PanaFlow™ MV80, MV82 & MV84

**Vortex Volumetric and Mass Flow Meters
User's Manual**

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BH030C11 EN F
May 2023

panametrics.com

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Customer Notice for Oxygen Service

Unless you have specifically ordered Panametrics optional O2 cleaning, this flow meter may not be fit for oxygen service. Some models can only be properly cleaned during the manufacturing process. Panametrics, is not liable for any damage or personal injury, whatsoever, resulting from the use of Panametrics standard mass flow meters for oxygen gas.

Specific Conditions of Use (ATEX/IECEx)

Contact Manufacturer regarding Flame path information.

Clean with a damp cloth to avoid any build-up of electrostatic charge.

The Model MV80, MV82, MV84 and MV84R Multi-Parameter Vortex Mass Flow Meters standard temperature option (ST) process temperature range is -40ºC to 260ºC. The high temperature option (HT) process temperature range is -40ºC up to +400ºC.

Table 1: Multi-Parameter Vortex Mass Vortex Flowmeters

Tmax (Process)	Temperature Class Value (Gas)	
	ST Version	HT Version
80ºC	T6	85ºC
95ºC	T5	100ºC
130ºC	T4	135ºC
195ºC	T3	200ºC
260ºC	T2	300ºC
400ºC	N/A	405ºC

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Services

Panametrics provides customers with an experienced staff of customer support personnel ready to respond to technical inquiries, as well as other remote and on-site support needs. To complement our broad portfolio of industry-leading solutions, we offer several types of flexible and scalable support services including: Training, Product Repairs, Extended Warranties, Service Agreements and more. Please visit

https://www.bakerhughes.com/panametrics/panametrics-services for more details.

Terms and Conditions

Sales *Terms and Conditions* for your recent purchase of a Panametrics product, including the applicable product Warranty, can be found on our website.

Typographical Conventions

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.**

Attention European Customers! **To meet CE Marking requirements for all units intended for use in the EU, all electrical cables must be installed as described in this manual.**

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 this 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

RoHS

The PanaFlow™ M80, M82, M84 and M84R fully complies with RoHS regulations (Directive 2011/65/EU).

Waste Electrical and Electronic Equipment (WEEE) Directive

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

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

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

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

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

Chapter 1. Introduction

Chapter 2. Installation

Chapter 4. Serial Communications

Chapter 5. Troubleshooting and Repair

Appendix A. Product Specifications

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Chapter 1.   Introduction

1.1   Multi-Parameter Vortex Mass Flow Meters

The Panametrics PanaFlow™ MV80 & MV82 Vortex Flow Meters 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 Flow Meters

Mass flow meters 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 Flow Meters

The primary sensing element of a volumetric flow meter 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 flow meters 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, MODBUS, and BACnet 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 Flow Meter Operates

PanaFlow MV80, MV82, and MV84 Multi-Parameter Vortex Mass Flow Meters (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 flow meter 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.
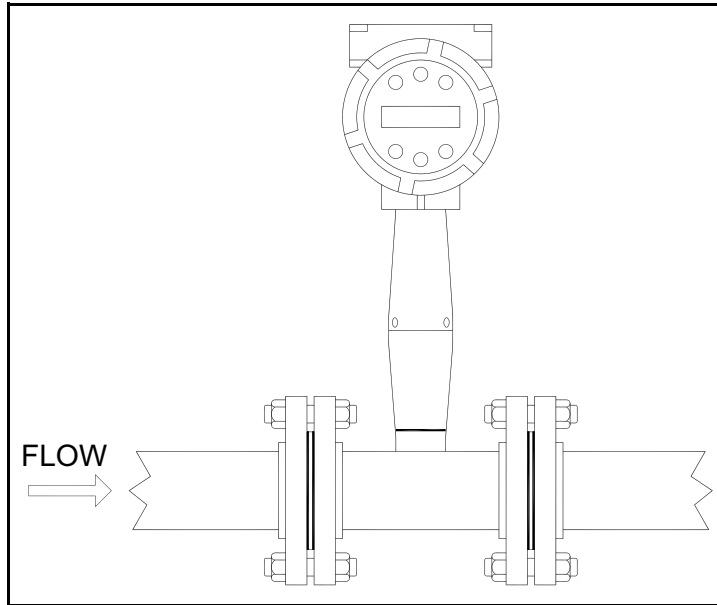
Figure 1: In-Line Vortex Multi-Parameter Mass Flow Meter

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 flow meters. 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 turn-down, 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™ Flow Meter computes the total fluid volume.
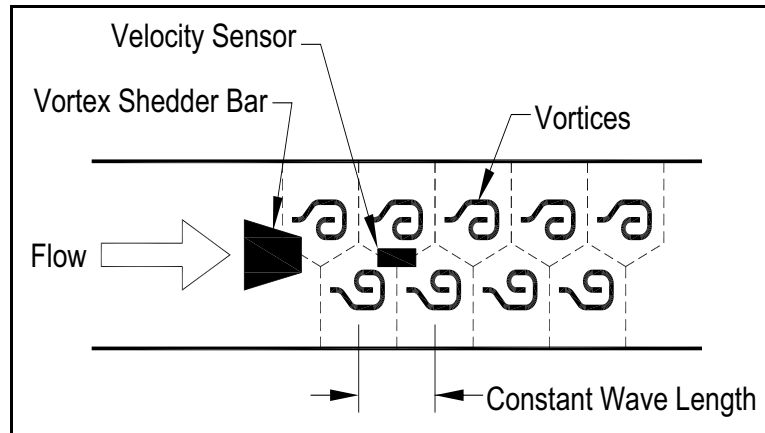
Figure 2: Measurement Principle of Vortex Flow Meters

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 flow meters 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}	$\sqrt{\dfrac{25ft/s}{\rho}}$	1 ft/s	English ρ (lb/ft^3)
V_{max} 0.5 in. 0.75 in. 1 in. 1.5 in. and greater	175 ft/s 250 ft/s 250 ft/s 300 ft/s	30 ft/s 30 ft/s 30 ft/s 30 ft/s	
V_{min}	$\sqrt{\dfrac{37m/s}{\rho}}$	0.3 m/s	Metric ρ (kg/m^3)
V_{max} DN15 DN20 DN25 DN40 and greater	53 m/s 76 m/s 76 m/s 91 m/s	9.1 m/s 9.1 m/s 9.1 m/s 9.1 m/s	

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:

$$Re = \frac{\rho VD}{\mu}$$

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:

$$St = \frac{fd}{V}$$

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

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.
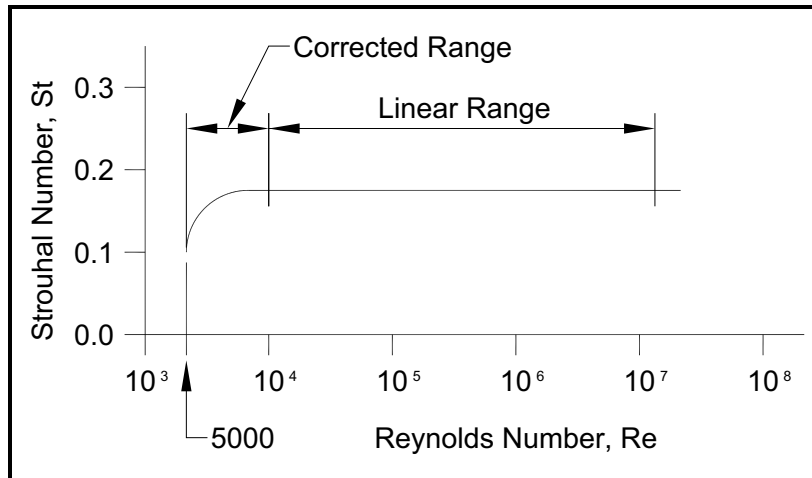
Figure 3: Reynolds Number Range for the PanaFlow MV

1.4   Pressure Drop

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

$\Delta P = .00024\ \rho V^2$ English units (ΔP in psi, ρ in lb/ft^3, V in ft/sec)

$\Delta P = .000011\ \rho V^2$ Metric units (ΔP in bar, ρ in kg/m^3, V in m/sec)

1.5   Minimum Back Pressure

A minimum back pressure is required to prevent cavitation in the vortex flow meter when installed in liquid applications. Cavitation is a phenome-non wherein a liquid passing through a low pressure zone no longer can remain in the liquid phase and therefore partially flashes (or "boils") into its vapor phase. The resulting two-phase flow degrades the liquid calibration accuracy. For some applications, a valve downstream of the flow meter may be required to increase the pressure in the meter, thereby avoiding cavitation. The following equation defines the minimum back pressure to prevent cavitation.

$$P = 2.9\ \Delta P + 1.3\ P_V$$

Where:

P = Minimum line pressure five pipe diameters downstream of the flow meter required to avoid cavitation (psia or bara).

ΔP = Permanent pressure loss across the flow meter (psia or bara).

P_V = Liquid vapor pressure at actual flowing conditions (psia or bara).

1.6   Temperature Measurement

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

1.7   Pressure Measurement

PanaFlow Flow Meters 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).

1.8   Flow Meter Configurations

PanaFlow Vortex Mass Flow Meters are available in two model configurations:

- Series MV80 in-line flow meter (replaces a section of the pipeline)
- Series MV82 insertion flow meter (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 flow meter and an insertion flow meter is their method of measurement.

For an in-line vortex flow meter, 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 flow meters 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 flow meter 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 flow meter 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 Panametrics for specific installation advice.

1.8.1   Multivariable Options

The MV80, MV82 or MV84 models are available with the following options:

- **V** = volumetric flow meter
- **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
- **VETEP** = external RTD temperature input, external 4-20 mA input.

1.8.2   Line Size, Process Connections and Materials

The MV80 and MV84 In-line model is built for line sizes ½ through 4 inch wafer or ½ through 12 inch flanged design using ANSI 150, 300, 600, PN16, 40, or 63 class flanges. JIS flanges available upon request.

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 63 class flanges). The packing gland design can be ordered with a permanent or removable retractor.

The MV84 Non-reducing and MV84R Reducing In-line models have face to face lengths that are different from MV80. The MV84R In-line flanged or wafer model reduces by one pipe size to increase the ve-locity through the meter and is available for ANSI 150, 300, or 600 class flanges and 316/316L stainless steel.

The MV80 and MV84 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.

1.8.3   Flow Meter Electronics

PanaFlow flow meter 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, HART, and BACnet communications are also available.

PanaFlow flow meters include a local 2x16 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 flow meter to function immediately upon power up, or after an interruption in power. All flow meters are calibrated and configured for the customer's flow application.

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Chapter 2.   Installation

2.1   Installation Overview

PanaFlow Vortex Flow Meter installations are simple and straightforward. Both the Series MV80 In-Line and Series MV82 Insertion type flow meter installations are covered in this chapter. After reviewing the installation requirements given below, see page 10 for Series MV80 installation instructions. See *"Series MV82 Insertion Flow Meter Installation" on page 17* for Series MV82 installation instructions. Wiring instructions begin in *"Loop Power Flow Meter Wiring Connections" on page 34*.

2.1.1   Flow Meter Installation Requirements

WARNING!   **Consult the flow meter nameplate for specific flow meter approvals before any hazardous location installation.**

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

1.   Line pressure and temperature will not exceed the flow meter 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. The cable entry device shall be of a certified flameproof type, suitable for the conditions of use and correctly installed. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements.
5.   For remote installations, verify the supplied cable length is sufficient to connect the flow meter 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 flow meter 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.*

Example 1.
One 90° elbow before meter

Example 2.
Two 90° elbows before meter in one plane

Example 3.
Two 90° elbows before meter out of plane (if three 90° bends present, double recommended length)

Example 4.
Reduction before meter

Example 5.
Expansion before meter

Example 6.
Regulator or valve partially closed before meter (If valve is always wide open, base length requirements on fitting directly preceding it)

	Minimum Required Upstream Diameters				Minimum Required Downstream Diameters	
	No Flow Conditioner	With Flow Conditioner			No Flow Conditioner	With Flow Conditioner
Example	A	A	C	C'	B	B
1	10D	N/A	N/A	N/A	5D	5D
2	15D	10D	5D	5D	5D	5D
3	30D	10D	5D	5D	10D	5D
4	10D	10D	5D	5D	5D	5D
5	20D	10D	5D	5D	5D	5D
6	30D	10D	5D	5D	10D	5D
D = Internal diameter of channel. N/A = Not applicable.						

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

2.1.3   Recommended Meter Locations
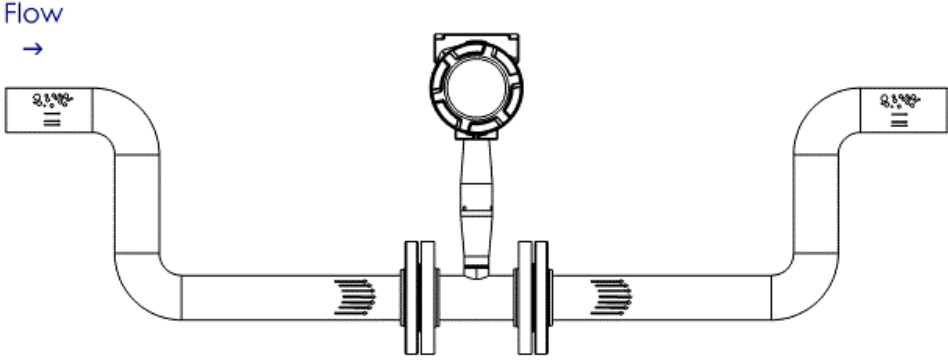
Figure 5: Liquid Horizontal
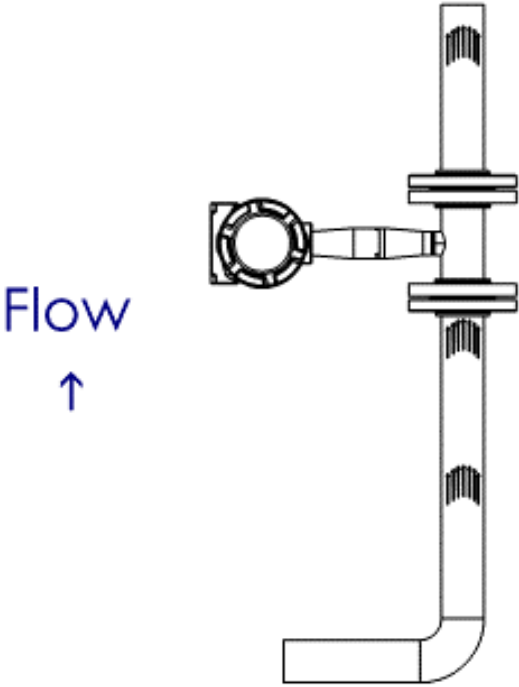
Figure 6: Liquid Vertical
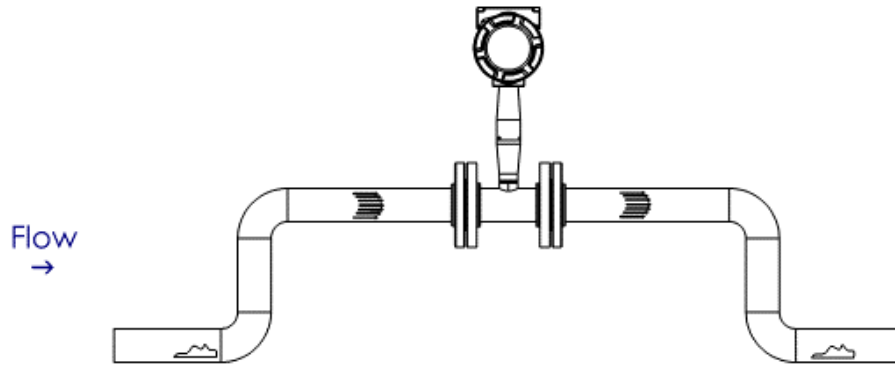
Figure 7: Gas or Steam Horizontal
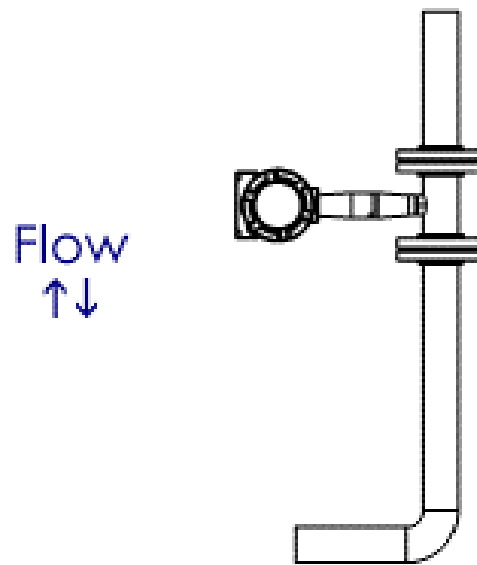
Figure 8: Gas or Steam Vertical

2.2   Series MV80 In-Line Flow Meter Installation

Install the Series MV80 In-Line Flow Meter between two conventional pipe flanges as shown in *Figure 10 on page 14* and *Figure 11 on page 16*.

The meter inside diameter is equal to the same size nominal pipe ID in schedule 80. For example, a 2 in. meter has an ID of 1.939 in. (2 in. 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 Panametrics 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 flow meter 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

Stud bolt lengths may be calculated using the following equation:

L = Meter face to face length + 2 (mounting flange thickness + flange raised face) + 2 (gasket thickness) + 4 (mounting nut thickness)

Refer to the mounting flange specification to select the correct stud bolt diameter.

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 9* below for the proper bolt tightening sequence.
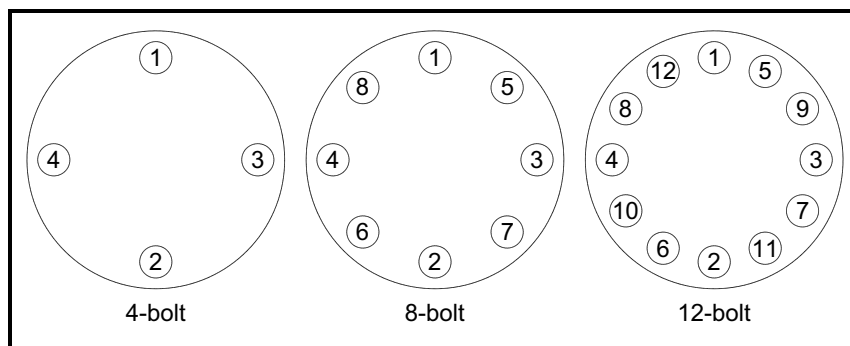
Figure 9: Flange Bolt Torquing Sequence

2.2.2   Installing Wafer-Style Flow Meters

Install the wafer-style meter between two conventional pipe flanges of the same nominal size as the flow meter (see *Figure 10* 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 flow meters are not suitable for two-phase flows, such as liquid and gas mixtures.*

For horizontal pipelines having a process temperature above 300º 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 31* and *"Enclosure Adjustment (Series MV80 Only)" on page 32*.

Enclosure and display/keypad are adjustable to suit most viewing angles.

Shedder bar (bluff body) is positioned upstream of the sensor.

Incorrect gasket position! Do not allow any gasket material to extend into the flow profile.
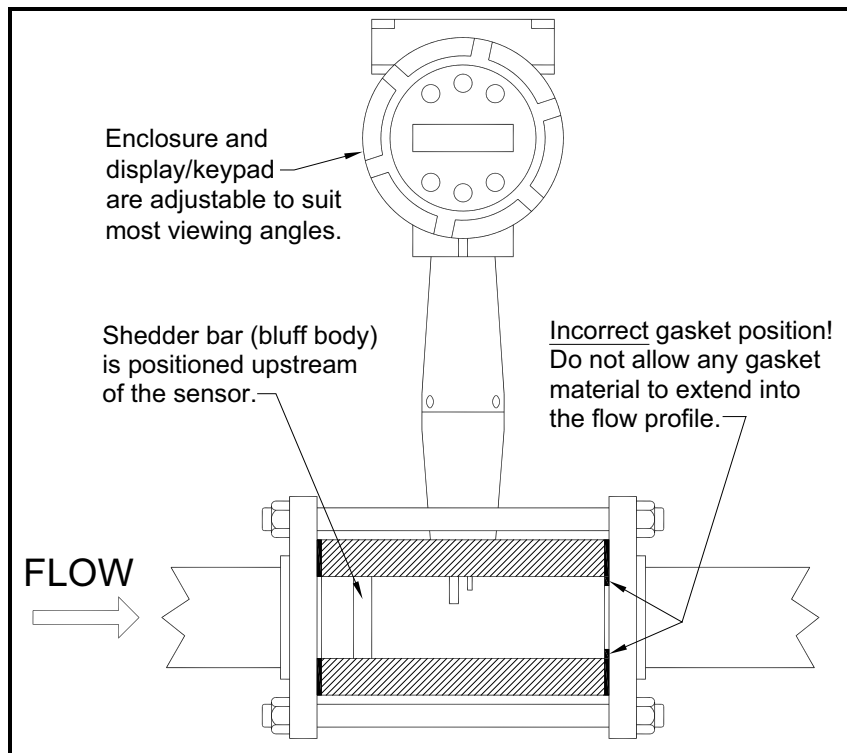
FLOW

Figure 10: Wafer-Style Flow Meter 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 flow meter.**

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 Flow Meters (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 9 on page 13*. Check for leaks after tightening the flange bolts.

2.2.3   Installing Flange-Style Flow Meters

Install the flange-style meter between two conventional pipe flanges of the same nominal size as the flow meter (see *Figure 11* 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 flow meters are not suitable for two-phase flows, such as liquid and gas mixtures.

For horizontal pipelines having a process temperature above 300º 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 31* and *"Enclosure Adjustment (Series MV80 Only)" on page 32*.
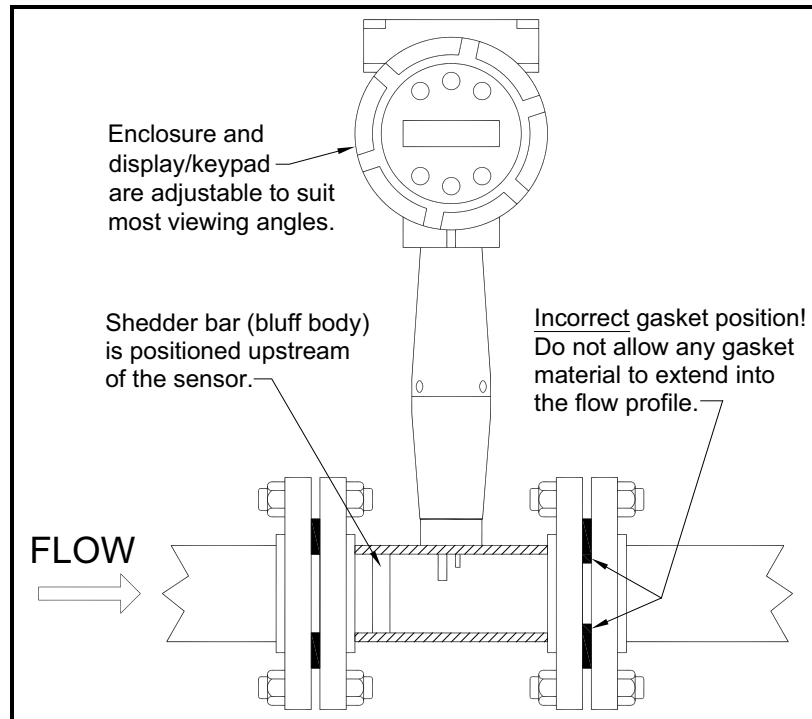
Figure 11: Flange-Style Flow Meter Installation

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 flow meter.**

 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 Flow Meters (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 9 on page 13*. Check for leaks after tightening the flange bolts.

2.3   Series MV82 Insertion Flow Meter 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 value requirements given in the following sub-sections.

2.3.1.1   Electronics Enclosure Clearance

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

2.3.1.2   Isolation Valve Selection

An isolation valve is available as an option with Series MV82 meters. If you supply the isolation valve, refer to *Figure 12* 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 flow meter'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 flow meter's sensor head will not interfere with the operation of the isolation valve.
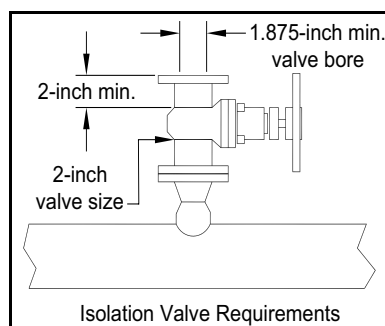
Figure 12: Isolation Valve Dimensions

2.3.1.3   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 flow meter.**

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 flow meter accuracy. Also, obstructions could damage the sensor assembly when inserting into the pipe.

WARNING! **All flow meter 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 flow meter pipe connection on the pipe. Make sure this connection is within ± 5° perpendicular to the pipe centerline (see *Figure 13* below).

Correct Alignment   Incorrect Alignment
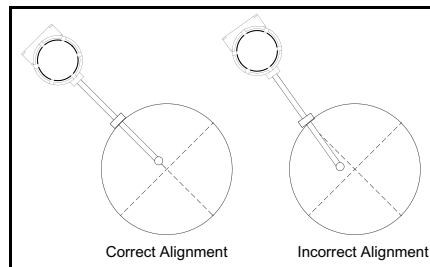
Figure 13: Connection Alignment

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.

2.3.1.4   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 flow meter 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 14* below are general in nature and are intended for guideline purposes only.

Check upstream and downstream piping requirements.

Weld mounting adapter.

Connect process connection (flange or NPT)

Connect isolation valve and test for leaks.

Hot tap pipe

FLOW

Purge pipe.

Connect meter to valve, calculate insertion depth, install flowmeter.
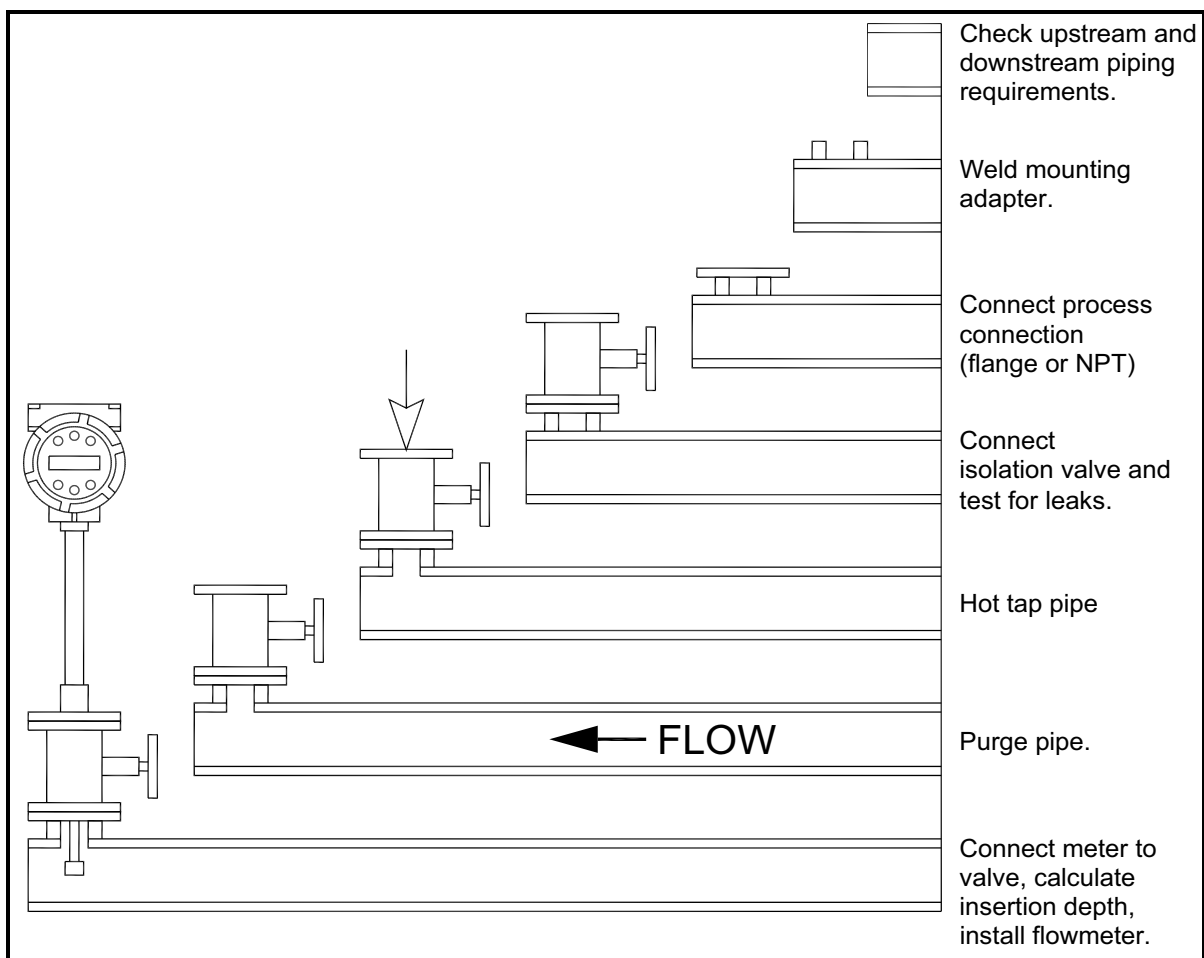
Figure 14: Hot Tap Sequence

2.3.1.4   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 ± 5° perpendicular to the pipe centerline (see *Figure 13 on page 18*). 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 flow meter 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.

2.3.1.5   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 flow meters 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 flow meters are available in three probe lengths:

- *Standard Probe* configuration is used with most flow meter 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 flow meter process connections. The length (**S**) of the stem is 41.47 inches.

2.3.1.6   Selecting the Correct Insertion Formula

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

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

- For flow meters with a compression type connection (NPT or flanged), follow the instructions beginning in *"Installing Flow Meters with a Compression Connection" on page 22*.
- For flow meters with a packing gland type connection (NPT or flanged), configured with an insertion tool, follow the instructions in *"Installing Flow Meters with a Packing Gland Connection" on page 25*.
- For flow meters with a packing gland type connection (NPT or flanged), configured without an insertion tool, follow the instructions in *"Installing Flow Meters with a Packing Gland Connection (No Insertion Tool)" on page 30*.

2.3.2   Installing Flow Meters with a Compression Connection

Refer to *Figure 15* below, and use the formula shown to determine insertion length for flow meters (NPT and flanged) with a compression process connection.
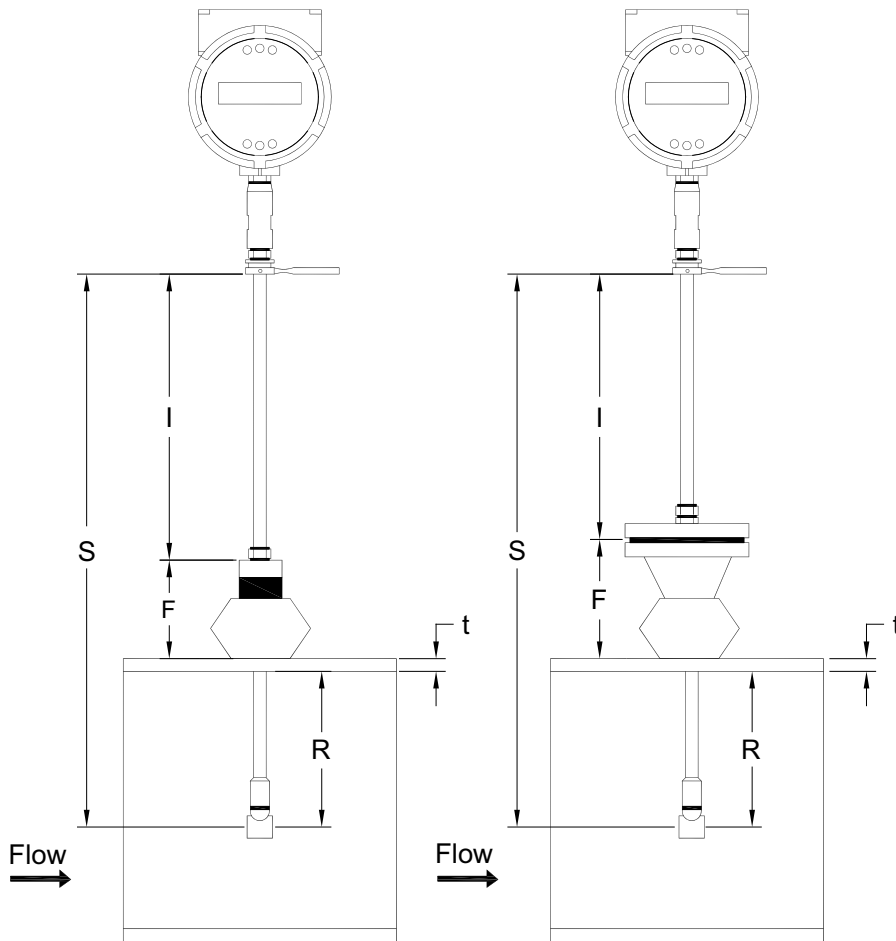
Insertion Length Formula

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

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 15: Insertion Calculation (Compression Type)

2.3.2 Installing Flow Meters 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 15 on page 22*, 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.
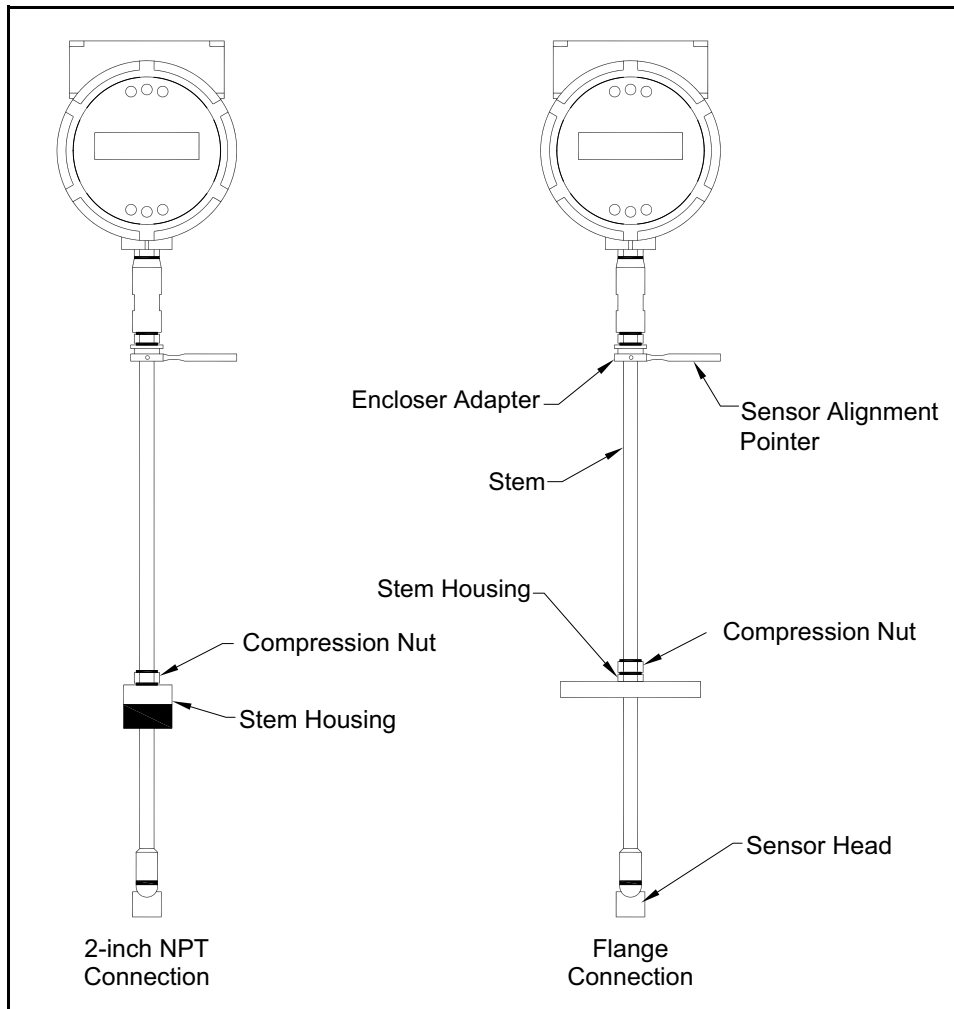
Figure 16: Flow Meter with a Compression Type Fitting

2.3.2   Installing Flow Meters 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 16 on page 23* and complete the following steps:

1. Refer to *Figure 15 on page 22* 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 flow meter 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 Flow Meters with a Packing Gland Connection

Use the formula in *Figure 17* below to determine the insertion depth for flow meters (NPT and flanged) equipped with an insertion tool. To install, see *"Insertion Procedure for Flow Meters with Permanent Insertion Tool" on page 26* for instructions for meters with a permanent insertion tool. For meters with a removable insertion tool, see *"Insertion Procedure for Flow Meters with Removable Insertion Tool" on page 28*.

Insertion Length Formula
$$I = F + R + t - 1.35$$

Where:

I = Insertion length.

F = Distance from the raised face of the flange or top of the process connection for NPT style meters to the top outside of the process pipe.

R = (Pipe inside diameter)/2 for pipe diameters 10 inches and smaller.

R = Five inches for pipe diameters larger than 10 inches.

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

Figure 17: Insertion Length Calculation for Meters with an Insertion Tool

Example 1 - Flange Style Meters:

To install a Series MV82 Flow Meter 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 17* above, the insertion length for this example is 16.09 inches.

2.3.3   Installing Flow Meters 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 subtracted in the equation shown in *Figure 17 on page 25*. 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 Flow Meters with Permanent Insertion Tool

Refer to *Figure 18* below, and follow the instructions on the next page.

Figure 18: Flow Meter with Permanent Insertion Tool

2.3.4 Insertion Procedure for Flow Meters 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 flow meter. Do not confuse this with possible interference in the pipe.*

1. Calculate the required sensor probe insertion length (see **Example 1** on *page 25*). Measure from the depth marker arrow down the stanchion and scribe a mark at the calculated insertion depth.

2. Fully retract the flow meter 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 Flow Meters with Removable Insertion Tool

Refer to *Figure 19* below, and follow the instructions on the next page.
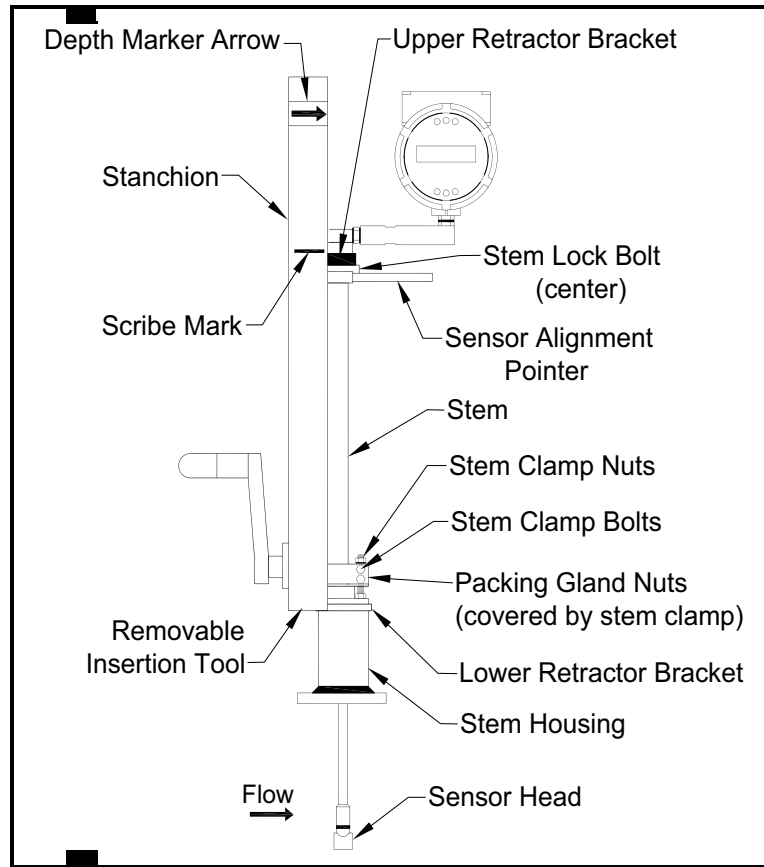
Figure 19: Flow Meter with Removable Insertion Tool

2.3.5 Insertion Procedure for Flow Meters with Removable Insertion Tool (cont.)

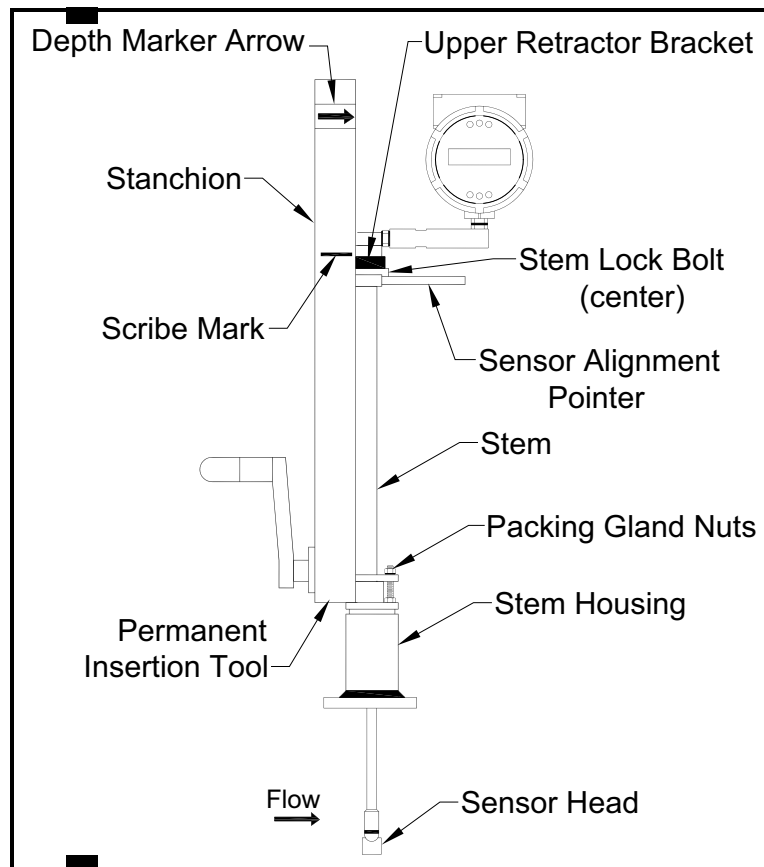⚠️ **CAUTION!** **The sensor alignment pointer must point downstream, in the direction of flow.**

Note: *If line pressure is above 500 psig, it could require up to 25 ft-lb of torque to insert the flow meter. 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 flow meter 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 flow meter, remove the four socket head cap bolts securing the upper and lower retractor brackets. Then, remove the insertion tool.

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

Use the formula in *Figure 20* below to determine the insertion depth for meters with a packing gland connection (NPT and flanged) without an insertion tool.

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 ($S = 41.47$ inches for 12 inch extended probes).

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 20: Insertion Calculation for Meters Without an Insertion Tool)

Example:

To install a Series MV82 Flow Meter 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 Flow Meters 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 21* below and complete the following steps:

Rotate display/keypad in 90° increments
(maximum 180° from original position).
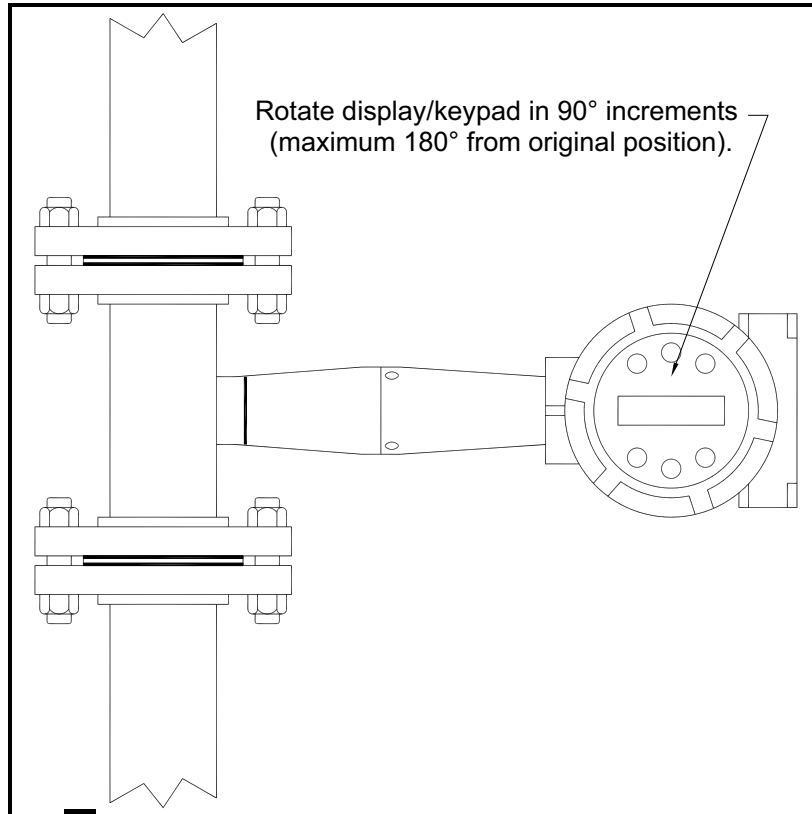
Figure 21: Display/Keypad Viewing Adjustment

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 flow meter.

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 22* below and complete the following steps:

Loosen three setscrews
and rotate enclosure
(maximum 180° from
original position)
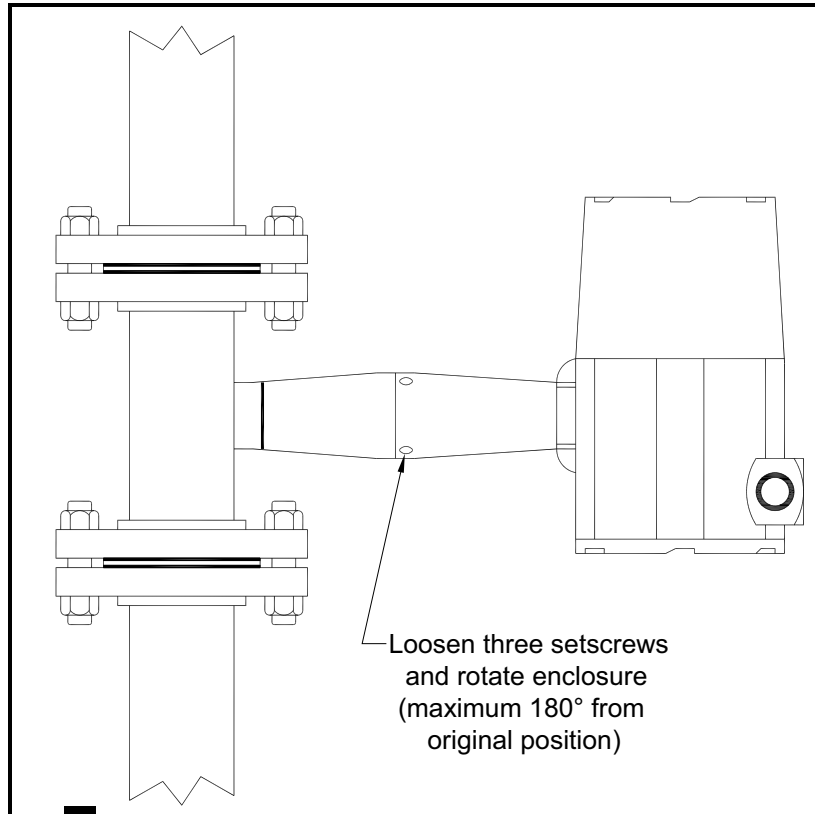
Figure 22: Enclosure Viewing Adjustment

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

1. Disconnect the power from the flow meter.
2. Loosen the three set screws shown in *Figure 22* above and rotate the display to the desired position. The maximum allowable rotation is 180º.
3. Tighten the three set screws and restore power to the meter.

2.5   Loop Power Flow 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 wiring procedures must be per-formed with the power off.**

Use a Class 2 isolated power supply that is grounded, provides DC output, and has no more than 10% output ripple.

A power switch is not provided with this meter, an approved switch meeting the power requirements listed in Appendix A must be provided by the user. It must be easily accessible and marked as the disconnect for the flow meter.

Only the connectors sup-plied with the meter are to be used for connecting wiring.

If the equipment is used in a manner not specified the protection provided by the equipment may be impaired.

The NEMA 4X enclosure contains an integral wiring compartment with one dual strip terminal block (located in the smaller end of the enclosure see *Figure 23* below). Two 3/4-inch female NPT conduit entries are available for separate power and signal wiring. For all hazardous area installations, only suitable certified cable glands, blanking plugs or thread adapters may be used. The cable entry device shall be of a certified flameproof type, suitable for the conditions of use and correctly installed. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements. If conduit seals are used, they must be installed within 18 inches (457 mm) of the enclosure.
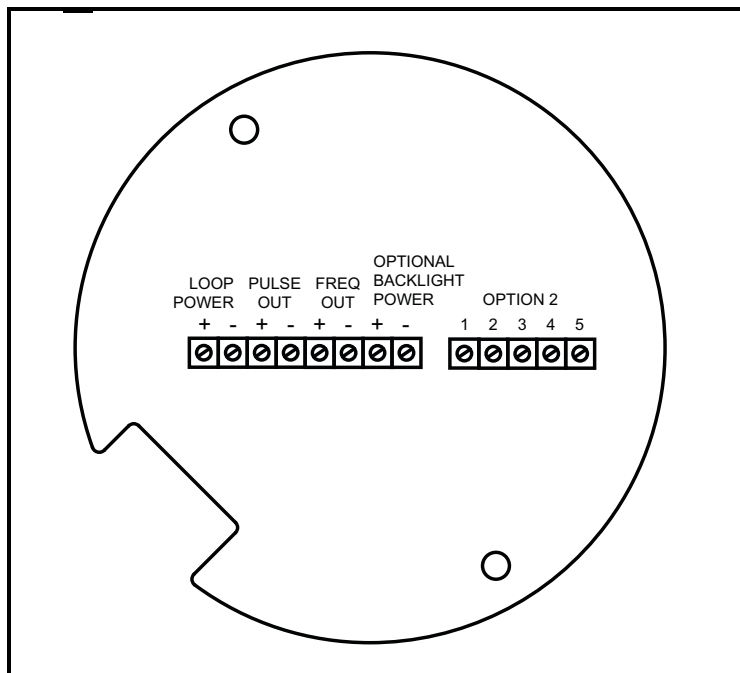

Figure 23: Loop Power Wiring Terminals

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 24* below). Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm). The DC power wire size must be 20 to 12 AWG with 1/4 inch (7 mm) of insulation stripped from each conductor.
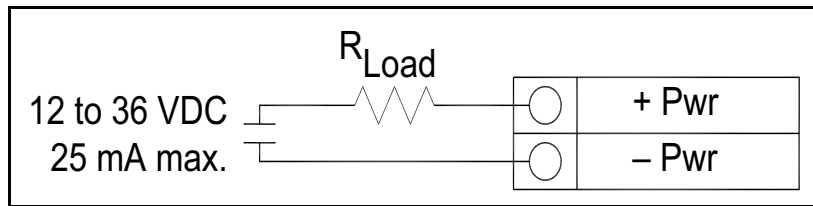
Figure 24: DC Power Connections

CAUTION! **The DC wire insulation temperature rating must meet or exceed 85°C (185°F), maximum operating voltage 300VRMS.**

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 ammeter (see *Figure 24* 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 25* below. The 4-20 mA loop is optically isolated from the flow meter 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:

$$R_{max\ load} = \frac{V_{supply} - 12V}{0.020A}$$
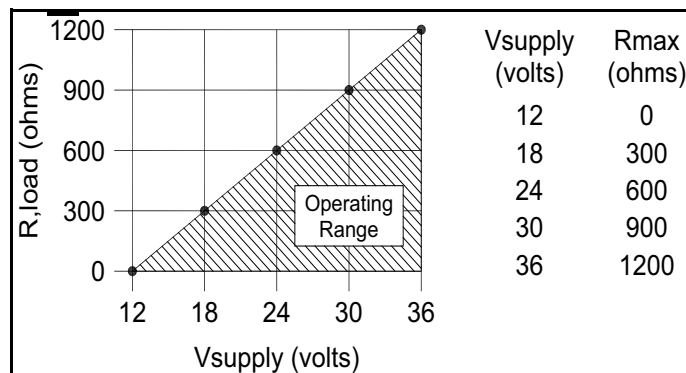
Figure 25: Load Resistance Versus Input Voltage

The current loop range is 3.8 to 20.5 mA.

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 83*) 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 (see *Figure 26* or *Figure 27* below). The pulse output optical relay is a normally-open single-pole relay. The relay can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply.
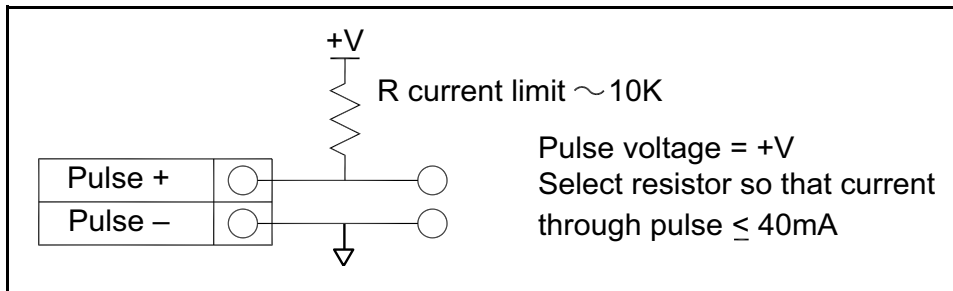
Figure 26: Isolated Pulse Output Using External Power Supply
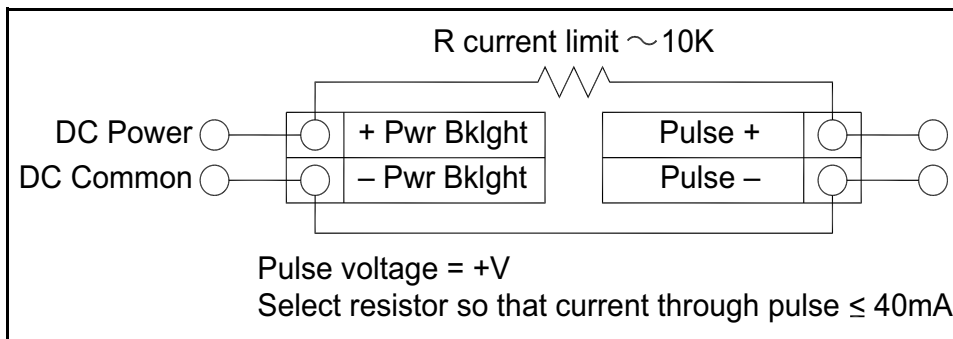
Figure 27: Non-Isolated Pulse Output Using External Power Supply

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 28* or *Figure 29* below). The frequency output optical relay is a normally-open single-pole relay. The output can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply.
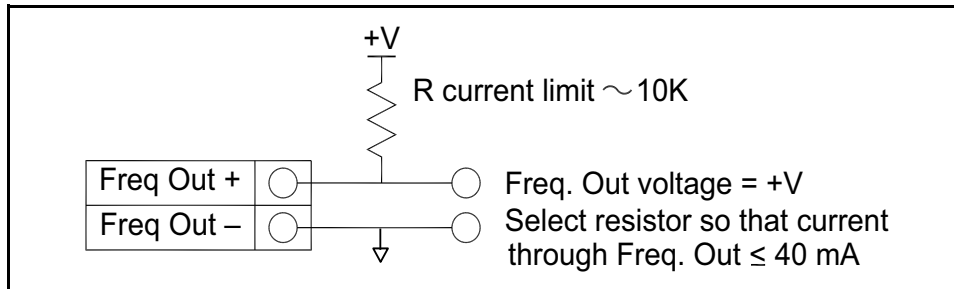
Figure 28: Isolated Frequency Output Using External Power Supply
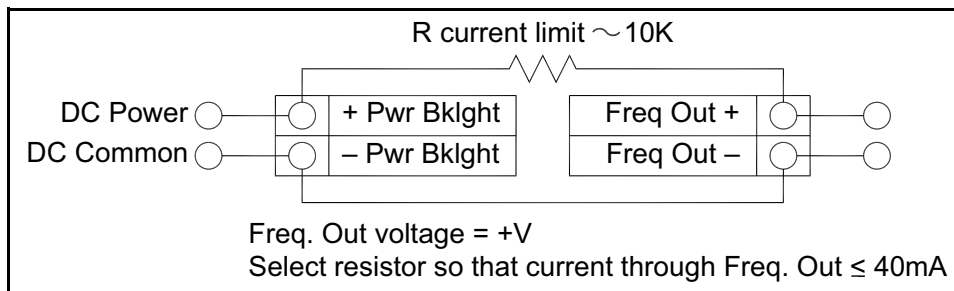
Figure 29: Non-Isolated Frequency Output Using External Power Supply

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 30* below.
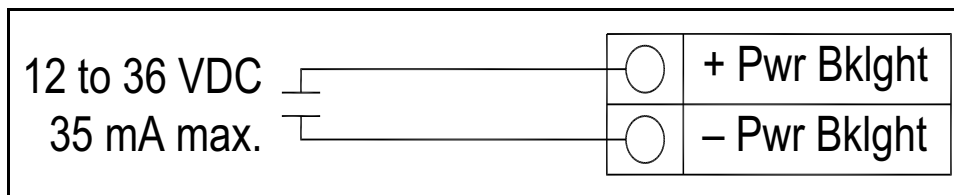
Figure 30: Backlight Using External Power Supply

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 31* 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. The cable entry device shall be of a certified flameproof type, suitable for the conditions of use and correctly installed. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements. 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.*
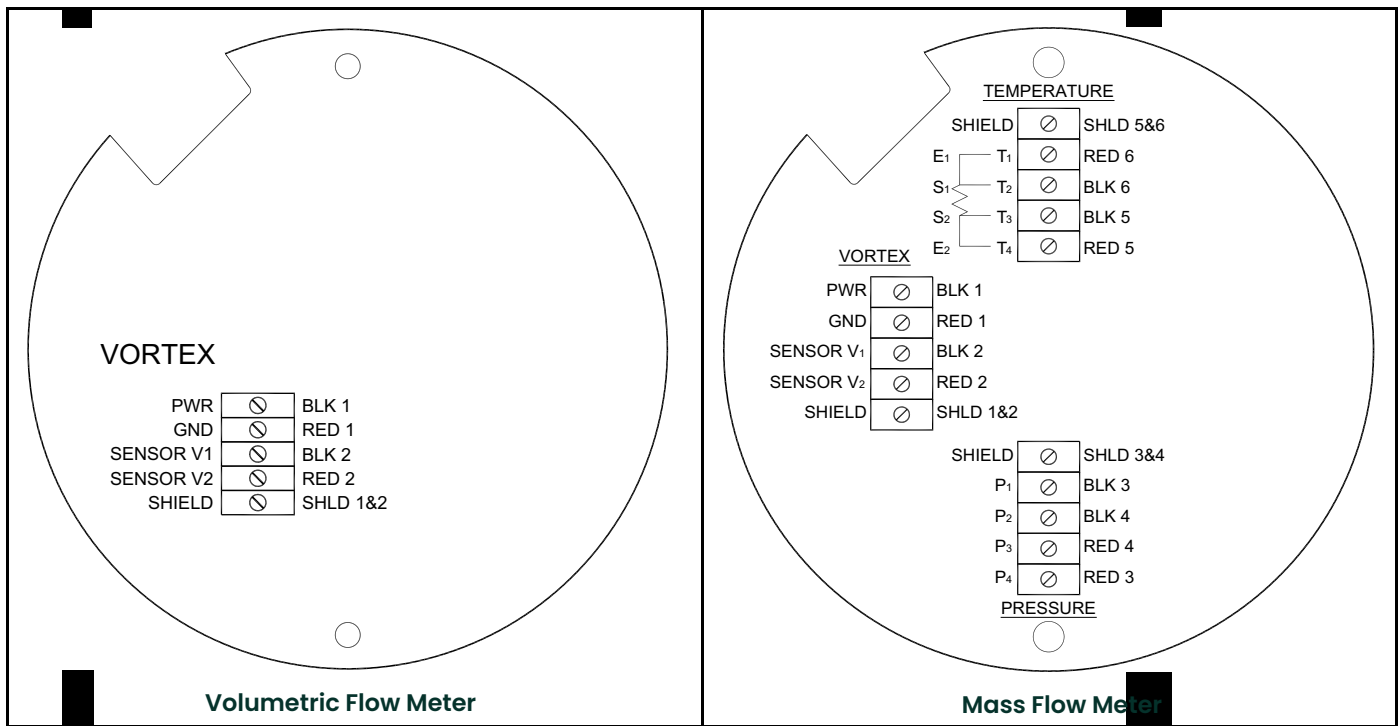
Figure 31: Loop Power Flow Meter Junction Box Sensor Connections

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.

A power switch is not provided with this meter, an approved switch meeting the power requirements listed in Appendix A must be provided by the user. It must be easily accessible and marked as the disconnect for the flow meter.

Only the connectors supplied with the meter are to be used for connecting wiring.

If the equipment is used in a manner not specified the protection provided by the equipment may be impaired.

The NEMA 4X enclosure contains an integral wiring compartment with one dual strip terminal block (located in the smaller end of the enclosure). Two 3/4-inch female NPT conduit entries are available for separate power and signal wiring. For all hazardous area installations, only suitable certified cable glands, blanking plugs or thread adapters may be used. The cable entry device shall be of a certified flameproof type, suitable for the conditions of use and correctly installed. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements. If conduit seals are used, they must be installed within 18 inches (457 mm) of the enclosure.

Figure 32: 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.

2.6.1.1   AC Power Wiring

⚠️ **CAUTION!**   **The AC wire insulation temperature rating must meet or exceed 90ºC (194ºF), maximum operating voltage 600VRMS.**

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 90ºC (194ºF). Connect 100 to 240 VAC (5 W maximum) to the **Hot** and **Neut** terminals on the terminal block (see *Figure 33* below), and connect the ground wire to the safety ground lug ⏚. Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm). Use a separate conduit entry for signal lines to reduce the possibility of AC noise interference.
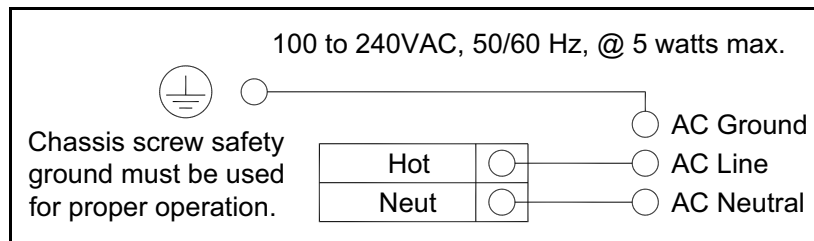
Figure 33: AC Power Connections

2.6.1.2   DC Power Wiring

⚠️ **WARNING!**   **Use a Class 2 isolated power supply that is grounded, provides DC output, and has no more than 10% output ripple.**

A power switch is not provided with this meter, an approved switch meeting the power requirements listed in Appendix A must be provided by the user. It must be easily accessible and marked as the disconnect for the flow meter.

Only the connectors supplied with the meter are to be used for connecting wiring.

If the equipment is used in a manner not specified the protection provided by the equipment may be impaired.

⚠️ **CAUTION!**   **The DC wire insulation temperature rating must meet or exceed 85ºC (185ºF), maximum operating voltage 300 VRMS.**

The DC power wire size must be 20 to 12 AWG with 1/4 inch (7 mm) of insulation stripped from each conductor. The wire insulation temperature must meet or exceed 85ºC (185ºF). Connect 18 to 36 VDC (300 mA, 9 W maximum) to the **+DC Pwr** and **−DC Pwr** terminals on the terminal block (see *Figure 34* below). Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm).

18 to 36 VDC @300 mA Max.

DC Power ○────────○ | + Pwr
DC Common ○────────○ | − Pwr
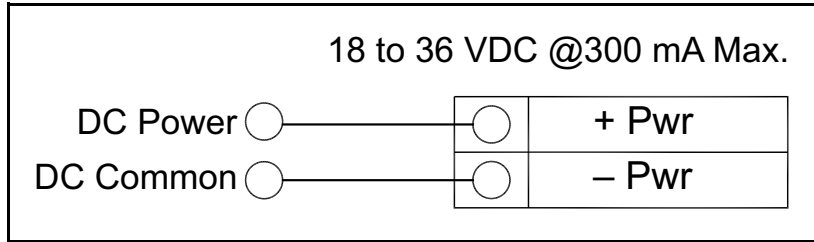
Figure 34: DC Power Connections

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 35*, *Figure 36* or *Figure 37* below). The current control electronics requires 12 volts at the input terminals to operate correctly.

For AC and DC powered meters

+V
mA Meter

4-20 mA +
4-20 mA −
$R_L \geq 250$
−V

4-20 mA voltage = +V

For Hart Communications signal loop must have a minimum of 250 ohms load resistance R_L.
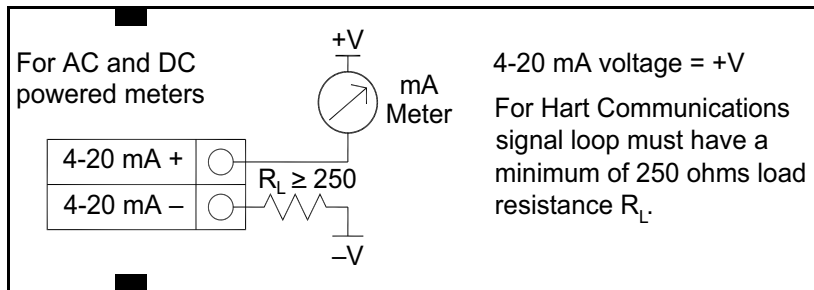
Figure 35: Isolated 4-20 mA Output with External Power Supply

mA Meter

DC Power ○
DC Common ○
+ Pwr
− Pwr

4-20 mA +
4-20 mA −

DC powered meters only

For HART communications, the signal loop must have a minimum of 250 ohms load resistance.

$R_L \geq 250$ Ohm
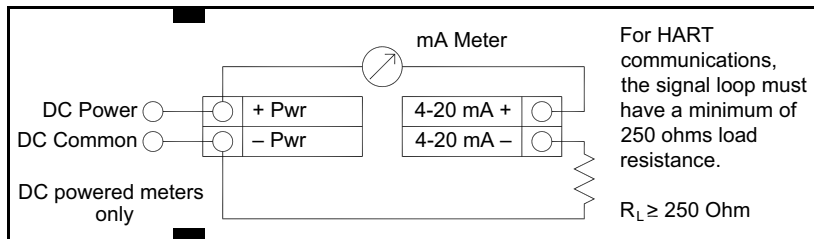
Figure 36: Non-Isolated 4-20 mA Output Using Meter Input Power Supply

mA Meter

+ 24 VDC
− 24 VDC

4-20 mA +
4-20 mA −

AC units only. Meter Provided DC Power

For HART communications, the signal loop must have a minimum of 250 ohms load resistance.

$R_L \geq 250$ Ohm
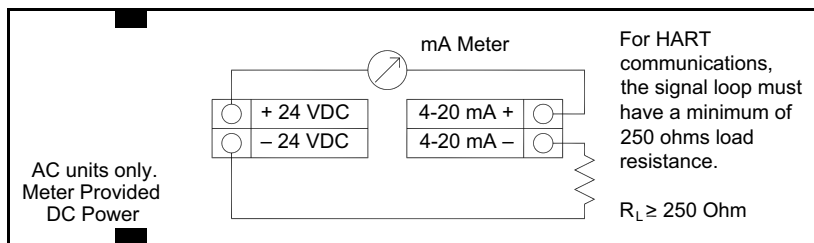
Figure 37: Isolated 4-20 mA Output Using Meter Provided Power Supply

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 38* below. The 4-20 mA loop is optically isolated from the flow meter 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:

$$R_{max\ load} = \frac{V_{supply} - 12V}{0.020A}$$
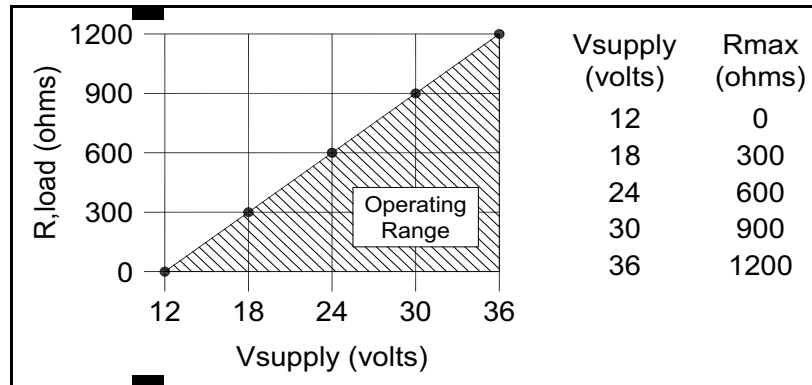
Figure 38: Load Resistance Versus Input Voltage

The current loop range is 3.8 to 20.5 mA.

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. The frequency output optical relay is a normally-open single-pole relay. The output can conduct a current up to 40 mA. It 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 39 on page 43*). 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 40 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 connected frequency counter comes from the meter's power supply.
- For AC powered meters only, use the internal 24 VDC power supply (see *Figure 41 on page 43*). 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.)
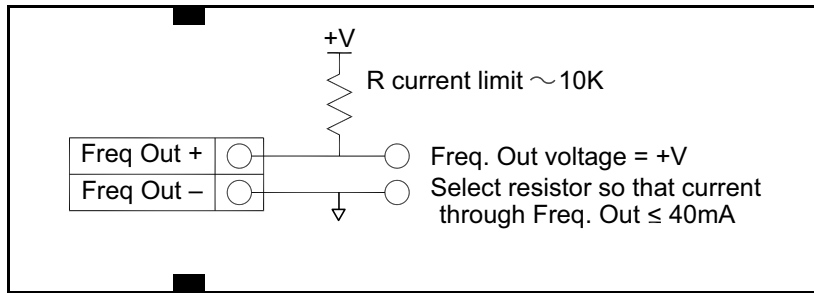
Figure 39: Isolated Frequency Output Using External Power Supply
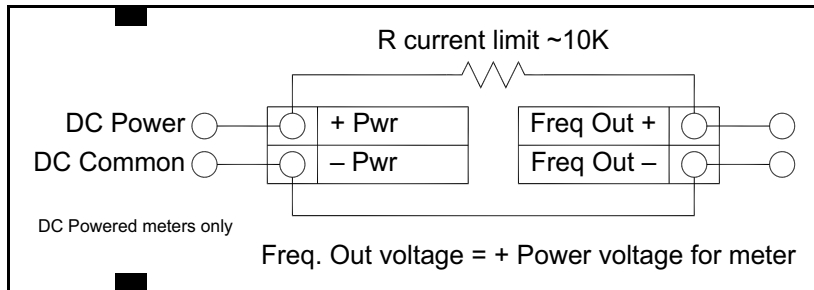
Figure 40: Non-Isolated Frequency Output Using Input Power Supply
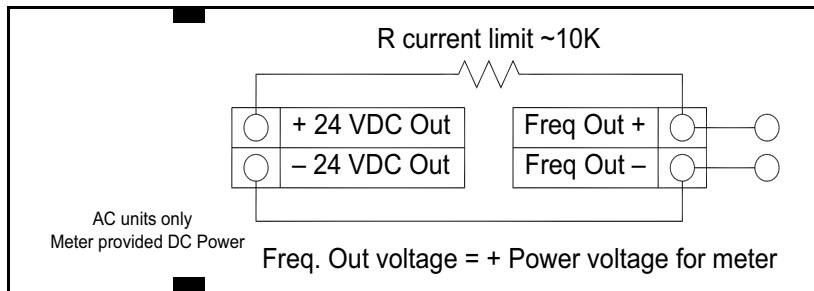
Figure 41: Isolated Frequency Output Using Meter-Provided Power Supply

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 83*) 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. The pulse output optical relay is a normally-open single-pole relay. The relay can conduct a current up to 40 mA. It 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 42 on page 44*). 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 43 on page 44*). 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 44 on page 44*). Use this option if the voltage of the pulse output is the same as the voltage supplied to the circuit.

Figure 42: Isolated Pulse Output with External Power Supply
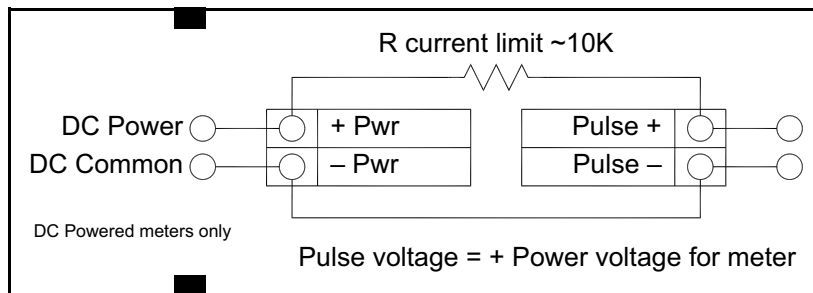
Figure 43: Non-Isolated Pulse Output Using Input Power Supply
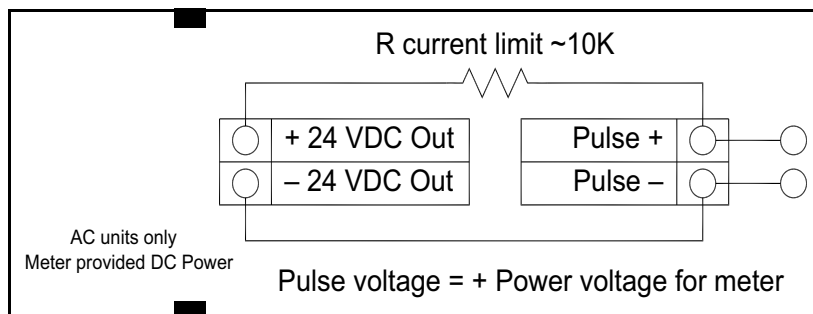
Figure 44: Isolated Pulse Output Using Provided Power Supply

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 80*).

The alarm output requires a separate 5 to 36 VDC power supply. The alarm output optical relay is a normally-open single-pole relay. The relay can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply. When the alarm relay is closed, the current draw will be 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 45 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 46 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 47 on page 45*). Use this option if the voltage of the alarm output is the same as the voltage supplied to the circuit.
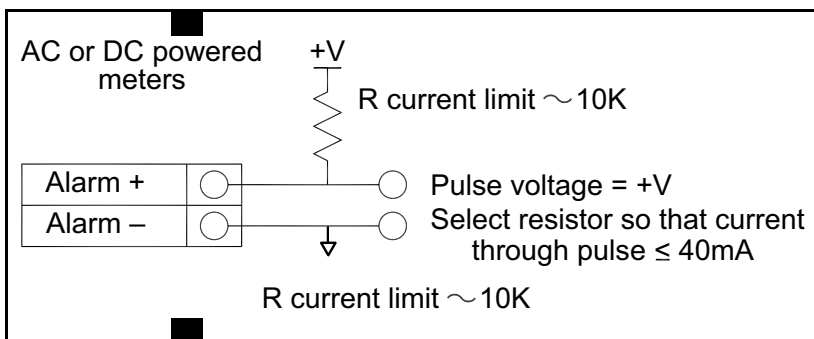
Figure 45: Isolated Alarm Output with External Power Supply

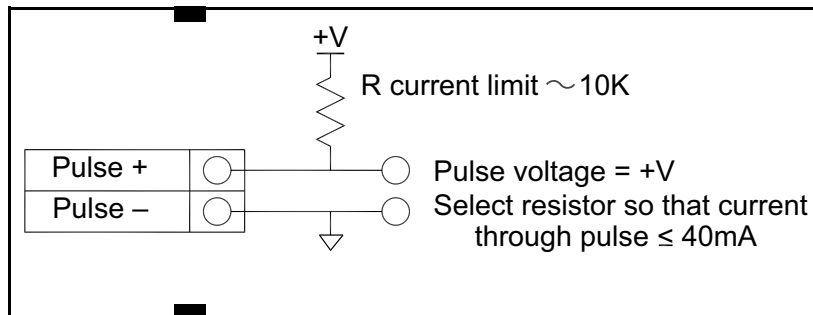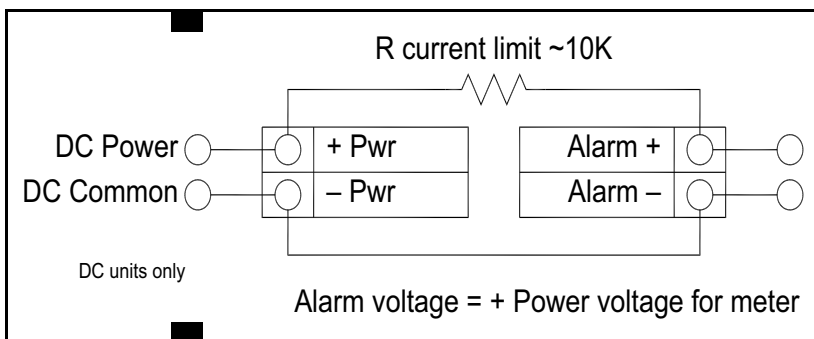**Figure 46: Non-Isolated Alarm Output Using Internal Power Supply**
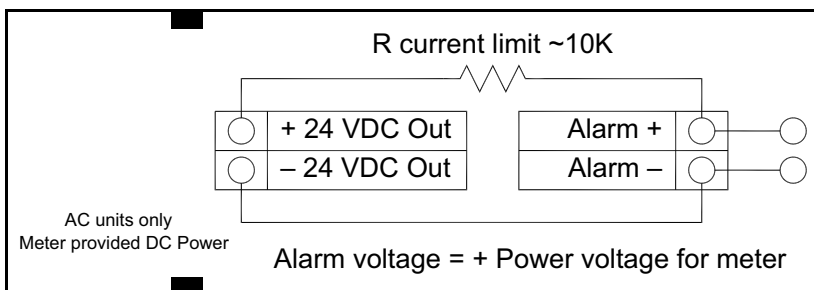
Figure 47: Isolated Alarm Output Using Meter Provided Power Supply

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 48* 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.*
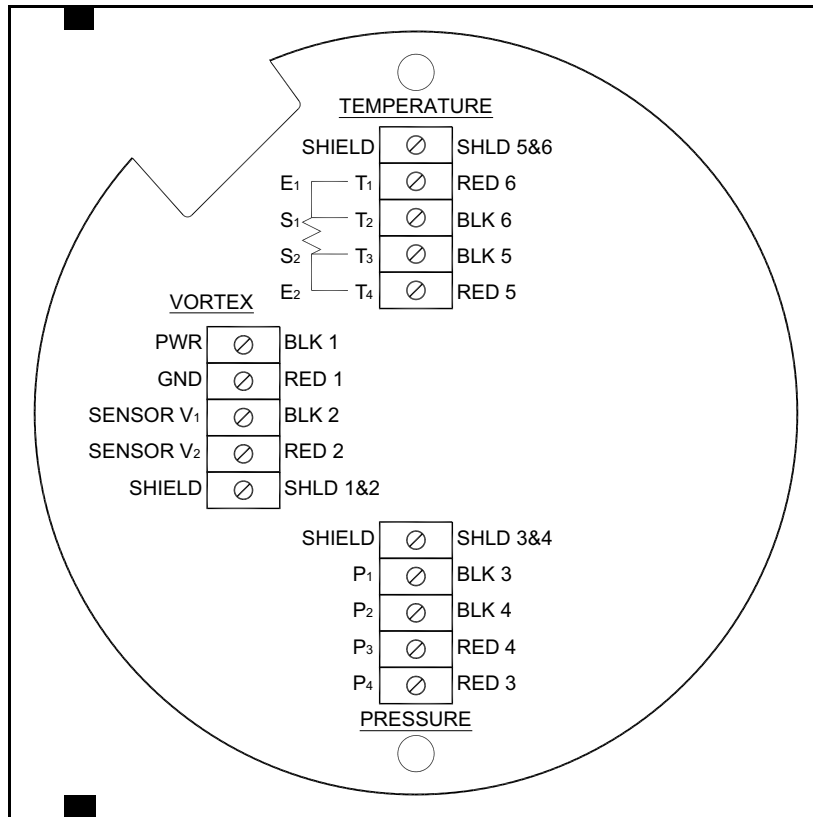
Figure 48: Flow Meter Junction Box Sensor Connections

2.6.7 Optional Input Wiring

The meter has two optional input wiring terminals, maximum wire size is 16 AWG. 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 49* 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.
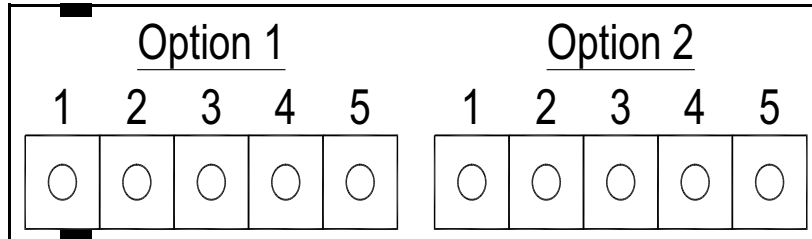
Figure 49: Optional Input Electronics Wiring

2.6.7.1 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 50* below for wiring details.

Loop Power
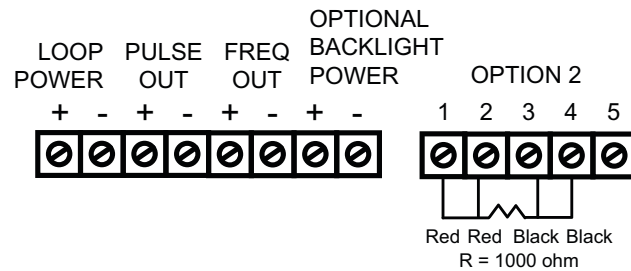
* Other input options available.

High Power
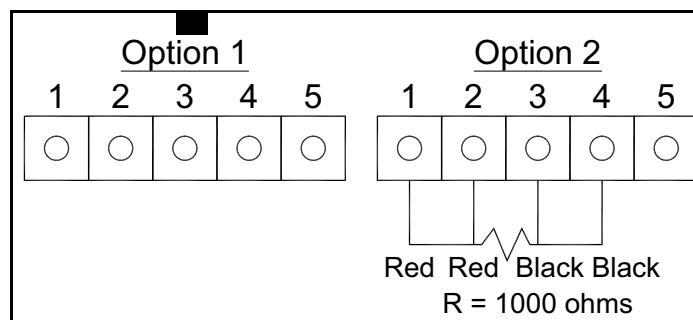
Figure 50: Optional Energy EMS RTD Input Wiring

2.6.7.2 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 129*.

Refer to *Figure 51* below to wire the external 4-20 mA input into the flow meter using an external power supply.
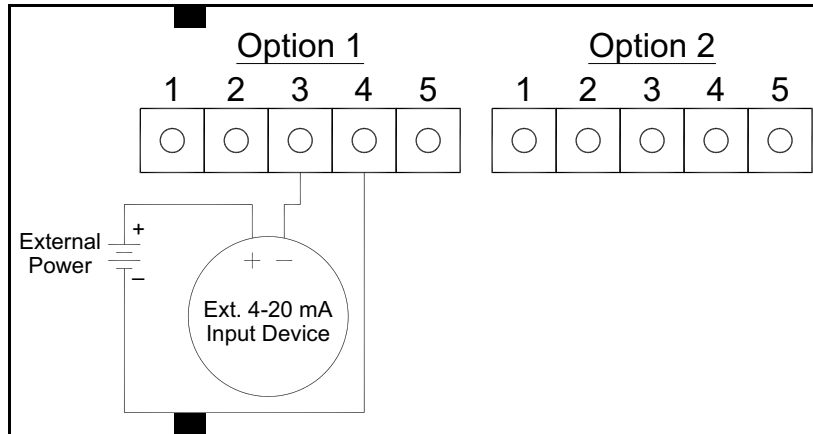
Figure 51: External 4-20 mA Input Wiring - External Power Supply

Refer to *Figure 52* below to wire the external 4-20 mA input into the flow meter using power supplied to the input of a DC powered meter.
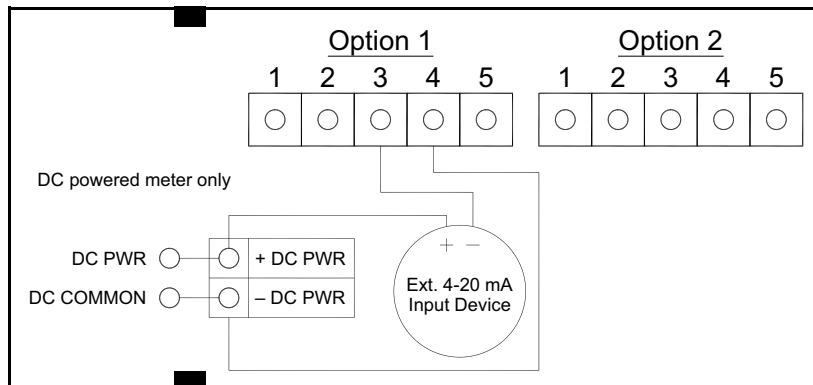
Figure 52: External 4-20 mA Input Wiring - DC Powered Meter

2.6.7.2 Optional External 4-20 mA Input Wiring (cont.)

Refer to *Figure 53* below to wire the external 4-20 mA input into the flow meter using power from the 24 VDC output of an AC powered meter.
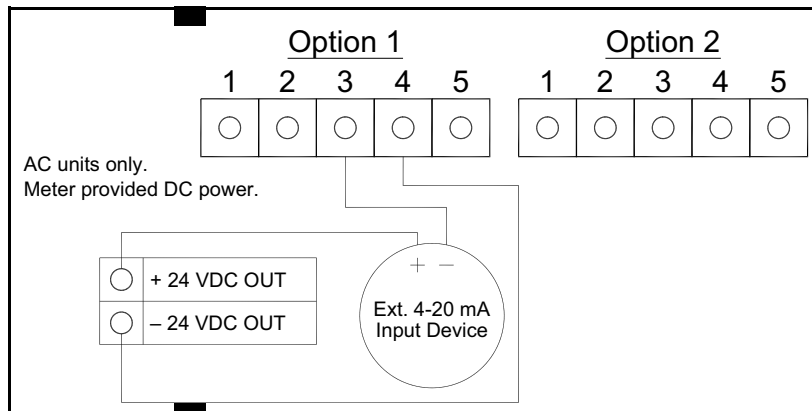
Figure 53: External 4-20 mA Input Wiring - AC Powered Meter

2.6.7.3 Optional External 4-20 mA Input and RTD Wiring
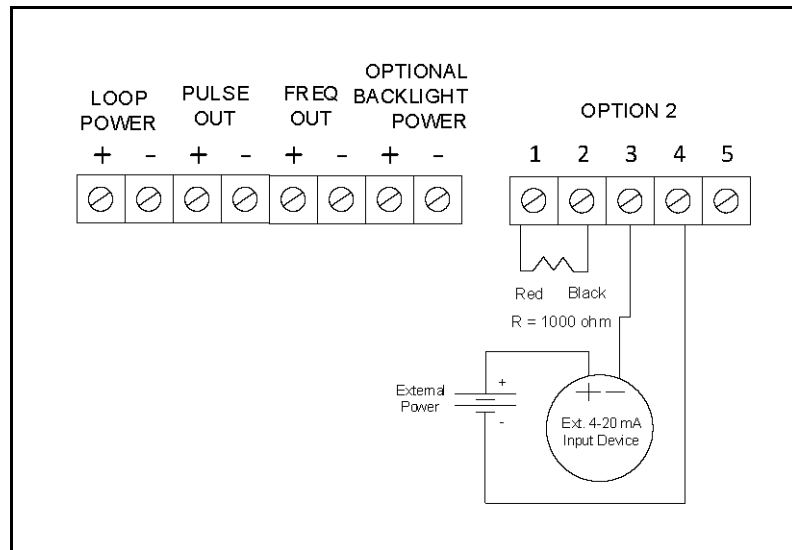
Loop Power

Figure 54: External 4-20 mA Input and RTD Wiring - Loop Power

High Power
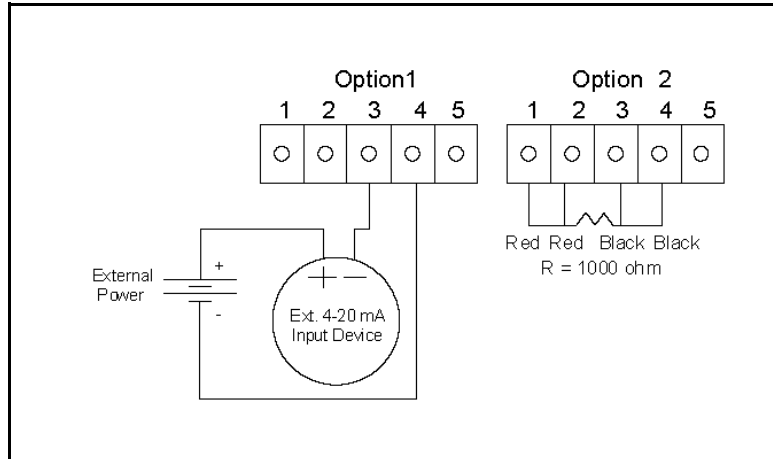
Figure 55: External 4-20 mA Input and RTD Wiring - High Power

2.6.7.4 Optional Energy EMS External 4-20 mA Input and RTD Wiring
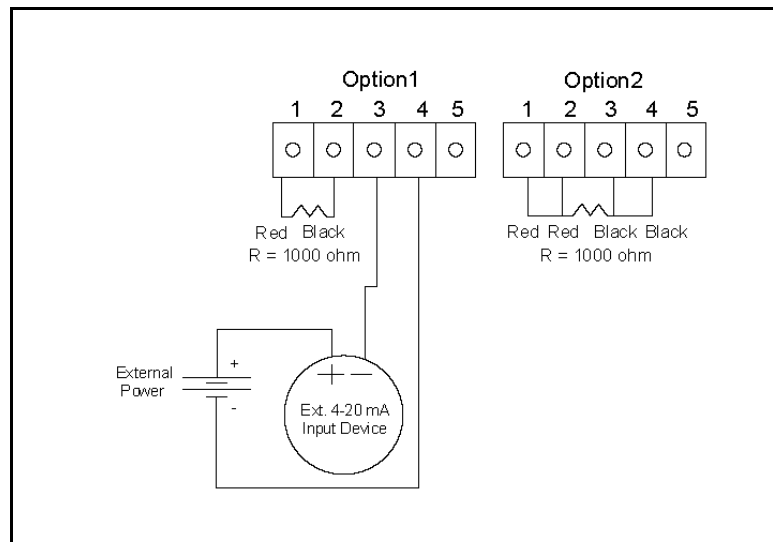
Figure 56: Energy EMS External 4-20 mA Input and RTD Wiring - High Power

2.6.7.5 Optional Contact Closure Input Wiring

Refer to *Figure 57* below to wire an external switch input into the flow meter. 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.
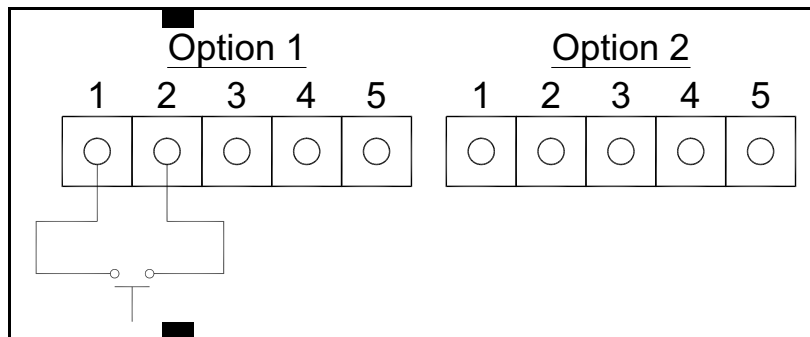
Figure 57: Optional Contact Closure Input Wiring

2.7   Meter Initial Setup

2.7.1   Power Over Ethernet (POE) Wiring Connections

The NEMA 4X enclosure contains an integral wiring compartment with one dual strip terminal block (located in the smaller end of the enclosure). 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. The cable entry device shall be of a certified flameproof type, suitable for the conditions of use and correctly installed. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements. If conduit seals are used, they must be installed within 18 inches (457 mm) of the enclosure.
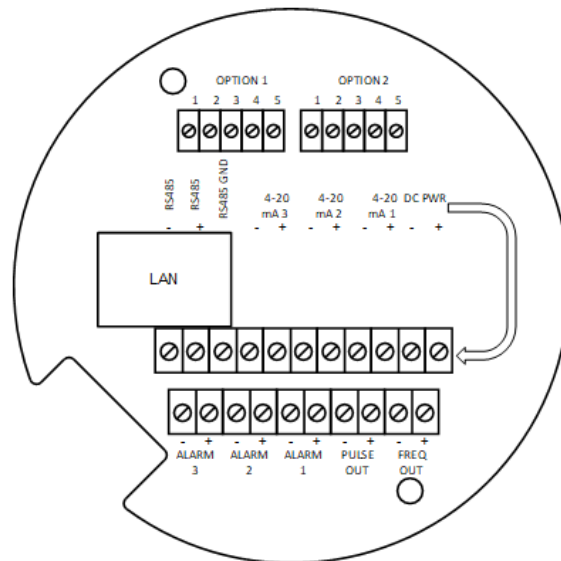
Figure 58: POE Wiring Terminals

There are two options for powering the POE version meters: DC Power and POE option.

2.7.2   DC Power Wiring

WARNING! **Use a Class I or Class II power supply.**

A power switch is not provided with this meter, an approved switch meeting the power requirements listed in Appendix A must be provided by the user. It must be easily accessible and marked as the disconnect for the flow meter.

Only the connectors supplied with the meter are to be used for connecting wiring.

If the equipment is used in a manner not specified the protection provided by the equipment may be impaired.

The DC power wire size must be 20 to 12 AWG with the wire stripped 1/4 inch (7 mm). Connect 18 to 36 VDC (300 mA, 9 W maximum) to the +DC Pwr and -DC Pwr terminals on the terminal block.

Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm).
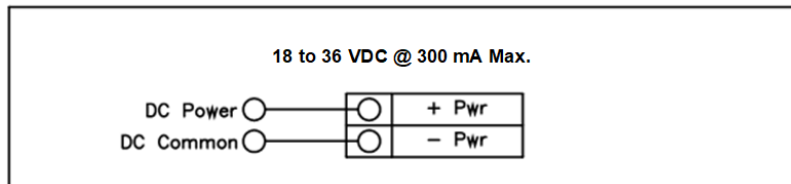
Figure 59: DC Power Connections

2.7.3 POE Power Wiring

⚠️ **CAUTION!** **The DC wire insulation temperature rating must meet or exceed 85°C (185°F), maximum operating voltage 300 VRMS.**
Alternatively POE injector may be used for example: TRENDnet TPE-115Gi.

Connect the unit with the Ethernet cable to POE enable Ethernet switch (POE option does not require a separate power supply).

Plug Ethernet drop off cable from your Local Area Network (LAN) switch to LAN Connector of Multivariable Mass Vortex Flow Meter. You should see a blinking orange LED and a solid green on the front of the LAN connector of the meter henCAT5 Ethernet cable is plugged in and communicating.
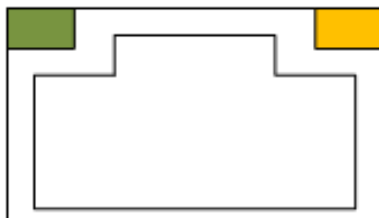
Figure 60: Front of the LAN connector

2.7.4 Direct Connection Options

The unit must be powered by one of the above options. If you are using DC powering option, connect a standard ethernet cable to your PC and the unit. If you are using POE ensure the switch is connected to your PC.

For testing and initial setup purposes, one may use direct connection to PC or Laptop. After reconnecting, you need to cycle the power to the meter. The meter will display the current IP address on the screen. Once the unit is connected it will try to request an IP address from non existent DHCP server and then switch to AutoIP address (unfortunately random), for example 169.254.xxx.xxx.

If you could not see the IP address after cycling the meters power, you can run the IPSetup utility program. See more instructions on how to use the IPSetup program below in Network Configuration. Once you find out assigned meter IP address or the NetBios name http://VRTXXXXX, type one of them into a browser to connect to the unit.

2.7.4.1 Connection issues:

The common issue is that PC does not recognize the plugged Ethernet cable. You maybe require to disable/enable Ethernet adapter to force it to "*see*" connected cable.

Alternatively, you may use static IP setting for both your PC and meter. The addresses should be on the same network, like 192.168.1.xxx or 10.10.10.xxx

Tip: to quickly find Microsoft Network configuration page, type WindowsKey+R   and in command window enter "*ncpa.cpl*".

2.7.5 Network Configuration

Vortex/TCP meter needs to be configured in order to be "**visible**" on your local network. There are two methods of configuration:

- Static IP address
- Dynamically assigned IP address via DHCP (Dynamic Host Configuration Protocol).

For static configuration consult your network administrator which IP address to use.

2.7.5.1   IP Setup Network Configuration Tool:

IPSetup is used to configure network settings on your Vortex/TCP device such as IP Address,

Mask, Gateway, DNS Server. If enabled in your device, IPSetup uses a *User Datagram Protocol (UDP)* broadcast on port 20034 to identify Vortex/TCP network devices. UDP broadcasts are not forwarded by routers, so IPSetup can only be used on a LAN or direct connection. You need to run it on a PC connected to the same switch as your device.

IP Setup is commonly used for:

- Determining the DHCP assigned IP address of your device.
- Configuring the network settings of your device.

IPSetup can be downloaded from file system of Vortex/TCP of which may be provided on USB flash drive/CD or available on the Vortex website for download. This program can run on any Windows or Linux machine under Windows emulator WINE.

2.7.5.2   Configuring the meter with IP Setup:

IPSetup/Configuration should only need to be done at initial commissioning on the customer's network.

Note: *Before you begin please ensure the device is on the same LAN or directly connected to a PC.*

Click on the **IPSetup Icon**.
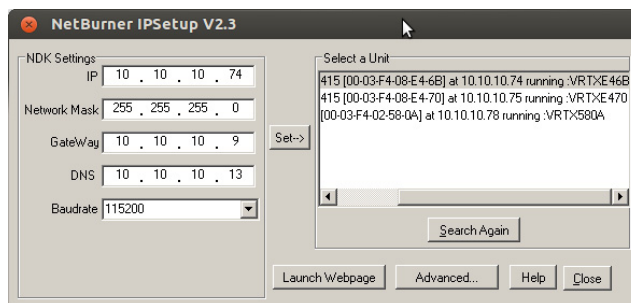
Figure 61: IPSetup Tool

To configure a device with IPSetup:

- Click on a device in the "**Select a Unit**" window.

Note: *Each unit has been assigned an unique identifier code that begins with VRTX as seen above. Also, the meter will display the current IP address upon powering up the meter.*

- Enter your configuration settings in the "*NDK Settings*" group. Configuration can either be set up as a static IP address assigned by your network administrator or can be set up to DHCP by setting the IP address to 0.0.0.0.
- Once you have specified all your configuration settings, click on the "**Set**" button to transmit them to your device.

Note: *Besides IP, Network Mask, GateWay and DNS, do not change any other parameters, such as Uart, delay, baud rate, etc. Correct GateWay settings are necessary if you are planning to access device from the Internet or other subnets of your local network.*

- The DHCP assigned address, or static IP address, will appear in the description next to each Vortex/TCP device in the Select a Unit window.

2.7.6   IPSetup Does Not Display Your Vortex/TCP Device

If IPSetup does not display your device, the issue could be one of the following:

- A firewall on your PC is blocking network port number 20034. Try temporarily disabling your firewall and try again.

- If you are trying to talk to a device on the other side of a router. Check to see if the PC and Vortex/TCP devices are on the same LAN.

2.7.7   IPSetup FAQ

- If DHCP serve can't assign an address to the meter, it will switch to **AutoIP**. AutoIPs are special addresses in the range 169.254.XXX.XXX. The XXX.XXX values are randomly selected with an attempt to avoid duplication. AutoIP is used for *DIRECT CONNECTION* to a PC.

- IPSetup shows the name of the application as shown on Fig. below. The name is composed of letters VRTX and 4 last HEX digits of unit's MAC address. For example: VRTXE46B also referred to as the NetBios name.
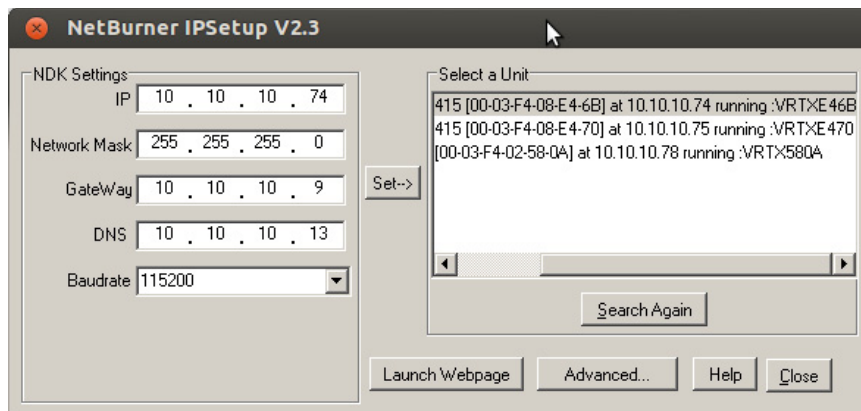
Figure 62: IPSetup displaying the unique identifer code VRTX (netbios name)

- You may access the unit by typing the name in address field of WEB browser, for example: http://VRTXE46B. This works on Microsoft computers and may not work on Linux machines. For Linux machines it needs to have SMB protocol enabled to understand the NetBios names.

Note: *There is linux nmblookup command, which shows IP address by NetBios name.*

- It is recommended to provide a correct GateWay address. DNS is necessary only if access to the Internet is needed for the device. in case, for example, accessing Network Time Servers. It may be set as 0.0.0.0.

2.7.8   Meter WEB pages

VRTX meter has an internal WEB server providing real time measurement information and a configuration interface.

The meter supports two protocols for accessing the WEB pages:

- HTTP – insecure connection to TCP port 80
- HTTPS – secure connection to configuration pages on TCP port 443.

It is possible to connect to all pages using HTTPS instead of HTTP. The assumption is that measurement data does not need to be secure, while configuration must be always encrypted.

2.7.8.1 WEB page

Figure 63: Main/home page

Above is a Figure of the main page of the webpage with the menu selections on the left side. When the meter is initially powered up, it scans for connected meters. This version is intended for master/slave configuration with multiple meters connected to a single gateway. Normally this Slave Address selector is not used and there is always only one selection possible.

Figure 64: Flow

The above Figure display what values are available on the *Flow Menu*.

Figure 65: Meter

The above Figure display what values are available in the *Meter Menu*.

Figure 66: Fluid

The above Figure displays the values of the *Fluid Menu*.

Figure 67: Diagnostics

The above Figure shows the values of the *Diagnostics Menu*.

Figure 68: Configuration

The above Figure shows the *Configuration* page options.

Figure 69: Data log

Figure 70: Startup log

2.7.9   WEB Configuration Interface

Clicking on **CONFIGURE** Menu link opens the following page.

In order to get access to Configuration page, you need to connect via HTTPS

Please, reconnect using HTTPS

Click here if you are on the local network

Click here if you are on the local network and reopen in this frame

Click here if you are on the Internet via port forward as: meter.vortekinst.com

Click to open meter.vortekinst.com in this frame

Otherwise you have to reconnect to the configuration page as https://your_ip /CONFMENU.HTML or https://your_ip - connect to ALL pages via https

There may be problems with some versions of Internet Explorer. (e.g. IE10) If IE does no show on "problem page" the link: "Continue to this website(not recommended)", either update IE to Rev. 11 or better use different browser, such as Firefox or Chrome.

Figure 71: Configuration

Connection to the Configuration interface is done using encrypted protocol HTTPS. When connected for the first time, your browser and the unit need to perform a verification. This process is slightly different in different browsers. For the initial set up of the webpage please click the link "**Click here if you are on the local network**". Below is an example of the browser FireFox:
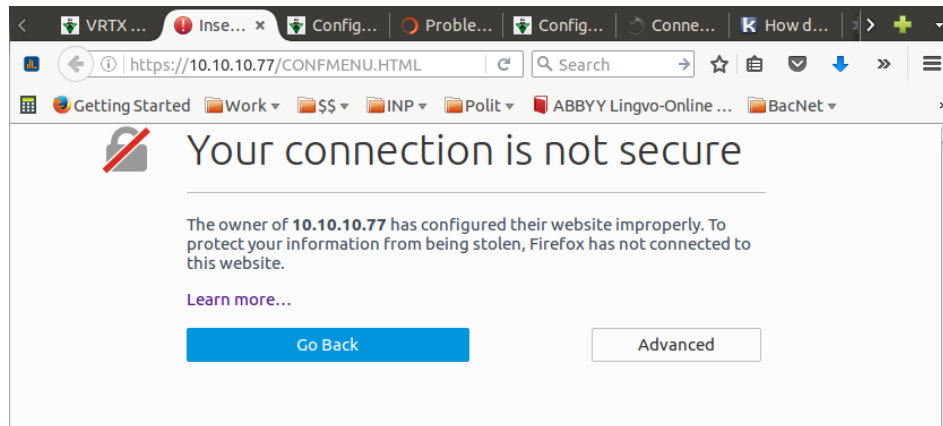
Figure 72: Fire Fox Verification Page

Please click the "**Advanced**" button. Once the advanced button is selected the next page is shown with the button "**Add Exception**" at the bottom.
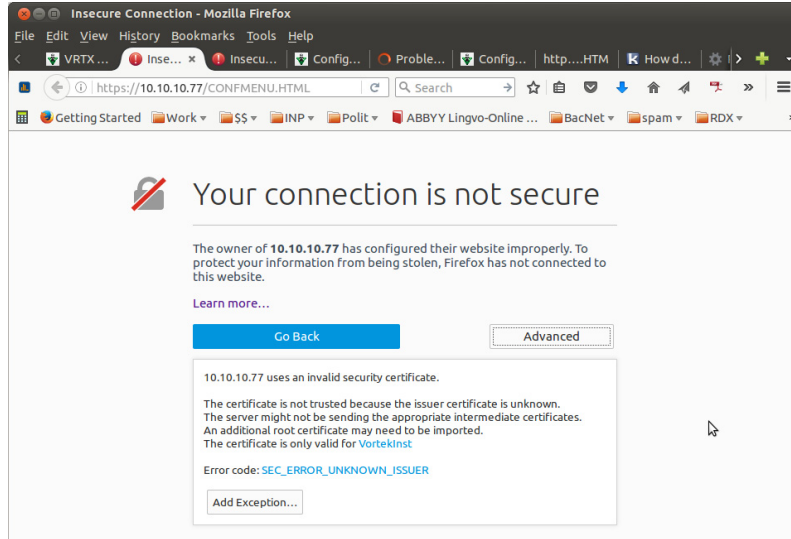
Figure 73: Fire Fox Add Exception

Note: *If you selected the link "Click* **here if you are on the local network and reopen in this frame**"*, the browser will not have the "***Add Exception***" button. We recommend using the first link when connecting to the new unit for the first time. After the initial setup, you may find it more convenient to use the second link and open configuration interface inside the frame.*

By clicking "**Add Exception**" the following screen is opened:

Figure 74: FireFox Add Security Exception

The browsers issue with the VortexInst certificate is that it is an IP address instead of a site name like myBank.org. You may view the certificate by clicking "**Confirm Security Exception**" and this certificate will be stored in your browser. The next time the browser knows which certificate to use for this IP. If you change the IP address of the meter, you'll need to go through this procedure again.

With other browsers, the procedure may be slightly different. However, you will need to repeat the steps to confirm the certificate for each browser.

On *Windows IE Explorer*, the browser will show page as shown below.

You need to click the link "**Continue to this website (not recommended)**". In some versions of IE it may not show this link. In such case upgrade IE to version 11 or better user different browser, e.g. Firefox.

Internet Explorer HTTPS warning page.
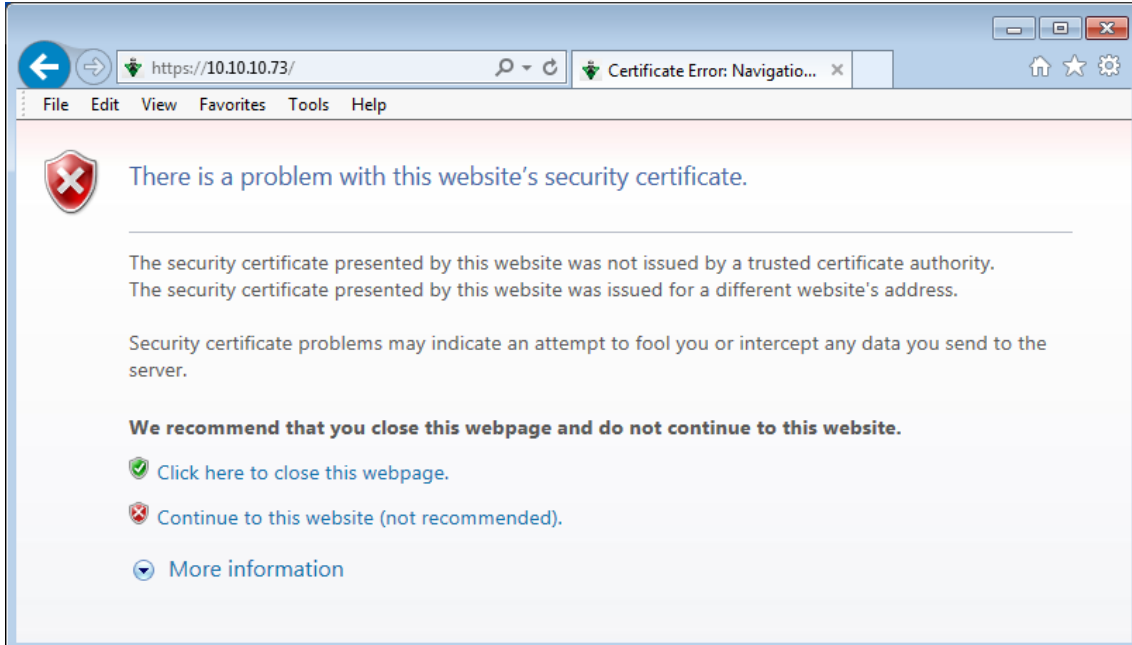
Figure 75: Internet Explorer Warning Page

After certificate acceptance is done you may enter the configuration page. It will ask for authentication.

*   User Name: creator
*   Password: 16363
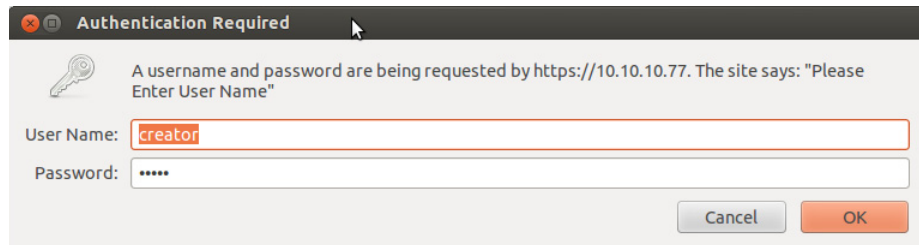
Figure 76: Authentication Required

It will show configuration page in full screen or in frame if second link is used.
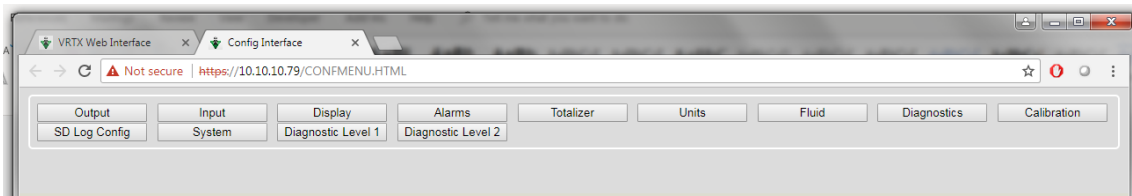
Figure 77: Configuration Interface New Tab
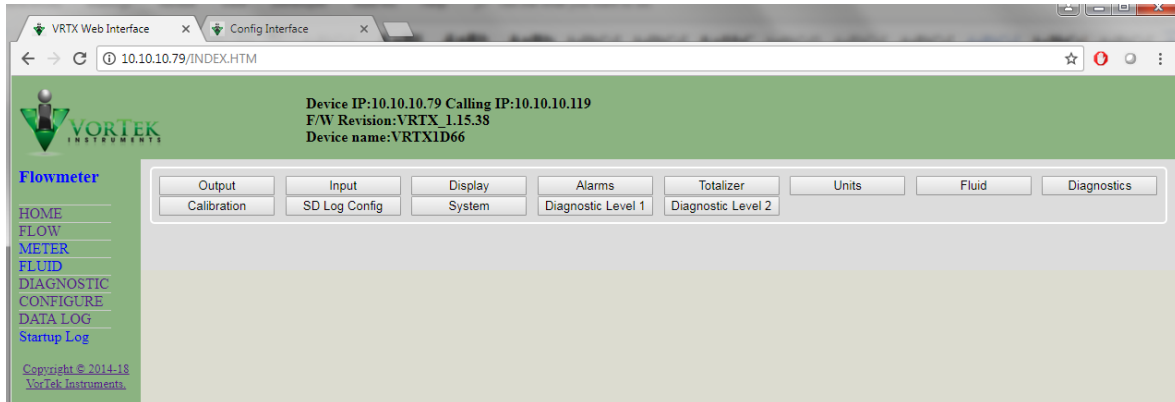
Figure 78: Configuration Interface In Frame

2.7.10   Internet connection to the meter, security issues

Typically the meter is connected to the *Local Area Network (LAN)* with non-routable *Private Network Address* (192.168.xx.xx, 10.xx.xx.xx, 172.16-31.xx.xx). Th ere are two options to setup the meter from the Internet:

•   Connect via Virtual Private Network (VPN)

•   Port Forwarding technique.

In case of VPN, your home PC becomes part of your corporate network which will allow access to all resources on the corporate LAN. Usually, your home PC is assigned an IP address from a different subnet than the meters. Therefore, the *IPSetup* program may not function correctly. You will need to know the specific IP address of the meter in order to connect. Please contact your IT department about availability of VPN and connection instructions.

Second method of *Port Forwarding* is configuring the corporate firewall to allow you access to certain internal (LAN) IP address by mapping it to your external corporate gateway IP and port number. This is usually done by mapping. See the following for an example. Assuming your corporate gateway is 50.202.79.132 and your meter IP on LAN is 10.10.10.75.

Example of port forwarding:

External IP 50.202.79.132 Port 8080   ====>mapped to====> 10.10.10.75 Port 80
External IP 50.202.79.132 Port 10502 ====>mapped to====> 10.10.10.75 Port 502
External IP 50.202.79.132 Port 10443 ====>mapped to====> 10.10.10.75 Port 443

Please contact your IT department for configuration on corporate routers. They will need the following information on the used network port:

TCP port 80	Non-secure access to main WEB pages. Read only. Protocol HTTP. It is also possible to access meter using only secure connection via Port 443.
TCP port 443	Secure encrypted access to configuration pages. Protocol HTTPS, SSL. Encryption 128 bit - does not require Export licensing. User/password protected (secure)
TCP port 502	Access by automation software to Modbus/TCP server. Protocol Modbus/TCP
Optional: TCP ports 20,21- Access to internal FTP server. Protocol FTP. User/password protected (insecure)	
UDP port 20034	Broadcast discover protocol. Used to find units on the local Network. It is not routable and therefore works only within the same subnet. Used by IPSetup (discover/IP config) and AutoUpdate (flash) programs. AutoUpdate works across Ethernet switches. It uses UDP with direct address. It may be blocked by most routers.
TCP port 20034	Firmware update using TcpUpdate utility. (Not enabled in Rev 1.0 of firmware).

Corporate gateways can have additional security enhancing measures, like sourcing. Sourcing addresses only allow access from certain individual IPs or networks. If security concerns are an issue, you may limit access to the meter using encrypted protocol only: port 443, https. On special request VortexInst can add special capability of Access Control List (ACL) to insecure by definition Modbus protocol. Using ACL user may define number of hosts or networks from which connection to Modbus port 502 can be accepted. Normally this function can be implemented in corporate firewall. ACL in meter may be needed when it is exposed to the Internet directly.

General information about Port Forwarding and instructions how to set up it in simple home routers available everywhere. E.g. here: http://www.howtogeek.com/66214/how-to-forward-ports-on-your-router/.

2.7.11   Modbus/TCP interface

Vortex TCP meter supports industry standard automation protocol *Modbus/TCP*.

Table 2: General specifications:

Protocol	TCP
Port	502
Number of simultaneous connections	20
Format of 16 bit registers	standard MSB first (big endian)
Format of 32 Long and Float values	Most significant word coming first (big endian)
Modbus Address	0
Supported Function Codes	3,4,16,5

2.7.11.1   Modbus utilities

We include for customer convenience two applications which may be used during integration into your automation system:

- MbusGui.exe   Windows GUI application for reading Modbus registers of the meter.
- mbus.exe   Generic DOS console application for reading Modbus/TCP registers.

These two applications are stored on SD card inside meter. To download them click on menu link "**LOG DATA**" and then select directory EXE. Right click on **MBUS.EXE** or **MBGUI.EXE** link to download it to your PC.
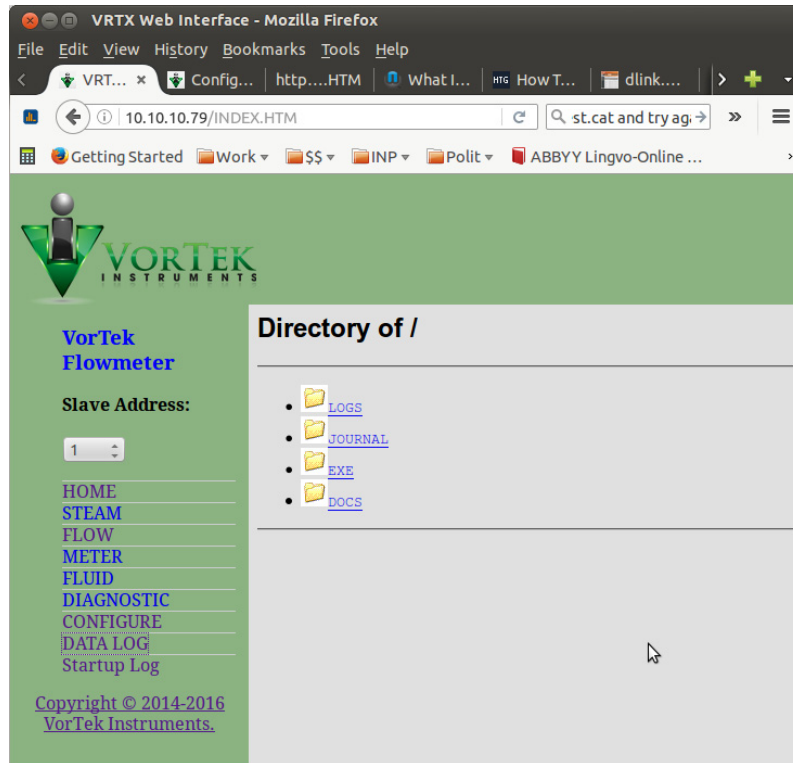
Figure 79: EXE Folder

2.7.11.2   MBGUI.EXE Simple Modbus/TCP client
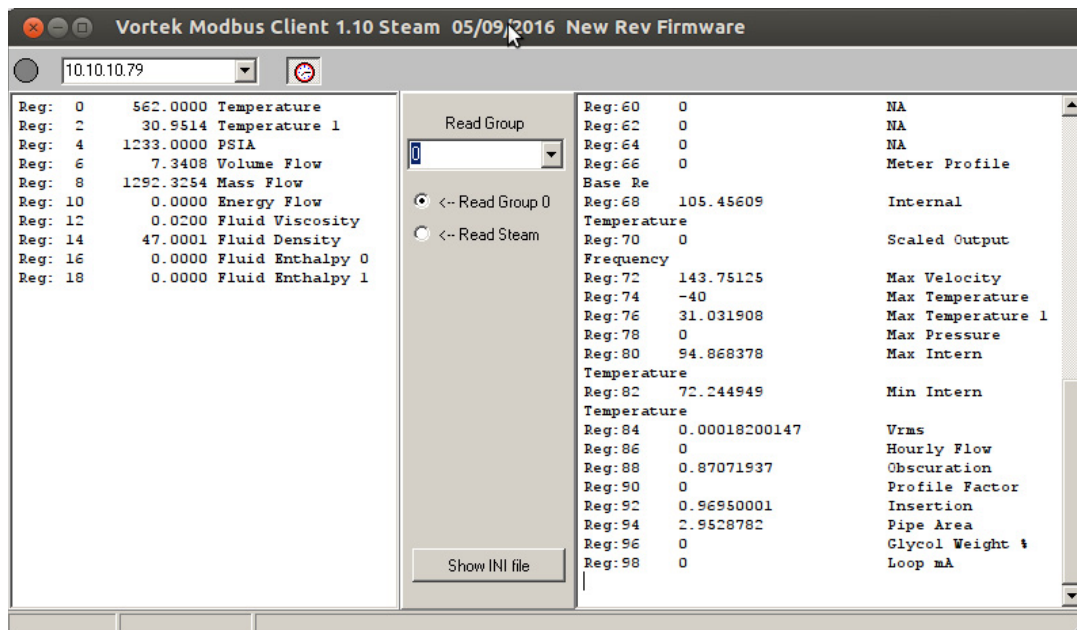
Figure 80: MBGUI.EXE Interface

This is a simple *Modbus/TCP* client configured for use with VRTX/TCP meter. The names and location of registers are stored in mbgui.ini file. This file is created at start up and contains default definitions. The structure of the application uses the following approach accepted for VorTex 's meters supporting Modbus/RTU. All registers are grouped by data types: float, long, etc. Two groups of Vortex registers 0 containing most of real time data and Group 200 - containing steam-related data can be viewed on a timer once in two seconds on the left panel. Selecting a group in "Read
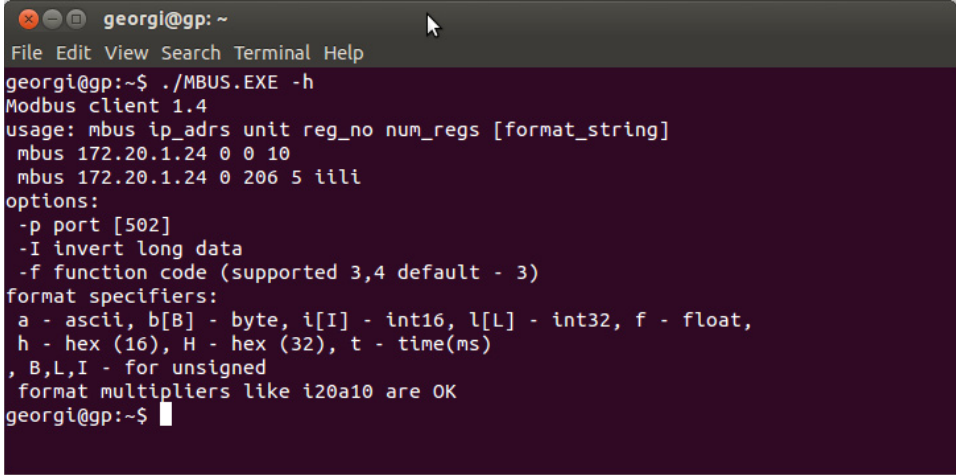
Group" selector will show it in right panel. You can rename the application to something more meaningful for you (please avoid spaces in program name). In this case it will rename accordingly the INI file. By this you may create several clients for different meters.

This application is compiled to run on Windows machine. It also can be run on *Linux* or *MAC* machine with 586 architecture under Windows emulator WINE. (MAC case was not tested).

2.7.11.3   Console Modbus/TCP client MBUS.EXE

This is simple *Modbus/TCP* client for reading Modbus registers and output data in specified format. It can be used for creating automation scripts in any scripting language, like bash, LabView, MatLab, DOS batch, etc.

Open in DOS window directory where you put the executable MBUS.EXE.
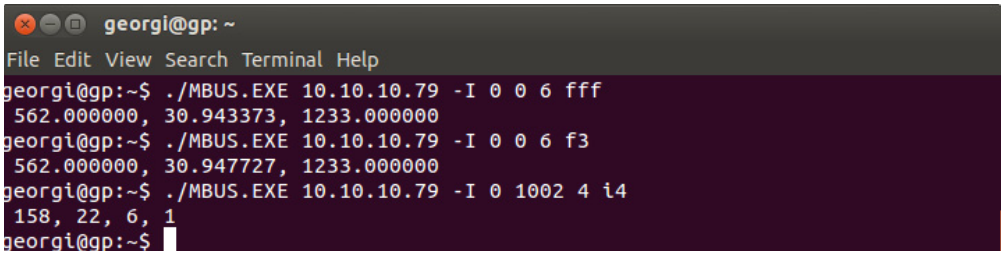
Figure 81: MBUS.exe

There is minimal help shown by command:

MBUS.EXE –h

It can read arbitrary Modbus registers. The only limitation it supports only "*classic*" order of bytes in 16 bit registers: big endian.

Examples:

Figure 82: MBUS.exe example

Read first 6 registers from group 0 and display as Float. Each "**f**" in first example corresponds for each read register or register pair for float. "**fff**" may be replaced by "**f3**".

Switch "**-I**" telling that float format is inverted: MSW coming first. This option should always be used with Vortex Meter. Line 3 reads 4 short integer registers from reg number 1002 and output as 16 bit integer.

For debug purpose during integration you may format output as HEX.

Figure 83: MBUS.exe Hex example

2.7.12 Data Logging

VRTX/TCP meter has internal logging capability. The data is logged to micro SD card inside unit. The capacity of SD card may vary from 4 to 32 GB. The size of card and free space are shown on StartUp Log page. Card is formatted as FAT32 with long file name disabled. All file names are in 8.3 format. To access the log files, click menu link "**DATA LOG**".
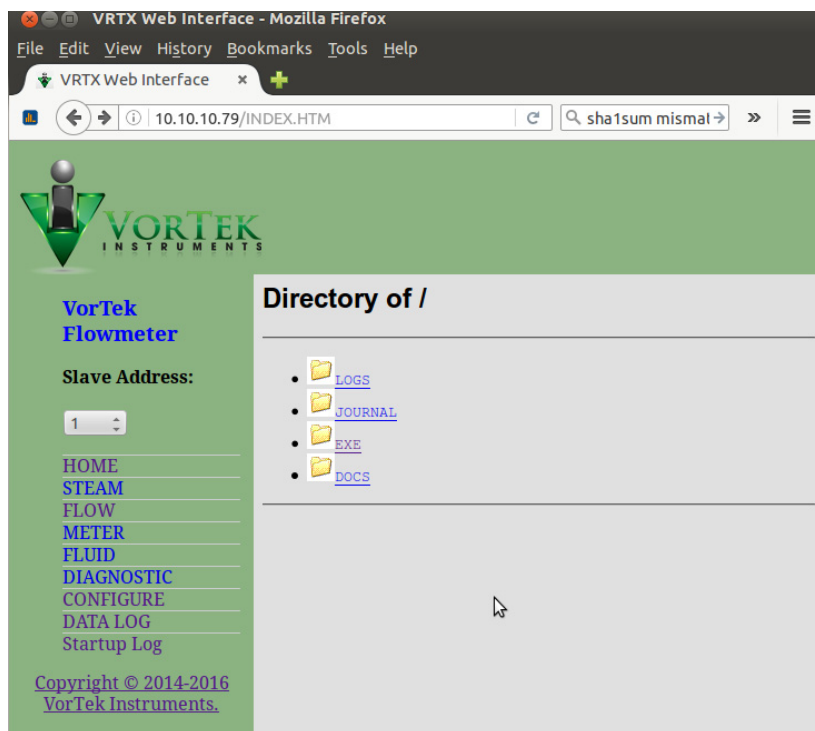
Figure 84: Data Log Menu

The following folders are in the *Data Log Menu*:

- LOGS   Contains Log files
- JOURNAL   Log files of unit on/off states as well as operator's actions
- EXE   Folder with several executables
- DOCS   Documentation

Log files are arranged as a tree:

LOGS

        2016   – Year

        01   – month

        02   – February

....

05   – May

160501.CSV

160502.CSV   – Daily files in Comma Separated Variables text format.
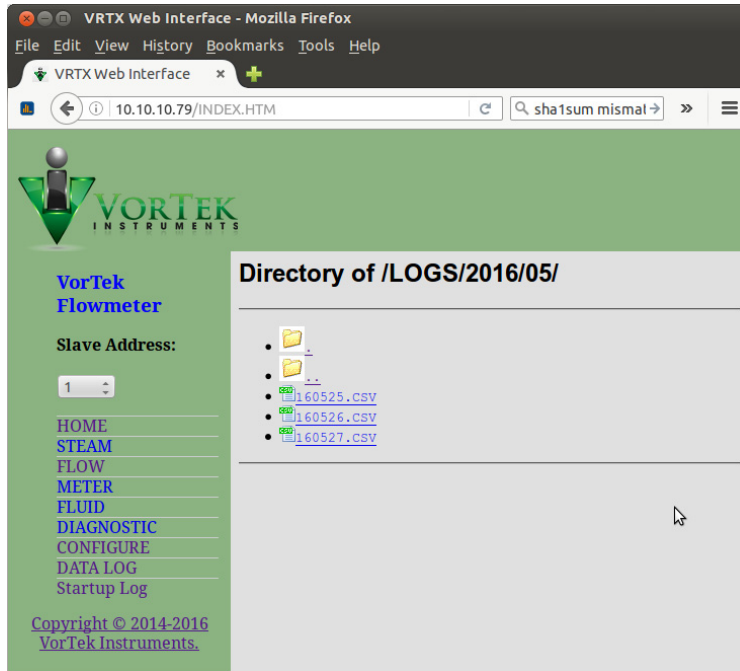
Figure 85: Log Files

To download file to your PC right click on it and select "**save**". You may also open it immediately. It will be opened as text file or in EXCEL depending on your settings of used browser. You may change it – consult HELP of used browser to find out how to configure default application for file extension .CSV.

Normally, browser asks what to do with this file extension.
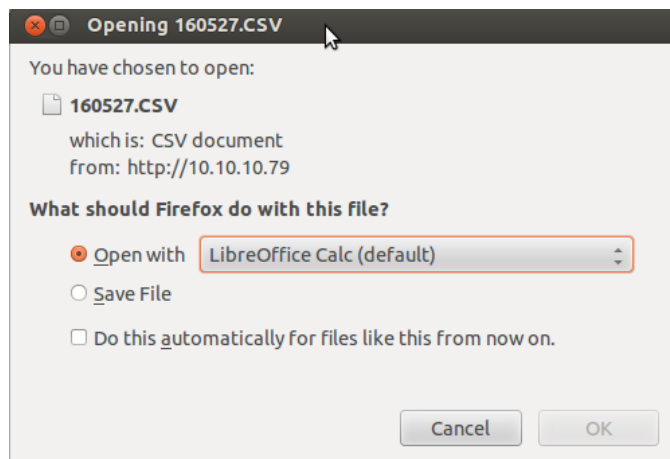
Figure 86: CSV log file

In this example it is offering to open the file in LibreOffice Calc - analog of Windows EXCEL. It then asks about details of CSV format: what to use as field separators. Select "**comma**".

Click **OK** and it will open the file in **EXCEL (CALC)**.
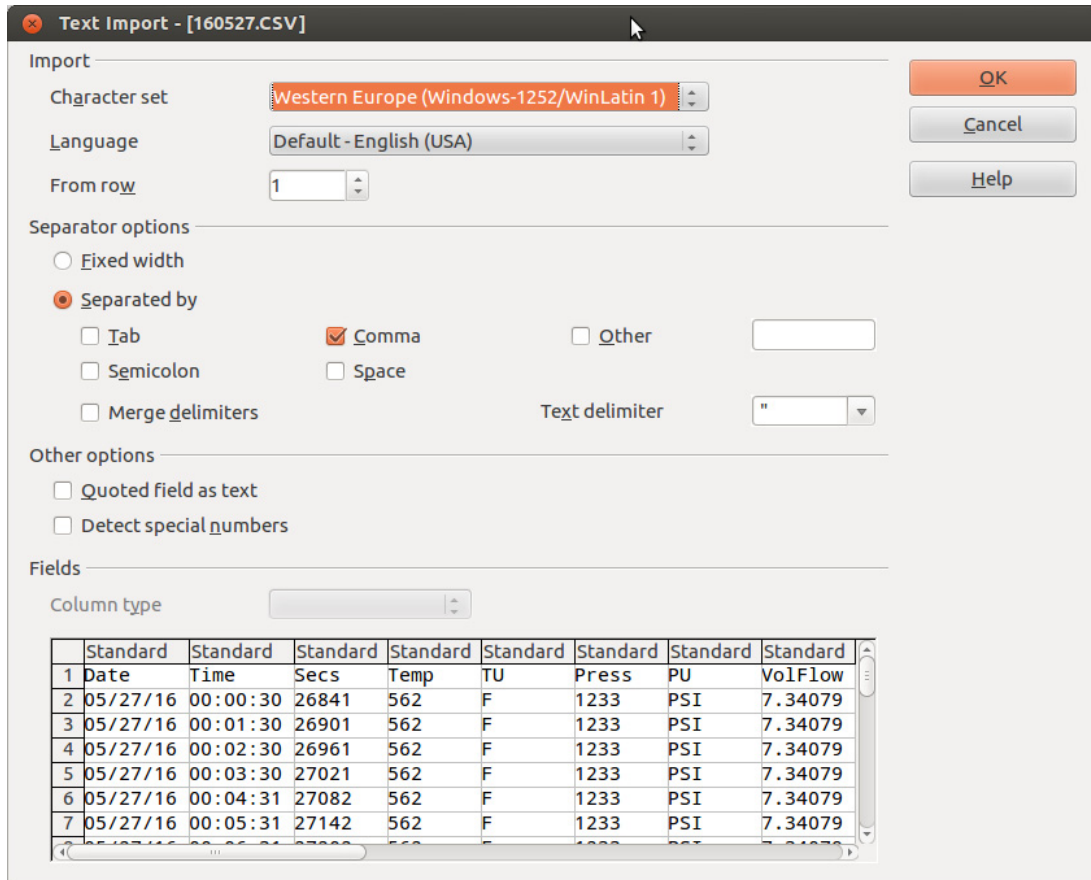
Figure 87: Text Import file

First three columns in table A, B, and C are fixed and always present. All other are configurable on SD Log Config page on *CONFIGURE* form.

The names of columns are self-explanatory. Column C (Secs) shows number of seconds since meter was restarted. Columns named PU, TU, VFU display Pressure, Temperature, Volume Flow Units accordingly. New header is output whenever operator changes the list of logged items. Log interval is set on configuration page and can vary from as low as 5 seconds to whatever you choose.

Figure 88: LibreOffice Calc Example

The SD Log Config page is the following. Just select desired items and click **SET** button at the bottom of the form.
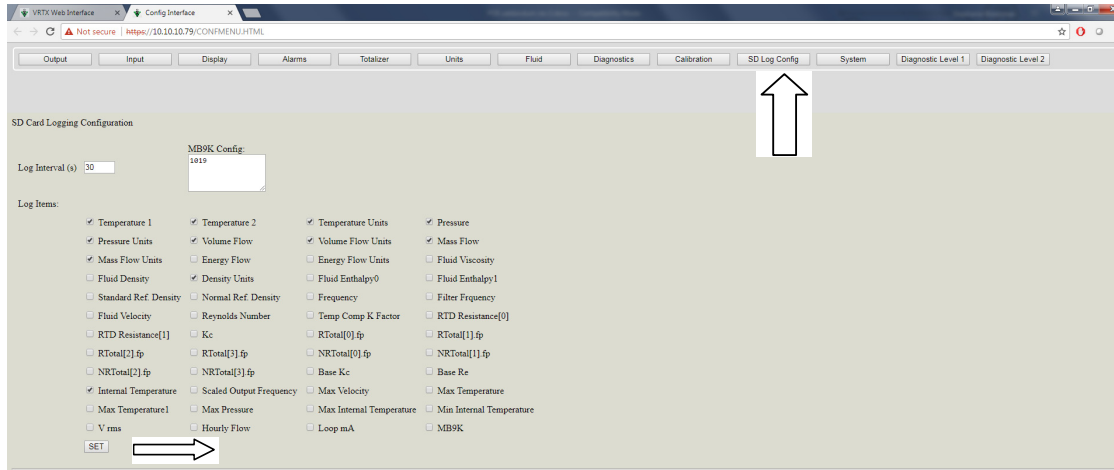
Figure 89: SD Card Configuration Page

2.7.12.1 Dummy registers group 9000

Client can read and write into *Dummy Modbus* registers 9000 to 9999. These registers may used for storing some process variables and logged synchronously with other *VRTX Meter* data.

Text area MB9K Config contains configuration of *Dummy Modbus* registers logging. Line beginning with "#" are comments and not used anywhere. The format of line:

offset, number of items, forms

If MB9K check box at the bottom is selected, logger will add to the end of log line items described in MB10K Config. Each line describes group of Dummy registers in Modbus regs 9000 to 9999.

In each line offset is position of the group in 9000 registers. Number of items is either number of registers in the group in case of 16 bit values or number of pairs of registers in case of Long and Float formats. Format is one character specifying format of items in the group:

i   16 bit signed integer

I   16 bit unsigned integer

l   32 bit signed integer

L   32 bit unsigned integer

f   32 bit floating point values

Customer may write into these registers with Function code 16 and read with Function codes 3 and 4.

Note: *The contents of these registers is not retained at cycling the power.*

The registers in Log file are named as Mxxx for "**i**" format, MxxxL for "**I**" format and Mxxxf for "**f**" format. Where xxx is register offset from 10000. All Dummy registers are in "*reversed*" format. Most significant word (MSW) is coming first.

MB8K log selector. If checked it will log Dummy registers 9000 according to format specifiers entered in M9K Config area.
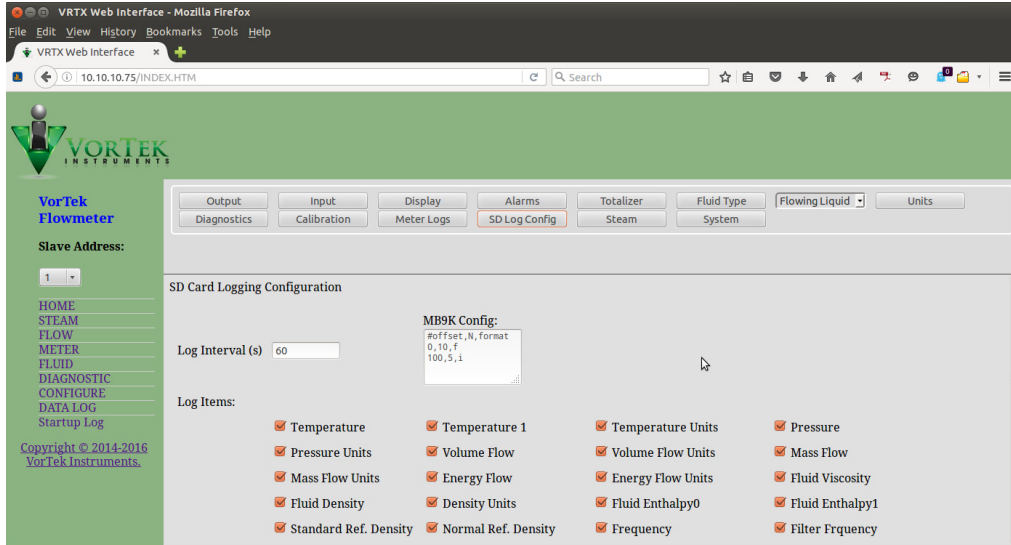
Figure 90: MB9K Config example

Example of Dummy registers log.

Figure 91: Dummy register log example

2.7.12.2   Other methods of retrieving log files

WGET:

Retrieving log files could be automated using Internet-standard utility WGET. This utility readily available on Linux machines and for Windows can downloaded from here: https://www.gnu.org/software/wget/ or install Linux simulator on Windows WinBash, which also contains WGET: http://win-bash.sourceforge.net/

To read daily file for specific date use the following WGET command:

WGET http://10.10.10.79/LOGS/2016/05/160527.CSV (where first 2 digits - year, next - month, next day). This instruction will download daily log file for date: 05/27/2016.

FTP:

VRTX/TCP meter has capability of accessing the file system on SD card via FTP protocol. For that you may use any specialized FTP client or even File browser on Linux or Windows systems.

In Windows Explorer enter in address field ftp://10.10.10.79 or whatever is IP of your meter. You may be asked first time for the User Name and Password. Use **User: "owner"** and **Password: "16363"**. You'll get almost full access to the file system on SD card. You may copy files, delete files and directories. Creating directories is not allowed.
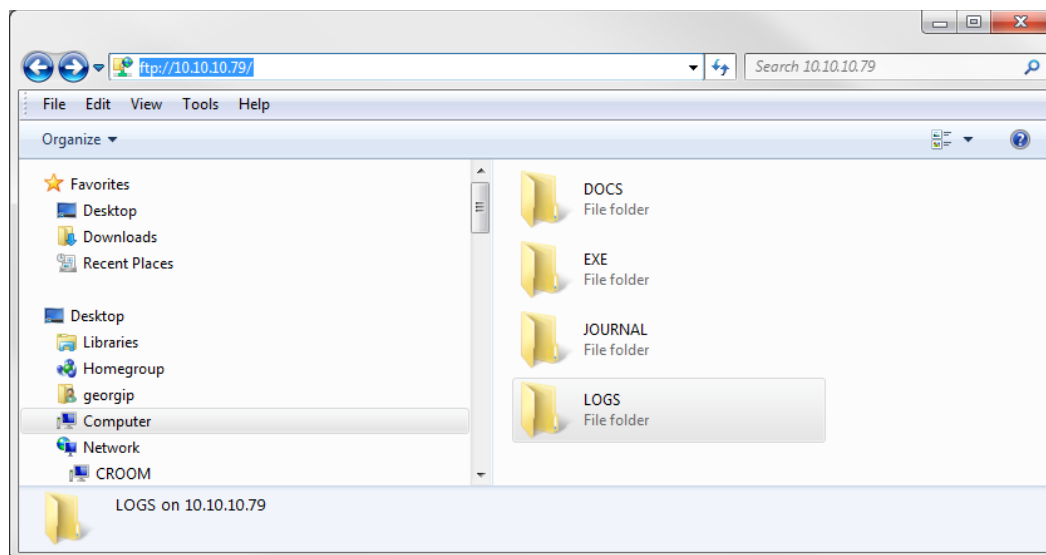
Figure 92: FTP example

FTP access may be automated with mentioned above WGET application. The string to query single file is the following: WGET ftp://owner:16363@10.10.10.79/LOGS/2016/05/160527.CSV (Note how to supply user name and password when accessing via FTP.).

Note: *You may use FTP access to clean SD card by removing unnecessary data or wrong directories created due to misread Real Time Clock of the meter.*

2.7.13   Update of Firmware

VORTEX meter firmware can be updated on-line. For that there are two applications:

- AutoUpdate   Standard update utility using UDP protocol. Local network only.
- TcpUpdate   Update utility using TCP protocol allowing access from other networks.

In revision 1.0 of VORTEX/TCP TcpUpdate is disabled. AutoUpdate should always be used.

The AutoUpdate application can be downloaded from EXE directory on SD file system of the unit.
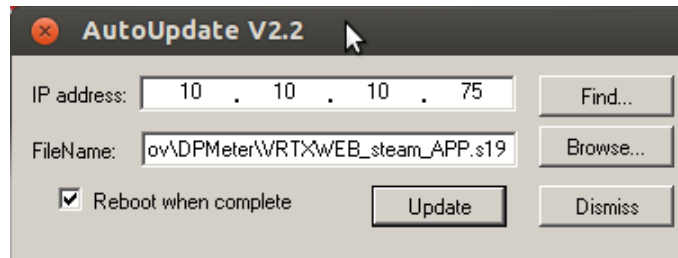
Figure 93: AutoUpdate

Usage:

- Enter IP address of you meter (or find meter on the local network).
- Browse for provided by VortexInst application file in xxx_APP.s19 format.
- Click update.

Update with TcpUpdate is also the same, but FIND option may not work across routers/switches.

Chapter 3.   Operating Instructions

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

> **WARNING!**   Do not open covers when an explosive atmosphere may be present.

3.1   Pressurization Guidelines

> **WARNING!**   During operation of the flow meter, it is important to minimize the risk of severe damage to the instrumentation which can be caused by a pipeline pressure surge.

Pipeline pressure surges are caused by a sudden increase in pressure produced when a line is charged too rapidly, often by quickly opening a control valve. The following steps should be taken to minimize the likelihood of a pressure surge damaging the PanaFlow MV80/82 vortex flow meter:

1.   The vortex flow meter must be located a minimum of 10 pipe diameters downstream from the pressure release valve, but 15 pipe diameters is recommended whenever possible.

2.   Gradual pressurization of the process line is essential. It is important to control and minimize the rate of pipeline pressurization in order to minimize the pressure surge and water hammer effect.

> **WARNING!**   A rapid increase in the pipeline pressure can result in exceeding the flow meter design specifications and result in risks to safety, assets, and the environment.

3.2   Flow Meter Display/Keypad

The flow meter 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 94 on page 74*). To secure the enclosure cover use a 1/16" hex key wrench to tighten the 6-32 x 1/4 cup point socket set locking screw.

3.2   Flow Meter Display/Keypad (cont.)
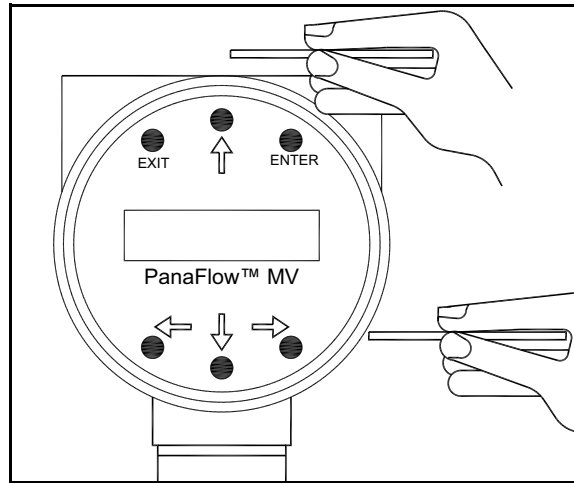
Figure 94: Magnetic Keypad Operation

Figure 95 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 ⬆ ⬇ ⬅➡ keys to select new parameters. The ⬆ ⬇ ⬅➡ keys advance through each screen of the current menu. When changing a system parameter, all ⬆ ⬇ ⬅➡ 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 95: Flow Meter Display/Keypad

3.3 Display Contrast Adjustment

The flow meter display contrast is set at the factory but if the dis-play characters appear too dark or too light proceed as follows:

1. Hold down the "Exit" button on the front panel for 5 to 10 seconds. "Setting Contrast" will appear.

2. Push the "Up" arrow to darken the display or the "Down" arrow to lighten it.

3. Push the "Enter" button to save the contrast setting.

3.4 Start-Up

To begin flow meter operation:

1. Verify that the flow meter 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 flow meter 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 96* 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.

Run Mode Screens

Mass Flow Rate → **ENTER** → Password

Password → **ENTER** → Setup Menus

Press EXIT to return to Run Mode

Mass Flow Rate

Volume Flow Rate

Temperature

Pressure

* Energy

Density

Total

Alarm 1 Status

Alarm 2 Status

Alarm 3 Status

Fluid

Date & Time

* Energy EMS Meters Only

Use ⬆⬇ keys to access each item
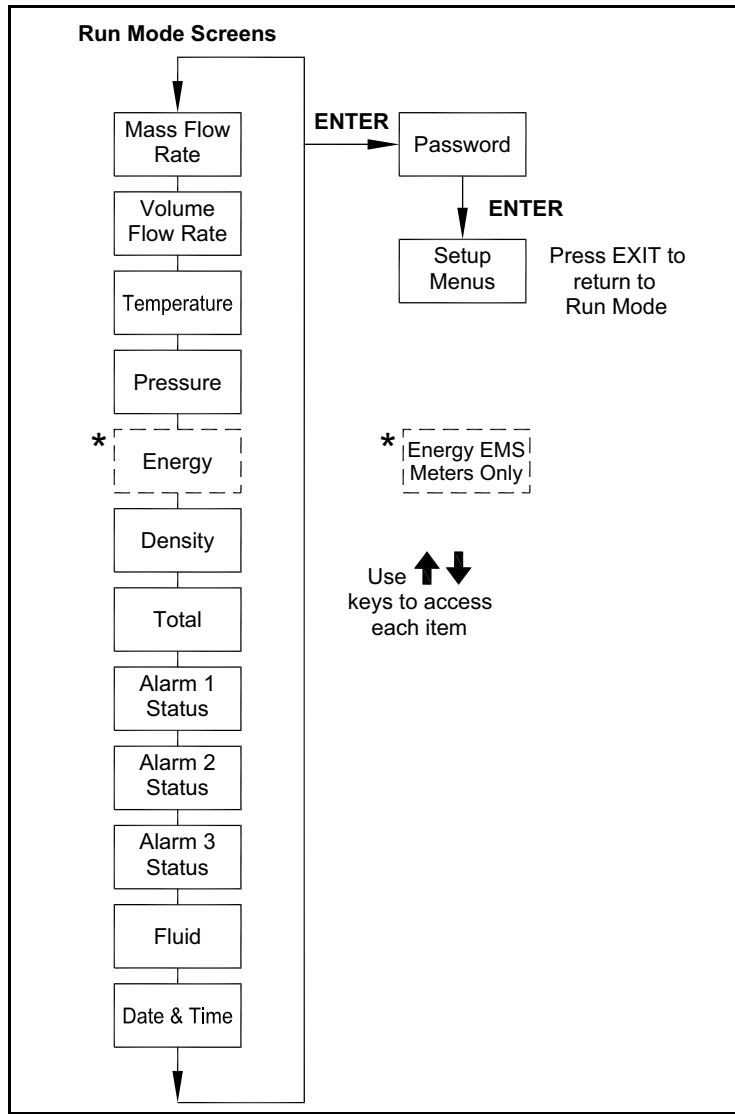
Figure 96: Run Mode Screens

3.5 Using the Setup Menus

3.5.1 A Menu Map
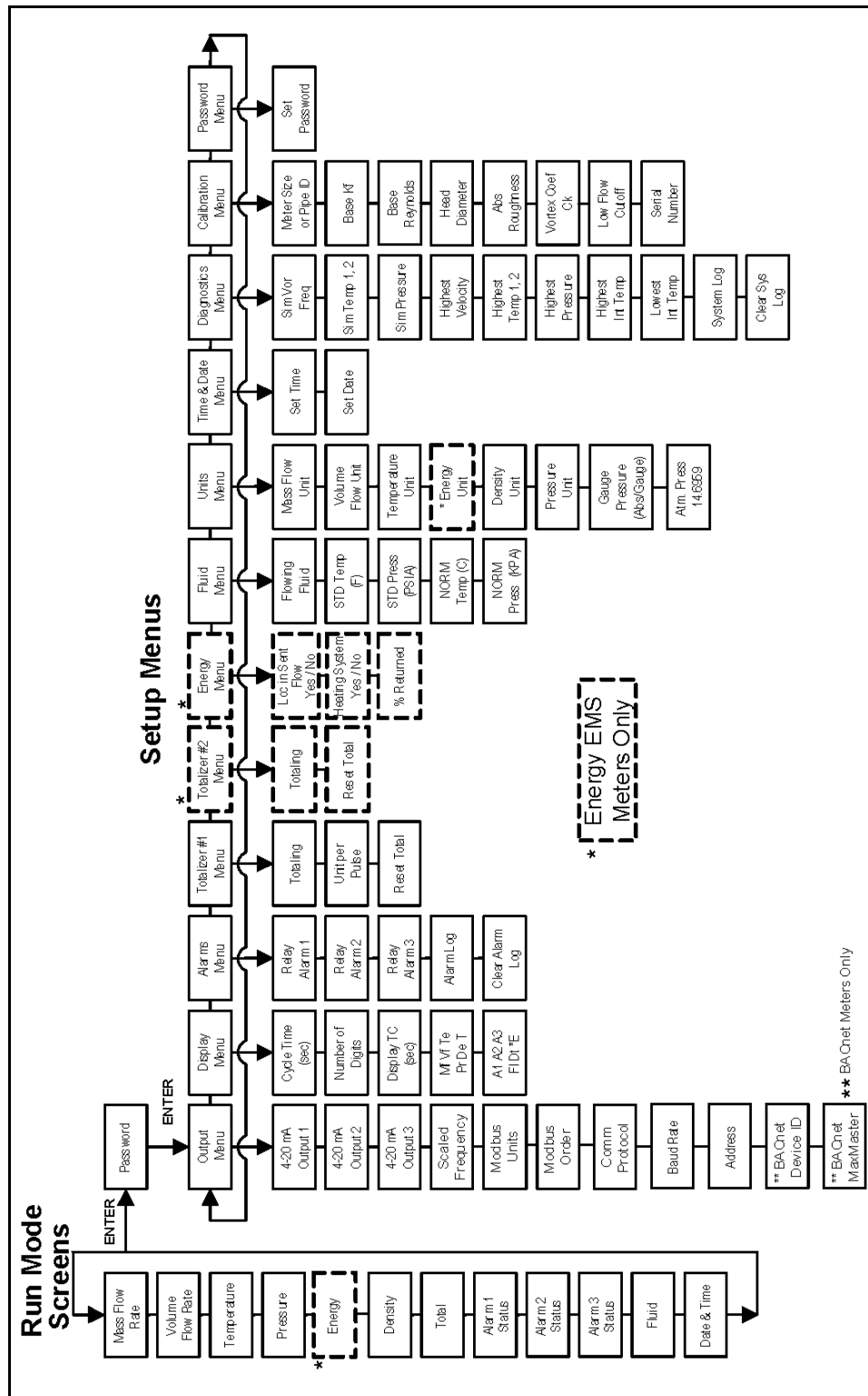
Figure 97: Complete Map of Setup Menus

3.5.2   Programming the Flow Meter

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 ⬆ ⬇ ⬅ ➡ 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 97* below may not be displayed, based on flow meter configuration settings**.**

4. To activate a parameter, press ENTER. Use the ⬆ ⬇ ⬅ ➡ 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.

3.5.3   The Output Menu

As an example of how to set an output, refer to *Figure 98 on page 79*. 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 ⬅ ➡ keys to move to the Units Menu (see *"The Units Menu" on page 90*).

2. Press the ⬇ key until Mass Flow Unit appears. Press ENTER.

3. Press the ⬇ key until lb appears in the numerator. Press the ➡ key to move the underline cursor to the denominator. Press the ⬇ key until hr appears in the denominator. Press ENTER to select.

4. Press the ⬆ key until Units Menu appears.

Second, set the analog output:

1. Use the ⬅ ➡ keys to move to the Output Menu.

2. Press the ⬇ key until 4-20 mA Output 1 appears.

3. Press the ➡ key to access Measure selections. Press ENTER and press the ⬇ key to select Mass. Press ENTER.

4. Press the ➡ key to set the 4 mA point in the units you have selected for mass of lb/hr. Press ENTER and use the ⬆ ⬇ ⬅ ➡ keys to set 0 or 0.0. Press ENTER.

5. Press the ➡ key to set the 20 mA point. Press ENTER and use the ⬆ ⬇ ⬅ ➡ keys to set 100 or 100.0. Press ENTER.

6. Press the ➡ key to select the Time Constant. Press ENTER and use the ⬆ ⬇ ⬅ ➡ keys to select 5. Press ENTER.

7. Press the EXIT key and answer YES to permanently save your changes.

3.5.3 The Output Menu (cont.)
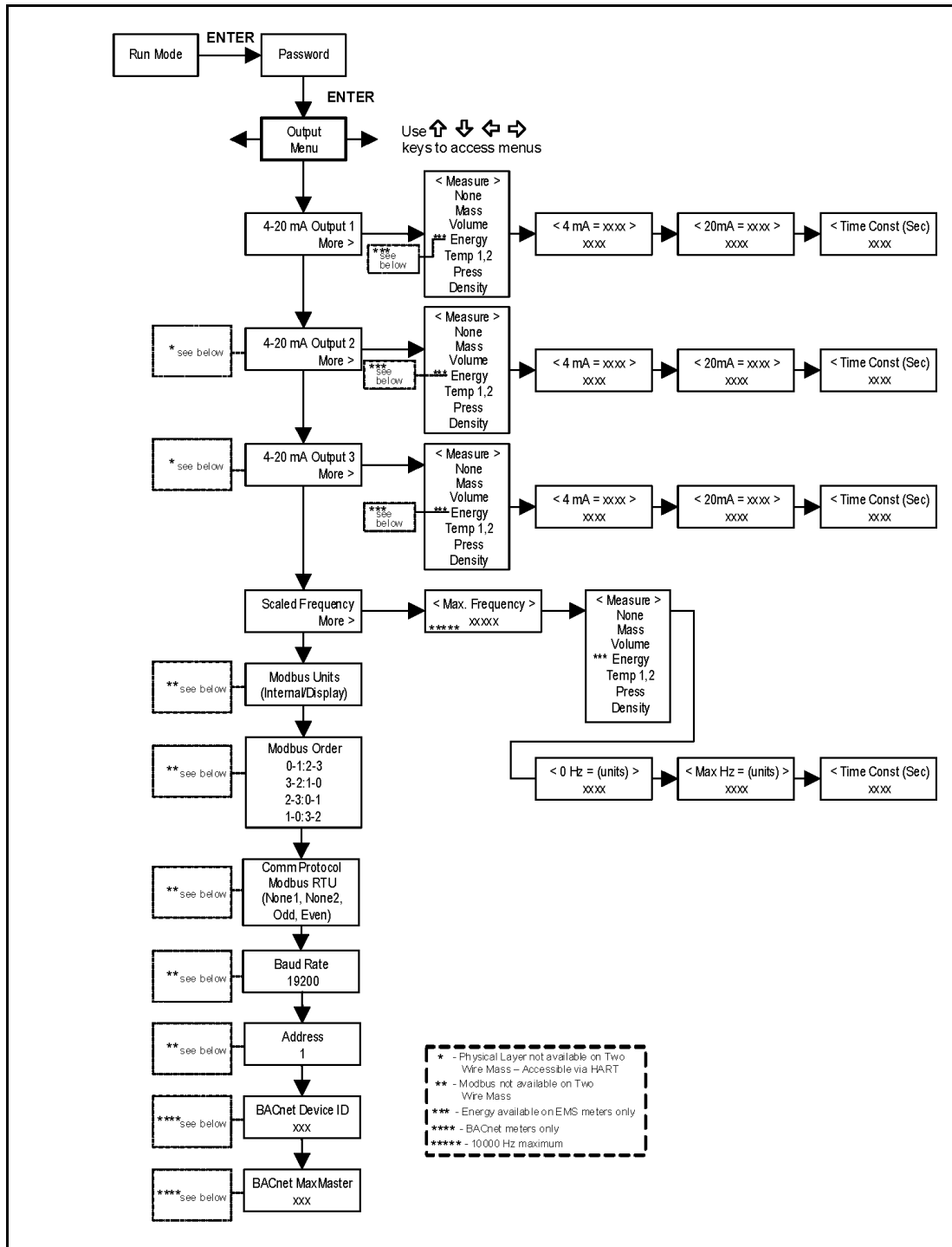
Figure 98: Output Menu Map

3.5.4 Example for Calculating Output Current

Assume Output 1 is scaled as above for mass flow with 4 mA = 0 lb/hr and 20 mA = 100 lb/hr. Output 1 current = ((Flow rate / 100) x 16 mA) + 4 mA.

3.5.5 The Display Menu

Use the *Display Menu* shown in *Figure 99* 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 99* 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.
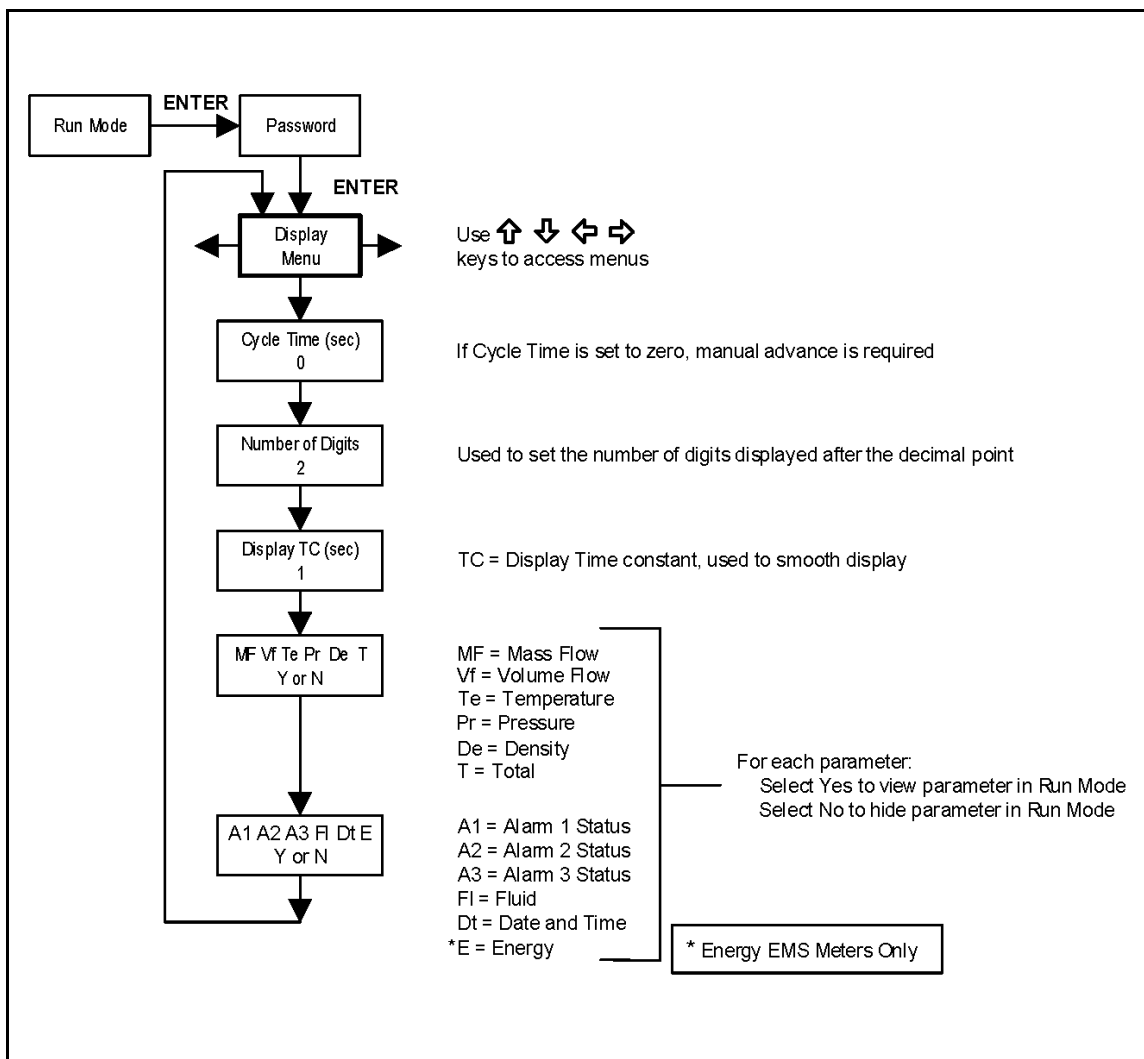
Figure 99: The Display Menu

3.5.6 The Alarms Menu

As an example of how to set an output, refer to *Figure 100 on page 82*. 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 ⬆ ⬇ 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 ⬅ ➡ keys to move to the Units Menu (see *"The Units Menu" on page 90*).

2. Press the ⬇ key until Mass Flow Unit appears. Press ENTER.

3. Press the ⬇ key until lb appears in the numerator. Press the ➡ key to move the underline cursor to the denominator. Press the ⬇ key until hr appears in the denominator. Press ENTER to select.

4. Press the ⬆ key until Units Menu appears.

Second, set the alarm:

1. Use ⬅ ➡ keys to move to the Alarms Menu.

2. Press the ⬇ key until Relay Alarm 1 appears.

3. Press the ➡ key to access Measure selections. Press ENTER and use the ⬇ key to select Mass. Press ENTER.

4. Press the ➡ key to select the alarm Mode. Press ENTER and use ⬇ key to select HIGH Alarm. Press ENTER.

5. Press the ➡ key to select the value that must be exceeded before the alarm activates. Press ENTER and use ⬆ ⬇ ⬅ ➡ 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.

3.5.6   The Alarms Menu (cont.)
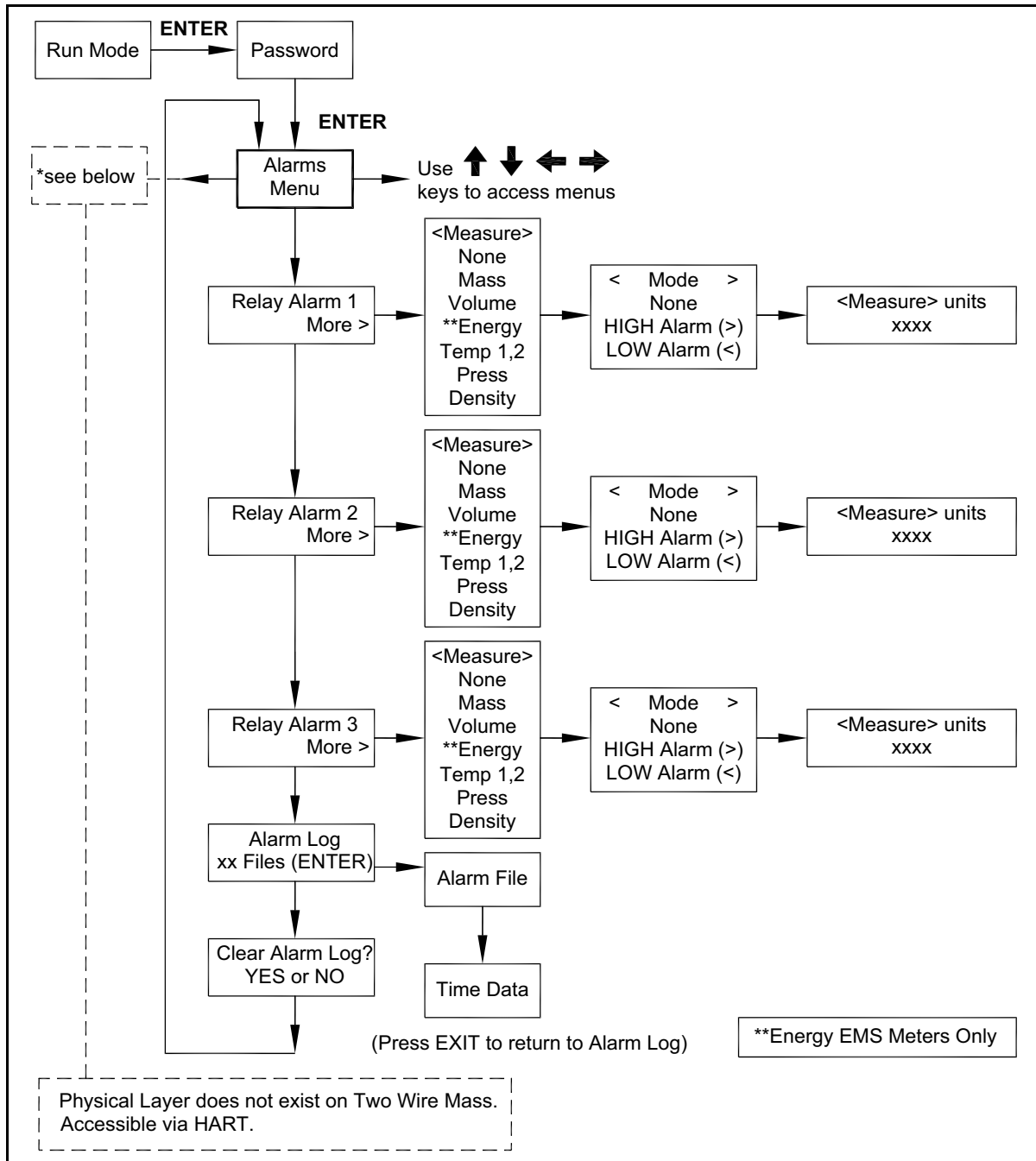
Figure 100: The Alarms Menu

3.5.7 The Totalizer #1 Menu

Use the Totalizer Menu to configure and monitor the totalizer. The totalizer maximum count is 999,999,999 at which point it will roll over to 0. 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 101 on page 84*. 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 90*).

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.

3.5.7   The Totalizer #1 Menu (cont.)
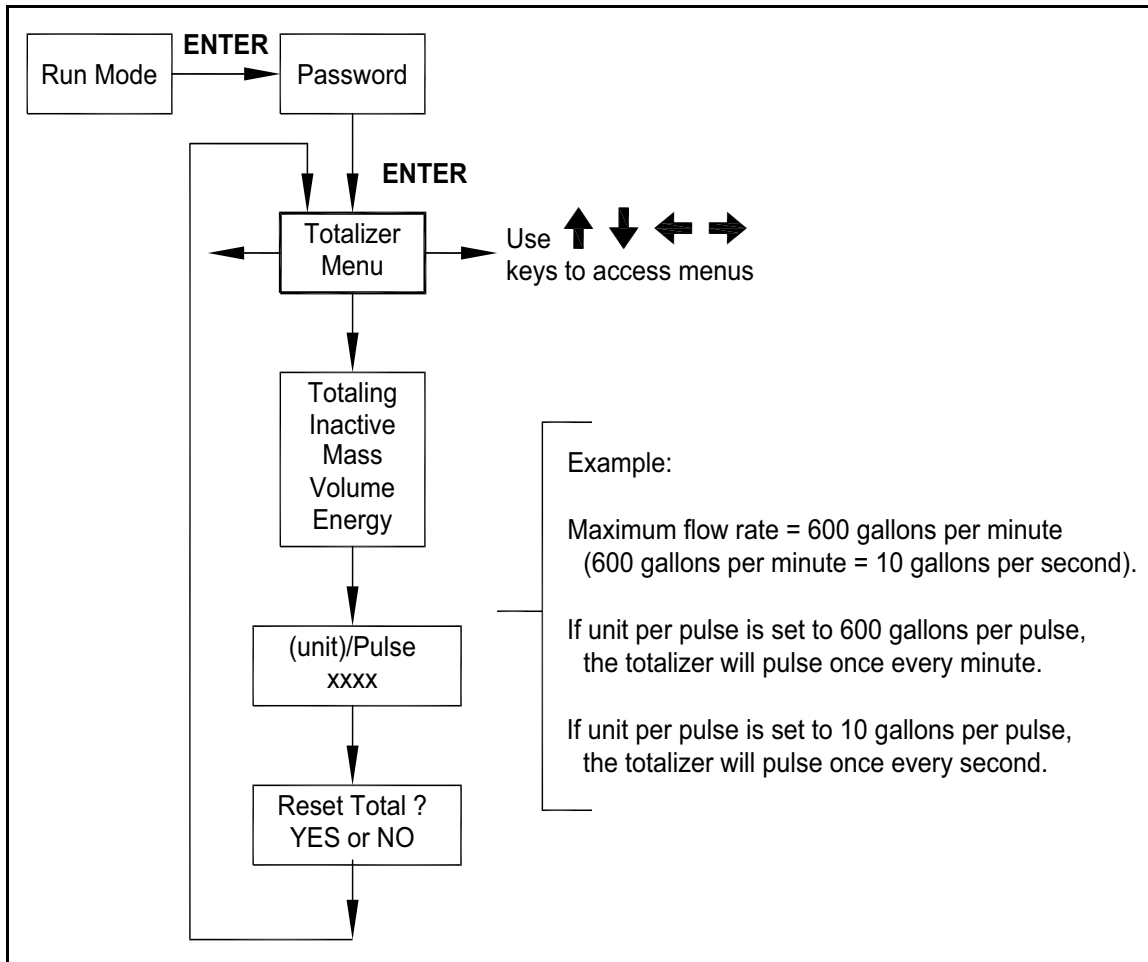
Figure 101: The Totalizer #1 Menu

3.5.8   The Totalizer #2 Menu

Refer to *Figure 102* below, and use Totalizer #2 to Monitor Flow or Energy. The totalizer maximum count is 999,999,999 at which point it will roll over to 0.

Note: *Totalizer #2 does not operate a relay – it is for monitoring only.*
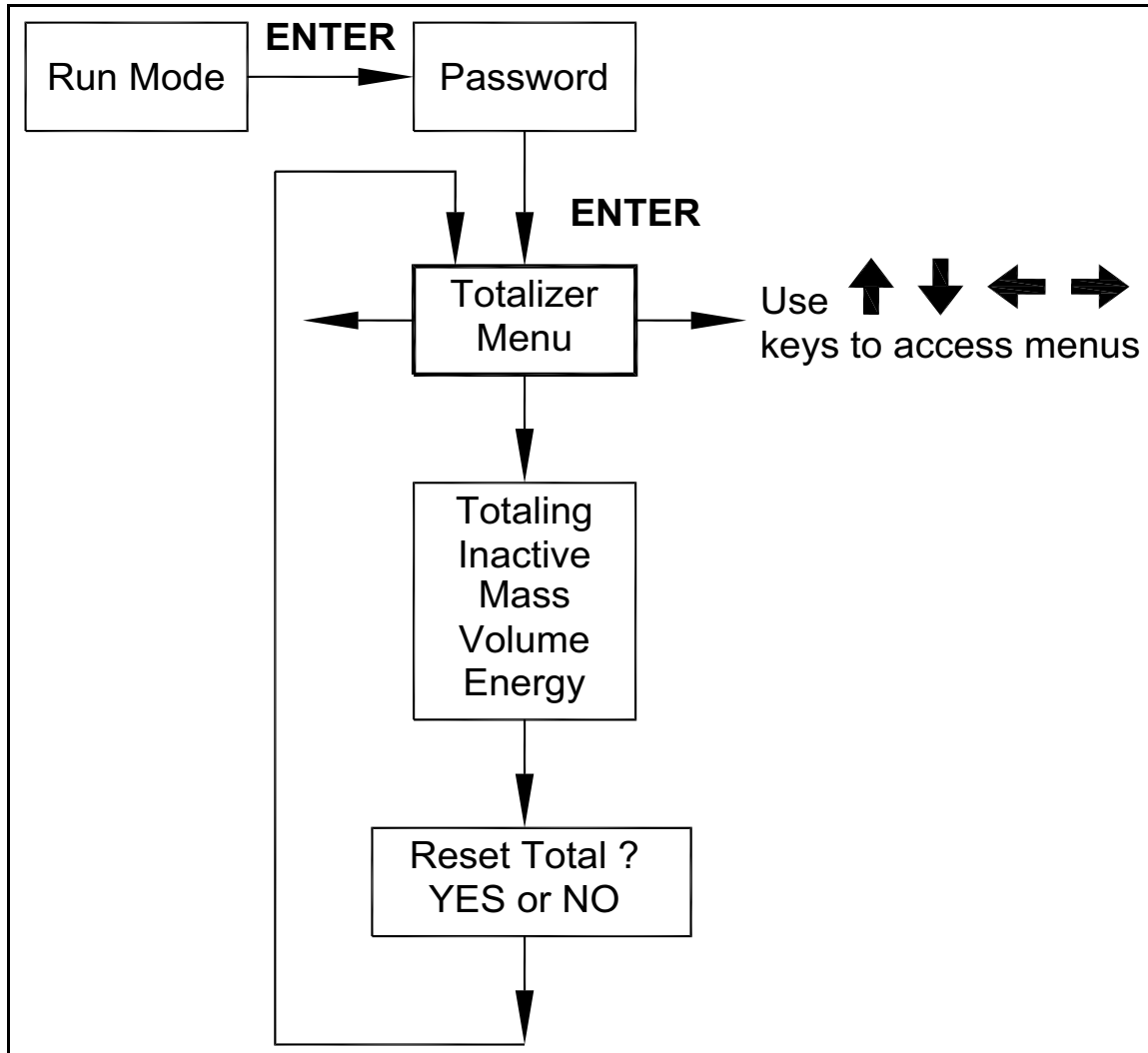
Figure 102: The Totalizer #2 Menu

3.5.9   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 103 on page 87*) 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.*

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

```
┌──────────┐   ENTER   ┌──────────┐
│ Run Mode │──────────▶│ Password │
└──────────┘           └──────────┘
                              │
       ┌──────────────────────┤
       │              ENTER    │
       │                       ▼
       │              ┌──────────────┐        Use ⬆ ⬇ ⬅ ➡
       │◀─────────────│   Energy     │──────▶ keys to access menus
       │              │    Menu      │
       │              └──────────────┘
       │                     │
       │                     ▼
       │              ┌──────────────┐
       │              │ Loc in Sent  │
       │              │    Flow      │
       │              │  Yes or No   │
       │              └──────────────┘
       │                     │
       │                     ▼
       │              ┌──────────────┐
       │              │   Heating    │
       │              │   System     │
       │              │  Yes or No   │
       │              └──────────────┘
       │                     │
       │                     ▼
       │              ┌──────────────┐
       │              │  % Returned  │
       │              │     xxx      │
       │              └──────────────┘
       │                     │
       └─────────────────────┘
```
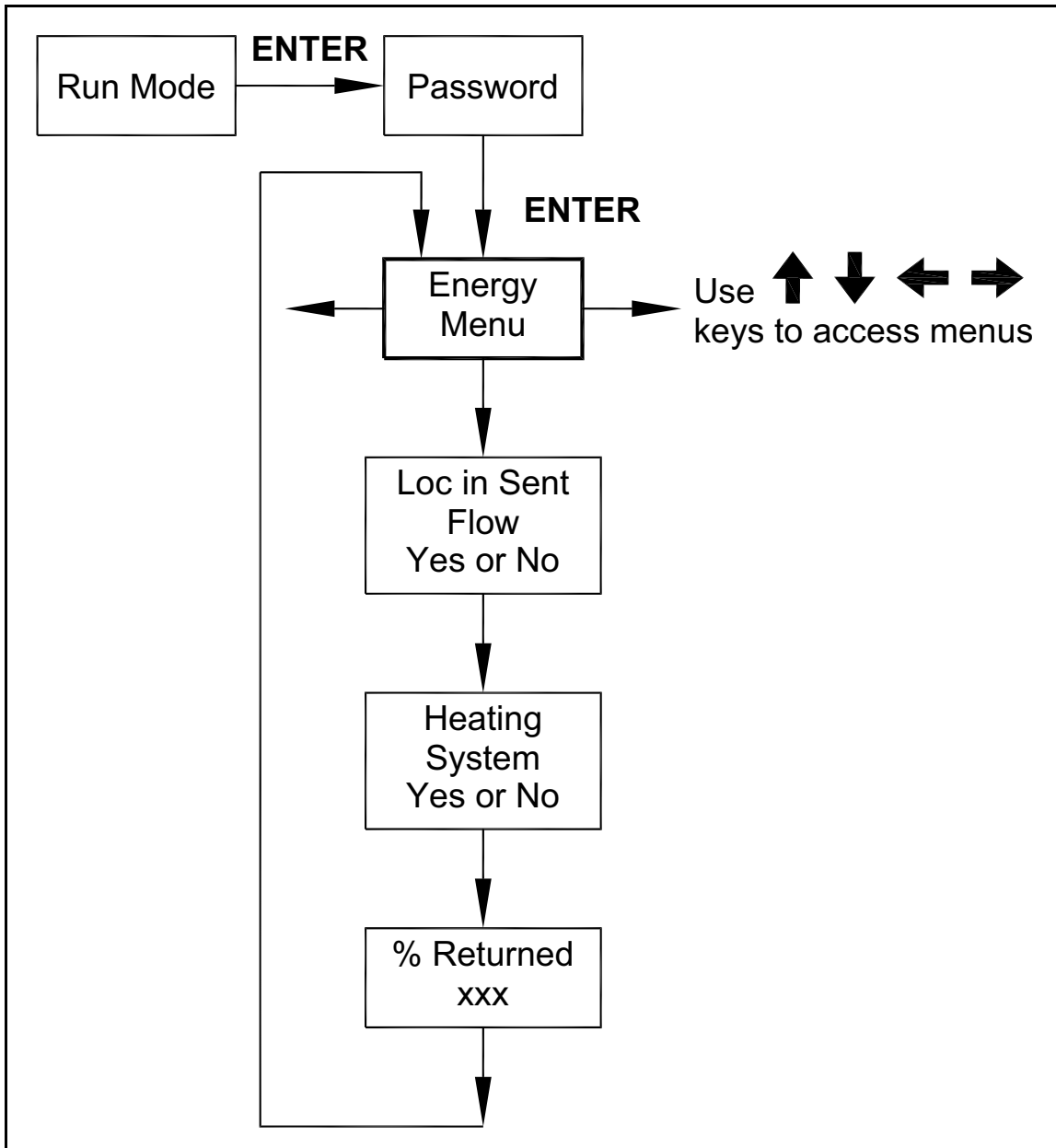
Figure 103: The Energy Menu for EMS Energy Meters Only

3.5.10   The Fluid Menu

Use the Fluid Menu (see *Figure 104 on page 89*) to configure the flow meter for use with common gases, liquids and steam. Your flow meter 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 = $lb_m/(lb_m \cdot mol)$
- CRIT PRESS = psia
- CRIT TEMP = °R
- Density = lbm/ft^3
- Viscosity = cP (centipoise).

3.5.10   The Fluid Menu (cont.)
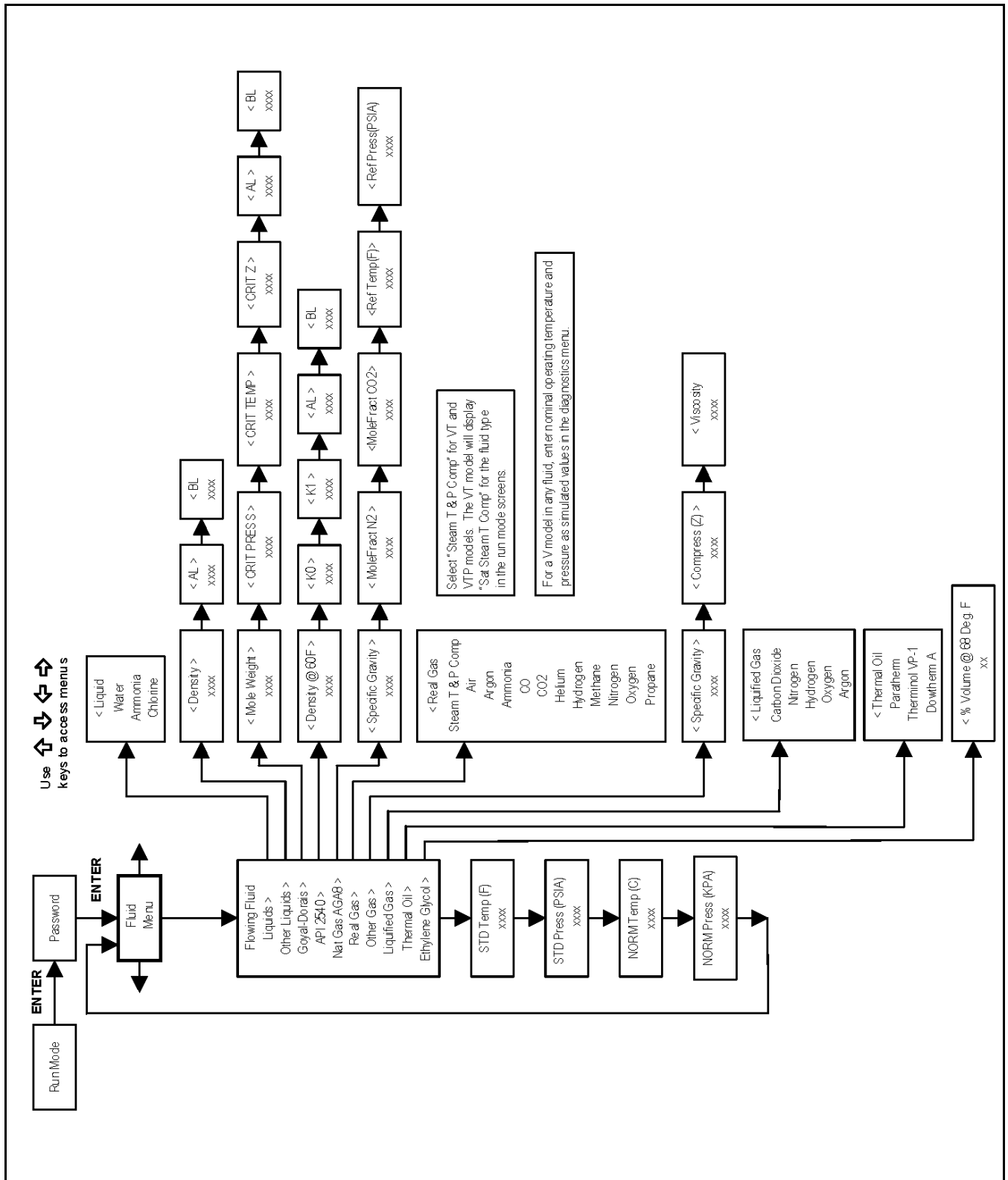
Figure 104: The Fluid Menu

3.5.11   The Units Menu

Use the Units Menu (see *Figure 105* below) to configure the flow meter with the desired units of measurement. These are global settings and determine what appears on all screens.
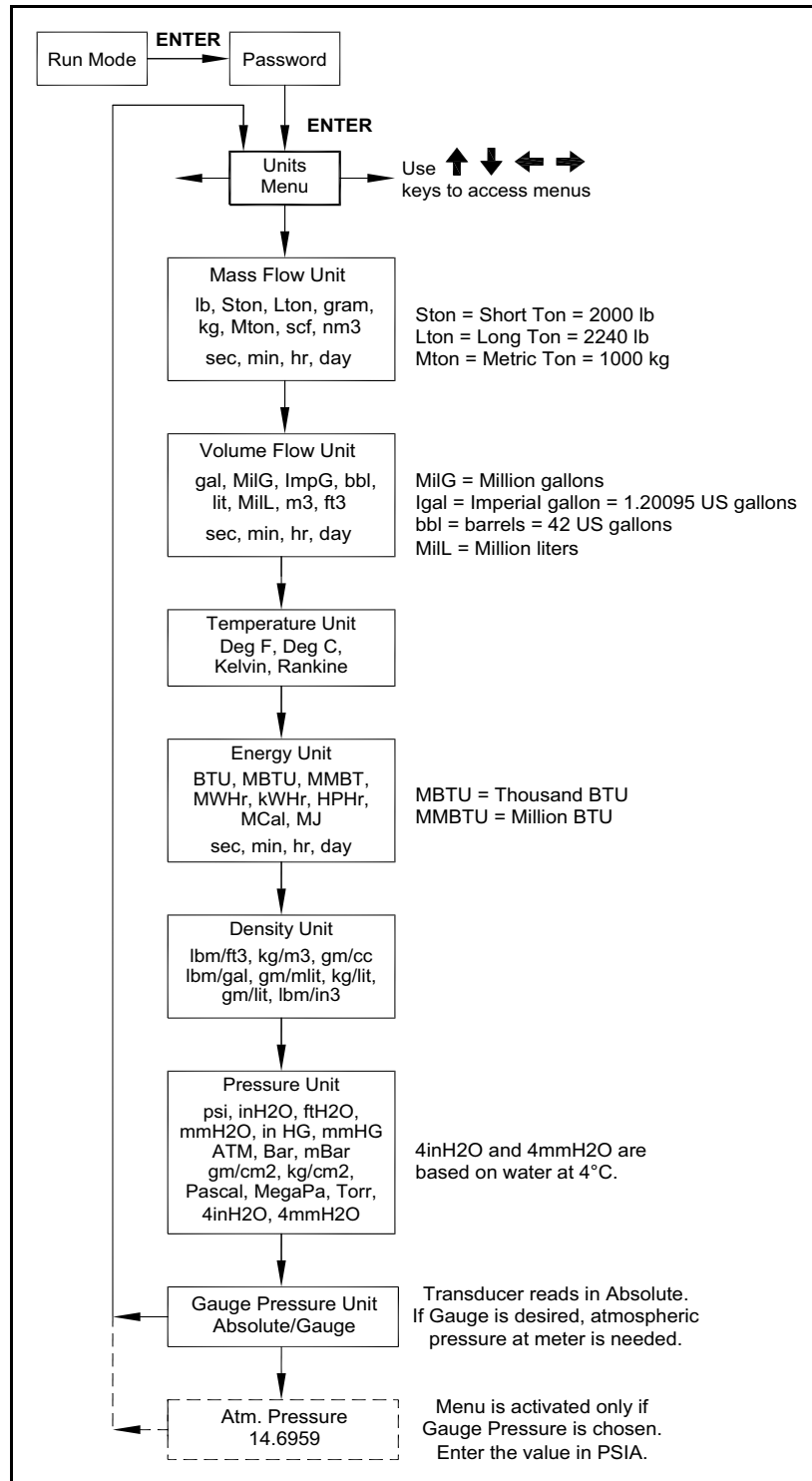
Figure 105: The Units Menu

3.5.12   The Time & Date Menu

Use the Time and Date Menu (see *Figure 106* below) to enter the correct time and date into the flow meter'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 ⬆ ⬇ keys until the Time & Date screen appears.

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

1.   Use ⬅➡ keys to move to the Time and Date Menu.

2.   Press the ⬇ key until Set Time appears. Press ENTER.

3.   Press the ⬇ key until 1 appears. Press the ➡ key to move the underline cursor to the next digit. Press the ⬇ 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.
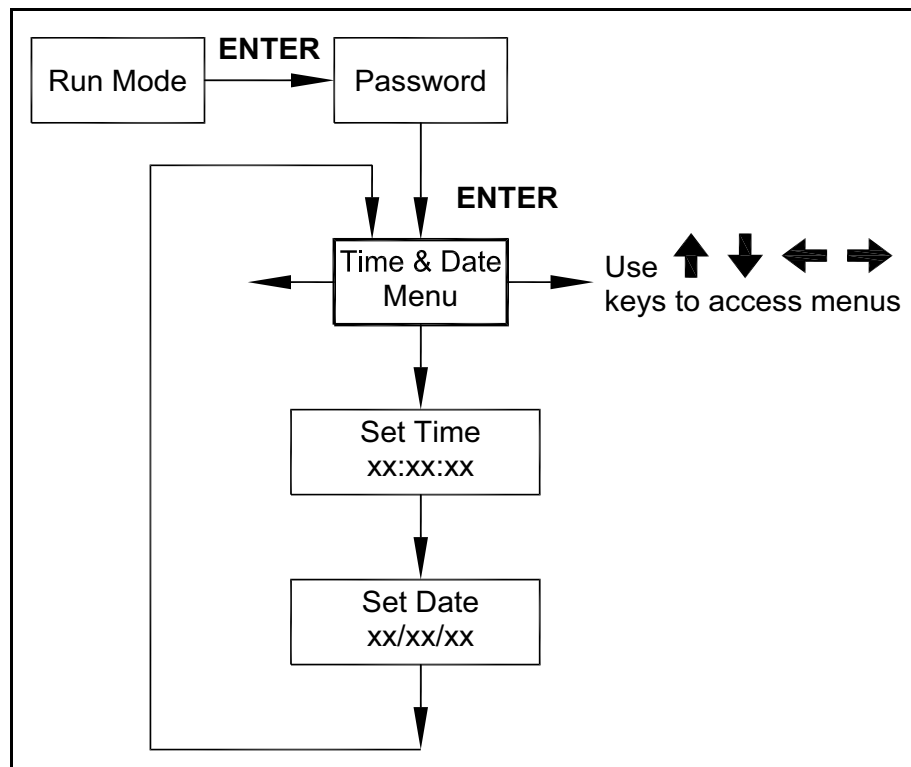
Figure 106: The Time & Date Menu

3.5.13   The Diagnostics Menu

Use the Diagnostics Menu (see *Figure 107 on page 93*) to simulate operation and review the system files. The system log files contain time/date stamped messages including: power on, power off, programmed 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 flow meter.**

3.5.13   The Diagnostics Menu (cont.)
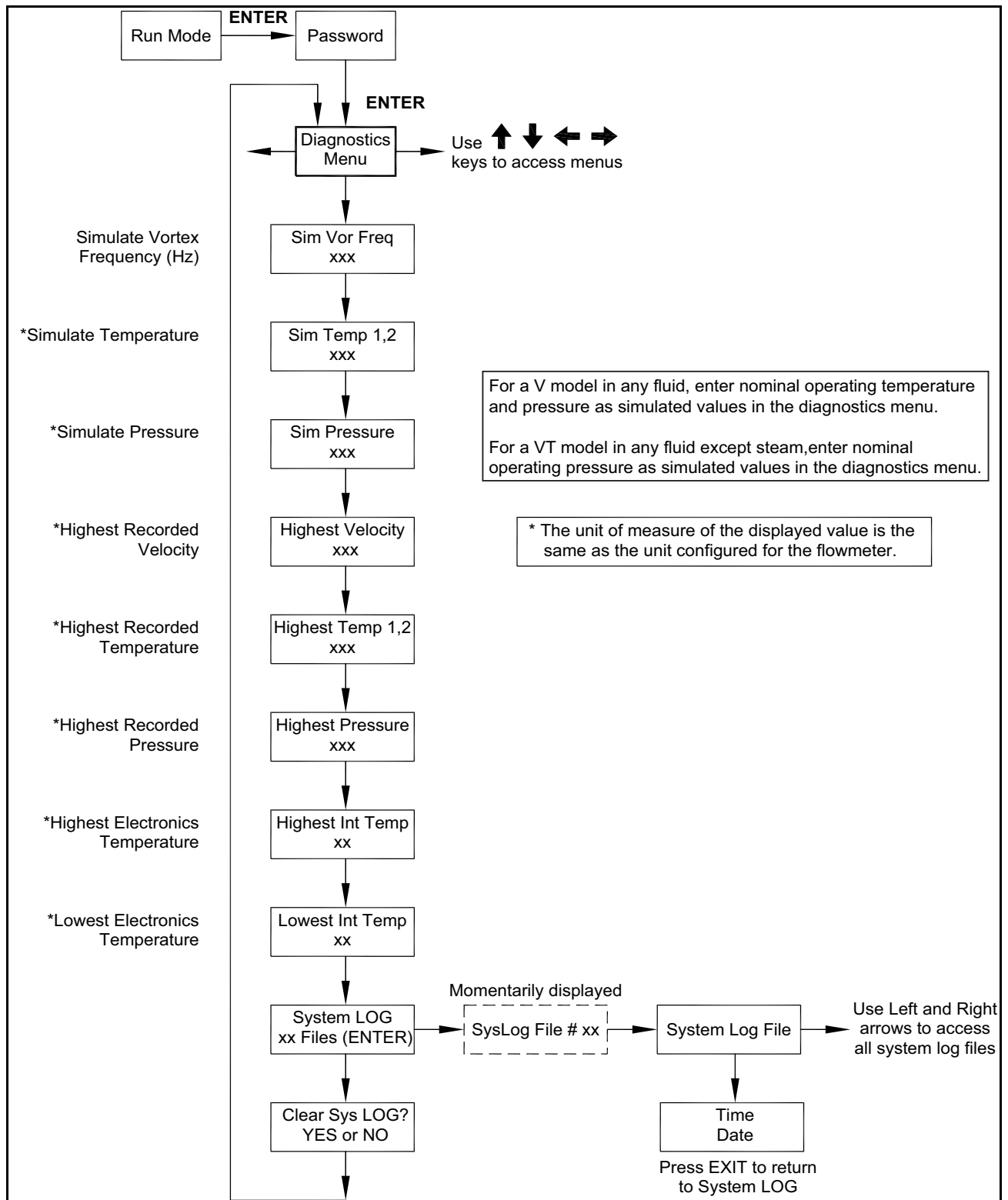
Figure 107: The Diagnostics Menu

3.5.14 The Calibration Menu

The Calibration Menu (see *Figure 108* below) contains the calibration coefficients for the flow meter. These values should by changed only by properly trained personnel. The **Vortex Coef Ck** and **Low Flow Cutoff** are set at the factory. Consult Panametrics for help with these settings if the meter is showing erratic flow rate readings.

```
   ENTER
Run Mode ──────▶ Password

              ENTER

        ◀── Calibration ──▶    Use ⬆ ⬇ ⬅ ➡
            Menu              keys to access menus

            Meter Size        Inline style meter – meter size
            or Pipe ID        Insertion style meter – pipe internal diameter (inches)

            Base Kf           Meter calibration constant
            xx.xxx            Inline style meter – pulses / ft³
                              Insertion style meter – pulses / ft

            Base Reynolds     Meter calibration constant
            xxxx.xx

            Head Diameter in. ID of insertion head
            x.xxx

            Abs Roughness in. Pipe roughness
            x.xxxx            Default value = 0.003

            Vortex Coef Ck    Adaptive filter setting
            xx

            Low Flow Cutoff ──▶ < Vol (xxx/xxx) > ──▶ < Mass (xxx/xxx) >
            xx                      xxx                     xxx

            Serial Number       Low Flow Cutoff         Low Flow Cutoff
            xxxxxxxxx           setting displayed       setting displayed
                                in volumetric flow      in mass flow
                                units (view only)       units (view only)
```

Typical Surface Roughness (inches)	
Type of Pipe	Roughness
Steel, drawn, new	0.0024
Steel, welded, new	0.003
Steel, sheet, smooth	0.0028
Steel, galvanized, new	0.006
Steel, lightly corroded	0.01
Steel, severely corroded	0.068
Steel, light scaling	0.05
Steel, heavy scaling	0.11
Cast Iron, new	0.025
Cast Iron, corroded	0.06
Cast Iron, with scaling	0.1
Drawn Tubing, plastic	0.00006

Figure 108: The Calibration Menu

3.5.15 The Password Menu

Use the Password Menu (see *Figure 109* below) to set or change the system password. The factory-set password is **1234**.
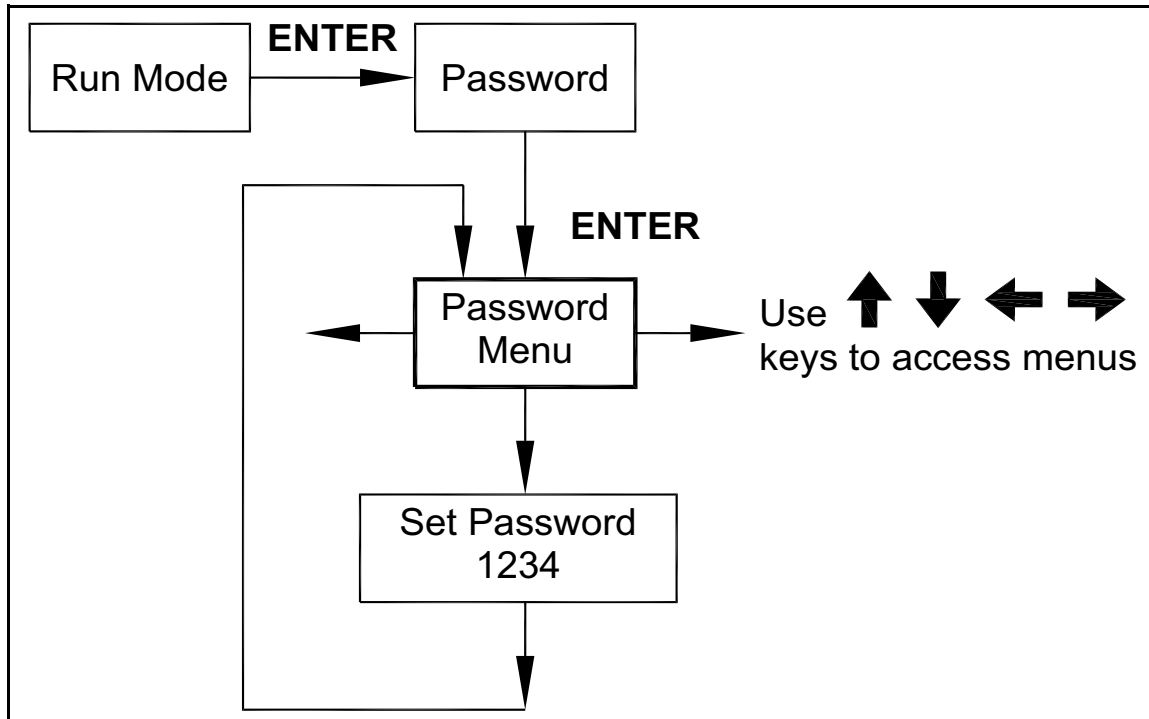
Figure 109: The Password Menu

[no content intended for this page]

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:

4.1.1.1 HART Loop Powered Meter Wiring
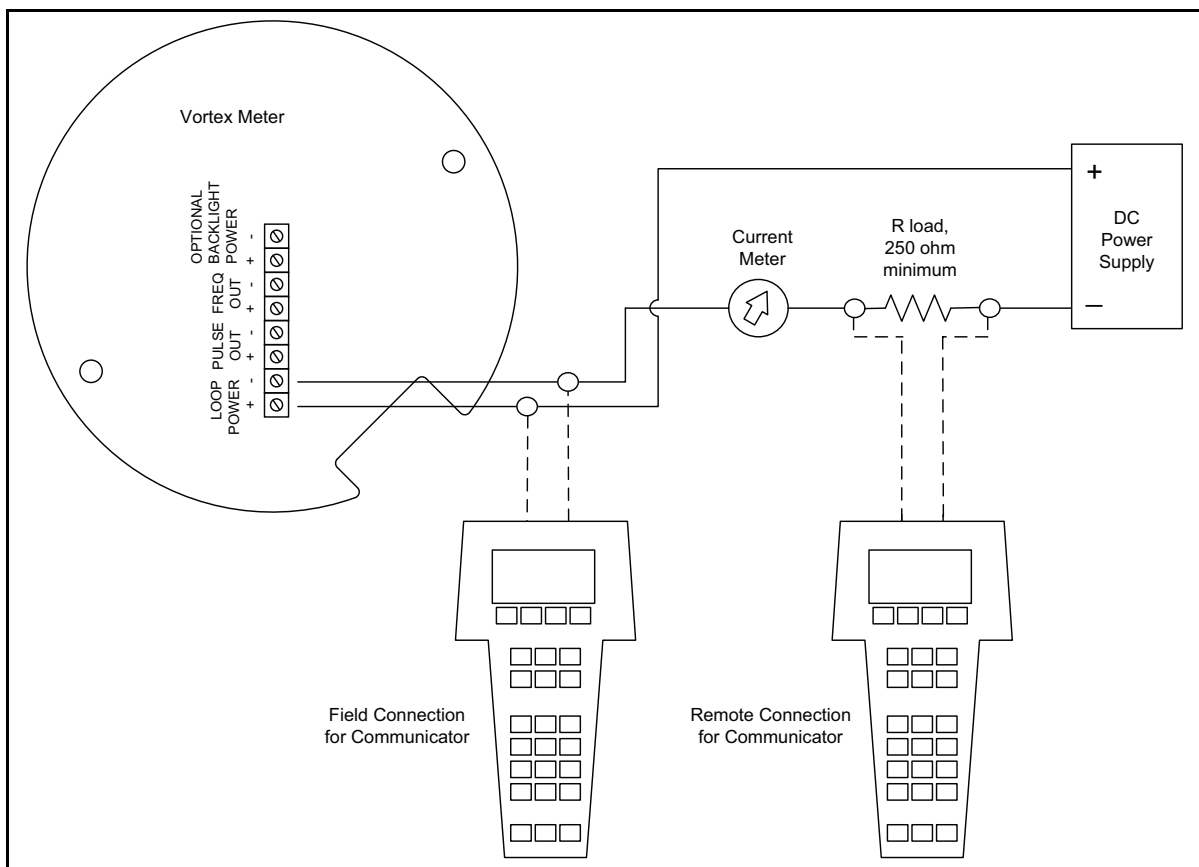
Figure 110: HART Loop Powered Meter Wiring

4.1.1.2   HART DC Powered Meter Wiring
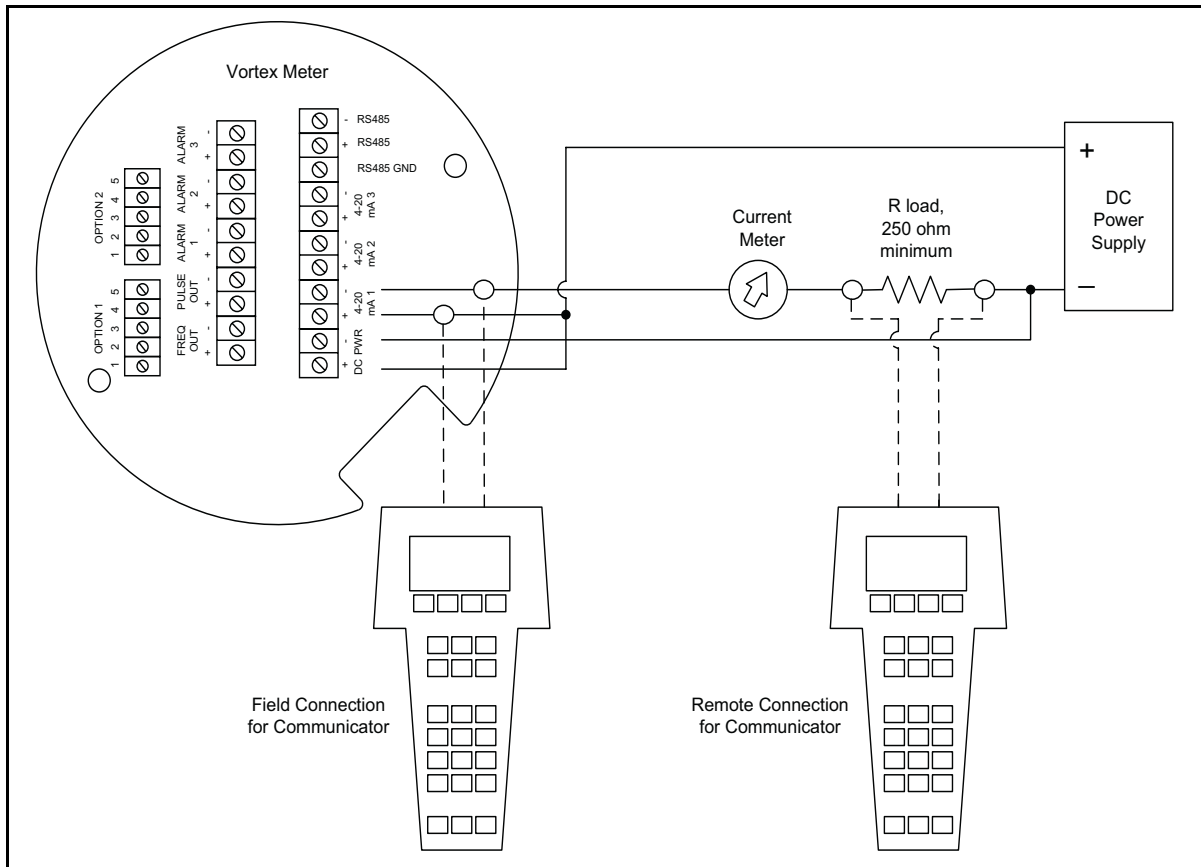
Figure 111: HART DC Powered Meter Wiring

4.1.1.3 HART AC Powered Meter Wiring
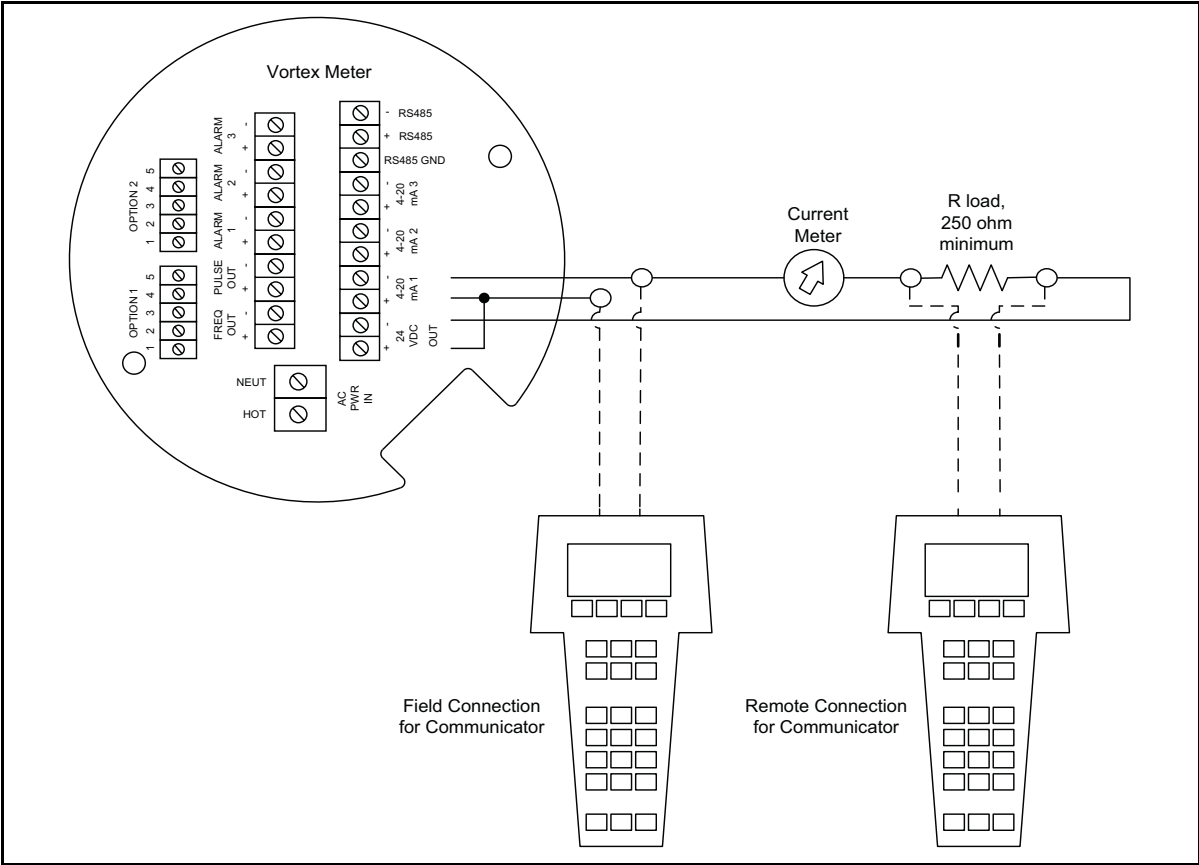
Figure 112: HART AC Powered Meter Wiring

4.1.2   HART Commands with the Digital Display Menu

Figure 113: HART Commands with the Online Menu

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

Figure 114: HART Commands with the Analog Output Menu

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

Figure 115: HART Commands with the Fluid Menu

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

Diagnostics Menu

From Online Menu

| 1 Vel |
| 2 Pres |
| 3 Temp |
| 4 Temp 2 |
| 5 Internal Temp |
| 6 Vortex Diag. |
| 7 Press Diag. |
| 8 Temp Diag. |
| 9 Int Temp Diag |
| Log |
| Status |

| 1 Vtx Freq |
| 2 Sim Vtx Freq |
| 3 Vtx AtoD |
| 4 Filter Set |
| 5 Change Filter Set |
| 6 High Pass Filter |
| 7 Gain Set |
| 8 Change Gain Set |
| 9 Re |
| Vel |
| Max Vel |
| AD1 |
| AD2 |
| AD3 |
| AD4 |
| Ck |
| Level |

| 1 Press |
| 2 Sim Press |
| 3 Excite |
| 4 Excite AtoD |
| 5 Sense |
| 6 Sense AtoD |
| 7 Max Press |

Review Menu

From Online Menu

| 1 Model |
| 2 Distributor |
| 3 Write protect |
| 4 Manufacturer |
| 5 Dev id |
| 6 Tag |
| 7 Descriptor |
| 8 Message |
| 9 Date |
| Final asmbly num |
| Universal rev |
| Fld dev rev |
| Software rev |
| Poll addr |
| Num req preams |

| 1 Temp |
| 2 Sim Temp |
| 3 RTD1 |
| 4 RTD1 AtoD |
| 5 Max temp |
| 6 Temp 2 |
| 7 Sim Temp 2 |
| 8 RTD2 |
| 9 RTD2 AtoD |
| Max temp 2 |

| SPI not communicating |
| Freq. Input Overrange |
| FRAM CRC error |
| Signal Board Power ... |
| RTD1 Fault |
| RTD2 Fault |
| Press. Transducer Fault |

| 1 Internal Temp (F) |
| 2 Internal Temp (C) |
| 3 Int. Max temp |
| 4 Int. Min temp |

| 1 Records in Log |
| 2 Read System Log |
| 3 System Log Clear |

| Totalizer Relay Overrange |

| 1 Status group 0 |
| 2 Status group 1 |
| 3 Status group 2 |

| Alarm 1 Set |
| Alarm 2 Set |
| Alarm 3 Set |

Figure 116: HART Commands with the Diagnostics Menu

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

Sensor Cal Menu

From Online Menu →

1 Calibration Review
2 Vortex Sensor
3 Vortex Cal
4 Press Sensor
5 Press Cal
6 Temp Sensor
7 Temp 1 & 2 Cal
8 Temp 2 Sensor
9 Cal. Correction

---

1 Vol unit
2 USL
3 LSL
4 Min Span
5 Snsr s/n
6 Sim Vtx freq
7 Max Vel
8 Vortex Diag

1 Vtx Freq
2 Sim Vtx Freq
3 Vtx AtoD
4 Filter Set
5 Change Filter Set
6 High Pass Filter
7 Gain Set
8 Change Gain Set
9 Re
   Vel
   Max Vel
   AD1
   AD2
   AD3
   AD4
   Ck
   Level

1 K Factor
2 Base Reynolds *
2 Ck Value
3 Low flow cutoff
4 Auto Set Ck
5 Auto Set LFC

1 K Factor
2 Base Reynolds *
2 Ck Value
3 Low flow cutoff
4 RTD1 R0
5 RTD1 alpha
6 RTD1 beta
7 RTD2 R0
8 RTD2 alpha
9 RTD2 beta
Pcal B00, Pcal B01
Pcal B02, Pcal B10
Pcal B11, Pcal B12
Pcal B20, Pcal B21
Pcal B22
Ref. Resistance
Internal Temp. Cal
Cal current
Flow 1
Deviation 1
Flow 2
Deviation 2
Flow 3
Deviation 3
Flow 4
Deviation 4
Flow 5
Deviation 5
Flow 6
Deviation 6
Flow 7
Deviation 7
Flow 8
Deviation 8
Flow 9
Deviation 9
Flow 10
Deviation 10
Ext. Loop Zero Count
Ext. Loop Span Count

1 Flow 1
2 Deviation 1
3 Flow 2
4 Deviation 2
5 Flow 3
6 Deviation 3
7 Flow 4
8 Deviation 4
9 Flow 5
   Deviation 5
   Flow 6
   Deviation 6
   Flow 7
   Deviation 7
   Flow 8
   Deviation 8
   Flow 9
   Deviation 9
   Flow 10
   Deviation 10

1 Line pres unit
2 USL
3 LSL
4 Min span
5 Snsr s/n
6 Sim Press
7 Max Press
8 Press Diag

1 Press
2 Sim Press
3 Excite
4 Excite AtoD
5 Sense
6 Sense AtoD
7 Max Press

* If insertion vortex

1 PCal B00
2 PCal B01
3 PCal B02
4 PCal B10
5 PCal B11
6 PCal B12
7 PCal B20
8 PCal B21
9 PCal B22
   Ref. Resistance
   Internal Temp. Cal
   Cal Current

1 Temp unit
2 USL
3 LSL
4 Min span
5 Snsr s/n
6 Sim Temp
7 Max Temp
8 Temp Diag

1 Temp
2 Sim Temp
3 RTD1
4 RTD1 AtoD
5 Max Temp
6 Temp 2
7 Sim Temp 2
8 RTD2
9 RTD2 AtoD
   Max temp 2

1 RTD1 Ro
2 RTD1 alpha
3 RTD1 beta
4 RTD2 Ro
5 RTD2 alpha
6 RTD2 beta

1 Temp unit
2 USL
3 LSL
4 Min span
5 Sim Temp 2
6 Max Temp 2
7 Temp Diag

1 Temp
2 Sim Temp
3 RTD1
4 RTD1 AtoD
5 Max Temp
6 Temp 2
7 Sim Temp 2
8 RTD2
9 RTD2 AtoD
   Max temp 2

Figure 117: HART Commands with the Sensor Cal Menu

4.1.3 HART Commands with the Generic Digital Display Menu

Note: Use password 16363.

Figure 118: HART Commands with the Generic Online Menu

4.2   Modbus Communications

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

4.2.1   Applicable Flow Meter Models

PanaFlow Mass Flow Meters, Models MV80 and MV82 with Modbus communication protocol and firmware version 4.00.58 and above are capable of Modbus commuinications.

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 Flow Meter. 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 119* below, is recommended. Do not use a star, ring, or cluster arrangement.
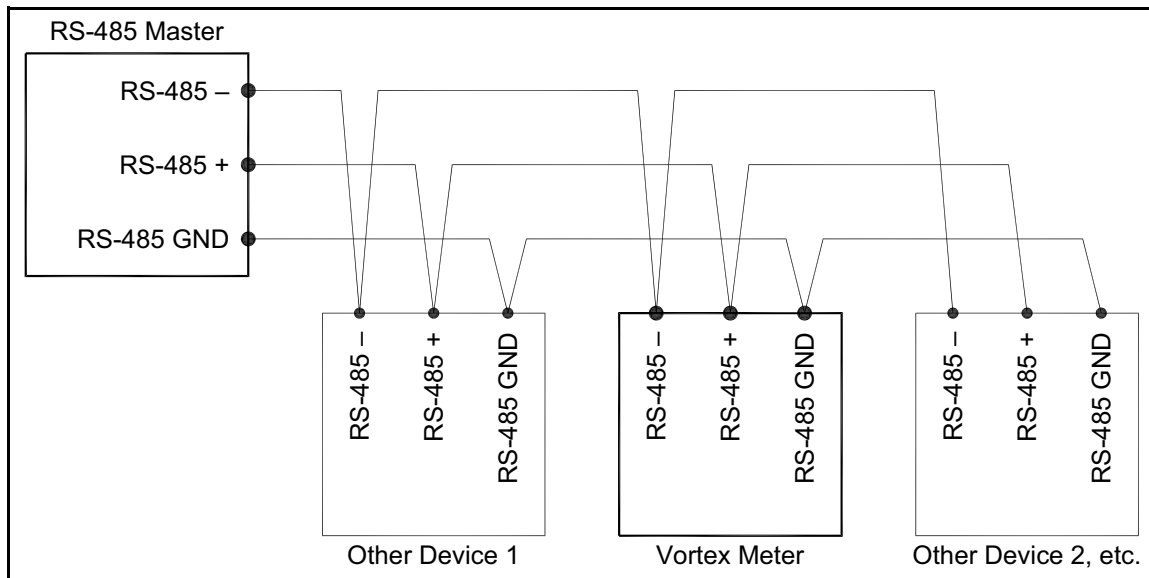
Figure 119: RS-485 Modbus Wiring

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.

4.2.6.1   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.

4.2.6.2   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.

4.2.6.3   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, ft^3/sec, Btu/sec, lbm/ft^3. The display variables are displayed in the user selected display units.

4.2.6.4   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 4 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 4: 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.

4.2.6.5   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 5* below) which is derived from the original Modicon Modbus protocol specification. This convention is used by many vendors of Modbus capable products.

Table 5: 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 6* below.

Table 6: 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

4.2.6.6   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 flow meter 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 7* 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 108*) 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 7: 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

4.2.6.6   Register Definitions (cont.)

Table 8 below shows the registers that are available with the energy meter firmware.

Table 8: 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 9 below shows the registers that contain the display units strings:

Table 9: 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.

4.2.6.7   Exception Status Definitions

The Read Exception Status command (function code 07) returns the exception status byte, which is defined as shown in *Table 10* below. This byte may be cleared by setting "coil" register #00003 (function code 5, address 2, data = 0xff00).

Table 10: Exception Status BIts

Bit(s)	Definition
0-1	Byte order (see Modbus Order on *"Modbus Order" on page 108*) • 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

4.2.6.8   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 11* 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 11: 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

4.2.6.9   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.

4.2.6.10 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 12* below).

Table 12: 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.

4.2.6.11 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 13: 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

4.2.6.12 Normal Response Message Format

Table 14: 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

4.2.6.13 Exception Response Message Format

Table 15: Exception Response Message Format

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

4.2.6.14   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.*

4.2.6.14   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

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 "BACnet" 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. 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 16* below shows the implemented properties for each Vortex Mass Flow Meter object type.

Table 16: Properties Object Types

Properties	Object Types			
	Device	Analog Input	Binary Input	Binary Value
Object_Identifier	☑	☑	☑	☑
Object_Name	☑	☑	☑	☑
Object_Type	☑	☑	☑	☑
System_Status	☑			
Vendor_Name	☑			
Vendor_Identifier	☑			
Model_Name	☑			
Firmware_Revision	☑			
Application-Software-Version	☑			
Protocol_Version	☑			
Protocol_Revision	☑			
Protocol_Services_Supported	☑			
Protocol_Object_Types_Supported	☑			
Object_List	☑			
Max_ADPU_Length_Accepted	☑			
Segmentation_Supported	☑			
ADPU_Timeout	☑			
Number_Of_ADPU_Retries	☑			
Max_Masters	☑			
Max_Info_Frames	☑			
Device_Address_Binding	☑			
Database_Revision	☑			
Status_Flags				
Event_State		☑	☑	☑

Table 16: Properties Object Types

Properties	Object Types			
	Device	Analog Input	Binary Input	Binary Value
Reliability				
Out_Of_Service		☑ (W)	☑ (W)	☑ (W)
Units		☑		
Polarity			☑ (W)	
Priority_Array				
Relinquish_Default				
Status_Flag		☑	☑	☑
Present_Value		☑ (W)	☑ (W)	☑ (W)
Inactive_Text				
Active_Text				
Note: *(W) = Writable Property.*				

4.3.4.1 Device Object

The Device object default property values are listed in *Table 17* below.

Table 17: Properties Default Values

Properties	Default Values
object–identifier	7
object–name	Device,1
object–type	Device
system–status	operational
vendor–name	Panametrics Measurement & Control
vendor–identifier	441
model–name	Multivariable Flow Meter
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,T,F,T,T,T,T,F,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: *Device Communication Control: Password –* **VorTex**.	

4.3.4.2   Analog Input Object

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

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

Object Instance	Object Name	Unit	Description
7	Energy Flow	Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	TBD
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

Object Instance	Object Name	Unit	Description
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

4.3.4.3   Binary Input Objects

The MV 80 and MV82 Vortex Mass Flow Meters Binary Input type objects are described in *Table 18* below.

Table 18: 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.*

4.3.4.4   Binary Value Objects

The MV 80 and MV82 Vortex Mass Flow Meters Binary Value type objects are described in *Table 19* below.

Table 19: 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: VorTex 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: VorTex 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 20 below lists all BACnet Interoperability Building Blocks Supported (Annex K):

Table 20: 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 21: 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 messagesWindow Size

☐Able to receive segmented messages Window Size

Standard Object Types Supported:

Table 22: 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 23: 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 24: 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 25: 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 flow meter repair, verify that the line is not pressurized. Always remove the main power before disassembling any part of the mass flow meter.**

5.1   Hidden Diagnostics Menus

The menus shown in *Figure 120 on page 130* 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 120 on page 130* are defined and specific troubleshooting steps are described in the following sections.

5.1   Hidden Diagnostics Menus (cont.)

(--------- Level One Values ---------)   (---------------------- Level Two Values ----------------------)

f fi G A	O I	4-20(1), Zero xxxx	Alarm(1) Test Low	Output Type None
A1 A2 A3 A4	Pulse Out Queue xxxxxxxxxx	4-20(1), FScale xxxx	Alarm(2) Test Low	Calibration Mode
Kc It Kb	TOF G f	4-20(2), Zero xxxx	Alarm(3) Test Low	A2D Ref. Resistor 2700
V Re	Sig. Rev Micro Rev	4-20(2), FScale xxxx	Reynolds Correction	Pres Cal Current 0.0003
Rtd1 = x.x Rtd2 = x.x	AD R T F PT V	4-20(3), Zero xxxx	Gain Control	Press 9 C's More >
Pe(v) = 0.0 Pv(v) = 0.0	Spi Err Rcv Sent	4-20(3), FScale xxxx	Filter Control	RTD 1 More >
Std = 1.000 Nrml = 1.000	ISR Diagnostic 0	Ext. 4mA Cal. x	High Pass Filt. 0.33	RTD 2 More >
Visc = xxxx Cp	Power Fail No	Ext. 20mA Cal. x	Factory Defaults	Correction Pairs
x Cnts Ext x.xxx mA	External Power Yes	External Input Inactive Temp 1 Temp 2 Press	Meter Type	Roughness xe-xx
Ck Lvl	External Alarm No		Config Code 1BFE	Force Recal?
Adj. Filter xx dB	Display Cg Pwr	Ext. Full Scale x	Test Pulse Out	Min Delta H 1
Iso. Power Volts x.x vdc	Internal Temp xx.xx Deg F	Ext. Zero Scale x	Test Scaled Freq x	Init Displ. (sec) xxx

* Not present on MV80 Models   ** Energy EMS Meters Only

Figure 120: 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.

- **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 flow meter 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 fi value to a constant. A value of zero activates the automatic filter control which sets fi at a level that floats above the f value.
- **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.
- **Correction Pairs**
- **ft3/sec** (1 through 10)
- **%Dev.** (1 through 10)
- **Roughness** = Factory use only.
- **Force Recal?** = Factory use only.
- **Min. Delta H** - Energy EM 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   Display Contrast Adjustment

The flow meter display contrast is set at the factory but if the display characters appear too dark or too light proceed as follows:

1.   Hold down the "Exit" button on the front panel for 5 to 10 seconds. "Setting Contrast" will appear.
2.   Push the "Up" arrow to darken the display or the "Down" arrow to lighten it.
3.   Push the "Enter" button to save the contrast setting.

5.4   Troubleshooting the Flow Meter

WARNING!   Before attempting any flow meter repair, verify that the line is not pressurized. Always remove the main power before disassembling any part of the flow meter. 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 flow meter, record the values listed in *Table 26* below from the Run Menu with the meter installed:

Table 26: Run Mode Values

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

5.4   Troubleshooting the Flow Meter (cont.)

Record These Values (cont.)

Record the values listed in *Table 27* below from the *Hidden Diagnostics Menu* with the meter installed: (Use the password **16363** to access the Hidden Diagnostics Menu).

Table 27: Hidden Diagnostics Menu Values

Parameter	With Flow	With No Flow (if possible)
f =		
fi =		
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 28* below from the *Calibration Menu*.

Table 28: Calibration Menu Values

Parameter	With Flow	With No Flow (if possible)
Meter Size / Pipe ID =		
Meter Factor =		
Vortex Coef Ck =		
Low Flow Cutoff =		
Serial Number =		

5.5   Determine the Fault

5.5.1   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.

5.5.2   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.

5.5.3   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 121* below) or the remote feed through board (see *Figure 122* below). Measure the resistance from each outside pin to the meter ground (see *Figure 123 on page 138*) – each should be open. Measure the resistance from the center pin to the meter ground – this should be grounded to the meter.
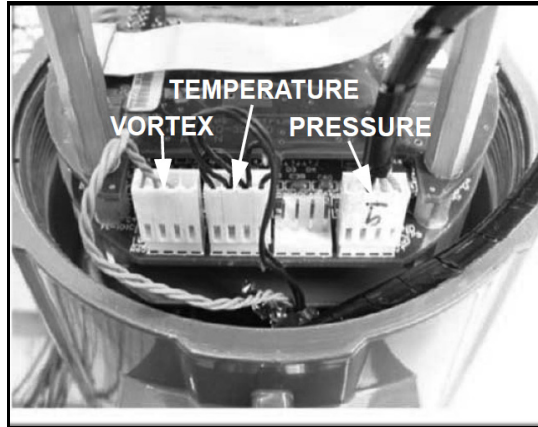
Figure 121: Electronics Stack Sensor Connections
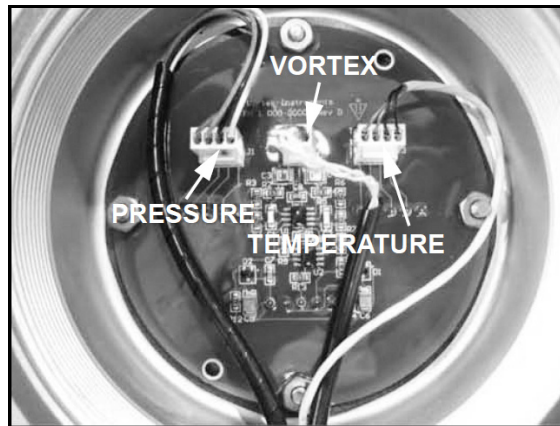
Figure 122: Remote Feed Through Board Sensor Connections

5.5.3   Symptom: No Output (cont.)
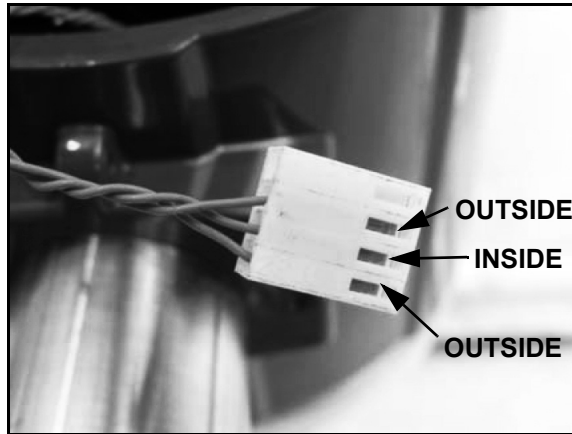
Figure 123: Vortex Sensor Connector Pins

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 Panametrics if necessary.

5.5.4   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 121 on page 137*) or the remote feed through board (see *Figure 122 on page 137*). Measure the resistance across the outside pins of the temperature sensor connector (see *Figure 124* below). It should read approximately 1080 ohms at room temperature (higher resistance at higher temperatures). Measure the resistance across the inside pins, they should read the same.

4. Measure the resistance from one of the outside pins to case ground then from one of the inside pins to case ground. They should read open.
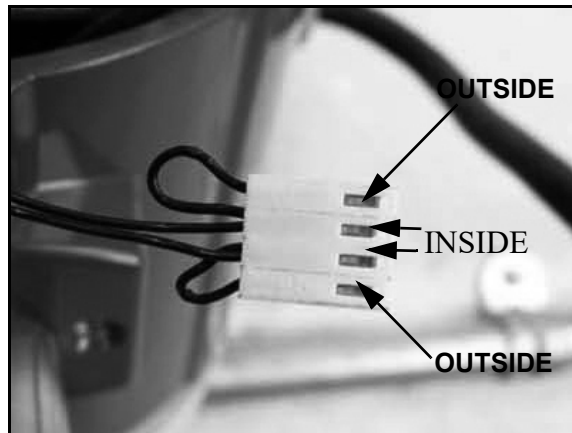
Figure 124: Temperature Sensor Connector Pins

5. Consult Panametrics with your findings

5.5.5   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 121 on page 137*) or the remote feed through board (see *Figure 122 on page 137*). Measure the resistance across the outside pins of the pressure sensor connector, then across the inside pins (see *Figure 125* below). Both readings should be approximately 4400 ohms.
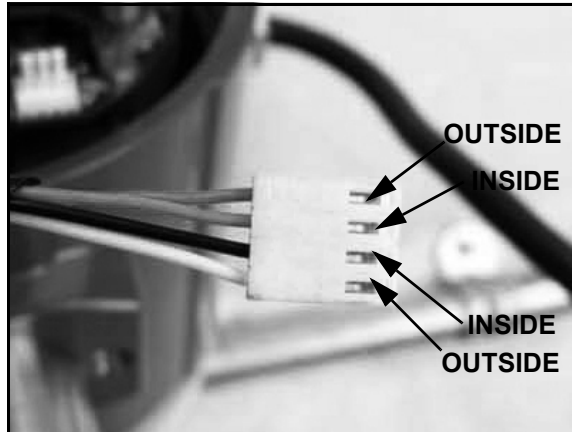
Figure 125: Pressure Sensor Connector

3. Measure the resistance from one of the outside pins to case ground then from one of the inside pins to case ground. They should read open.

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

5.6   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 flow meter repair, verify that the line is not pressurized. Always remove the main power before disassembling any part of the mass flow meter.**

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 flow meter and attaches to the circuit boards. Make note of the location of each sensor connection (see Figure 121 on page 137 or Figure 122 on page 137). 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.

5.7   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.

5.8   Returning Equipment to the Factory

Before returning any PanaFlow MV flow meter to the factory, you <u>must</u> request a Return Material Authorization (**RMA**) number. To obtain an **RMA** number and the correct shipping address, contact *Panametrics 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 Flow Meter" on page 134* 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	±2º F (±1ºC)	±2º F (±1ºC)	±2º F (±1ºC)	±2º F (±1ºC)
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

[1]Accuracies stated are for the total mass flow through the pipe.
[2]Over 50 to 100% of the pressure transducer's full scale.
[3]Nominal 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: ± 0.2º F (± 0.1º 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: ± 0.1º F (± 0.5º 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 Flow Meter:
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 Flow Meter:
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 Panametrics for sizing assistancApril 2019e.

Water Minimum and Maximum Flow Rates									
	½-inch	¾-inch	1-inch	1.5-inch	2-inch	3-inch	4-inch	6-inch	8-inch
Units	15 mm	20 mm	25 mm	40 mm	50 mm	80 mm	100 mm	150 mm	200 mm
gpm	1 22	1.3 40	2.2 67	5.5 166	9.2 276	21 618	36 1076	81 2437	142 4270
m³/hr	0.23 5	0.3 9.1	0.5 15	1.3 38	2.1 63	4.7 140	8.1 244	18 554	32 970

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

Flow Rates (cont.)

Typical Air (@20°F) Minimum and Maximum Flow Rates (nm^3/hr)									
	Nominal Pipe Size (mm)								
Pressure	15	20	25	40	50	80	100	150	200
0 barg	3 28	5 66	9 142	21 350	36 584	79 1307	138 2275	313 5157	549 9034
5 barg	7 165	13 390	21 847	52 2080	87 3476	194 7775	337 13533	764 30682	1339 53749
10 barg	9 304	17 716	29 1554	70 3819	117 6381	262 14273	457 24844	1035 56329	1814 98676
15 barg	11 442	21 1044	34 2265	85 5565	142 9299	317 20801	551 36205	1250 82087	2190 143801
20 barg	13 582	24 1373	40 2979	97 7318	162 12229	363 27354	632 47612	1434 107949	2511 189105
30 barg	16 862	29 2034	48 4414	118 10843	198 18119	442 40529	770 70544	1745 159942	3057 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)									
	Nominal Pipe Size (in)								
Pressure	0.5	0.75	1	1.5	2	3	4	6	8
5 psig	6.5 52	12 122	20 265	49 650	82 1087	183 2431	318 4231	722 9594	1264 16806
100 psig	15 271	27 639	46 1386	112 3405	187 5690	419 12729	728 22156	1652 50233	2893 87998
200 psig	20 493	37 1163	62 2525	151 6203	253 10365	565 23184	983 40354	2229 91494	3905 160279
300 psig	24 716	45 1688	74 3664	182 9000	304 15040	680 33642	1184 58556	2685 132763	4704 232575
400 psig	28 941	51 2220	85 4816	209 11831	349 19770	780 44222	1358 76971	3079 174516	5393 305717
500 psig	31 1170	57 2760	95 5988	233 14711	389 24582	870 54987	1514 95710	3433 217001	6014 380148

Typical Saturated Steam Minimum and Maximum Flow Rates (kg/hr)									
	Nominal Pipe Size (mm)								
Pressure	15	20	25	40	50	80	100	150	200
0 barg	3 28	5 66	9 142	19 350	32 584	72 1307	126 2275	286 5157	500 9034
5 barg	6 95	11 224	18 485	45 1192	75 1992	167 4455	290 7754	658 17581	1153 30799
10 barg	8 168	15 397	24 862	59 2118	99 3539	222 7915	387 13777	877 31237	1537 54720
15 barg	9 241	17 569	29 1236	71 3036	119 5073	266 11347	463 19750	1050 44779	1840 78444
20 barg	11 314	20 742	33 1610	81 3956	136 6611	304 14787	529 25738	1199 58355	2100 102226
30 barg	13 463	24 1092	40 2370	99 5822	165 9729	369 21763	642 37880	1455 85884	2548 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, PN63
Wafer	316L SS, A105 Carbon Steel, C276 Hastelloy	600 lb, PN63

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 PN63	316L SS	ANSI 600 lb, PN63	C600, C63
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, DN50 PN40	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 PN63	316L SS	ANSI 600 lb	P600R, P63R

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

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

Use a Class 2 isolated power supply that is grounded, provides DC output, and has no more than 10% output ripple.

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

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

User is responsible for the provision of an external Disconnect Means, disconnect line 1 and line 2 when 220/240 VAC power is used, also provide 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 500ºF (−200 to 260ºC)
High temperature sensor: to 750ºF (400ºC)

Ambient:
Operating temperature range: −40 to 140º F (−40 to 60º C)
Storage temperature range: −40 to 185º F (−40 to 85º 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 Signals[1]

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

Communications:
HART, MODBUS, RS485, BACnet

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.

[1]All 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 and MV84 In-Line Flow Meter:
316L stainless steel standard
C276 hastelloy or A105 carbon steel optional

Series MV82 Insertion Flow Meter:
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 and MV84: Wafer, 150, 300, 600 lb ANSI flange, PN16, PN40, PN63 flange
Series MV82 Permanent installation: 2-inch MNPT; 150, 300, 600 lb ANSI flange, PN16, PN40, PN63 flange with compression fitting probe seal
Series MV82 Hot Tap[1] Installation: 2-inch MNPT; 150, 300, 600 lb ANSI flange, PN16, PN40, PN63 flange and optional retractor with packing gland probe seal. [1]Removable under line pressure

Mounting Position

Series MV80 and MV84 In-Line Flow Meter: No effect
Series MV82 Insertion Flow Meter: Meter must be perpendicular within ±5° 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 Flow Meter

A	-	B	-	C	-	D	-	E	-	F	-	G	-	H	-	I	-	J	-	K

Parent Number Code:

MV80	In-line Multivariable Mass Vortex Flow Meter

Feature 1: Multivariable Options

V	Volumetric flow meter for liquid, gas and steam
VT	Velocity and temperature sensors
VTP	Velocity, temperature and pressure sensors
VT-EM	Energy output options
VTP-EM	Energy options with pressure sensor
VT-EP	Velocity and temperature sensors with analog input for pressure
VTEP-EM	Energy option with external pressure sensor

Feature 2: Flow Body

04	1/2-inch Nominal Bore (15 mm)
06	3/4-inch Nominal Bore (20 mm)
08	1-inch Nominal Bore (25 mm)
12	1.5-inch Nominal Bore (40 mm)
16	2-inch Nominal Bore (50 mm)
24	3-inch Nominal Bore (80 mm)
32	4-inch Nominal Bore (100 mm)
48	6-inch Nominal Bore (150 mm)
64	8-inch Nominal Bore (200 mm)
80	10-inch Nominal Bore (250mm)
96	12-inch Nominal Bore (300mm)

Feature 3: Meter Body Material

C	Carbon Steel
S	316 Stainless Steel
H	Hastelloy

Feature 4: Process Connection

150	ANSI 150# Flange
300	ANSI 300# Flange
600	ANSI 600# Flange
W	Wafer ANSI 600#
16	PN 16
40	PN 40
63	PN 63

Feature 5: Electronics Enclosure

L	Type 4X enclosure
R (25)	Remote electronics Type 4X, 25 ft (8 m) cable
R (50)	Remote electronics Type 4X, 50 ft (8 m) cable

Feature 6: Display Options

DD	Digital Display and Programming Buttons
ND	No Display

Feature 7: Input Power

DC2	12 to 36 VDC required on 2-wire (loop powered) meters with 1AHL only
DC4	12 to 36 VDC standard volumetric meter on 4-wire
AC	100-240 VAC, 50/60 Hz
DC4POE	12-28 VDC or Power over Ethernet (5 Watts maximum), Requires TCP/IP option

Feature 8: Output

1AHL	Loop powered option - one analog output (4-20mA), one pulse, one frequency, HART (DC2 option only)
1AH	1AH One analog output (4-20mA), one alarm, one pulse, one frequency, HART (DC4 or AC option only)
1AM	One analog output (4-20mA), one alarm, one pulse, one frequency, Modbus/RTU (DC4 or AC option only)
1AMIP	One analog output (4-20mA), one alarm, one pulse, one frequency, Modbus TCP/IP (DC4POE option only)
1AB	One analog output (4-20mA), one alarm, one pulse, one frequency, BACnet/MSTP (DC4 or AC option only)
1ABIP	One analog output (4-20mA), one alarm, one pulse, one frequency, BACnet TCP/IP (DC4POE option only)
3AH	Three analog output (4-20mA), three alarm, one pulse, one frequency, HART (DC4 or AC option only)
3AM	Three analog output (4-20mA), three alarm, one pulse, one frequency, Modbus RTU (DC4 or AC option only)
3AMIP	Three analog output (4-20mA), three alarms, one pulse, one frequency, Modbus TCP/IP (DC4POE option only)
3AB	Three analog output (4-20mA), three alarm, one pulse, one frequency, BACnet/MSTP (DC4 or AC option only)
3ABIP	Three analog output (4-20mA), three alarms, one pulse, one frequency, BACnet TCP/IP (DC4POE option only)

Feature 9: Process Temperature Options

ST	Standard Process Temperature -40° to 500°F (-40° to 260°C)
HT	High Process Temperature up to 750°F (400°C)

Feature 10: Process Pressure

P0	No pressure sensor
P1	Maximum 30 psia (2 bara), Proof 60 psia (4 bara)
P2	Maximum 100 psia (7 bara), Proof 200 psia (14 bara)
P3	Maximum 300 psia (20 bara), Proof 600 psia (41 bara)
P4	Maximum 500 psia (34 bara), Proof 1000 psia (64 bara)
P5	Maximum 1500 psia (100 bara), Proof 2500 psia (175 bara)

MV80	-	V	-	24	-	S	-	300	-	L	-	DD	-	AC	-	1AM	-	ST	-	P1	(example part number string)

Model Number Information: Series MV82 Insertion Flow Meter

A	-	B	-	C	-	D	-	E	-	F	-	G	-	H	-	I	-	J

Parent Number Code:

MV82	Insertion Multivariable Mass Vortex Flowmeter

Feature 1: Multivariable Options

V	Volumetric flow meter for liquid, gas and steam
VT	Velocity and temperature sensors
VTP	Velocity, temperature and pressure sensors
VT-EM	Energy output options
VTP-EM	Energy options with pressure sensor
VT-EP	Velocity and temperature sensors with analog input for pressure
VTEP-EM	Energy option with external pressure sensor

Feature 2: Probe Length

SL	Standard length
CL	Compact length
EL	Extended length

Feature 3: Electronics Enclosure

L	
R (25)	
R (50)	

Feature 4: Display Options

DD	Digital Display and Programming Buttons
ND	No Display

Feature 5: Input Power

DC2	Digital Display and Programming Buttons
DC4	No Display
AC	100-240 VAC, 50/60 Hz
DC4POE	12-28 VDC or Power over Ethernet (5 Watts maximum), Requires TCP/IP option

Feature 6: Output Signal

1AHL	Loop powered option - one analog output (4-20mA), one pulse, one frequency, HART (DC2 option only)
1AH	One analog output (4-20mA), one alarm, one pulse, one frequency, HART (DC4 or AC option only)
1AM	One analog output (4-20mA), one alarm, one pulse, one frequency, Modbus/RTU (DC4 or AC option only)
1AMIP	One analog output (4-20mA), one alarm, one pulse, one frequency, Modbus TCP/IP (DC4POE option only)
1AB	One analog output (4-20mA), one alarm, one pulse, one frequency, BACnet/MSTP (DC4 or AC option only)
1ABIP	One analog output (4-20mA), one alarm, one pulse, one frequency, BACnet TCP/IP (DC4POE option only)
3AH	Three analog output (4-20mA), three alarm, one pulse, one frequency, Modbus RTU (DC4 or AC option only)
3AM	Three analog outputs (4-20 mA), three alarms, one pulse, MODBUS, (VT, VTP only)
3AMIP	Three analog output (4-20mA), three alarms, one pulse, one frequency, Modbus TCP/IP (DC4POE option only)
3AB	Three analog output (4-20mA), three alarm, one pulse, one frequency, BACnet/MSTP (DC4 or AC option only)
3ABIP	Three analog output (4-20mA), three alarms, one pulse, one frequency, BACnet TCP/IP (DC4POE option only)

Feature 7: Process Temperature Options

ST	Standard process temperature -40° to 500°F (-40° to 260°C)
HT	High process temperature 750°F (400°C)

Feature 8: Pressure Options

P0	No pressure sensor
P1	Maximum 30 psi (2 barg), Proof 60 psia (4barag)
P2	Maximum 100 psi (7 barg), Proof 200 psia (14barag)
P3	Maximum 300 psi (20 barg), Proof 600 psia (41 barag)
P4	Maximum 500 psi (34 barg), Proof 1000 psia (64 barag)
P5	Maximum 1500 psi (100 barg), Proof 2500 psia (175 barag)

Feature 9: Process Connections

CNPT	Compression, 2 inch NPT
C150	Compression, 2 inch 150# Flange
C16	Compression, DN50 PN16 Flange
C300	Compression, 2 inch 300# Flange
C40	Compression, DN50 PN40 Flange
C600	Compression, 2 inch 600# Flange
C63	Compression, DN50 PN63 Flange
PNPT	Packing Gland, 2 inch NPT
P150	Packing Gland, 2 inch 150# Flange
P16	Packing Gland, DN50 PN16 Flange
P300	Packing Gland, 2 inch 300# Flange
P40	Packing Gland, DN50 PN40 Flange
PNPTR	Packing Gland, 2 inch NPT, Retractor
P150R	Packing Gland, 2 inch 150# Flange, Retractor
P16R	Packing Gland, DN50 PN16 Flange, Retractor
P300R	Packing Gland, 2 inch 300# Flange, Retractor
P40R	Packing Gland, DN50 PN40 Flange, Retractor
P600R	Packing Gland, 2 inch 600# Flange, Retractor
P63R	Packing Gland, DN50 PN63 Flange, Retractor

MV82	-	V	-	SL	-	L	-	DD	-	DC2	-	1AM	-	ST	-	P1	-	C16	(example part number string)

Model Number Information: Series MV84 Inline Mass Vortex Flow Meter

A	-	B	-	C	-	D	-	E	-	F	-	G	-	H	-	I	-	J	-	K

Parent Number Code:

MV84	In-line Multivariable Mass Vortex Flow Meter
MV84R	In-line Reducing Multivariable Mass Vortex Flow Meter

Feature 1: Multivariable Options

V	Volumetric flow meter for liquid, gas and steam
VT	Velocity and temperature sensors
VTP	Velocity, temperature and pressure sensors
VT-EM	Energy output options
VTP-EM	Energy options with pressure sensor
VT-EP	Velocity and temperature sensors with analog input for pressure
VTEP-EM	Energy option with external pressure sensor

Feature 2: Flow Body

04	1/2-inch Nominal Bore (15 mm)
06	3/4-inch Nominal Bore (20 mm)
08	1-inch Nominal Bore (25 mm)
12	1.5-inch Nominal Bore (40 mm)
16	2-inch Nominal Bore (50 mm)
24	3-inch Nominal Bore (80 mm)
32	4-inch Nominal Bore (100 mm)
48	6-inch Nominal Bore (150 mm)
64	8-inch Nominal Bore (200 mm)
80	10-inch Nominal Bore (250mm)
96	12-inch Nominal Bore (300mm)

Feature 3: Meter Body Material

C	Carbon Steel
S	316 Stainless Steel
H	Hastelloy

Feature 4: Process Connection

150	ANSI 150# Flange
300	ANSI 300# Flange
600	ANSI 600# Flange
W	Wafer ANSI 600#
16	PN 16
40	PN 40
63	PN 63

Feature 5: Electronics Enclosure

L	Type 4X enclosure
R (25)	Remote electronics Type 4X, 25 ft (8 m) cable
R (50)	Remote electronics Type 4X, 50 ft (8 m) cable

Feature 6: Display Options

DD	Digital Display and Programming Buttons
ND	No Display

Feature 7: Input Power

DC2	12 to 36 VDC required on 2-wire (loop powered) meters with 1AHL only
DC4	12 to 36 VDC standard volumetric meter on 4-wire
AC	100-240 VAC, 50/60 Hz
DC4POE	12-28 VDC or Power over Ethernet (5 Watts maximum), Requires TCP/IP option

Feature 8: Output

1AHL	Loop powered option - one analog output (4-20mA), one pulse, one frequency, HART (DC2 option only)
1AH	1AH One analog output (4-20mA), one alarm, one pulse, one frequency, HART (DC4 or AC option only)
1AM	One analog output (4-20mA), one alarm, one pulse, one frequency, Modbus/RTU (DC4 or AC option only)
1AMIP	One analog output (4-20mA), one alarm, one pulse, one frequency, Modbus TCP/IP (DC4POE option only)
1AB	One analog output (4-20mA), one alarm, one pulse, one frequency, BACnet/MSTP (DC4 or AC option only)
1ABIP	One analog output (4-20mA), one alarm, one pulse, one frequency, BACnet TCP/IP (DC4POE option only)
3AH	Three analog output (4-20mA), three alarm, one pulse, one frequency, HART (DC4 or AC option only)
3AM	Three analog output (4-20mA), three alarm, one pulse, one frequency, Modbus RTU (DC4 or AC option only)
3AMIP	Three analog output (4-20mA), three alarms, one pulse, one frequency, Modbus TCP/IP (DC4POE option only)
3AB	Three analog output (4-20mA), three alarm, one pulse, one frequency, BACnet/MSTP (DC4 or AC option only)

Feature 9: Process Temperature Options

ST	Standard Process Temperature -40° to 500°F (-40° to 260°C)
HT	High Process Temperature up to 750°F (400°C)

Feature 10: Process Pressure

P0	No pressure sensor
P1	Maximum 30 psia (2 bara), Proof 60 psia (4 bara)
P2	Maximum 100 psia (7 bara), Proof 200 psia (14 bara)
P3	Maximum 300 psia (20 bara), Proof 600 psia (41 bara)
P4	Maximum 500 psia (34 bara), Proof 1000 psia (64 bara)
P5	Maximum 1500 psia (100 bara), Proof 2500 psia (175 bara)

MV84	-	V	-	08R	-	C	-	50	-	L	-	DD	-	DC2	-	1AHL	-	ST	-	P0	(example part number string)

[no content intended for this page]

Appendix B.   Approvals

ATEX-IECEx Specifications / Approval

EN IEC 60070-0 (2018)
Electrical Apparatus for explosive gas atmospheres
General Requirements

EN IEC 60079-1 (2014)
Electrical Apparatus for explosive gas atmospheres
Flameproof enclosures "d"

EN 60079-31 (2014)
Explosive atmospheres. Equipment dust ignition protection by enclosure "t"

Directive 2014/34/EU
Equipment Intended for use in Potentially Explosive Atmospheres (ATEX)

-0001
(PanaFlow Model **MV80, MV82, MV84** *and*
MV84R, **ST**, w/ATEX *and* IECEx)
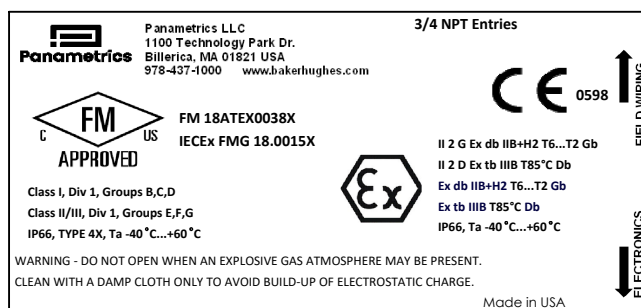
-0002
(PanaFlow Model **MV80, MV82, MV84** *and*
MV84R, **HT**, w/ATEX *and* IECEx)
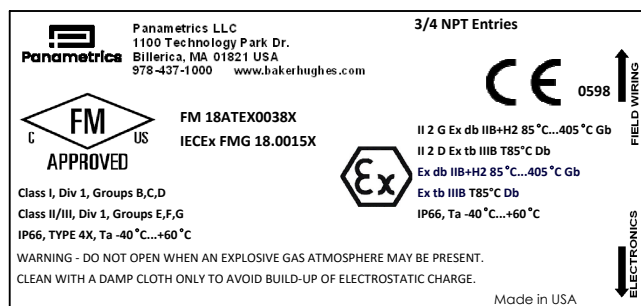
Technical assistance may be obtained by contacting *Panametrics Customer Service* using the information on the back cover of this manual.

[no content intended for this page]

Appendix C. Flow Meter Calculations

C.1   In-Line Flow Meter 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 (ft^2)

f = Vortex shedding frequency (pulses/sec)

K = Meter factor corrected for thermal expansion (pulses/ft^3)

Q_M = Mass flow rate (lbm/sec)

Q_V = Volume flow rate (ft^3/sec)

V_f = Flowing velocity (ft/sec)

ρ = Density (lbm/ft^3)

C.2   Insertion Flow Meter 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 (ft^2)

f = Vortex shedding frequency (pulses/sec)

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

Q_V = Volume flow rate (ft^3/sec)

Q_M = Mass flow rate (lbm/sec)

V_f = Flowing velocity (ft/sec)

ρ = Density (lbm/ft^3)

C.3   Energy Flow Calculations

Energy is calculated for a steam supply/condensate return or hot/chilled water system. For steam/water, the meter must be located in the supply line; otherwise, the meter may be located in either the supply line or in the return line.

C.3.1   Steam supply, water return, meter steam supply

Energy = mdot * (h0 - pctRet * h1)

Where:

mdot = mass flow at the meter, lbm/sec

pctRet = estimated percent of mass flow returned

h0 = Steam Enthalpy (t0, p)

h1 = Water Enthalpy (t1)

t0 = steam temperature

t1 = return water temperature

p = steam pressure

C.3.2   Water supply and return, meter supply

Energy = mdot * (h0 - pctRet * h1)

Where:

h0 = Water Enthalpy (t0)

h1 = Water Enthalpy (t1)

t0 = supply water temperature

t1 = return water temperature

C.3.3   Water supply and return, meter return

Energy = mdot * (h1/pctRet - h0)

Where:

h0 = Water Enthalpy (t0)

h1 = Water Enthalpy (t1)

t0 = supply water temperature

t1 = return water temperature

The energy flow is positive if less energy is returned than is supplied. This implies that chilled water systems will indicate negative energy flow. Positive and negative energy flows are accumulated in separate totalizers.

C.4   Fluid Calculations

C.4.1   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.4.1a   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

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

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

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

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

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

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

Where:
τ is 1/ temperature in Kelvin
density = 1/(v/ standard density of water)

C.4.1b   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.4.2   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.4.2a   Density

The density for real gases is calculated from the equation:

$$\delta = \frac{G M_{w, \text{Air}} p_f}{Z_f R_0 T_f}$$

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 PanaFlow MV internal fluid data table with the other coefficients.

C.4.2b   Viscosity

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

$$\mu_{cP} = aT_K^n$$

Where:
a 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

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

C.4.3   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.4.3a   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:

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

The specific gravity can then be converted into density.

C.4.3b   Viscosity

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

Andrade's equation:

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

To find A and B:

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

and

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

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

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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 flow meter, 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
Ft^2	Square feet, measure of area
Ft^3	Cubic feet, measure of volume
GPM	Gallons Per Minute
Hz	Hertz, cycles per second
In-Line Flow Meter	A flow meter which includes a short section of piping which is put in-line with the user's piping

Insertion Flow Meter	A flow meter 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
ṁ	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/ρ). The Reynolds number is an important number for vortex flow meters 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 flow meters 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 Panametrics is warranted to be free from defects in material and workmanship. Liability under this warranty is limited to restoring the instrument to normal operation or replacing the instrument, at the sole discretion of Panametrics. Fuses and batteries are specifically excluded from any liability. This warranty is effective from the date of delivery to the original purchaser. If Panametrics determines that the equipment was defective, the warranty period is:

- One year from delivery for electronic or mechanical failures

- One year from delivery for sensor shelf life

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

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

Return Policy

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

1. Notify Panametrics, giving full details of the problem, and provide the model number and serial number of the instrument. If the nature of the problem indicates the need for factory service, Panametrics will issue a RETURN AUTHORIZATION NUMBER (RAN), and shipping instructions for the return of the instrument to a service center will be provided.

2. If Panametrics instructs you to send your instrument to a service center, it must be shipped prepaid to the authorized repair station indicated in the shipping instructions.

3. Upon receipt, Panametrics will evaluate the instrument to determine the cause of the malfunction.

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

- If the damage is covered under the terms of the warranty, the instrument will be repaired at no cost to the owner and returned.

- If Panametrics 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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BH030C11 EN F (05/2023)

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