
01	Invalid function code - function code not supported by device.
02	Invalid data address - address defined by the start address and number of registers is out of range.
03	Invalid data value - number of registers = 0 or >125, or incorrect data with the Write Single Coil command.

If the first byte of a message is not equal to the unit's Modbus address or if the unit detects a parity error in any character in the received message (with even or odd parity enabled) or if the message CRC is incorrect, the unit will not respond.

4.2.6k Command Message Format

The start address is equal to the desired first register number minus one. The addresses derived from the start address and the number of registers must all be mapped to valid defined registers, or an invalid data address exception will occur.

Table 14: Address Register Mapping

Device Address	Function Code	Start Address	N = No. of Registers	CRC
8 bits, 1...247	8 bits	16 bits, 0...9998	16 bits, 1...125	16 bits

4.2.6l Normal Response Message Format

Table 15: Normal Response Message Format

Device Address	Function Code	Byte Count = 2 x N	Data	CRC
8 bits, 1...247	8 bits	8 bits	(N) 16-bit registers	16 bits

4.2.6m Exception Response Message Format

Table 16: Exception Response Message Format

Device Address	Function Code + 0x80	Exception Code	CRC
8 bits, 1...247	8 bits	8 bits	16 bits

4.2.6n Examples

Read the exception status byte from the device with address 1:

01 07 41 E2

01 Device address

07 Function code

04 = read exception status

A typical response from the device is as follows:

01 07 03 62 31

01 Device address

07 Function code

03 Exception status byte

62 31 CRC

Request the first 12 registers from device with address 1:

01 04 00 00 00 0C F0 0F

01 Device address

04 Function code, 04 = read input register

00 00 Starting address

00 0C Number of registers = 12

F0 0F CRC

A typical response from the device is as follows:

01 04 18 00 00 03 E8 00 00 7A 02 6C 62 00 00 41

BA 87 F2 3E BF FC 6F 42 12 EC 8B 4D D1

01 Device address

04 Function code

18 Number of data bytes = 24

00 00 03 E8 Serial number = 1000 (unsigned long)

00 00 7A 02 Totalizer = 31234 lbm (unsigned long)

6C 62 00 00 Totalizer units = "lb" (string, unused characters are 0)

41 BA 87 F2 Mass flow rate = 23.3164 lbm/sec (float)

3E BF FC 6F Volume flow rate = 0.3750 ft³/sec (float)

42 12 EC 8B Pressure = 36.731 psia (float)

4D D1 CRC

Note: *These are the older register definitions.*

4.2.6n Examples (cont.)

An attempt to read register(s) that don't exist:

01 04 00 00 00 50 F1 D2

01 Device address

04 Function code 4 = read input register

00 00 Starting address

00 50 Number of registers = 80

F0 36 CRC

This results in an error response as follows:

01 84 02 C2 C1

01 Device address

84 Function code with most significant bit set indicates error response

02 Exception code 2 = invalid data address

C2 C1 CRC

Request the state all three alarms:

01 02 00 00 00 03 38 0B

01 Device address

02 Function code 2 = read discrete inputs

00 00 Starting address

00 03 Number of inputs = 3

38 0B CRC

and the unit responds with:

01 02 01 02 20 49

01 Device address

02 Function code

01 Number of data bytes = 1

02 Alarm #2 on, alarms #1 and #3 off

20 49 CRC

4.2.6n Examples (cont.)

To reset the totalizer:

01 05 00 00 FF 00 8C 3A

01 Device address

05 Function code 5 = write single coil

00 09 Coil address = 9

FF 00 Data to reset totalizer

8C 3A CRC (*not the correct CRC EJS-02-06-07*)

The unit responds with an identical message to that transmitted, and the totalizer is reset. If the “coil” is turned off as in the following message, the response is also identical to the transmitted message, but the totalizer is not affected.

01 05 00 00 00 00 CD CA

01 Device address

05 Function code 5 = write single coil

00 00 Coil address = 0

00 00 Data to “turn off coil” does not reset totalizer

CD CA CRC

4.3 BACnet MS/TP Communications

4.3.1 BACnet MS/TP Description

The BACnet Master-Slave/Token-Passing (MSTP) driver implements a data link protocol that uses the services of the RS-485 physical layer. The MS/TP bus is based on BACnet standard protocol SSPC-135, Clause 9. BACnet MS/TP protocol is a peer-to-peer, multiple master protocols based on token passing. Only master devices can receive the token, and only the device holding the token is allowed to originate a message on the bus. The token is passed from master device to master device using a small message. The token is passed in consecutive order starting with the lowest address. Slave devices on the bus only communicate on the bus when responding to a data request from a master device.

4.3.2 Baud Rates on the MS/TP Bus

An MS/TP bus can be configured to communicate at one of four different baud rates. It is very important that all of the devices on an MS/TP bus communicate at the same baud rate. The baud rate setting determines the rate at which devices communicate data over the bus. The baud rate settings available on MV80 and MV 82 Vortex Mass Flow Meters are 9600, 19200 and 38400.

4.3.3 Baud Rate and MAC Address Configuration

1. Power on the IUT.
2. Press **Enter** to go to the configuration menu.
3. Give the factory password **16363** (use Up and Down arrows to enter the digits).
4. Navigate to the Diagnostics menu.
5. Press **Enter** and press the right button immediately.
6. Navigate to the Config Code screen by continuously pressing the down button.
7. After reaching the Config Code screen, press the right button to navigate to the Comm. Type screen.
8. Change the Comm. Type to “Modbus” and press **Enter**.

Note: *Modbus will enable Baud Rate and MAC address screens.*

9. Press **Exit** twice to return to the Diagnostics Menu.
10. Navigate to the Output menu by using the right or left arrow buttons.
11. Press the down button until you reach the Baud Rate and MAC address screens.
12. Change the required settings and press the **Exit** and **Enter** buttons to save the configuration.
13. Complete the steps from **b** to **g**, and change the Comm. Type to **Hart**.
14. Reboot the device by powering it off and on.

Note: *a. IUT supports 9600, 19200, 38400 baud rates.
b. MAC address range is 0-127.*

4.3.4 Supported BACnet Objects

A BACnet object represents physical or virtual equipment information, as a digital input or parameters. The MV 80 and MV 82 Vortex Mass Flow Meters present the following object types:

- a. Device Object
- b. Analog Input
- c. Binary Input
- d. Binary Value

Each object type defines a data structure composed of properties that allow access to the object information. *Table 17* below shows the implemented properties for each Vortex Mass Flow Meter object type.

Table 17: Properties Object Types

Properties	Object Types			
	Device	Analog Input	Binary Input	Binary Value
Object_Identifier	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Object_Name	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Object_Type	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
System_Status	<input checked="" type="checkbox"/>			
Vendor_Name	<input checked="" type="checkbox"/>			
Vendor_Identifier	<input checked="" type="checkbox"/>			
Model_Name	<input checked="" type="checkbox"/>			
Firmware_Revision	<input checked="" type="checkbox"/>			
Application-Software-Version	<input checked="" type="checkbox"/>			
Protocol_Version	<input checked="" type="checkbox"/>			
Protocol_Revision	<input checked="" type="checkbox"/>			
Protocol_Services_Supported	<input checked="" type="checkbox"/>			
Protocol_Object_Types_Supported	<input checked="" type="checkbox"/>			
Object_List	<input checked="" type="checkbox"/>			
Max_ADPU_Length_Accepted	<input checked="" type="checkbox"/>			
Segmentation_Supported	<input checked="" type="checkbox"/>			
ADPU_Timeout	<input checked="" type="checkbox"/>			
Number_Of_ADPU_Retries	<input checked="" type="checkbox"/>			
Max_Masters	<input checked="" type="checkbox"/>			
Max_Info_Frames	<input checked="" type="checkbox"/>			
Device_Address_Binding	<input checked="" type="checkbox"/>			
Database_Revision	<input checked="" type="checkbox"/>			

Table 17: Properties Object Types (cont.)

Properties	Object Types			
	Device	Analog Input	Binary Input	Binary Value
Status_Flags				
Event_State		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Reliability				
Out_Of_Service		<input checked="" type="checkbox"/> (W)	<input checked="" type="checkbox"/> (W)	<input checked="" type="checkbox"/> (W)
Units		<input checked="" type="checkbox"/>		
Polarity			<input checked="" type="checkbox"/> (W)	
Priority_Array				
Relinquish_Default				
Status_Flag		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Present_Value		<input checked="" type="checkbox"/> (W)	<input checked="" type="checkbox"/> (W)	<input checked="" type="checkbox"/> (W)
Inactive_Text				
Active_Text				

Note: (W) = Writable Property.

4.3.4a Device Object

The Device object default property values are listed in *Table 18* below.

Table 18: Properties Default Values

Properties	Default Values
object-identifier	7
object-name	Device,1
object-type	Device
system-status	operational
vendor-name	GE Measurement & Control
vendor-identifier	558
model-name	Multivariable Flowmeter
firmware-revision	N/A
application-software-version	1.07
protocol-version	1
protocol-revision	4
protocol-services-supported	{F,F,F,F,F,F,F,F,F,F,F,F,F,T,F,T,T,T,T,F,F,F,F,F,F,F,F,F,F,F,T,T,F,F,F,F,F}
protocol-object-types-supported	{T,F,F,T,F,T,F,F,T,F,F,F,F,F,F,F,F,F,F,F,F,F,F}
object-list	{(analog-input,1),(analog-input,2),(analog-input,3),(analog-input,4), (analog-input,5), (analog-input,6),(analog-input,7),(analog-input,8) (analog-input,9),(analog-input,10), (analog-input,11), (analog-input,12), (analog-input,13),(analog-input,14), (analog-input,15),(analog-input,16),(analog-input,17), (analog-input,18),(analog-input,19),(binary-input,1),(binary-input,2),(binary-input,3),(binary-input,4), (binary-value,1), (device,7)}
max-apdu-length-accepted	300
segmentation-supported	no-segmentation
apdu-timeout	3000
number-of-APDU-retries	1
max-master	127
max-info-frames	1
device-address-binding	()
database-revision	0
Note: <i>Device Communication Control: Password – vortek.</i>	

4.3.4b Analog Input Object

MV 80 and MV 82 Vortex Mass Flow Meters Analog Input type objects are described in table below.

Table 19: Analog Input Object Types

Object Instance	Object Name	Unit	Description
1	Volume Flow	cubic-feet-per-second, cubic-feet-per-minute, us-gallons-per-minute, imperial-gallons-per-minute, liters-per-minute, liters-per-second, liters-per-hour, cubic-meters-per-second, cubic-meters-per-minute, cubic-meters-per-hour	This AI object is used to measure volume flow.
2	Mass Flow	pounds-mass-per-second, grams-per-second, kilograms-per-second, kilograms-per-minute, kilograms-per-hour, pounds-mass-per-minute, pounds-mass-per-hour, tons-per-hour, grams-per-second, grams-per-minute	This AI object is used to measure mass flow.
3	Temperature 1	degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit	This AI object measures Temperature in one of the given Unit.
4	Temperature 2	degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit	This AI object measures Temperature in one of the given Unit.
5	Pressure	pounds-force-per-square-inch, inches-of-water, inches-of-mercury, millimeters-of-mercury, bars, millibars, pascals, kilopascals	TBD
6	Density	kilograms-per-cubic-meter	TBD
7	Energy Flow	Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	TBD

Table 19: Analog Input Object Types (cont.)

Object Instance	Object Name	Unit	Description
8	Totalizer 1 and Totalizer 2	If Totalizer selection for Mass measure – pounds-mass-per-second, grams-per-second, kilograms-per-second, kilograms-per-minute, kilograms-per-hour, pounds-mass-per-minute, pounds-mass-per-hour, tons-per-hour, grams-per-second, grams-per-minute If Totalizer selection for Volume measure – cubic-feet-per-second, cubic-feet-per-minute, us-gallons-per-minute, imperial-gallons-per-minute, liters-per-minute, liters-per-second, liters-per-hour, cubic-meters-per-second, cubic-meters-per-minute, cubic-meters-per-hour If Totalizer selection for Energy measure – Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	An electronic counter which records the total accumulated flow over a certain range of time.
10	StatusRegister	NO UNITS	TBD
11	Channel 1 (4-20mA)	milliamperes	TBD
12	Channel 2 (4-20mA)	milliamperes	TBD
13	Channel 3 (4-20mA)	milliamperes	TBD
14	Scaled Freq	hertz	TBD
15	Flow Velocity	feet-per-second	TBD
16	Viscosity	centipoises	TBD
17	Frequency	hertz	TBD
18	VorTex Amp	millivolts	TBD
19	FilterSetting	hertz	TBD

4.3.4c Binary Input Objects

The MV 80 and MV82 Vortex Mass Flow Meters Binary Input type objects are described in *Table 20* below.

Table 20: Binary Input Object Types

Object Instance	Object Name	Description
1	Alarm1	The status of the three alarms may be monitored via the Modbus command. The value returned indicates the state of the alarm, and will be 1 only if the alarm is enabled and active. A zero value is transmitted for alarms that are either disabled or inactive
2	Alarm2	
3	Alarm3	
4	External	TBD

Note: *Binary Input 4, Present value always read zero because no information is available from the client. So, the polarity property has no impact on the Present value property when the Out of service property is false.*

4.3.4d Binary Value Objects

The MV 80 and MV82 Vortex Mass Flow Meters Binary Value type objects are described in *Table 21* below.

Table 21: Binary Value Object Types

Object Instance	Object Name	Description
1	Reset	Reset's Totalizer

4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement

Date: 19-April-2012

Vendor Name: VorTek Instruments

Product Name: Pro-V M22 multivariable flow-meter

Product Model Number: M22/M23 VT/VTP

Applications Software Version: 1.07

Firmware Revision: N/A

BACnet Protocol Revision: 4

Product Description: VorTek multivariable flow-meter

BACnet Standardized Device Profile (Annex L):

- BACnet Operator Workstation (B-OWS)
- BACnet Advanced Operator Workstation (B-AWS)
- BACnet Operator Display (B-OD)
- BACnet Building Controller (B-BC)
- BACnet Advanced Application Controller (B-AAC)
- BACnet Application Specific Controller (B-ASC)
- BACnet Smart Sensor (B-SS)
- BACnet Smart Actuator (B-SA)

Table 22 below lists all BACnet Interoperability Building Blocks Supported (Annex K):

Table 22: Annex K Building Blocks

BIBBs
DS-RP-B
DS-WP-B
DM-DDB-B
DM-DOB-B
DM-DCC-B
DS-RPM-B
DS-WPM-B

4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement (cont.)

Table 23: Services Supported

Read Property	Execute
Write Property	Execute
Read Property Multiple	Execute
Write Property Multiple	Execute
Who-Is	Execute
I-Am	Initiate
Who-Has	Execute
I-Have	Initiate
Device Communication Control	Execute

Segmentation Capability:

Able to transmit segmented messages

Window Size

Able to receive segmented messages

Window Size

Standard Object Types Supported:

Table 24: Standard Object Types Supported

Object Type	Dynamically Create-able	Dynamically Delete-able	Additional Writable Properties	Range Restrictions
Analog Input (AI)	No	No	None	None
Binary Input (BV)	No	No	None	None
Binary Value	No	No	None	None
Device	No	No	None	None

Table 25: Supported Writable Properties

Object Type	Properties		
Analog Input (AI)	Present Value	Out-Of-Service	
Binary Input (BV)	Present Value	Out-Of-Service	Polarity
Binary Value	Present Value	Out-Of-Service	
Device			

4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement (cont.)

Object List:

Table 26: Properties of Analog Input/Value Object Types

ID	Name	Present Value	Status Flags	Event State	Out of Service	Units
AI1	Volume Flow	?	F,F,F,F	Normal	False	?
AI2	Mass Flow	?	F,F,F,F	Normal	False	?
AI3	Temperature 1	?	F,F,F,F	Normal	False	?
AI4	Temperature 2	?	F,F,F,F	Normal	False	?
AI5	Pressure	?	F,F,F,F	Normal	False	?
AI6	Density	?	F,F,F,F	Normal	False	?
AI7	Energy Flow	?	F,F,F,F	Normal	False	?
AI8	Totalizer 1	?	F,F,F,F	Normal	False	?
AI9	Totalizer 2	?	F,F,F,F	Normal	False	?
AI10	StatusRegister	?	F,F,F,F	Normal	False	?
AI11	Channel 1 (4-20mA)	?	F,F,F,F	Normal	False	?
AI12	Channel 2 (4-20mA)	?	F,F,F,F	Normal	False	?
AI13	Channel 3 (4-20mA)	?	F,F,F,F	Normal	False	?
AI14	Scaled Freq	?	F,F,F,F	Normal	False	?
AI15	Flow Velocity	?	F,F,F,F	Normal	False	?
AI16	Viscosity	?	F,F,F,F	Normal	False	?
AI17	Frequency	?	F,F,F,F	Normal	False	?
AI18	VorTex Amp	?	F,F,F,F	Normal	False	?
AI19	FilterSetting	?	F,F,F,F	Normal	False	?
ID	Name	Present Value	Status Flags	Event State	Out of Service	Polarity
BI1	Alarm1	?	F,F,F,F	Normal	False	Normal
BI2	Alarm2	?	F,F,F,F	Normal	False	Normal
BI3	Alarm3	?	F,F,F,F	Normal	False	Normal
BI4	External	?	F,F,F,F	Normal	False	Normal
ID	Name	Present Value	Status Flags	Event State	Out of Service	Out of Service
BV1	Reset	?	F,F,F,F	Normal	False	False

4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement (cont.)

Data Link Layer Options:

- BACnet IP, (Annex J)
- BACnet IP, (Annex J), Foreign Device
- ISO 8802-3, Ethernet (Clause 7)
- ANSI/ATA 878.1, 2.5 Mb. ARCNET (Clause 8)
- ANSI/ATA 878.1, EIA-485 ARCNET (Clause 8), baud rate(s)
- MS/TP master (Clause 9), baud rate(s): 9600, 19200, 38400
- MS/TP slave (Clause 9), baud rate(s):
- Point-To-Point, EIA 232 (Clause 10), baud rate(s):
- Point-To-Point, modem, (Clause 10), baud rate(s):
- LonTalk, (Clause 11), medium:
- Other:

Device Address Binding:

Is static device binding supported? (This is currently necessary for two-way communication with MS/TP slaves and certain other devices.): Yes No

Networking Options:

- Router, Clause 6 - List all routing configurations, e.g., ARCNET-Ethernet, Ethernet-MS/TP, etc.
- Annex H, BACnet Tunneling Router over IP
- BACnet/IP Broadcast Management Device (BBMD)

Does the BBMD support registrations by Foreign Devices? Yes No

Does the BBMD support network address translation? Yes No

Network Security Options:

- Non-secure Device - is capable of operating without BACnet Network Security
- Secure Device - is capable of using BACnet Network Security (NS-SD BVBB)
- Multiple Application-Specific Keys:
- Supports encryption (NS-ED BVBB)
- Key Server (NS-KS BVBB)

4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement (cont.)

Character Sets Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

- ANSI X3.4
- IBM™/Microsoft™DBCS
- ISO 8859-1
- ISO 10646 (UCS-2)
- ISO 10646 (UCS-4)
- JIS C 6226

If this product is a communication gateway, describe the types of non-BACnet equipment/network(s) that the gateway supports:

- N/A

4.3.6 Acronyms and Definitions

Table 27: Acronym Definitions

Acronym	Definition
APDU	Application Protocol Data Unit
BACnet	Building Automation and Control Network- Data communication protocol
MS/TP	Master-Slave Token passing (a twisted pair RS485 network created by BACnet)
BIBB	BACnet Interoperability Building Block (Specific individual function blocks for data exchange between interoperable devices).
BV	Binary Value
BI	Binary Input
AI	Analog Input
RP	Read Property
WP	Write Property
RPM	Read Property Multiple
WPM	Write Property Multiple.
DDB	Dynamic Device Binding
DOB	Dynamic Object Binding
DCC	Device communication Control

[no content intended for this page]

Chapter 5. Troubleshooting and Repair



WARNING! Before attempting any flowmeter repair, verify that the line is not pressurized. Always remove the main power before disassembling any part of the mass flowmeter.

5.1 Hidden Diagnostics Menus

The menus shown in *Figure 77 on page 110* can be accessed using the password **16363** and then completing the following steps:

1. Navigate to the display that reads *Diagnostics Menu*.
2. Press ENTER instead of one of the arrow keys.
3. Use the RIGHT arrow key to move to the second column.
4. Press EXIT to move from the second column back to the first column.
5. Press EXIT while in the first column to return to the setup menus.



CAUTION! Password **16363** allows full access to meter configuration and should be used carefully to avoid changes that can adversely alter the function of the meter.

Each of the menus in *Figure 77 on page 110* are defined and specific troubleshooting steps are described in the following sections.

5.1 Hidden Diagnostics Menus (cont.)

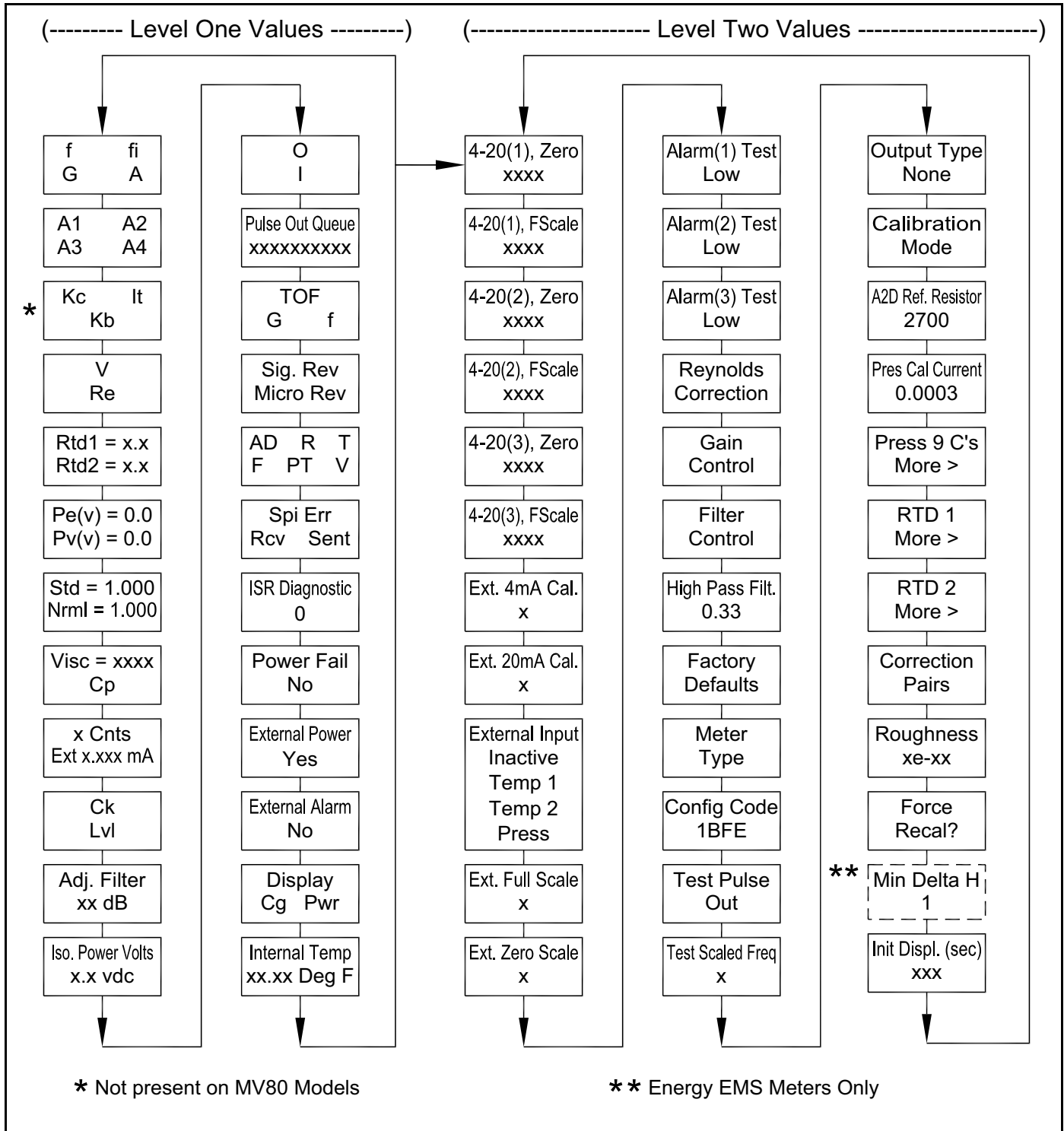


Figure 77: Diagnostics Menus

5.1.1 Level One Hidden Diagnostics Values

- **f** = Vortex shedding frequency (Hz).
- **fi** = Adaptive filter - should be about 25% higher than the vortex shedding frequency, this is a low-pass filter. If the meter is using the Filter Control (see below) in manual mode, **fi** will be displayed as **fm**.
- **G** = Gain (applied to vortex signal amplitude).
Gain defaults to 1.0 and can be changed using the Gain Control (see below).
- **A** = Amplitude of vortex signal in Volts rms.
- **A1, A2, A3, A4** = A/D counts representing the vortex signal amplitude. Each stage (A1-A4) cannot exceed 512. Beginning with stage A1, the A/D counts increase as the flow increases. When stage A1 reaches 512, it will shift to stage A2. This will continue as the flow rate increases until all 4 stages read 512 at high flow rates. Higher flow rates (stronger signal strength) will result in more stages reading 512.
- **Kc, It, Kb** = Profile equation (factory use only). Model MV82 only.
- **V** = Calculated average pipe velocity (ft/sec).
- **Re** = Calculated Reynolds number.
- **RTD1** = Resistance value of integral RTD in ohms.
- **RTD2** = Optional RTD resistance value in ohms.
- **Pe(v)** = Pressure transducer excitation voltage
- **Pv(v)** = Pressure transducer sense voltage.
- **Stnd** = Density of fluid at standard conditions.
- **Nrml** = Density of fluid at normal conditions.
- **Viscosity** = Calculated viscosity of flowing fluid.
- **x Cnts** = A/D counts from the external 4-20 mA input.
- **Ext x.xxx mA** = Calculated external 4-20 mA input from the digital counts.

5.1.1 Level One Hidden Diagnostics Values (cont.)

- **Ck** = Calculated **Ck** at current operating conditions. **Ck** is a variable in the equation that relates signal strength, density, and velocity for a given application. It is used for noise rejection purposes. **Ck** directly controls the **fi** value (see above). If the **Ck** is set too low (in the calibration menu), then the **fi** value will be too low and the vortex signal will be rejected resulting in zero flow rate being displayed. The calculated **Ck** value in this menu can be compared to the actual **Ck** setting in the calibration menu to help determine if the **Ck** setting is correct.
- **Lvl** = Threshold level. If the Low Flow Cutoff in the calibration menu is set above this value, the meter will read zero flow. The **Lvl** level can be checked at no flow. At no flow, the **Lvl** must be below the Low Flow Cutoff setting or the meter will have an output at no flow.
- **Adj. Filter** = Adjustable filter. Displays the filtering in decibels. Normally reads zero. If this value is consistently -5 or -10 , for example, the **Ck** or density setting may be wrong.
- **Iso. Power Volts** = Nominally 2.7 VDC. If less than this, check the flowmeter input power.
- **O,I** = Factory use only.
- **Pulse Out Queue** = Pulse output queue. This value will accumulate if the totalizer is accumulating faster than the pulse output hardware can function. The queue will allow the pulses to “catch up” later if the flow rate decreases. A better practice is to slow down the totalizer pulse by increasing the value in the (unit)/pulse setting in the totalizer menu.
- **TOF, G, f** = Factory use only.
- **Sig. Rev** = Signal board hardware and firmware revision.
- **Miro Rev** = Microprocessor board hardware and firmware revision.
- **AD, R, T, F, PT, V** = Factory use only.
- **SPI Err, Rcv, Sent** = Factory use only.
- **ISR Diagnostic** = Factory use only.
- **Power Fail** = Factory use only.
- **External Power** = Factory use only.
- **External Alarm** = Factory use only.
- **Display CG, PWR** = Factory use only.
- **Internal Temperature** = Electronics temperature.

5.1.2 Column Two Hidden Diagnostics Values

- **4-20(1) Zero** = Analog counts to calibrate zero on analog output 1.
- **4-20(1) FScale** = Analog counts to cal. full scale on analog output 1.
- **4-20(2) Zero** = Analog counts to calibrate zero on analog output 2.
- **4-20(2) FScale** = Analog counts to cal. full scale on analog output 2.
- **4-20(3) Zero** = Analog counts to calibrate zero on analog output 3.
- **4-20(3) FScale** = Analog counts to cal. full scale on analog output 3.
- **Ext. 4 mA Cal.** = Enter 0 for auto calibration or enter factory supplied A/D counts. Note: You must connect a known 4.00 mA input if you are going to calibrate the unit.
- **Ext. 20 mA Cal.** = Enter 0 for auto calibration or enter factory supplied A/D counts. Note: You must connect a known 20.00 mA input if you are going to calibrate the unit.
- **External Input** = Enter what the external 4-20 mA input represents, i.e. Temperature 1, Temperature 2, or Pressure. The meter will use this for its internal calculations.
- **Ext. Full Scale** = Enter the full scale units that correlate to the 20 mA point. Note: It must be in the units for the selected input type such as Deg F, Deg C, PSIA, Bar A, etc.
- **Ext. Zero Scale** = Same as previous value, but for the 4 mA point.
- **Alarm (1) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Alarm (2) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Alarm (3) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Reynolds Corr.** = Reynolds number correction for the flow profile. Set to Enable for MV82 insertion and set to Disable for MV80 inline.
- **Gain Control** = Manual gain control (factory use only). Leave set at 1.
- **Filter control** = Manual filter control. This value can be changed to any number to force the f_i value to a constant. A value of zero activates the automatic filter control which sets f_i at a level that floats above the f value.

5.1.2 Level Two Hidden Diagnostics Values (cont.)

- **High Pass Filter** = Filter setting - Factory use only
- **Factory Defaults** = Reset factory defaults. If you change this to Yes and press ENTER, all the factory configuration is lost and you must reconfigure the entire program. Consult the factory before performing this process, it is required only in very rare cases.
- **Meter Type** = Insertion (MV82) or Inline (MV80) meter.
- **Config Code** = Factory use only.
- **Test Pulse Out** = Force totalizer pulse. Set to Yes and press ENTER to send one pulse. Very useful to test totalizer counting equipment.
- **Test Scaled Freq** = Enter a frequency value to test the scaled frequency output. Return to 0 to stop the test.
- **Output Type** = Factory use only.
- **Calibration Mode** = Factory use only.
- **A2D Ref. Resistor** = Factory use only.
- **Pressure Cal Current** = Calibration value for the electronics and pressure transducer combination. Consult Factory for value.
- **Pressure 9Cs** = Nine pressure coefficients unique to the pressure transducer. Use the RIGHT ARROW to access all nine coefficients.
- **Press. Max psi** = Based on installed sensor.
- **Press. Min psi** = 0 psia
- **RTD1** Press the RIGHT arrow to access:
 - **Ro** = RTD resistance at 0°C (1000 ohms).
 - **A** = RTD coefficient A (.0039083).
 - **B** = RTD coefficient B (-5.775e-07).
 - **RTD1 Max Deg. F** = 500
 - **RTD1 Min Deg. F** = -330
- **RTD2** = Second RTD configuration, for special applications only.

5.1.2 Level Two Hidden Diagnostics Values (cont.)

- **Correction Pairs**
- **ft3/sec** (1 through 10)
- **%Dev.** (1 through 10)
- **Roughness** = Factory use only.
- **Force Recal?** = Factory use only.
- **Min. Delta H** - Energy EMS meters only. Sets the deadband for totalization to begin. Must be greater than this number (1 default) to initiate the totalizer.
- **Init Displ. (sec)** = Enter a value in seconds to initialize the display every xxx seconds. Enter a value of 0 to disable initializing the display.

5.2 Analog Output Calibration

To check the 4-20 mA circuit, connect a DVM in series with the output loop. Select zero or full scale (from the second column of the hidden diagnostics) and then press the ENTER key twice. This action will cause the meter to output its 4 mA or 20 mA signal. If the DVM indicates a current variation greater than ± 0.006 mA from the 4 mA or 20 mA signal, adjust the setting up or down until the output is calibrated.

Note: *These settings are not for adjusting the output zero and span values to match a flow range. That function is located in the Output Menu.*

5.3 Troubleshooting the Flowmeter



WARNING! Before attempting any flowmeter repair, verify that the line is not pressurized. Always remove the main power before disassembling any part of the flowmeter. Use hazardous area precautions if applicable. Static sensitive electronics - use electrostatic discharge precautions.

Check These Items:

- Installation Direction Correct
- Installation Depth Correct (Insertion style meter)
- Power and Wiring Correct
- Application Fluid Correct
- Meter Range Correct for the Application
- Meter Configuration Correct
- Describe Installation Geometry (e.g., upstream diameters, valve position, downstream diameters, etc.)

Record These Values:

To determine the status of the flowmeter, record the values listed in *Table 28* below from the Run Menu with the meter installed:

Table 28: Run Mode Values

Parameter	With Flow	With No Flow (if possible)
Flow =		
Temperature =		
Pressure =		
Density =		
Error Messages? =		

5.3 Troubleshooting the Flowmeter (cont.)

Record These Values (cont.)

Record the values listed in *Table 29* below from the *Hidden Diagnostics Menu* with the meter installed: (Use the password **16363** to access the Hidden Diagnostics Menu).

Table 29: Hidden Diagnostics Menu Values

Parameter	With Flow	With No Flow (if possible)
f =		
f _i =		
A =		
A1 =		
A2 =		
A3 =		
A4 =		
V =		
RTD1 =		
RTD2 =		
Pe(V) =		
Pv(V) =		
Ck =		
Lvl =		
Adj. Filter =		
Iso. Power Volts =		
Sig. Rev =		

Record the values listed in *Table 30* below from the *Calibration Menu*.

Table 30: Calibration Menu Values

Parameter	With Flow	With No Flow (if possible)
Vortex Coef Ck =		
Low Flow Cutoff =		

5.4 Determine the Fault

5.4.1 Symptom: Output at No Flow

- The low flow cutoff is set too low. At no flow, go to the first column of the hidden diagnostics menu and record the **Lvl** value. The low flow cutoff must be set above this value.
- Example: at no flow, **Lvl** = 25. Set the low flow cutoff in the Calibration Menu to approximately 28 and the meter will no longer read a flow rate at no flow.

5.4.2 Symptom: Erratic Output

- The flow rate may be too low, just at the cutoff of the meter range, and the flow cycles above and below the cutoff making an erratic output. Consult the factory if necessary to confirm the meter range based on current operating conditions. It may be possible to lower the low flow cutoff to increase the meter range. See the example above for output at no flow, only this time the low flow cutoff is set too high. You can lower this value to increase the meter range as long as you do not create the output at no flow condition previously described.
- Mechanical installation may be incorrect. Verify the straight run is adequate, as described in *Chapter 2*. For in-line meters, make sure the meter is not installed backwards and there are no gaskets protruding into the flow stream. For insertion meters, verify the insertion depth and flow direction.
- The meter may be reacting to actual changes in the flow stream. The output can be smoothed using a time constant. The displayed values can be smoothed using the time constant in the *Display Menu*. The analog outputs can be smoothed using the time constant in the *Output Menu*. A time constant of 1 will result in the change in value reaching 63% of its final value in one second. A time constant of 4 is 22%, 10 is 9.5% and 50 is 1.9% of the final value in one second. The time constant equation is shown below (TC = Time Constant).

$$\% \text{ change in final value in one second} = 100(1 - e^{-1/TC})$$

- The vortex coefficient **Ck** may be incorrectly set. The **Ck** is a value in the equation used to determine if a frequency represents a valid vortex signal given the fluid density and signal amplitude. In practice, the **Ck** value controls the adaptive filter, **fi**, setting. During flow, view the **f** and **fi** values in the first column of the hidden diagnostics. The **fi** value should be approximately 10-20% higher than the **f** value. If you raise the **Ck** setting in the *Calibration Menu*, then the **fi** value will increase. The **fi** is a low pass filter, so by increasing it or lowering it, you can alter the range of frequencies that the meter will accept. If the vortex signal is strong, the **fi** value will increase to a large number - this is correct.

5.4.3 Symptom: No Output

1. For remote mounted electronics, carefully check all the wiring connections in the remote mount junction box. There are 18 connections that must be correct, verify each color (black and red), shield, and wire number.
2. Turn on the pressure and temperature display in the *Display Menu* and verify that the pressure and temperature are correct.
3. Using ESD precautions and hazardous area precautions, remove the electronics enclosure window cover. Disconnect the vortex sensor from the electronics stack (see *Figure 78* below) or the remote feed through board (see *Figure 79* below). Measure the resistance from each outside pin to the meter ground (see *Figure 80 on page 120*) - each should be open. Measure the resistance from the center pin to the meter ground - this should be grounded to the meter.

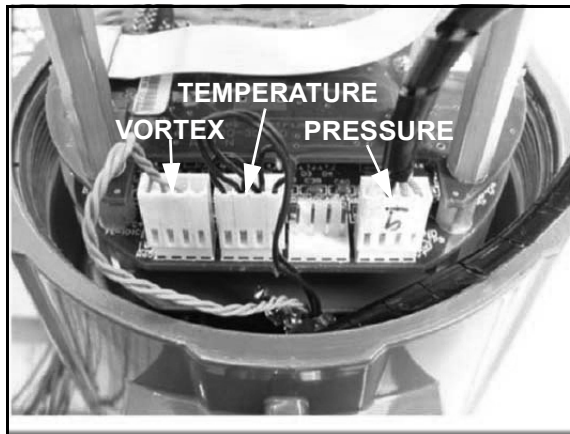


Figure 78: Electronics Stack Sensor Connections

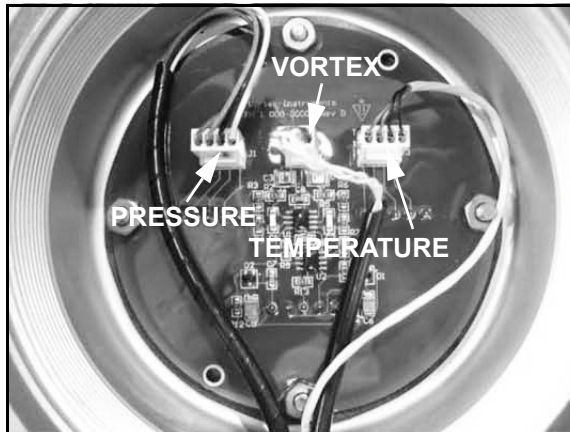


Figure 79: Remote Feed Through Board Sensor Connections

5.4.3 Symptom: No Output (cont.)

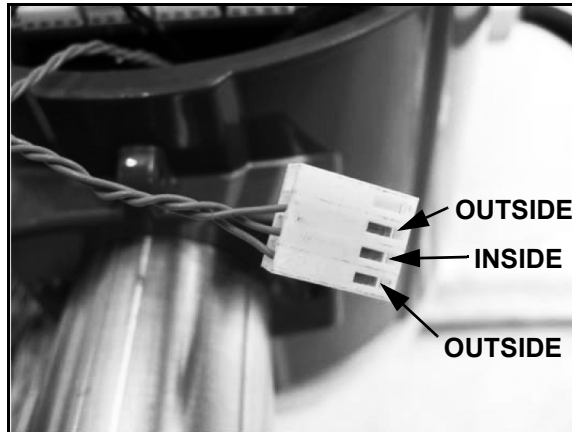


Figure 80: Vortex Sensor Connector Pins

4. With the sensor still disconnected, go to the first column of the hidden diagnostics and display the vortex shedding frequency, f . Hold a finger on the three exposed pins on the analog board. The meter should read electrical noise, 60 Hz for example. If all readings are correct, re-install the vortex sensor wires.
5. Verify all meter configuration and troubleshooting steps previously described. There are many possible causes of this problem. Consult GE if necessary.

5.4.4 Symptom: Meter Displays Temperature Fault

1. For remote mounted electronics, carefully check all the wiring connections in the remote mount junction box. There are 18 connections that must be correct. Verify each color (black and red), shield, and wire number.
2. Go to the first column of the hidden diagnostics and check the resistance of the RTD1. It should be about 1080 ohms at room temperature.
3. Using ESD precautions and hazardous area precautions, remove the electronics enclosure window cover. Disconnect the temperature sensor from the electronics stack (see *Figure 78 on page 119*) or the remote feed through board (see *Figure 79 on page 119*). Measure the resistance across the outside pins of the temperature sensor connector (see *Figure 81 below*). It should read approximately 1080 ohms at room temperature (higher resistance at higher temperatures).

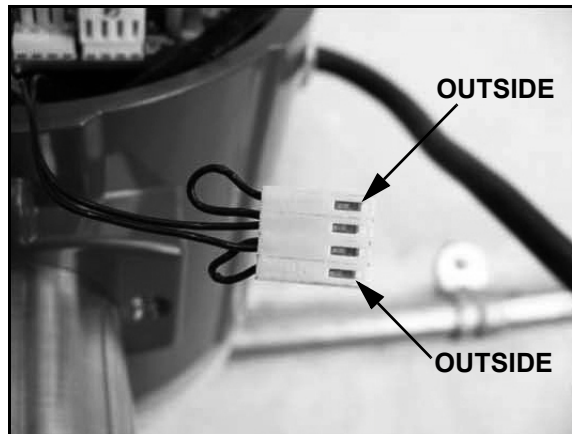


Figure 81: Temperature Sensor Connector Pins

4. Consult GE with your findings

5.4.5 Symptom: Meter Displays Pressure Fault

1. For remote mounted electronics, carefully check all the wiring connections in the remote mount junction box. There are 18 connections that must be correct. Verify each color (black and red), shield, and wire number.
2. Using ESD precautions and hazardous area precautions, remove the electronics enclosure window cover. Disconnect the pressure sensor from the electronics stack (see *Figure 78 on page 119*) or the remote feed through board (see *Figure 79 on page 119*). Measure the resistance across the outside pins of the pressure sensor connector, then across the inside pins (see *Figure 82 below*). Both readings should be approximately 4000 ohms.

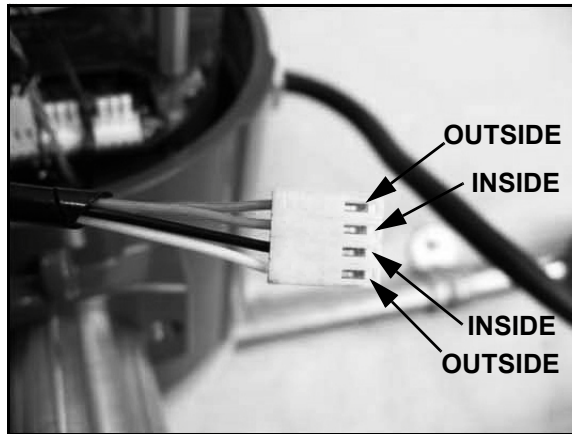


Figure 82: Pressure Sensor Connector

3. Go to the first column of the hidden diagnostics and record the **Pe(V)** and **Pv(V)** values and consult GE with your findings.

5.5 Electronics Assembly Replacement (All Meters)



CAUTION! The electronics boards are electrostatically sensitive. Wear a grounding wrist strap and make sure to observe proper handling precautions required for static-sensitive components.



WARNING! Before attempting any flowmeter repair, verify that the line is not pressurized. Always remove the main power before disassembling any part of the mass flowmeter.

1. Turn off the power to the unit.
2. Locate and loosen the small set screw which locks the larger enclosure cover in place. Unscrew the cover to expose the electronics stack.
3. Locate the sensor harnesses which come up from the neck of the flowmeter and attaches to the circuit boards. Make note of the location of each sensor connection (see Figure 78 on page 119 or Figure 79 on page 119). The vortex sensor connection is on the left, the temperature sensor connection (if present) is second from the left, and the pressure sensor connection (if present) is on the right. Use small pliers to pull the sensor wiring connectors off of the circuit boards.
4. Locate and loosen the small set screw which locks the smaller enclosure cover in place. Unscrew the cover to expose the field wiring strip. Tag and remove the field wires.
5. Remove the screws that hold the black wiring label in place and remove the label.
6. Locate the 4 Phillips head screws which are spaced at 90-degrees around the terminal board. These screws hold the electronics stack in the enclosure. Loosen these screws (Note that these are captive screws and they will stay inside the enclosure).
7. Carefully remove the electronics stack from the opposite side of the enclosure. If the electronics stack will not come out, gently tap the terminal strip with the screw driver handle. This will loosen the rubber sealing gasket on the other side of the enclosure wall. Be careful that the stack does not become tangled on the loose sensor harnesses.
8. Repeat steps 1 through 6 in reverse order to install the new electronics stack.

5.6 Pressure Sensor Replacement (Series MV80 Only)

1. For local mounted electronics, remove the electronics stack as previously described. For remote mount electronics, remove all wires and sensor connectors from the remote feed through board in the junction box at the meter.
2. Loosen the three set screws at the center of the adapter between the meter and the enclosure.
3. Remove the top half of the adapter to expose the pressure transducer.
4. Remove the transducer and replace it with the new one using appropriate thread sealant.
5. Reassemble in reverse order.

5.7 Returning Equipment to the Factory

Before returning any PanaFlow MV flowmeter to the factory, you must request a Return Material Authorization (RMA) number. To obtain an RMA number and the correct shipping address, contact *GE Customer Service* using the information on the back cover of this manual.

IMPORTANT: *When contacting Customer Service, be sure to have the meter serial number and model code available.*

When requesting further troubleshooting guidance, please record the values in the tables provided in “*Troubleshooting the Flowmeter*” on page 116 and have this information available.

Appendix A. Product Specifications

Accuracy

Process Variables	MV80 Series In-Line Meters		MV82 Series Insertion Meters ¹	
	Liquids	Gas & Steam	Liquids	Gas & Steam
Mass Flow Rate	±1% of rate over a 30:1 range ³	±1.5% of rate ² over a 30:1 range ³	±1.5% of rate over a 30:1 range ³	±2% of rate ² over a 30:1 range ³
Volumetric Flow Rate	±0.7% of rate over a 30:1 range ³	±1% of rate over a 30:1 range ³	±1.2% of rate over a 30:1 range ³	±1.5% of rate over a 30:1 range ³
Temperature	±2° F (±1°C)	±2° F (±1°C)	±2° F (±1°C)	±2° F (±1°C)
Pressure	0.3% of transducer full scale	0.3% of transducer full scale	0.3% of transducer full scale	0.3% of transducer full scale
Density	0.3% of reading	0.5% of reading	0.3% of reading	0.5% of reading

¹Accuracies stated are for the total mass flow through the pipe.
²Over 50 to 100% of the pressure transducer's full scale.
³Nominal rangeability is stated. Precise rangeability depends on fluid and pipe size.

Repeatability

Mass Flow Rate: 0.2% of rate

Volumetric Flow Rate: 0.1% of rate

Temperature: ± 0.2° F (± 0.1° C)

Pressure: 0.05% of full scale

Density: 0.1% of reading

Stability Over 12 Months

Mass Flow Rate: 0.2% of rate maximum

Volumetric Flow Rate: Negligible error

Temperature: ± 0.1° F (± 0.5° C) maximum

Pressure: 0.1% of full scale maximum

Density: 0.1% of reading maximum

Response Time

Adjustable from 1 to 100 seconds

Material Capability

Series MV80 In-Line Flowmeter:

Any gas, liquid or steam compatible with 316L stainless steel, C276 hastelloy or A105 carbon steel.

Not recommended for multi-phase fluids.

Series MV82 Insertion Flowmeter:

Any gas, liquid or steam compatible with 316L stainless steel. Not recommended for multi-phase fluids.

Flow Rates

Typical mass flow ranges are given in the following table. Precise flow depends on the fluid and pipe size. MV82 insertion meters are used with pipe sizes from 2 inch and above. Consult GE for sizing assistance.

Water Minimum and Maximum Flow Rates									
Units	½-inch	¾-inch	1-inch	1.5-inch	2-inch	3-inch	4-inch	6-inch	8-inch
	15 mm	20 mm	25 mm	40 mm	50 mm	80 mm	100 mm	150 mm	200 mm
gpm	1	1.3	2.2	5.5	9.2	21	36	81	142
	22	40	67	166	276	618	1076	2437	4270
m ³ /hr	0.23	0.3	0.5	1.3	2.1	4.7	8.1	18	32
	5	9.1	15	38	63	140	244	554	970

Typical Air (@70°C) Minimum and Maximum Flow Rates (SCFM)									
Pressure	Nominal Pipe Size (in)								
	0.5	0.75	1	1.5	2	3	4	6	8
0 psig	1.8	3	5	13	22	50	87	198	347
	18	41	90	221	369	826	1437	3258	5708
100 psig	5	9	15	38	63	141	245	555	972
	138	325	704	1730	2890	6466	11254	25515	44698
200 psig	7	13	21	52	86	193	335	761	1332
	258	609	1322	3248	5427	12140	21131	47911	83931
300 psig	8	15	25	63	104	234	407	922	1615
	380	896	1944	4775	7978	17847	31064	70431	123375
400 psig	10	18	29	72	120	269	467	1060	1857
	502	1183	2568	6309	10542	23580	41043	93057	163000
500 psig	11	20	33	80	134	300	521	1182	2071
	624	1472	3195	7849	13115	28034	51063	115775	203000

Flow Rates (cont.)

Typical Air (@20°F) Minimum and Maximum Flow Rates (nm ³ /hr)									
Pressure	Nominal Pipe Size (mm)								
	15	20	25	40	50	80	100	150	200
0 barg	3	5	9	21	36	79	138	313	549
	28	66	142	350	584	1307	2275	5157	9034
5 barg	7	13	21	52	87	194	337	764	1339
	165	390	847	2080	3476	7775	13533	30682	53749
10 barg	9	17	29	70	117	262	457	1035	1814
	304	716	1554	3819	6381	14273	24844	56329	98676
15 barg	11	21	34	85	142	317	551	1250	2190
	442	1044	2265	5565	9299	20801	36205	82087	143801
20 barg	13	24	40	97	162	363	632	1434	2511
	582	1373	2979	7318	12229	27354	47612	107949	189105
30 barg	16	29	48	118	198	442	770	1745	3057
	862	2034	4414	10843	18119	40529	70544	159942	280187

Linear Range

Smart electronics corrects for lower flow down to a Reynolds number of 5,000. The Reynolds number is calculated using the fluid's actual temperature and pressure monitored by the meter. Rangeability depends on the fluid, process connections and pipe size. Consult factory for your application. Typical velocity range ability in standard applications is as follows:

Liquids 30:1

1 foot per second velocity minimum
30 feet per second velocity maximum

Gases 30:1

10 feet per second velocity minimum
300 feet per second velocity maximum

Flow Rates (cont.)

Typical Saturated Steam Minimum and Maximum Flow Rates (lb/hr)									
Pressure	Nominal Pipe Size (in)								
	0.5	0.75	1	1.5	2	3	4	6	8
5 psig	6.5	12	20	49	82	183	318	722	1264
	52	122	265	650	1087	2431	4231	9594	16806
100 psig	15	27	46	112	187	419	728	1652	2893
	271	639	1386	3405	5690	12729	22156	50233	87998
200 psig	20	37	62	151	253	565	983	2229	3905
	493	1163	2525	6203	10365	23184	40354	91494	160279
300 psig	24	45	74	182	304	680	1184	2685	4704
	716	1688	3664	9000	15040	33642	58556	132763	232575
400 psig	28	51	85	209	349	780	1358	3079	5393
	941	2220	4816	11831	19770	44222	76971	174516	305717
500 psig	31	57	95	233	389	870	1514	3433	6014
	1170	2760	5988	14711	24582	54987	95710	217001	380148

Typical Saturated Steam Minimum and Maximum Flow Rates (kg/hr)									
Pressure	Nominal Pipe Size (mm)								
	15	20	25	40	50	80	100	150	200
0 barg	3	5	9	19	32	72	126	286	500
	28	66	142	350	584	1307	2275	5157	9034
5 barg	6	11	18	45	75	167	290	658	1153
	95	224	485	1192	1992	4455	7754	17581	30799
10 barg	8	15	24	59	99	222	387	877	1537
	168	397	862	2118	3539	7915	13777	31237	54720
15 barg	9	17	29	71	119	266	463	1050	1840
	241	569	1236	3036	5073	11347	19750	44779	78444
20 barg	11	20	33	81	136	304	529	1199	2100
	314	742	1610	3956	6611	14787	25738	58355	102226
30 barg	13	24	40	99	165	369	642	1455	2548
	463	1092	2370	5822	9729	21763	37880	85884	150451

Linear Range

Smart electronics corrects for lower flow down to a Reynolds number of 5,000. The Reynolds number is calculated using the fluid's actual temperature and pressure monitored by the meter. Rangeability depends on the fluid, process connections and pipe size. Consult factory for your application. Velocity rangeability under ideal conditions is as follows:

Liquids 30:1

1 foot per second velocity minimum
30 feet per second velocity maximum

Gases 30:1

10 feet per second velocity minimum
300 feet per second velocity maximum

Process Fluid Pressure

MV80 Pressure Ratings		
Process Connection	Material	Rating
Flanged	316L SS, A105 Carbon Steel, C276 Hastelloy	150, 300, 600 lb, PN16, PN40, PN64
Wafer	316L SS, A105 Carbon Steel, C276 Hastelloy	600 lb, PN64

MV82 Pressure Ratings				
Probe Seal	Process Connection	Material	Rating	Ordering Code
Compression Fitting	2-inch MNPT	316L SS	ANSI 600 lb	CNPT
	2-inch 150 lb flange, DN50 PN16	316L SS	ANSI 150 lb, PN16	C150, C16
	2-inch 300 lb flange, DN50 PN40	316L SS	ANSI 300 lb, PN40	C300, C40
	2-inch 600 lb flange, DN50 PN64	316L SS	ANSI 600 lb, PN64	C600, C64
Packing Gland	2-inch MNPT	316L SS	50 psig	PNPT
	2-inch 150 lb flange, DN50 PN16	316L SS	50 psig	P150, P16
	2-inch 300 lb flange	316L SS	50 psig	P300, P40
Packing Gland with Removable Retractor	2-inch MNPT	316L SS	ANSI 300 lb	PM, RR
	2-inch 150 lb flange, DN50 PN16	316L SS	ANSI 150 lb	P150, P16, RR
	2-inch 300 lb flange	316L SS	ANSI 300 lb	P300, P40, RR
Packing Gland with Permanent Retractor	2-inch MNPT	316L SS	ANSI 600 lb	PNPTR
	2-inch 150 lb flange, DN50 PN16	316L SS	ANSI 150 lb	P150R, P16R
	2-inch 300 lb flange, DN50 PN40	316L SS	ANSI 300 lb	P300R, P40R
	2-inch 600 lb flange, DN50 PN64	316L SS	ANSI 600 lb	P600R, P64R

Pressure Transducer Ranges

Pressure Sensor Ranges ¹ , psia (bara)			
Full Scale Operating Pressure		Maximum Over-Range Pressure	
psia	bara	psia	bara
30	2	60	4
100	7	200	14
300	20	600	40
500	35	1000	70
1500	100	2500	175

¹To maximize accuracy, specify the lowest full scale operating pressure range for the application. To avoid damage, the flowmeter must never be subjected to pressure above the over-range pressure shown above.

Power Requirements

12 to 36 VDC, 25 mA, 1 W max., Loop Powered Volumetric or Mass
 12 to 36 VDC, 300 mA, 9 W max. Multiparameter Mass options
 100 to 240 VAC, 50/60 Hz, 5 W max. Multiparameter Mass options

Class I Equipment (Grounded Type)

Installation (Over-voltage) Category II for transient over-voltages

AC & DC Mains supply voltage fluctuations are not to exceed $\pm 10\%$ of the rated supply voltage range.

User is responsible for the provision of an external Disconnect Means (and Over-Current Protection) for the equipment (both AC and DC models).

Display

Alphanumeric 2 x 16 LCD digital display:

Six push-button switches (UP, DOWN, RIGHT, LEFT, ENTER, EXIT) operable through explosion-proof window using hand-held magnet. Viewing at 90-degree mounting intervals.

Process Fluid and Ambient Temperature

Process Fluid:

Standard temperature sensor: -330 to 500°F (-200 to 260°C)

High temperature sensor: to 750°F (400°C)

Ambient:

Operating temperature range: -40 to 140° F (-40 to 60° C)

Storage temperature range: -40 to 185° F (-40 to 85° C)

Maximum relative humidity: 0-98%, non-condensing conditions

Maximum altitude: -2000 to 14,000 feet (-610 to 4268 meters)

Pollution Degree 2 for the ambient environment

Output Signals¹

Analog:

Volumetric Meter: field rangeable linear 4-20 mA output signal (1200 Ohms maximum loop resistance) selected by user for mass flow rate or volumetric flow rate.

Communications:

HART, MODBUS, RS485

Multiparameter Meter:

Up to three field rangeable linear 4-20 mA output signals (1200 Ohms maximum loop resistance) selected from the five parameters-mass flow rate, volumetric flow rate, temperature, pressure and density.

Pulse:

Pulse output for totalization is a 50-millisecond duration pulse operating a solid-state relay capable of switching 40 VDC, 40 mA maximum.

¹All outputs are optically isolated and require external power for operation.

Alarms

Up to three programmable solid-state relays for high, low or window alarms capable of switching 40 VDC, 40 mA maximum.

Totalizer

Based on user-determined flow units, six significant figures in scientific notation. Total stored in non-volatile memory.

Wetted Materials

Series MV80 In-Line Flowmeter:

316L stainless steel standard

C276 hastelloy or A105 carbon steel optional

Series MV82 Insertion Flowmeter:

316L stainless steel standard.

Teflon® packing gland below 500° F (260° C)

Graphite packing gland above 500° F (260° C)

Enclosure Protection Classification

NEMA 4X and IP66 cast enclosure

Electrical Ports

Two 3/4-inch female NPT ports

Mounting Connections

Series MV80: Wafer, 150, 300, 600 lb ANSI flange, PN16, PN40, PN64 flange

Series MV82 Permanent installation: 2-inch MNPT; 150, 300, 600 lb ANSI flange, PN16, PN40, PN64 flange with compression fitting probe seal

Series MV82 Hot Tap¹ Installation: 2-inch MNPT; 150, 300, 600 lb ANSI flange, PN16, PN40, PN64 flange and optional retractor with packing gland probe seal. ¹Removable under line pressure

Mounting Position

Series MV80 In-Line Flowmeter: No effect

Series MV82 Insertion Flowmeter: Meter must be perpendicular within $\pm 5^\circ$ of the pipe centerline

Certifications

Material Certificate - US Mill certifications on all wetted parts

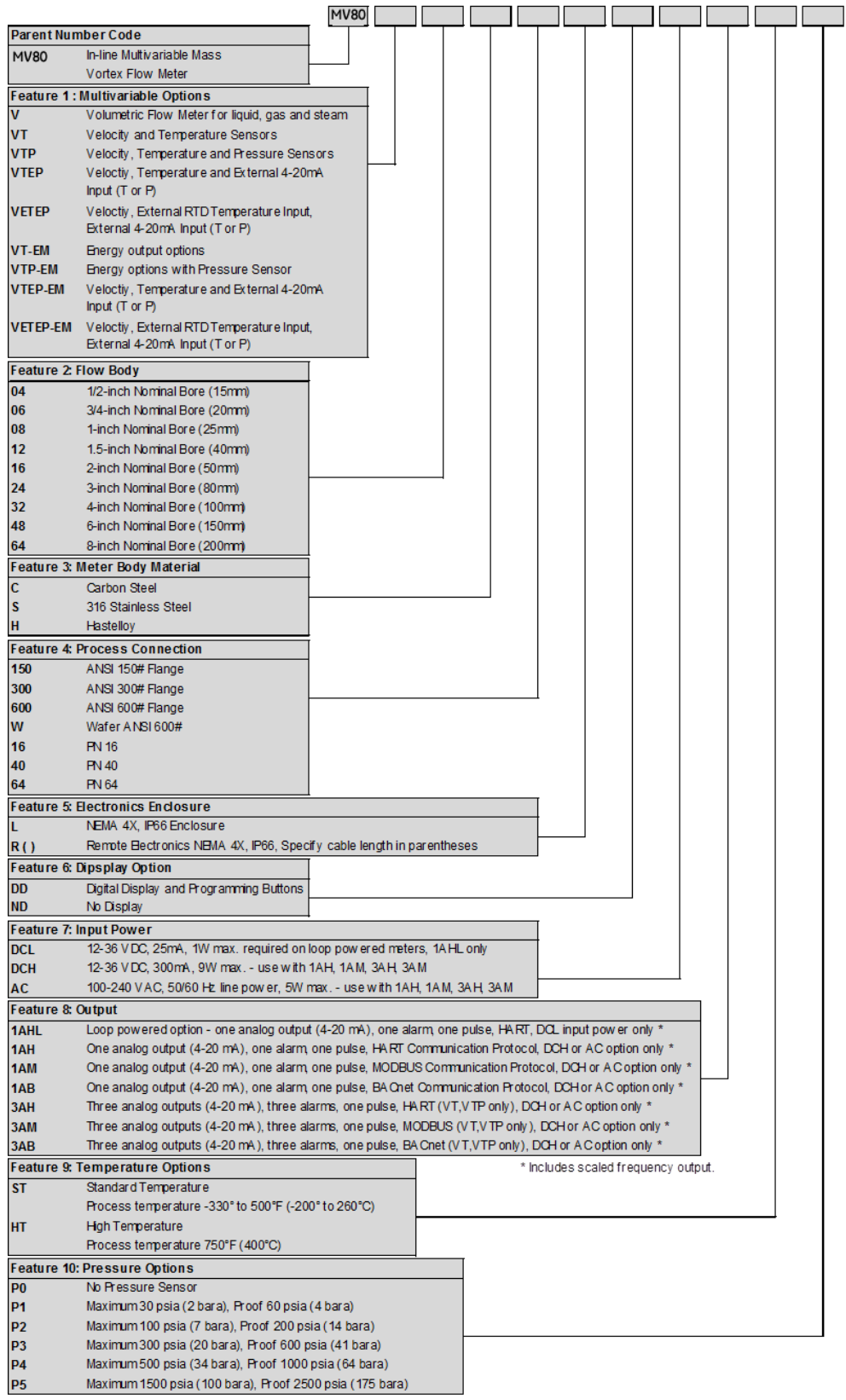
Pressure Test Certificate

Certificate of Conformance

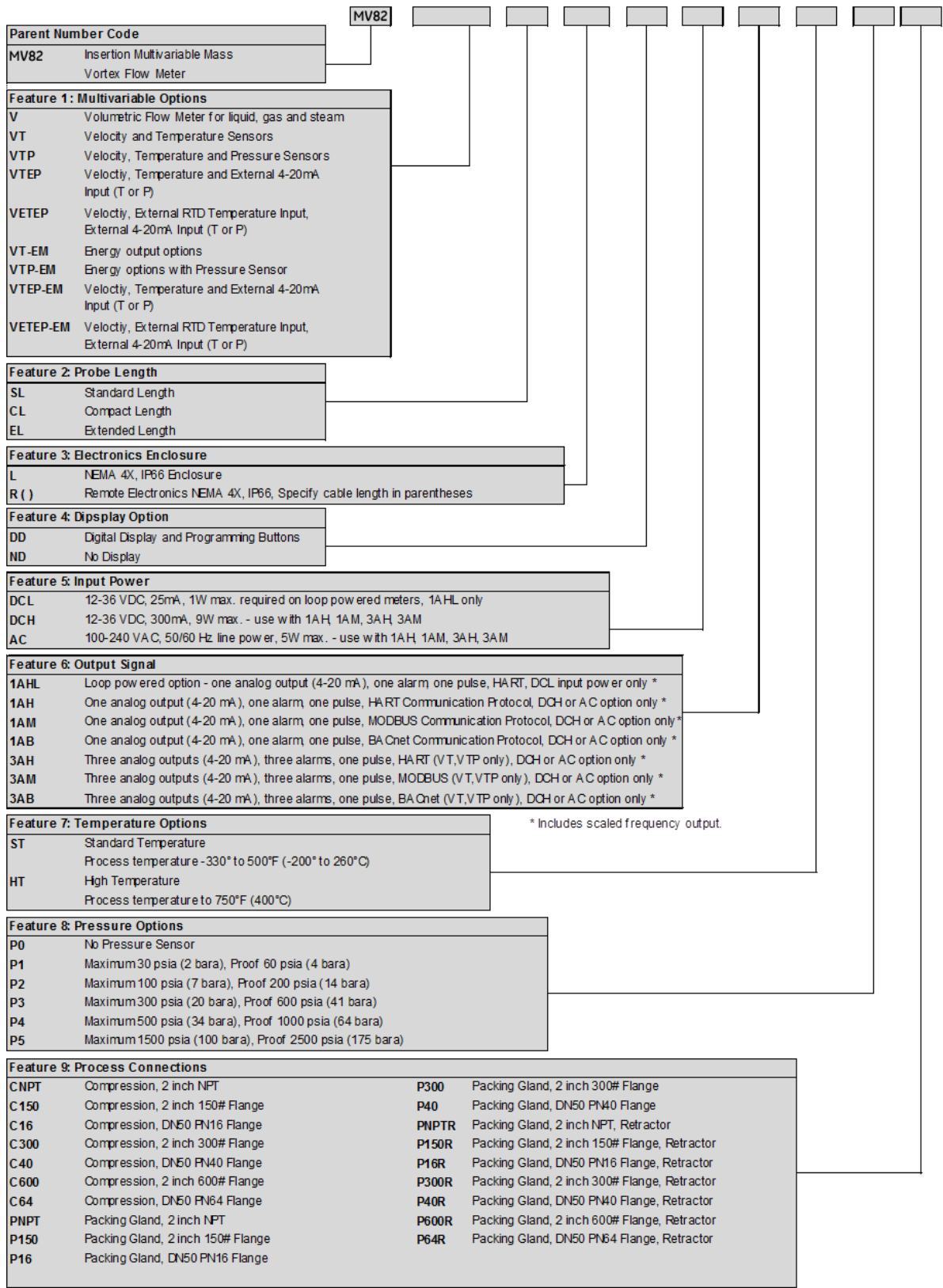
NACE Certification (MR0175-2003)

Oxygen Cleaning (CGA G-4)

Model Number Information —Series MV80 In-Line Flowmeter



Model Number Information: Series MV82 Insertion Flowmeter



Appendix B. Approvals

FM / FMC Approval

Class I, Division 1, Groups B, C, & D,
Class II/III, Division 1, Groups E, F, & G
Type 4X and IP66, T6 Ta = -40 to 60°C

ATEX-IECEX Specifications / Approval

EN 60079-0 (2006)
IEC 60079-0 (2004)
Electrical Apparatus for explosive gas atmospheres
General Requirements

EN IEC 60079-1 (2007)
Electrical Apparatus for explosive gas atmospheres
Flameproof enclosures “d”

EN 61241-0 (2006)
IEC 61241-0 (2004)
EN IEC 61241-1 (2004)

Directive 94/9/EC (1994)
Equipment Intended for use in Potentially Explosive Atmospheres
(ATEX)

Cable entries are ¾ NPT.



ID 0344



II 2 G Ex d IIB + H2 T6
II 2 D Ex tD A21 IP66 T85°C
KEMA 08ATEX0083



Ex d IIB + H2 T6
Ex tD A21 IP66 T85°C
IECEX KEM 08.0018

Technical assistance may be obtained by contacting *GE Customer Service* using the information on the back cover of this manual.

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Appendix C. Flowmeter Calculations

C.1 In-Line Flowmeter Calculations

C.1.1 Volume Flow Rate

$$Q_V = \frac{f}{K}$$

C.1.2 Mass Flow Rate

$$Q_M = Q_V \rho$$

C.1.3 Flowing Velocity

$$V_f = \frac{Q_V}{A}$$

Where:

A = Cross sectional area of the pipe (ft²)

f = Vortex shedding frequency (pulses/sec)

K = Meter factor corrected for thermal expansion (pulses/ft³)

Q_M = Mass flow rate (lbm/sec)

Q_V = Volume flow rate (ft³/sec)

V_f = Flowing velocity (ft/sec)

ρ = Density (lbm/ft³)

C.2 Insertion Flowmeter Calculations

C.2.1 Flowing Velocity

$$V_f = \frac{f}{K_C}$$

C.2.2 Volume Flow Rate

$$Q_V = V_f A$$

C.2.3 Mass Flow Rate

$$Q_M = V_f A \rho$$

Where:

A = Cross sectional area of the pipe (ft²)

f = Vortex shedding frequency (pulses/sec)

K_C = Meter factor corrected for Reynolds Number (pulses/ft)

Q_V = Volume flow rate (ft³/sec)

Q_M = Mass flow rate (lbm/sec)

V_f = Flowing velocity (ft/sec)

ρ = Density (lbm/ft³)

C.3 Fluid Calculations

C.3.1 Calculations for Steam T & P

When “Steam T & P” is selected in the “Real Gas” selection of the Fluid Menu, the calculations are based on the equations below.

C.3.1a Density

The density of steam is calculated from the formula given by Keenan and Keys. The given equation is for the volume of the steam

$$v = \frac{4.555.04 \cdot T}{\rho} + B$$

$$B = B_0 + B_0^2 g_1(\tau) \tau \cdot \rho + B_0^4 g_2(\tau) \tau^3 \cdot \rho^3 - B_0^{134} g_3(\tau) \tau^{12} \cdot \rho^{12}$$

$$B_0 = 1.89 - 2641.62 \cdot t \cdot 10^{80870r^2}$$

$$g_1(\tau) = 82.546 \cdot \tau - 1.6246 \cdot 10^5 \cdot \tau^2$$

$$g_2(\tau) = 0.21828 - 1.2697 \cdot 10^5 \cdot \tau^2$$

$$g_3(\tau) = 3.635 \cdot 10^{-4} - 6.768 \cdot 10^{64} \cdot \tau^{24}$$

Where:

tau is 1/ temperature in Kelvin

density = 1/(v/ standard density of water)

C.3.1b Viscosity

The viscosity is based on an equation given by Keenan and Keys:

$$\eta(\text{poise}) = \frac{1.501 \cdot 10^{-5} \sqrt{T}}{1 + 446.8/T}$$

Where:

T is the temperature in Kelvin.

C.3.2 Calculations for Gas (“Real Gas” and “Other Gas”)

Use this formula to determine the settings for “Real Gas” selections and “Other Gas” selections entered in the Fluid Menu. The calculations for gas were taken from Richard W. Miller, Flow Measurement Engineering Handbook (Third Edition, 1996).

C.3.2a Density

The density for real gases is calculated from the equation:

$$\delta = \frac{GM_{w, Air} p_f}{Z_f R_0 T_f}$$

Where:

G = specific gravity

M_w = molecular weight of air

p_f = flowing pressure

Z = flowing compressibility

R_0 = universal gas constant

T = flowing temperature

The specific gravity, and R_0 are known and are stored in a table used by the Vortex meter.

The hard coefficient to find is the compressibility, Z. Z is found using the Redlich-Kwong Equation (Miller page 2-18).

The Redlich-Kwong Equation uses the reduced temperature and pressure to calculate the compressibility factor. The equations are non linear and an iterative solution is used. The Vortex program uses Newton's Method on the Redlich-Kwong equations to iteratively find the compressibility factor. The critical temperature and pressure used in the Redlich-Kwong equation are stored in the fluid data table with the other coefficients.

C.3.2b Viscosity

The viscosity for real gases is calculated using the exponential equation for two known viscosities. The equation is:

$$\mu_{cP} = \alpha T_K^n$$

Where:

α and n are found from two known viscosities at two temperatures:

$$n = \frac{\ln[(\mu_{cP})_2 / (\mu_{cP})_1]}{\ln(T_{K2} / T_{K1})}$$

and

$$\alpha = \frac{(\mu_{cP})_1}{T_{K1}^n}$$

C.3.3 Calculations for Liquid

Use this formula to determine the settings for “Goyal-Dorais” selections and “Other Liquid” selections entered in the Fluid Menu. The liquid calculations were taken from Richard W. Miller, Flow Measurement Engineering Handbook (Third Edition, 1996).

C.3.3a Density

The liquid density is found using the Goyal-Doraiswamy Equation. Goyal-Doraiswamy uses the critical compressibility, critical pressure and critical temperature, along with the molecular weight to find the density. The equation for specific gravity is:

$$G_F = \frac{p_c Mw}{T_c} \left(\frac{0.008}{Z_c^{0.773}} - 0.01102 \frac{T_f}{T_c} \right)$$

The specific gravity can then be converted into density.

C.3.3b Viscosity

The liquid viscosity is found by Andrade's equation. This uses two viscosities at different temperatures to extrapolate the viscosity.

Andrade's equation:

$$\mu = A_L \exp \frac{B_L}{T_{\text{degR}}}$$

To find A and B:

$$B_L = \frac{T_{\text{degR1}} T_{\text{degR2}} \ln(\mu_1 / \mu_2)}{T_{\text{degR2}} - T_{\text{degR1}}}$$

and

$$A_L = \frac{\mu_1}{\exp(B_L / T_{\text{degR1}})}$$

The temperatures are all in degrees Rankin. Do not misinterpret the subscript R to mean that they are reduced temperatures.

Appendix D. Glossary

A	Cross sectional area
ACFM	Actual Cubic Feet Per Minute (volumetric flow rate)
ASME	American Society of Mechanical Engineers
Bluff Body	Non-streamlined body placed into a flow stream to create vortices. Also called Shedder Bar.
BTU	British Thermal Unit, an energy measurement
Cenelec	European Electrical Code
Compressibility Factor	A factor used to correct for the non-ideal changes in a fluid's density due to changes in temperature and/or pressure
CSA	Canadian Standards Association
d	Width of a bluff body or shedder bar
D	Diameter of a flow channel
f	Frequency of vortices generated in a vortex flowmeter, usually in Hz
Flow Channel	A pipe, duct, stack, or channel containing flowing fluid
Flow Profile	A map of the fluid velocity vector (usually non-uniform) in a cross-sectional plane of a flow channel (usually along a diameter)
FM	Factory Mutual
Ft	Foot, 12 inches, a measure of length
Ft²	Square feet, measure of area
Ft³	Cubic feet, measure of volume
GPM	Gallons Per Minute

Hz	Hertz, cycles per second
In-Line Flowmeter	A flowmeter which includes a short section of piping which is put in-line with the user's piping
Insertion FlowMeter	A flowmeter which is inserted into a hole in the user's pipeline
Joule	A unit of energy equal to one watt for one second; also equal to a Newton-meter
LCD	Liquid crystal display
\dot{m}	Mass flow rate
mA	Milliampere, one thousandth of an ampere of current
μ	Viscosity, a measure of a fluid's resistance to shear stress. Honey has high viscosity, alcohol has low viscosity
nm³/hr	Normal cubic meters per hour (flow rate converted to normal conditions, as shipped 101 kPa and 0° C). User definable.
ΔP	Permanent pressure loss
P	Line pressure (psia or bar absolute)
ρ_{act}	The density of a fluid at the actual temperature and pressure operating conditions
ρ_{std}	The density of a fluid at standard conditions (usually 14.7 psia and 20° C)
Permanent Pressure Loss	Unrecoverable drop in pressure
Piezoelectric Crystal	A material which generates an electrical charge when the material is put under stress
PRTD	Resistance temperature detector (RTD) with platinum element. Used because of high stability
psia	Pounds per square inch absolute (equals psig + atmospheric pressure). Atmospheric pressure is typically 14.696 psi at sea level

psig	Pounds per square inch gauge
P_v	Liquid vapor pressure at flowing conditions (psia or bar absolute)
Q	Flow rate, usually volumetric
Rangeability	Highest measurable flow rate divided by the lowest measurable flow rate
Reynolds Number or Re	A dimensionless number equal to the density of a fluid times the velocity of the fluid times the diameter of the fluid channel, divided by the fluid viscosity (i.e., $Re = VD/\rho$). The Reynolds number is an important number for vortex flowmeters because it is used to determine the minimum measurable flow rate. It is the ratio of the inertial forces to the viscous forces in a flowing fluid.
RTD	Resistance temperature detector, a sensor whose resistance increases as the temperature rises
scfm	Standard cubic feet per minute (flow rate converted to standard conditions, as shipped 14.696 psia and 59° F). User definable.
Shedder Bar	A non-streamlined body placed into a flow stream to create vortices. Also called a Bluff Body.
Strouhal Number or St	A dimensionless number equal to the frequency of vortices created by a bluff body times the width of the bluff body divided by the velocity of the flowing fluid (i.e., $St = fd/V$). This is an important number for vortex flowmeters because it relates the vortex frequency to the fluid velocity.
Totalizer	An electronic counter which records the total accumulated flow over a certain range of time
Traverse	The act of moving a measuring point across the width of a flow channel
Uncertainty	The closeness of agreement between the result of a measurement and the true value of the measurement
V	Velocity or voltage
VAC	Volts, alternating current
VDC	Volts, direct current
VORTEX	An eddy of fluid

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Warranty

Each instrument manufactured by GE 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 GE Sensing. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If GE 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 GE 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 GE 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 GE Sensing instrument malfunctions within the warranty period, the following procedure must be completed:

1. Notify GE 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, GE 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 GE 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, GE 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 GE 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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We,

GE Sensing
1100 Technology Park Drive
Billerica, MA 01821
USA

declare under our sole responsibility that the

PanaFlow Multi-Parameter Vortex Mass Flow Meters, Series MV80 and MV82

to which this declaration relates, are in conformity with the following standards:

- EN 60079-0: 2006
- EN 60079-1: 2007
- EN 61241-1: 2004
- EN 61241-0: 2006
- II 2 G Ex d IIB +H₂ T6; KEMA 08ATEX0128 (KEMA Quality B.V., The Netherlands - NoBo 0344)
- II 2 D Ex tD A21 IP66 T85°C; KEMA 08ATEX0128 (KEMA Quality B.V., The Netherlands - NoBo 0344)
- EN 61326-1: 2006, Class A, Table 2, Industrial Locations
- EN 61326-2-3: 2006

following the provisions of the 2004/108/EC EMC and 94/9/EC ATEX Directives.

- Ambient Temperature Range: -40°C to +60°C

The units listed above and any ancillary equipment supplied with them do not bear CE marking for the Pressure Equipment Directive, as they are supplied in accordance with Article 3, Section 3 (sound engineering practices and codes of good workmanship) of the Pressure Equipment Directive 97/23/EC for DN<25.

Billerica - September 1, 2015

Issued



Mr. Gary Kozinski
Certification & Standards, Lead Engineer



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