PanaFlow™ MV80 & MV82

Vortex Volumetric and Mass Flow Meters

User’s Manual
CUSTOMER NOTICE FOR OXYGEN SERVICE! Unless you have specifically ordered optional \( \text{O}_2 \) cleaning, this flow meter may not be fit for oxygen service. Some models can only be properly cleaned during the manufacturing process. GE Oil & Gas is not liable for any damage or personal injury, whatsoever, resulting from the use of the MV80 or MV 82 standard mass flow meters for oxygen gas.
Information Paragraphs

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

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

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

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

Safety Issues

![WARNING!] It is the responsibility of the user to make sure all local, county, state and national codes, regulations, rules and laws related to safety and safe operating conditions are met for each installation. The safety of any system incorporating the equipment is the responsibility of the assembler of the system.

Auxiliary Equipment

Local Safety Standards

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

Working Area

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

![WARNING!] Make sure that power to the auxiliary equipment is turned OFF and locked out before you perform maintenance procedures on the equipment.
Qualification of Personnel

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

Personal Safety Equipment

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

Unauthorized Operation

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

Environmental Compliance

Waste Electrical and Electronic Equipment (WEEE) Directive

GE Measurement & Control is an active participant in Europe’s *Waste Electrical and Electronic Equipment (WEEE)* take-back initiative, directive 2012/19/EU.

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

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

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

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

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Chapter 1. Introduction

1.1 Multi-Parameter Vortex Mass Flow Meters

The GE 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 and MODBUS protocols
- Chapter 5 covers troubleshooting and repair
- Appendix A lists the product specifications
- Appendix B shows current agency approvals
- Appendix C Discusses flow meter calculations
- Appendix D lists a glossary of terms
1.2 How the PanaFlow Vortex Mass Flow Meter Operates

PanaFlow MV80 and MV82 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](image)

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 turndown, reliability and simplicity.
1.3.1 Vortex Shedding Frequency

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

![Vortex Shedding Frequency Diagram](image)

**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>
<thead>
<tr>
<th>Parameter</th>
<th>Gas</th>
<th>Liquid</th>
<th>Units for (\rho)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{\text{min}})</td>
<td>(\frac{25\text{ft/s}}{\sqrt{\rho}})</td>
<td>1 ft/s</td>
<td>English (\rho) (lb/ft(^3))</td>
</tr>
<tr>
<td>(V_{\text{max}})</td>
<td>300 ft/s</td>
<td>30 ft/s</td>
<td></td>
</tr>
<tr>
<td>(V_{\text{min}})</td>
<td>(\frac{37\text{m/s}}{\sqrt{\rho}})</td>
<td>0.3 m/s</td>
<td>Metric (\rho) (kg/m(^3))</td>
</tr>
<tr>
<td>(V_{\text{max}})</td>
<td>91 m/s</td>
<td>9.1 m/s</td>
<td></td>
</tr>
</tbody>
</table>

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

\[
\Delta P = 0.00024 \rho V^2 \quad \text{English units (}\Delta P\text{ in psi, }\rho\text{ in lb/ft}^3, V\text{ in ft/sec)}
\]

\[
\Delta P = 0.00011 \rho V^2 \quad \text{Metric units (}\Delta P\text{ in bar, }\rho\text{ in kg/m}^3, V\text{ in m/sec)}
\]

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

\[
Re = \frac{\rho V D}{\mu}
\]

Where, \(Re\) = Reynolds Number
\(\rho\) = mass density of the fluid being measured
\(V\) = velocity of the fluid being measured
\(D\) = internal diameter of the flow channel
\(\mu\) = 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
1.3.3 Flow Velocity Range (cont.)

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

![Figure 3: Reynolds Number Range for the PanaFlow MV](image)

1.4 Temperature Measurement

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

1.5 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).
1.6 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 GE for specific installation advice.

1.6.1 Multivariable Options

The MV80 or MV82 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.
1.6.2 Line Size, Process Connections and Materials

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

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

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

1.6.3 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 or HART communications are also available.

PanaFlow flow meters include a local 2 x 16 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.
no content intended for this page
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 11 for Series MV80 installation instructions. See “Series MV82 Insertion Flow Meter Installation” on page 15 for Series MV82 installation instructions. Wiring instructions begin in “Loop Power Flow Meter Wiring Connections” on page 32.

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.
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.

---

<table>
<thead>
<tr>
<th>Example</th>
<th>Minimum Required Upstream Diameters</th>
<th>Minimum Required Downstream Diameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Flow Conditioner</td>
<td>With Flow Conditioner</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>10D</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>15D</td>
<td>10D</td>
</tr>
<tr>
<td>3</td>
<td>25D</td>
<td>10D</td>
</tr>
<tr>
<td>4</td>
<td>10D</td>
<td>10D</td>
</tr>
<tr>
<td>5</td>
<td>20D</td>
<td>10D</td>
</tr>
<tr>
<td>6</td>
<td>25D</td>
<td>10D</td>
</tr>
</tbody>
</table>

D = Internal diameter of channel. N/A = Not applicable.

---

Figure 4: Recommended Pipe Length Requirements for Installation of Series MV80 & MV82
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 6 on page 12 and Figure 7 on page 14. Table 2 below provides the recommended minimum stud bolt lengths for wafer-style meter body size and different flange ratings.

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

Series MV80 Meters require customer-supplied gaskets. When selecting gasket material make sure that it is compatible with the process fluid and pressure ratings of the specific installation. Verify that the inside diameter of the gasket is larger than the inside diameter of the 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

Table 2: Minimum Recommended Stud Bolt Lengths for Wafer Meters

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

The required bolt load for sealing the gasket joint is affected by several application-dependent factors. Therefore the required torque for each application may be different. Refer to the ASME Pressure Vessel Code guidelines for bolt tightening standards and refer to Figure 5 below for the proper bolt tightening sequence.
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 6 below). If the process fluid is a liquid, make sure the meter is located where the pipe is always full. This may require locating the meter at a low point in the piping system.

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

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

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.

**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.
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 5 on page 11. 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 7 below). If the process fluid is a liquid, make sure the meter is located where the pipe is always full. This may require locating the meter at a low point in the piping system.

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

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

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**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 5 on page 11. 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.

2.3.1a Electronics Enclosure Clearance

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

2.3.1b Isolation Valve Selection

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

1. A minimum valve bore diameter of 1.875 inches is required, and the valve’s body size should be two inches. Normally, gate valves are used.

2. Verify that the valve’s body and flange rating are within the 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 8: Isolation Valve Dimensions](image-url)
2.3.1c Cold Tap Guidelines

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

**CAUTION!** When using toxic or corrosive gases, purge the line with inert gas for a minimum of four hours at full gas flow before installing the 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 9 below).

![Figure 9: Connection Alignment](image-url)

7. Install the isolation valve (if used).
8. When welding is complete and all fittings are installed, close the isolation valve or cap the line. Run a static pressure check on the welds. If pressure loss or leaks are detected, repair the joint and retest.
9. Connect the meter to the pipe process connection.
10. Calculate the sensor probe insertion depth and insert the sensor probe into the pipe as described on the following pages.
2.3.1d Hot Tap Guidelines

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

**WARNING!** All 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 10 below are general in nature and are intended for guideline purposes only.

![Figure 10: Hot Tap Sequence](image)

Check upstream and downstream piping requirements.

Weld mounting adapter.

Connect process connection (flange or NPT)

Connect isolation valve.

Hot tap pipe

Test for leaks, purge pipe.

Connect meter to valve, calculate insertion depth, install flowmeter.
2.3.1d  *Hot Tap Guidelines (cont.)*

Proceed as follows:

1. Confirm that the installation site meets the minimum upstream and downstream pipe diameter requirements.
2. Weld a two inch mounting adapter on the pipe. Make sure the mounting adapter is within ± 5° perpendicular to the pipe centerline (see *Figure 9 on page 16*). The pipe opening must be at least 1.875 inches in diameter.
3. Connect a two inch process connection on the mounting adapter.
4. Connect an isolation valve on the process connection. The valve's full open bore must be at least 1.875 inches in diameter.
5. Run a static pressure check on the welds. If pressure loss or leaks are detected, repair the joint and re-test.
6. Connect the hot tapping equipment to the isolation valve, open the isolation valve and drill at least a 1.875 inch diameter hole.
7. Retract the drill, close the isolation valve, and remove the hot tapping equipment.
8. Connect the 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.
2.3.1e Insertion Guidelines

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

Insertion 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.

2.3.1f 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 20.
- 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 23.
- 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 28.
2.3.2 Installing Flow Meters with a Compression Connection

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

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.)
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 11 on page 20, the insertion length for this example is 21.03 inches. Insert the stem through the fitting until an insertion length of 21.03 inches is measured with a ruler.

Figure 12: 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 12 on page 21 and complete the following steps:

1. Refer to Figure 11 on page 20 and calculate the required sensor probe insertion length for your system.

2. Fully retract the stem until the sensor head is touching the bottom of the stem housing. Slightly tighten the compression nut to prevent slippage.

3. Bolt or screw the 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 13 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 24 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 26.

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

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.)

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 13 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 13 on page 23. The length of the threaded portion of the NPT meter is 1.18 inches. Measure the threaded portion still visible after the installation and subtract that amount from 1.18 inches. This gives you the thread engagement length. If this cannot be measured, use 0.55 inch for this amount.

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

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

2.3.4 Insertion Procedure for Flow Meters with Permanent Insertion Tool

Refer to Figure 14 below, and follow the instructions on the next page.
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 23). 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 15 below, and follow the instructions on the next page.
Chapter 2. Installation

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

![Insertion Length Formula](image)

**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 \( \div 2 \) 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.)

**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 17 below and complete the following steps:

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.

**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.
2.4.2 Enclosure Adjustment (Series MV80 Only)

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

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

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

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

![Figure 19: Loop Power Wiring Terminals](image)
2.5.1 DC Input Power Connections

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

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

![Figure 20: DC Power Connections](image)

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 20 above). The current control electronics requires 12 volts at the input terminals to operate correctly.

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

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

![Figure 21: Load Resistance Versus Input Voltage](image)
2.5.3 Pulse Output Connections

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

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

Figure 22: Isolated Pulse Output Using External Power Supply

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

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

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

![Figure 24: Isolated Frequency Output Using External Power Supply](#)

![Figure 25: Non-Isolated Frequency Output Using External Power Supply](#)

2.5.5 Optional Backlight Connection

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

![Figure 26: Backlight Using External Power Supply](#)
2.5.6 Remote Electronics Wiring

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

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

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

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

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

![Figure 27: Loop Power Flow Meter Junction Box Sensor Connections](image-url)
2.6 Line Power Meter Wiring Connections

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

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

![Figure 28: Line Power Wiring Terminals](image)

**Figure 28: Line Power Wiring Terminals**
2.6.1 Input Power Connections

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

2.6.1a AC Power Wiring

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

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

Figure 29: AC Power Connections

2.6.1b DC Power Wiring

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

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

Figure 30: DC Power Connections
2.6.2 4-20 mA Output Connections

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

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

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

**Figure 33: Isolated 4-20 mA Output Using Meter Provided Power Supply**
2.6.2 4-20 mA Output Connections (cont.)

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

\[ R_{\text{load}} = R_{\text{wire}} + R_{\text{sense}} \]

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:

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

![Figure 34: Load Resistance Versus Input Voltage](image)

2.6.3 Frequency Output Connections

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

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

There are three connection options for the frequency output:

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

**Figure 35: Isolated Frequency Output Using External Power Supply**

- AC or DC powered meters
- Freq Out +
- Freq Out –
- Freq. Out voltage = +V
- Select resistor so that current through Freq. Out ≤ 40mA
- R current limit ~10K

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

- DC Power
- DC Common
- R current limit ~10K
- Freq. Out voltage = + Power voltage for meter

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

- Freq Out +
- Freq Out –
- Freq. Out voltage = + Power voltage for meter
2.6.4 Pulse Output Connections

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

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

There are three connection options for the pulse output:

- For AC or DC powered meters, use a separate 5 to 36 VDC power supply (see Figure 38 on page 43). Use this option if a specific voltage is needed for the pulse output.

- For DC powered meters only, use the flow meter power supply (see Figure 39 on page 43). Use this option if the voltage at the flow meter power supply is an acceptable driver voltage for the connected load, taking into account that the current used by the pulse load comes from the meter’s power supply.

- For AC powered meters only, use the internal 24 VDC power supply (see Figure 40 on page 43). Use this option if the voltage of the pulse output is the same as the voltage supplied to the circuit.
2.6.4 Pulse Output Connections (cont.)

Figure 38: Isolated Pulse Output with External Power Supply

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

Figure 40: Isolated Pulse Output Using Provided Power Supply
2.6.5 Alarm Output Connections

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

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

There are three connection options for the alarm output:

- For AC or DC powered meters, use a separate 5 to 36 VDC power supply (see Figure 41 on page 45). Use this option if a specific voltage is needed for the alarm output.

- For DC powered meters only, use the flow meter power supply (see Figure 42 on page 45). Use this option if the voltage at the flow meter power supply is an acceptable driver voltage for the connected load, taking into account that the current used by the alarm load comes from the meter’s power supply.

- For AC powered meters only, use the internal 24 VDC power supply (see Figure 43 on page 45). Use this option if the voltage of the alarm output is the same as the voltage supplied to the circuit.
2.6.5 Alarm Output Connections (cont.)

Figure 41: Isolated Alarm Output with External Power Supply

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

Figure 43: Isolated Alarm Output Using Meter Provided Power Supply
2.6.6 Remote Electronics Wiring

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

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

Note: Incorrect connections will cause the meter to malfunction.

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

Figure 44: Flow Meter Junction Box Sensor Connections
2.6.7 Optional Input Wiring

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

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

**Figure 45: Optional Input Electronics Wiring**

2.6.7a Optional Energy EMS RTD Input Wiring

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

<table>
<thead>
<tr>
<th>Option 1</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Red Red Black Black
R = 1000 ohms

**Figure 46: Optional Energy EMS RTD Input Wiring**
### 2.6.7b Optional External 4-20 mA Input Wiring

The meter is set to have *Option 1* used for the external input. Programming menus that pertain to the optional 4-20 mA input are located in “Hidden Diagnostics Menus” on page 107.

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

Refer to *Figure 48* below to wire the external 4-20 mA input into the flow meter using power supplied to the input of a DC powered meter.
2.6.7b  Optional External 4-20 mA Input Wiring (cont.)

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

![Figure 49: External 4-20 mA Input Wiring - AC Powered Meter](image)

2.6.7c  Optional Contact Closure Input Wiring

Refer to Figure 50 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 50: Optional Contact Closure Input Wiring](image)
[no content intended for this page]
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.

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 51 on page 52).
3.2 Flow Meter Display/Keypad (cont.)

Figure 51: Magnetic Keypad Operation

Figure 52 below shows a picture of the display/keypad. From Run Mode, the ENTER key enables access to the Setup Menus through a password screen. Within the Setup Menus, pressing ENTER activates the current field. To set new parameters, press the ENTER key until an underline cursor appears. Use the ↑ ↓ ← → 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.
3.3 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 53* below may not be displayed. Press the ↑ ↓ arrow keys to view the Run Mode screens.

4. Press the ENTER key from any Run Mode screen to access the Setup Menus. Use the Setup Menus to configure the meter’s multi-parameter features to fit your application.

![Figure 53: Run Mode Screens](image-url)
3.4 Using the Setup Menus

3.4.1 A Menu Map

Figure 54: Complete Map of Setup Menus
3.4.2 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 54 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.

3.4.3 The Output Menu

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

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

First, set the desired units of measurement:

1. Use the ← → keys to move to the Units Menu (see “The Units Menu” on page 67).

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.
### 3.4.3 The Output Menu (cont.)

#### Figure 55: Output Menu Map

<table>
<thead>
<tr>
<th>Menu Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-20mA Output 1</td>
<td>More &gt; &lt;4mA = xxxx &gt; &lt;20mA = xxxx &gt; &lt;TimeConst[Sec] xxxx</td>
</tr>
<tr>
<td>4-20mA Output 2</td>
<td>More &gt; &lt;4mA = xxxx &gt; &lt;20mA = xxxx &gt; &lt;TimeConst[Sec] xxxx</td>
</tr>
<tr>
<td>4-20mA Output 3</td>
<td>More &gt; &lt;4mA = xxxx &gt; &lt;20mA = xxxx &gt; &lt;TimeConst[Sec] xxxx</td>
</tr>
<tr>
<td>Scaled Frequency</td>
<td>&lt;Max, Frequency &gt; xxxx</td>
</tr>
<tr>
<td>Modbus Units</td>
<td>(Internal/Display)</td>
</tr>
<tr>
<td>Modbus Order</td>
<td>0-1:2-3 3-2:1-0 2-3:0-1 1-0:3-2</td>
</tr>
<tr>
<td>CommProtocol</td>
<td>Modbus RTU (None1, None2, Odd, Even)</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>19200</td>
</tr>
<tr>
<td>Address</td>
<td>1</td>
</tr>
<tr>
<td><strong>Physical Layer not available on Two Wire Mass - Accessible via HART.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Modbus not available on Two Wire Mass.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Energy available on EMS meters only.</strong></td>
<td></td>
</tr>
</tbody>
</table>

* see below

---

**see below**

---

*see below*
3.4.4 The Display Menu

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

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

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

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

![Figure 56: The Display Menu](image-url)
3.4.5 The Alarms Menu

As an example of how to set an output, refer to Figure 57 on page 59. This example shows how to set Relay Alarm 1 to activate if the mass flow rate is greater than 100 lb/hr. You can check the alarm configuration in Run Mode by pressing the ‹› 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 67).
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.
3.4.5 The Alarms Menu (cont.)

![Diagram of the Alarms Menu]

- **Run Mode** Enter
- **Password** Enter

*Use keys to access menus*

**Figure 57: The Alarms Menu**

- **Relay Alarm 1** More >
  - **<Measure>** None
  - **Mode** None
  - **Mass** Volume
  - **Energy** Temp 1,2
  - **Press Density**

- **Relay Alarm 2** More >
  - **<Measure>** None
  - **Mode** None
  - **Mass** Volume
  - **Energy** Temp 1,2
  - **Press Density**

- **Relay Alarm 3** More >
  - **<Measure>** None
  - **Mode** None
  - **Mass** Volume
  - **Energy** Temp 1,2
  - **Press Density**

- **Alarm Log** xx Files (ENTER)
  - **Clear Alarm Log?** YES or NO
    - (Press EXIT to return to Alarm Log)

- **Alarm File**
  - **Time Data**

**Physical Layer does not exist on Two Wire Mass. Accessible via HART.**

**<Measure> units**

**Energy EMS Meters Only**
3.4.6 The Totalizer #1 Menu

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

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

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

First, set the desired units of measurement:

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

Second, set the pulse output:

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

![Diagram of the Totalizer #1 Menu]

Example:
- Maximum flow rate = 600 gallons per minute (600 gallons per minute = 10 gallons per second).
- If unit per pulse is set to 600 gallons per pulse, the totalizer will pulse once every minute.
- If unit per pulse is set to 10 gallons per pulse, the totalizer will pulse once every second.

Figure 58: The Totalizer #1 Menu
3.4.7 The Totalizer #2 Menu

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

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

![Figure 59: The Totalizer #2 Menu](image-url)
3.4.8 The Energy Menu for EMS Energy Meters Only

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

Table 3: Configuration Options

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Meter Location</th>
<th>Second RTD</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>“Sent” Flow Line</td>
<td>“Return” Flow Line</td>
<td>Change in Energy</td>
</tr>
<tr>
<td>Water</td>
<td>“Return” Flow Line</td>
<td>“Sent” Flow Line</td>
<td>Change in Energy</td>
</tr>
<tr>
<td>Water</td>
<td>“Sent” Flow Line</td>
<td>None</td>
<td>Outgoing Energy</td>
</tr>
<tr>
<td>Steam</td>
<td>“Sent” Flow Line</td>
<td>“Return” Flow Line (condensate)</td>
<td>Change in Energy</td>
</tr>
<tr>
<td>Steam</td>
<td>“Sent” Flow Line</td>
<td>None</td>
<td>Outgoing Energy</td>
</tr>
</tbody>
</table>

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

1. **Loc in Sent Flow?** Select Yes or No based on where the meter is located. Refer to Table 3 above.

2. **Heating System?** Select Yes for a hot water system used for heating. Select No for a chilled water system used for cooling. Always select Yes for a steam system.

3. **% Returned.** Select a number between 0% and 100%. Estimate the amount of water that returns. It is usually 100%, or can be less than 100% if historical data shows the amount of makeup water used. If a second RTD is not used, set to 0%. When 0% is selected, the energy calculation represents the outgoing energy only (no return energy is subtracted).

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

Figure 60: The Energy Menu for EMS Energy Meters Only
3.4.9 The Fluid Menu

Use the Fluid Menu (see Figure 61 on page 66) 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.


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

- Mole Weight = lbₘ/(lbₘ·mol)
- CRIT PRESS = psia
- CRIT TEMP = °R
- Density = Kg/m³
- Viscosity = cP (centipoise).
3.4.9 The Fluid Menu (cont.)

Figure 61: The Fluid Menu
3.4.10 The Units Menu

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

- **Mass Flow Unit**
  - lb, Ston, Lton, gram, kg, Mton, scf, nm3
  - sec, min, hr, day
  - Ston = Short Ton = 2000 lb
  - Lton = Long Ton = 2240 lb
  - Mton = Metric Ton = 1000 kg

- **Volume Flow Unit**
  - gal, MiG, ImpG, bbl, lit, Mill, m3, ft3
  - sec, min, hr, day
  - MiIG = Million gallons
  - lgal = Imperial gallon = 1.20095 US gallons
  - bbl = barrels = 42 US gallons
  - Mill = Million liters

- **Temperature Unit**
  - Deg F, Deg C, Kelvin, Rankine

- **Energy Unit**
  - BTU, MBTU, MMBT, MCal, MJ
  - sec, min, hr, day
  - MBTU = Thousand BTU
  - MMBTU = Million BTU

- **Density Unit**
  - lbm/ft3, kg/m3, gm/mlit, kg/lit, gm/lit, lbm/ln3
  - lbm/gal, gm/mlit, kg/lit, gm/lit, lbm/ln3

- **Pressure Unit**
  - psi, inH2O, RH2O, mmH2O, in HG, mmHG
  - ATM, Bar, mBar
  - gm/cm2, kg/cm2, Pascal, MegaPa, Torr
  - 4inH2O, 4mmH2O
  - 4inH2O and 4mmH2O are based on water at 4°C.

- **Gauge Pressure Unit**
  - Absolute/Gauge
  - Transducer reads in Absolute.
  - If Gauge is desired, atmospheric pressure at meter is needed.

- **Atm. Pressure**
  - 14.6959

**Menu is activated only if Gauge Pressure is chosen. Enter the value in PSIA.**

Figure 62: The Units Menu
3.4.11 The Time & Date Menu

Use the Time and Date Menu (see Figure 63 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 63: The Time & Date Menu](image-url)
3.4.12 The Diagnostics Menu

Use the Diagnostics Menu (see Figure 64 on page 70) to simulate operation and review the system files. The system log files contain time/date stamped messages including: power on, power off, 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.
3.4.12 The Diagnostics Menu (cont.)

**Figure 64: The Diagnostics Menu**

For a V model in any fluid, enter nominal operating temperature and pressure as simulated values in the diagnostics menu.

* The unit of measure of the displayed value is the same as the unit configured for the flowmeter.
3.4.13 The Calibration Menu

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

![Figure 65: The Calibration Menu](image-url)

- **Run Mode**
- **Password**
- **Enter**
- **Calibration Menu**
  - **Meter Size or Pipe ID**
    - Series MV80 - meter size
    - Series MV82 - pipe internal diameter (inches)
  - **Meter Factor xxxx**
    - Meter calibration constant
    - Series MV80 - pulses/ft$^3$
    - Series MV82 - pulses/ft
  - **Vortex Coef Ck xx**
    - Adaptive filter setting
  - **Low Flow Cutoff xx**
    - Low Flow Cutoff Setting displayed in volumetric flow units (view only)
  - **Serial Number xxxxxxxxxx**
    - Low Flow Cutoff Setting displayed in mass flow units (view only)
3.4.14 The Password Menu

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

![Figure 66: The Password Menu](image_url)
Chapter 4. Serial Communications

4.1 HART Communications

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

4.1.1 Wiring

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

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

4.1.1a HART Loop Powered Meter Wiring

![HART Loop Powered Meter Wiring Diagram](image)
4.1.1b  HART DC Powered Meter Wiring

Figure 68: HART DC Powered Meter Wiring
4.1.1c  HART AC Powered Meter Wiring

Figure 69: HART AC Powered Meter Wiring
4.1.2 HART Commands with the Digital Display Menu

Figure 70: HART Commands with the Online Menu
4.1.2 HART Commands with the Digital Display Menu (cont.)

**Figure 71: HART Commands with the Analog Output Menu**

- **From Online Menu**
  - 1 Fix Analog Output
  - 2 Trim Analog Output
  - 3 Configure AO1
  - 4 PV is
  - 5 PV AO1 Out
  - 6 PV % mge
  - 7 Configure AO2
  - 8 SV is
  - 9 SV AO2 Out
    - SV % mge
    - Configure AO3
    - TV is
    - TV AO
    - TV % mge
    - Configure AO4
  - QV is
  - QV AO
  - QV % mge

- **PV Menu**
  - 1 PV is
  - 2 PV AO1 Out
  - 3 PV
  - 4 PV % mge
  - 5 Apply values
  - 6 PV Rnge unit
  - 7 PV LRV
  - 8 PV URV
  - 9 PV AO1 Lo end pt
    - PV AO1 Hi end pt
    - PV AO1 Added damp

- **SV Menu**
  - 1 SV is
  - 2 SV AO2 Out
  - 3 SV
  - 4 SV % mge
  - 5 Apply values
  - 6 SV Rnge unit
  - 7 SV LRV
  - 8 SV URV
  - 9 SV AO2 Lo end pt
    - SV AO2 Hi end pt
    - SV AO2 Added damp

- **TV Menu**
  - 1 TV is
  - 2 TV AO
  - 3 TV
  - 4 TV % mge
  - 5 Apply values
  - 6 TV Rnge unit
  - 7 TV LRV
  - 8 TV URV
  - 9 TV AO3 Lo end pt
    - TV AO3 Hi end pt
    - TV AO3 Added damp

- **QV Menu**
  - 1 QV is
  - 2 QV AO
  - 3 QV
  - 4 QV % mge
  - 5 Apply values
  - 6 QV Rnge unit
  - 7 QV LRV
  - 8 QV URV
  - 9 QV AO1 Lo end pt
    - QV AO1 Hi end pt
    - QV AO1 Added damp
4.1.2 HART Commands with the Digital Display Menu (cont.)

**Fluid Menu**

From Online Menu

1 Fluid
2 Fluid Type

1. Liquid
   - Other Liquid
   - Goyal-Dorais
   - API-2540
   - Nat Gas AGA8
   - Real Gas
   - Other Gas
   - Liquified Gas

2. Water
   - Ammonia
   - Chlorine

3. Other Liquid Density
   - Viscosity Coef AL
   - Viscosity Coef BL

4. Mol Weight
   - Crit Press
   - Crit Temp
   - Compressibility
   - AL
   - BL

5. Density @ 60F
   - API K0
   - API K1
   - API AL
   - API BL

6. AGA Ref Temp
   - AGA Ref Press
   - Specific Gravity
   - Mole Fract N2
   - Mole Fract CO2

7. Steam
   - Air
   - Argon
   - Ammonia
   - CO
   - CO2
   - Helium
   - Hydrogen
   - Methane
   - Nitrogen
   - Oxygen
   - Propane

8. Specific gravity
   - Compress
   - Viscosity

9. Carbon Dioxide
   - Nitrogen
   - Hydrogen
   - Oxygen
   - Argon
   - Nitrous Oxide

Figure 72: HART Commands with the Fluid Menu
4.1.2 HART Commands with the Digital Display Menu (cont.)

![Diagram of the HART Commands with the Digital Display Menu]

Figure 73: HART Commands with the Diagnostics Menu
4.1.2 HART Commands with the Digital Display Menu (cont.)

Figure 74: HART Commands with the Sensor Cal Menu
4.1.3  HART Commands with the Generic Digital Display Menu

Note:  Use password 16363.

Figure 75: HART Commands with the Generic Online Menu
### 4.1.4 Fast Key Sequence

**Note:** Use password 16363.

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Description</th>
<th>Access</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,1,1</td>
<td>Snsr</td>
<td>View</td>
<td>Primary variable value</td>
</tr>
<tr>
<td>1,1,2</td>
<td>AI % Rnge</td>
<td>View</td>
<td>Analog input % range</td>
</tr>
<tr>
<td>1,1,3</td>
<td>AO1</td>
<td>View</td>
<td>Analog output, mA</td>
</tr>
<tr>
<td>1,2,1</td>
<td>Test Device</td>
<td>N/A</td>
<td>Not used</td>
</tr>
<tr>
<td>1,2,2,1</td>
<td>4 mA</td>
<td>View</td>
<td>Loop test, fix analog output at 4 mA</td>
</tr>
<tr>
<td>1,2,2,2</td>
<td>20 mA</td>
<td>View</td>
<td>Loop test, fix analog output at 20 mA</td>
</tr>
<tr>
<td>1,2,2,3</td>
<td>Other</td>
<td>Edit</td>
<td>Loop test, fix analog output at mA value entered</td>
</tr>
<tr>
<td>1,2,2,4</td>
<td>End</td>
<td>Exit</td>
<td>Exit loop test</td>
</tr>
<tr>
<td>1,2,3,1,1</td>
<td>4 mA</td>
<td>N/A</td>
<td>Not used, apply values</td>
</tr>
<tr>
<td>1,2,3,1,2</td>
<td>20 mA</td>
<td>N/A</td>
<td>Not used, apply values</td>
</tr>
<tr>
<td>1,2,3,1,3</td>
<td>Exit</td>
<td>Exit</td>
<td>Exit apply values</td>
</tr>
<tr>
<td>1,2,3,2,1</td>
<td>PV LRV</td>
<td>Edit</td>
<td>Primary variable lower range value</td>
</tr>
<tr>
<td>1,2,3,2,2</td>
<td>PV URV</td>
<td>Edit</td>
<td>Primary variable upper range value</td>
</tr>
<tr>
<td>1,2,3,2,3</td>
<td>PV USL</td>
<td>View</td>
<td>Primary variable upper sensor limit</td>
</tr>
<tr>
<td>1,2,3,2,4</td>
<td>PV LSL</td>
<td>View</td>
<td>Primary variable lower sensor limit</td>
</tr>
<tr>
<td>1,2,4</td>
<td>D/A Trim</td>
<td>Edit</td>
<td>Calibrate electronics 4mA and 20mA values</td>
</tr>
<tr>
<td>1,3,1</td>
<td>Tag</td>
<td>Edit</td>
<td>Tag</td>
</tr>
<tr>
<td>1,3,2</td>
<td>PV unit</td>
<td>Edit</td>
<td>Primary variable units</td>
</tr>
<tr>
<td>1,3,3,1</td>
<td>PV LRV</td>
<td>Edit</td>
<td>Primary variable lower range value</td>
</tr>
<tr>
<td>1,3,3,2</td>
<td>PV URV</td>
<td>Edit</td>
<td>Primary variable upper range value</td>
</tr>
<tr>
<td>1,3,3,3</td>
<td>PV LSL</td>
<td>View</td>
<td>Primary variable upper sensor limit</td>
</tr>
<tr>
<td>1,3,3,4</td>
<td>PV USL</td>
<td>View</td>
<td>Primary variable lower sensor limit</td>
</tr>
<tr>
<td>1,3,4,1</td>
<td>Distributor</td>
<td>N/A</td>
<td>Not used</td>
</tr>
<tr>
<td>1,3,4,2</td>
<td>Model</td>
<td>N/A</td>
<td>Not used</td>
</tr>
<tr>
<td>1,3,4,3</td>
<td>Dev id</td>
<td>View</td>
<td>Device identification</td>
</tr>
<tr>
<td>1,3,4,4</td>
<td>Tag</td>
<td>Edit</td>
<td>Tag</td>
</tr>
<tr>
<td>1,3,4,5</td>
<td>Date</td>
<td>Edit</td>
<td>Date</td>
</tr>
<tr>
<td>1,3,4,6</td>
<td>Write Protect</td>
<td>View</td>
<td>Write protect</td>
</tr>
<tr>
<td>1,3,4,7</td>
<td>Descriptor</td>
<td>Edit</td>
<td>Vortex flow meter</td>
</tr>
<tr>
<td>1,3,4,8</td>
<td>Message</td>
<td>Edit</td>
<td>32 character alphanumeric message</td>
</tr>
<tr>
<td>1,3,4,9</td>
<td>PV snsr s/n</td>
<td>View</td>
<td>Primary variable sensor serial number</td>
</tr>
<tr>
<td>1,3,4,menu</td>
<td>Final assy #</td>
<td>Edit</td>
<td>Final assembly number</td>
</tr>
<tr>
<td>1,3,4,menu,1</td>
<td>Universal Rev</td>
<td>View</td>
<td>Universal revision</td>
</tr>
<tr>
<td>1,3,4,menu,2</td>
<td>Fld dev Rev</td>
<td>View</td>
<td>Field device revision</td>
</tr>
<tr>
<td>1,3,4,menu,3</td>
<td>Software Rev</td>
<td>View</td>
<td>Software revision</td>
</tr>
<tr>
<td>1,3,5</td>
<td>PV Xfer fnctn</td>
<td>View</td>
<td>Linear</td>
</tr>
<tr>
<td>1,3,6</td>
<td>PV Damp</td>
<td>Edit</td>
<td>Primary variable damping (time constant) in seconds</td>
</tr>
<tr>
<td>1,4,1,1</td>
<td>PV</td>
<td>View</td>
<td>Primary variable value</td>
</tr>
</tbody>
</table>
### Table 4: Fast Key Sequence (cont.)

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

4.2.2 Overview

This section describes the preliminary implementation of the Modbus communication protocol for use in monitoring common process variables in the PanaFlow Vortex 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
### 4.2.4 Wiring

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

**Figure 76: RS-485 Modbus Wiring**

![RS-485 Wiring Diagram](image)

#### 4.2.5 Pin Labeling Among Devices

- **RS-485 –** = “A” = “TxD–/RxD–” = “Inverting pin”
- **RS-485 +** = “B” = “TxD+/RxD+” = “Non-Inverting pin”
- **RS-485 GND** = “GND” = “G” = “SC” = “Reference”
4.2.6 Menu Items

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

4.2.6a Address

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

4.2.6b Comm Protocol

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

4.2.6c Modbus Units

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

4.2.6d Modbus Order

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

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

<table>
<thead>
<tr>
<th>Order</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1:2-3</td>
<td>Most significant register first, most significant byte first (default)</td>
</tr>
<tr>
<td>2-3:0-1</td>
<td>Least significant register first, most significant byte first</td>
</tr>
<tr>
<td>1-0:3-2</td>
<td>Most significant register first, least significant byte first</td>
</tr>
<tr>
<td>3-2:1-0</td>
<td>Least significant register first, least significant byte first</td>
</tr>
</tbody>
</table>

*Table 5: Modbus Order Options*

All of the registers are affected by the byte order, including strings and registers representing 16-bit integers. The register order affects only the order of those registers representing 32-bit floating point and long integer data, but does not affect single 16-bit integers or strings.
4.2.6e  Modbus Protocol

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

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

<table>
<thead>
<tr>
<th>Registers</th>
<th>Usage</th>
<th>Valid Function Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>00001-09999</td>
<td>Read/write bits (“coils”)</td>
<td>01 (read coils) 05 (write single coil) 15 (write multiple coils)</td>
</tr>
<tr>
<td>10001-19999</td>
<td>Read-only bits (“discrete inputs”)</td>
<td>02 (read discrete inputs)</td>
</tr>
<tr>
<td>30001-39999</td>
<td>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</td>
<td>03 (read holding registers) 04 (read input registers)</td>
</tr>
<tr>
<td>40001-49999</td>
<td>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</td>
<td>03 (read holding registers) 06 (write single register) 16 (write multiple registers)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Registers</th>
<th>Function Codes</th>
<th>Data Type and Address Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>00001-09999</td>
<td>01, 05, 15</td>
<td>Read/write bits 0000-9998</td>
</tr>
<tr>
<td>10001-19999</td>
<td>02</td>
<td>Read-only bits 0000-9999</td>
</tr>
<tr>
<td>30001-39999</td>
<td>03, 04</td>
<td>Read-only 16-bit registers 0000-9998</td>
</tr>
<tr>
<td>40001-49999</td>
<td>03, 06, 16</td>
<td>Read/write 16-bit registers 0000-9998</td>
</tr>
</tbody>
</table>
4.2.6f Register Definitions

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

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

<table>
<thead>
<tr>
<th>Registers</th>
<th>Variable</th>
<th>Data Type</th>
<th>Units</th>
<th>Function Code</th>
<th>Addresses</th>
</tr>
</thead>
<tbody>
<tr>
<td>65100-65101</td>
<td>Serial number</td>
<td>unsigned long</td>
<td>--</td>
<td>03, 04</td>
<td></td>
</tr>
<tr>
<td>30525-30526</td>
<td>Totalizer</td>
<td>unsigned long</td>
<td>display units*</td>
<td>03, 04</td>
<td>524-525</td>
</tr>
<tr>
<td>32037-32042</td>
<td>Totalizer units</td>
<td>string</td>
<td>--</td>
<td>03, 04</td>
<td>2036-2041</td>
</tr>
<tr>
<td>30009-30010</td>
<td>Mass flow</td>
<td>float</td>
<td>display units*</td>
<td>03, 04</td>
<td>8-9</td>
</tr>
<tr>
<td>30007-30008</td>
<td>Volume flow</td>
<td>float</td>
<td>display units*</td>
<td>03, 04</td>
<td>6-7</td>
</tr>
<tr>
<td>30005-30006</td>
<td>Pressure</td>
<td>float</td>
<td>display units*</td>
<td>03, 04</td>
<td>4-5</td>
</tr>
<tr>
<td>30001-30002</td>
<td>Temperature</td>
<td>float</td>
<td>display units*</td>
<td>03, 04</td>
<td>0-1</td>
</tr>
<tr>
<td>30029-30030</td>
<td>Velocity</td>
<td>float</td>
<td>ft/sec</td>
<td>03, 04</td>
<td>28-29</td>
</tr>
<tr>
<td>30015-30016</td>
<td>Density</td>
<td>float</td>
<td>display units*</td>
<td>03, 04</td>
<td>14-15</td>
</tr>
<tr>
<td>30013-30014</td>
<td>Viscosity</td>
<td>float</td>
<td>cP</td>
<td>03, 04</td>
<td>12-13</td>
</tr>
<tr>
<td>30031-30032</td>
<td>Reynolds number</td>
<td>float</td>
<td>--</td>
<td>03, 04</td>
<td>30-31</td>
</tr>
<tr>
<td>30025-30026</td>
<td>Vortex frequency</td>
<td>float</td>
<td>Hz</td>
<td>03, 04</td>
<td>24-25</td>
</tr>
<tr>
<td>34532</td>
<td>Gain</td>
<td>char</td>
<td>--</td>
<td>03, 04</td>
<td>4531</td>
</tr>
<tr>
<td>30085-30086</td>
<td>Vortex amplitude</td>
<td>float</td>
<td>Vrms</td>
<td>03, 04</td>
<td>84-85</td>
</tr>
<tr>
<td>30027-30028</td>
<td>Filter setting</td>
<td>float</td>
<td>Hz</td>
<td>03, 04</td>
<td>26-27</td>
</tr>
</tbody>
</table>
4.2.6f Register Definitions (cont.)

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

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

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

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

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

The floating point registers with values in display units are scaled to the same units currently displayed, but they are instantaneous values that are not smoothed. If display smoothing is enabled (non-zero value entered in the Display TC item in the Display Menu), then the register values will not agree exactly with the displayed values.
4.2.6g Exception Status Definitions

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

<table>
<thead>
<tr>
<th>Bit(s)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Byte order (see Modbus Order on “Modbus Order” on page 86)</td>
</tr>
<tr>
<td></td>
<td>• 0 = 3-2:1-0  1 = 2-3:0-1</td>
</tr>
<tr>
<td></td>
<td>• 2 = 1-0:3-2  3 = 0-1:2-3</td>
</tr>
<tr>
<td>2</td>
<td>Temperature sensor fault</td>
</tr>
<tr>
<td>3</td>
<td>Pressure sensor fault</td>
</tr>
<tr>
<td>4</td>
<td>A/D converter fault</td>
</tr>
<tr>
<td>5</td>
<td>Period overflow</td>
</tr>
<tr>
<td>6</td>
<td>Pulse overflow</td>
</tr>
<tr>
<td>7</td>
<td>Configuration changed</td>
</tr>
</tbody>
</table>

4.2.6h Discrete Input Definitions

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

<table>
<thead>
<tr>
<th>Registers</th>
<th>Variable</th>
<th>Function Code</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>10001</td>
<td>Alarm #1 state</td>
<td>02</td>
<td>0</td>
</tr>
<tr>
<td>10002</td>
<td>Alarm #2 state</td>
<td>02</td>
<td>1</td>
</tr>
<tr>
<td>10003</td>
<td>Alarm #3 state</td>
<td>02</td>
<td>2</td>
</tr>
</tbody>
</table>

4.2.6i Control Register Definitions

The only writable registers in this implementation are the Reset Exception Status, Reset Meter and Reset Totalizer functions, which are implemented as “coils” which may be written with the Write Single Coil command (function code 05) to address 8 through 10, respectively, (register #00009 through #00011). The value sent with this command must be either 0x0000 or 0xff00, or the meter will respond with an error message; the totalizer will be reset or exception status cleared only with a value of 0xff00.
4.2.6j Error Responses

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

<table>
<thead>
<tr>
<th>Exception Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Invalid function code - function code not supported by device.</td>
</tr>
<tr>
<td>02</td>
<td>Invalid data address - address defined by the start address and number of registers is out of range.</td>
</tr>
<tr>
<td>03</td>
<td>Invalid data value - number of registers = 0 or &gt;125, or incorrect data with the Write Single Coil command.</td>
</tr>
</tbody>
</table>

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

4.2.6k Command Message Format

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

<table>
<thead>
<tr>
<th>Device Address</th>
<th>Function Code</th>
<th>Start Address</th>
<th>N = No. of Registers</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits, 1...247</td>
<td>8 bits</td>
<td>16 bits, 0...9998</td>
<td>16 bits, 1...125</td>
<td>16 bits</td>
</tr>
</tbody>
</table>

4.2.6l Normal Response Message Format

<table>
<thead>
<tr>
<th>Device Address</th>
<th>Function Code</th>
<th>Byte Count = 2 x N</th>
<th>Data</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits, 1...247</td>
<td>8 bits</td>
<td>8 bits</td>
<td>(N) 16-bit registers</td>
<td>16 bits</td>
</tr>
</tbody>
</table>

4.2.6m Exception Response Message Format

<table>
<thead>
<tr>
<th>Device Address</th>
<th>Function Code</th>
<th>Exception Code</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits, 1...247</td>
<td>8 bits</td>
<td>8 bits</td>
<td>16 bits</td>
</tr>
</tbody>
</table>
4.2.6n  Examples

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

01 07 41 E2  
01 Device address  
07 Function code  
04 = read exception status

A typical response from the device is as follows:

01 07 03 62 31  
01 Device address  
07 Function code  
03 Exception status byte  
62 31 CRC

Request the first 12 registers from device with address 1:

01 04 00 00 00 0C F0 0F  
01 Device address  
04 Function code, 04 = read input register  
00 00 Starting address  
00 0C Number of registers = 12  
F0 0F CRC

A typical response from the device is as follows:

01 04 18 00 00 03 E8 00 00 7A 02 6C 62 00 00 41  
BA 87 F2 3E BF FC 6F 42 12 EC 8B 4D D1  
01 Device address  
04 Function code  
18 Number of data bytes = 24  
00 00 03 E8 Serial number = 1000 (unsigned long)  
00 00 7A 02 Totalizer = 31234 lbm (unsigned long)  
6C 62 00 00 Totalizer units = “lb” (string, unused characters are 0)  
41 BA 87 F2 Mass flow rate = 23.3164 lbm/sec (float)  
3E BF FC 6F Volume flow rate = 0.3750 ft3/sec (float)  
42 12 EC 8B Pressure = 36.731 psia (float)  
4D D1 CRC

Note:  These are the older register definitions.
4.2.6n Examples (cont.)

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

01 04 00 00 00 50 F1 D2
01 Device address
04 Function code 4 = read input register
00 00 Starting address
00 50 Number of registers = 80
F0 36 CRC

This results in an error response as follows:

01 84 02 C2 C1
01 Device address
84 Function code with most significant bit set indicates error response
02 Exception code 2 = invalid data address
C2 C1 CRC

Request the state all three alarms:

01 02 00 00 00 03 38 0B
01 Device address
02 Function code 2 = read discrete inputs
00 00 Starting address
00 03 Number of inputs = 3
38 0B CRC

and the unit responds with:

01 02 01 02 20 49
01 Device address
02 Function code
01 Number of data bytes = 1
02 Alarm #2 on, alarms #1 and #3 off
20 49 CRC
4.2.6n Examples (cont.)

To reset the totalizer:

**01 05 00 00 FF 00 8C 3A**

01 Device address
05 Function code 5 = write single coil
00 09 Coil address = 9
FF 00 Data to reset totalizer
8C 3A CRC *(not the correct CRC EJS-02-06-07)*

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

**01 05 00 00 00 00 CD CA**

01 Device address
05 Function code 5 = write single coil
00 00 Coil address = 0
00 00 Data to “turn off coil” does not reset totalizer
CD CA CRC
4.3 BACnet MS/TP Communications

4.3.1 BACnet MS/TP Description

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

4.3.2 Baud Rates on the MS/TP Bus

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

4.3.3 Baud Rate and MAC Address Configuration

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

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

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

Note: 

- *a. IUT supports 9600, 19200, 38400 baud rates.*
- *b. MAC address range is 0-127.*
4.3.4 **Supported BACnet Objects**

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

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

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

<table>
<thead>
<tr>
<th>Properties</th>
<th>Device</th>
<th>Analog Input</th>
<th>Binary Input</th>
<th>Binary Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object_Identifier</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Object_Name</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Object_Type</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>System_Status</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor_Name</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendor_Identifier</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model_Name</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firmware_Revision</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application-Software-Version</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol_Version</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol_Revision</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol_Services_Supported</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protocol_Object_Types_Supported</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Object_List</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max_ADPU_Length_Accepted</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Segmentation_Supported</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADPU_Timeout</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number_Of_ADPU_Retries</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max_Masters</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max_Info_Frames</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device_Address_Binding</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Database_Revision</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 17: Properties Object Types*
<table>
<thead>
<tr>
<th>Properties</th>
<th>Object Types</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Device</td>
<td>Analog Input</td>
<td>Binary Input</td>
<td>Binary Value</td>
</tr>
<tr>
<td>Status_Flags</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Event_State</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Out_Of_Service</td>
<td>✓ (W)</td>
<td>✓ (W)</td>
<td>✓ (W)</td>
<td></td>
</tr>
<tr>
<td>Units</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarity</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priority_Array</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relinquish_Default</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status_Flag</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Present_Value</td>
<td>✓ (W)</td>
<td>✓ (W)</td>
<td>✓ (W)</td>
<td></td>
</tr>
<tr>
<td>Inactive_Text</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active_Text</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** 
(W) = Writable Property.
### 4.3.4a Device Object

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

<table>
<thead>
<tr>
<th>Properties</th>
<th>Default Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>object-identifier</td>
<td>7</td>
</tr>
<tr>
<td>object-name</td>
<td>Device, 1</td>
</tr>
<tr>
<td>object-type</td>
<td>Device</td>
</tr>
<tr>
<td>system-status</td>
<td>operational</td>
</tr>
<tr>
<td>vendor-name</td>
<td>GE Measurement &amp; Control</td>
</tr>
<tr>
<td>vendor-identifier</td>
<td>558</td>
</tr>
<tr>
<td>model-name</td>
<td>Multivariable Flow Meter</td>
</tr>
<tr>
<td>firmware-revision</td>
<td>N/A</td>
</tr>
<tr>
<td>application-software-version</td>
<td>1.07</td>
</tr>
<tr>
<td>protocol-version</td>
<td>1</td>
</tr>
<tr>
<td>protocol-revision</td>
<td>4</td>
</tr>
<tr>
<td>object-list</td>
<td>{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-value, 1}, {device, 7}</td>
</tr>
<tr>
<td>max-apdu-length-accepted</td>
<td>300</td>
</tr>
<tr>
<td>segmentation-supported</td>
<td>no-segmentation</td>
</tr>
<tr>
<td>apdu-timeout</td>
<td>3000</td>
</tr>
<tr>
<td>number-of-APDU-retries</td>
<td>1</td>
</tr>
<tr>
<td>max-master</td>
<td>127</td>
</tr>
<tr>
<td>max-info-frames</td>
<td>1</td>
</tr>
<tr>
<td>device-address-binding</td>
<td>()</td>
</tr>
<tr>
<td>database-revision</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:** *Device Communication Control: Password – vortek.*
### Analog Input Object

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

<table>
<thead>
<tr>
<th>Object Instance</th>
<th>Object Name</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Volume Flow</td>
<td>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</td>
<td>This AI object is used to measure volume flow.</td>
</tr>
<tr>
<td>2</td>
<td>Mass Flow</td>
<td>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</td>
<td>This AI object is used to measure mass flow.</td>
</tr>
<tr>
<td>3</td>
<td>Temperature 1</td>
<td>degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit</td>
<td>This AI object measures Temperature in one of the given Unit.</td>
</tr>
<tr>
<td>4</td>
<td>Temperature 2</td>
<td>degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit</td>
<td>This AI object measures Temperature in one of the given Unit.</td>
</tr>
<tr>
<td>5</td>
<td>Pressure</td>
<td>pounds-force-per-square-inch, inches-of-water, inches-of-mercury, millimeters-of-mercury, bars, millibars, pascals, kilopascals</td>
<td>TBD</td>
</tr>
<tr>
<td>6</td>
<td>Density</td>
<td>kilograms-per-cubic-meter</td>
<td>TBD</td>
</tr>
<tr>
<td>7</td>
<td>Energy Flow</td>
<td>Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts</td>
<td>TBD</td>
</tr>
</tbody>
</table>
### Table 19: Analog Input Object Types (cont.)

<table>
<thead>
<tr>
<th>Object Instance</th>
<th>Object Name</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Totalizer 1 and</td>
<td>If Totalizer selection for Mass measure –</td>
<td>An electronic counter which records the total accumulated flow over a certain range of time.</td>
</tr>
<tr>
<td></td>
<td>Totalizer 2</td>
<td>pounds-mass-per-second, grams-per-second, kilogram-mass-per-second, kilogram-mass-per-minute, kilogram-mass-per-hour, pounds-mass-per-minute, pounds-mass-per-hour, tons-per-hour, grams-per-second, grams-per-minute</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>StatusRegister</td>
<td>NO UNITS</td>
<td>TBD</td>
</tr>
<tr>
<td>11</td>
<td>Channel 1 (4-20mA)</td>
<td>milliamperes</td>
<td>TBD</td>
</tr>
<tr>
<td>12</td>
<td>Channel 2 (4-20mA)</td>
<td>milliamperes</td>
<td>TBD</td>
</tr>
<tr>
<td>13</td>
<td>Channel 3 (4-20mA)</td>
<td>milliamperes</td>
<td>TBD</td>
</tr>
<tr>
<td>14</td>
<td>Scaled Freq</td>
<td>hertz</td>
<td>TBD</td>
</tr>
<tr>
<td>15</td>
<td>Flow Velocity</td>
<td>feet-per-second</td>
<td>TBD</td>
</tr>
<tr>
<td>16</td>
<td>Viscosity</td>
<td>centipoises</td>
<td>TBD</td>
</tr>
<tr>
<td>17</td>
<td>Frequency</td>
<td>hertz</td>
<td>TBD</td>
</tr>
<tr>
<td>18</td>
<td>VorTex Amp</td>
<td>millivolts</td>
<td>TBD</td>
</tr>
<tr>
<td>19</td>
<td>FilterSetting</td>
<td>hertz</td>
<td>TBD</td>
</tr>
</tbody>
</table>
4.3.4c Binary Input Objects

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

Table 20: Binary Input Object Types

<table>
<thead>
<tr>
<th>Object Instance</th>
<th>Object Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alarm1</td>
<td>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.</td>
</tr>
<tr>
<td>2</td>
<td>Alarm2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Alarm3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>External</td>
<td>TBD</td>
</tr>
</tbody>
</table>

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

4.3.4d Binary Value Objects

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

Table 21: Binary Value Object Types

<table>
<thead>
<tr>
<th>Object Instance</th>
<th>Object Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reset</td>
<td>Reset’s Totalizer</td>
</tr>
</tbody>
</table>
4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement

Date: 19-April-2012

Vendor Name: VorTek Instruments

Product Name: Pro-V M22 multivariable flow-meter

Product Model Number: M22/M23 VT/VTP

Applications Software Version: 1.07

Firmware Revision: N/A

BACnet Protocol Revision: 4

Product Description: VorTek multivariable flow-meter

BACnet Standardized Device Profile (Annex L):

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

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

<table>
<thead>
<tr>
<th>BiBBs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DS-RP-B</td>
</tr>
<tr>
<td></td>
<td>DS-WP-B</td>
</tr>
<tr>
<td></td>
<td>DM-DDB-B</td>
</tr>
<tr>
<td></td>
<td>DM-DOB-B</td>
</tr>
<tr>
<td></td>
<td>DM-DCC-B</td>
</tr>
<tr>
<td></td>
<td>DS-RPM-B</td>
</tr>
<tr>
<td></td>
<td>DS-WPM-B</td>
</tr>
</tbody>
</table>
4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement (cont.)

Table 23: Services Supported

<table>
<thead>
<tr>
<th>Service</th>
<th>Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Read Property</td>
<td>Execute</td>
</tr>
<tr>
<td>Write Property</td>
<td>Execute</td>
</tr>
<tr>
<td>Read Property Multiple</td>
<td>Execute</td>
</tr>
<tr>
<td>Write Property Multiple</td>
<td>Execute</td>
</tr>
<tr>
<td>Who-Is</td>
<td>Execute</td>
</tr>
<tr>
<td>I-Am</td>
<td>Initiate</td>
</tr>
<tr>
<td>Who-Has</td>
<td>Execute</td>
</tr>
<tr>
<td>I-Have</td>
<td>Initiate</td>
</tr>
<tr>
<td>Device Communication Control</td>
<td>Execute</td>
</tr>
</tbody>
</table>

Segmentation Capability:

- ☐ Able to transmit segmented messages
  - Window Size
- ☐ Able to receive segmented messages
  - Window Size

Standard Object Types Supported:

Table 24: Standard Object Types Supported

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Dynamically Create-able</th>
<th>Dynamically Delete-able</th>
<th>Additional Writable Properties</th>
<th>Range Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Input (AI)</td>
<td>No</td>
<td>No</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Binary Input (BV)</td>
<td>No</td>
<td>No</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Binary Value</td>
<td>No</td>
<td>No</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Device</td>
<td>No</td>
<td>No</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Table 25: Supported Writable Properties

<table>
<thead>
<tr>
<th>Object Type</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog Input (AI)</td>
<td>Present Value</td>
</tr>
<tr>
<td></td>
<td>Out-Of-Service</td>
</tr>
<tr>
<td>Binary Input (BV)</td>
<td>Present Value</td>
</tr>
<tr>
<td></td>
<td>Out-Of-Service</td>
</tr>
<tr>
<td></td>
<td>Polarity</td>
</tr>
<tr>
<td>Binary Value</td>
<td>Present Value</td>
</tr>
<tr>
<td></td>
<td>Out-Of-Service</td>
</tr>
<tr>
<td>Device</td>
<td>Present Value</td>
</tr>
<tr>
<td></td>
<td>Out-Of-Service</td>
</tr>
</tbody>
</table>
### 4.3.5 ANNEX - BACnet Protocol Implementation Conformance Statement (cont.)

Object List:

#### Table 26: Properties of Analog Input/Value Object Types

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

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>Present Value</th>
<th>Status Flags</th>
<th>Event State</th>
<th>Out of Service</th>
<th>Out of Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>BV1</td>
<td>Reset</td>
<td>?</td>
<td>F,F,F,F</td>
<td>Normal</td>
<td>False</td>
<td>False</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>APDU</td>
<td>Application Protocol Data Unit</td>
</tr>
<tr>
<td>BACnet</td>
<td>Building Automation and Control Network - Data communication protocol</td>
</tr>
<tr>
<td>MS/TP</td>
<td>Master-Slave Token passing (a twisted pair RS485 network created by BACnet)</td>
</tr>
<tr>
<td>BIBB</td>
<td>BACnet Interoperability Building Block (Specific individual function blocks for data exchange between interoperable devices).</td>
</tr>
<tr>
<td>BV</td>
<td>Binary Value</td>
</tr>
<tr>
<td>BI</td>
<td>Binary Input</td>
</tr>
<tr>
<td>AI</td>
<td>Analog Input</td>
</tr>
<tr>
<td>RP</td>
<td>Read Property</td>
</tr>
<tr>
<td>WP</td>
<td>Write Property</td>
</tr>
<tr>
<td>RPM</td>
<td>Read Property Multiple</td>
</tr>
<tr>
<td>WPM</td>
<td>Write Property Multiple.</td>
</tr>
<tr>
<td>DDB</td>
<td>Dynamic Device Binding</td>
</tr>
<tr>
<td>DOB</td>
<td>Dynamic Object Binding</td>
</tr>
<tr>
<td>DCC</td>
<td>Device communication Control</td>
</tr>
</tbody>
</table>
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 77 on page 108* can be accessed using the password **16363** and then completing the following steps:

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

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

Each of the menus in *Figure 77 on page 108* are defined and specific troubleshooting steps are described in the following sections.
5.1 Hidden Diagnostics Menus (cont.)

Figure 77: Diagnostics Menus

* Not present on MV80 Models

** Energy EMS Meters Only
5.1.1 Level One Hidden Diagnostics Values

- \( f \) = Vortex shedding frequency (Hz).
- \( f_i \) = 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, \( f_i \) will be displayed as \( f_m \).
- \( G \) = 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.
- \( A_1, A_2, A_3, A_4 \) = 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.
- \( K_c, I_t, K_b \) = Profile equation (factory use only). Model MV82 only.
- \( V \) = Calculated average pipe velocity (ft/sec).
- \( R_e \) = Calculated Reynolds number.
- \( R_{TD1} \) = Resistance value of integral RTD in ohms.
- \( R_{TD2} \) = Optional RTD resistance value in ohms.
- \( P_e(v) \) = Pressure transducer excitation voltage
- \( P_v(v) \) = Pressure transducer sense voltage.
- \( S_{td} \) = Density of fluid at standard conditions.
- \( N_{rml} \) = Density of fluid at normal conditions.
- \( V_{iscosity} \) = Calculated viscosity of flowing fluid.
- \( x \ Cnts \) = A/D counts from the external 4-20 mA input.
- \( E_{xt \ xxx mA} \) = Calculated external 4-20 mA input from the digital counts.
5.1.1 Level One Hidden Diagnostics Values (cont.)

- **Ck** = Calculated $C_k$ at current operating conditions. $C_k$ is a variable in the equation that relates signal strength, density, and velocity for a given application. It is used for noise rejection purposes. $C_k$ directly controls the $f_i$ value (see above). If the $C_k$ is set too low (in the calibration menu), then the $f_i$ value will be too low and the vortex signal will be rejected resulting in zero flow rate being displayed. The calculated $C_k$ value in this menu can be compared to the actual $C_k$ setting in the calibration menu to help determine if the $C_k$ 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 $C_k$ 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.
5.1.2 **Level Two Hidden Diagnostics Values (cont.)**

- **High Pass Filter** = Filter setting - Factory use only

- **Factory Defaults** = Reset factory defaults. If you change this to Yes and press ENTER, all the factory configuration is lost and you must reconfigure the entire program. Consult the factory before performing this process, it is required only in very rare cases.

- **Meter Type** = Insertion (MV82) or Inline (MV80) meter.

- **Config Code** = Factory use only.

- **Test Pulse Out** = Force totalizer pulse. Set to Yes and press ENTER to send one pulse. Very useful to test totalizer counting equipment.

- **Test Scaled Freq** = Enter a frequency value to test the scaled frequency output. Return to 0 to stop the test.

- **Output Type** = Factory use only.

- **Calibration Mode** = Factory use only.

- **A2D Ref. Resistor** = Factory use only.

- **Pressure Cal Current** = Calibration value for the electronics and pressure transducer combination. Consult Factory for value.

- **Pressure 9Cs** = Nine pressure coefficients unique to the pressure transducer. Use the RIGHT ARROW to access all nine coefficients.

- **Press. Max psi** = Based on installed sensor.

- **Press. Min psi** = 0 psia

- **RTD1** Press the RIGHT arrow to access:

  - **Ro** = RTD resistance at 0°C (1000 ohms).
  - **A** = RTD coefficient A (.0039083).
  - **B** = RTD coefficient B (-5.775e-07).
  - **RTD1 Max Deg. F** = 500
  - **RTD1 Min Deg. F** = -330

- **RTD2** = Second RTD configuration, for special applications only.
5.1.2 Level Two Hidden Diagnostics Values (cont.)

- Correction Pairs
- ft3/sec (1 through 10)
- %Dev. (1 through 10)
- Roughness = Factory use only.
- Force Recal? = Factory use only.
- Min. Delta H - Energy 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 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 28 below from the Run Menu with the meter installed:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>With Flow</th>
<th>With No Flow (if possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Messages?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.3 Troubleshooting the Flow Meter (cont.)

**Record These Values (cont.)**

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>With Flow</th>
<th>With No Flow (if possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>f'</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTD1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTD2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pe(V)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pv(V)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lvl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adj. Filter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iso. Power Volts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. Rev</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>With Flow</th>
<th>With No Flow (if possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vortex Coef Ck =</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Flow Cutoff =</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.4 Determine the Fault

5.4.1 Symptom: Output at No Flow

- The low flow cutoff is set too low. At no flow, go to the first column of the hidden diagnostics menu and record the Lvl value. The low flow cutoff must be set above this value.

- Example: at no flow, Lvl = 25. Set the low flow cutoff in the Calibration Menu to approximately 28 and the meter will no longer read a flow rate at no flow.

5.4.2 Symptom: Erratic Output

- The flow rate may be too low, just at the cutoff of the meter range, and the flow cycles above and below the cutoff making an erratic output. Consult the factory if necessary to confirm the meter range based on current operating conditions. It may be possible to lower the low flow cutoff to increase the meter range. See the example above for output at no flow, only this time the low flow cutoff is set too high. You can lower this value to increase the meter range as long as you do not create the output at no flow condition previously described.

- Mechanical installation may be incorrect. Verify the straight run is adequate, as described in Chapter 2. For in-line meters, make sure the meter is not installed backwards and there are no gaskets protruding into the flow stream. For insertion meters, verify the insertion depth and flow direction.

- The meter may be reacting to actual changes in the flow stream. The output can be smoothed using a time constant. The displayed values can be smoothed using the time constant in the Display Menu. The analog outputs can be smoothed using the time constant in the Output Menu. A time constant of 1 will result in the change in value reaching 63% of its final value in one second. A time constant of 4 is 22%, 10 is 9.5% and 50 is 1.9% of the final value in one second. The time constant equation is shown below (TC = Time Constant).

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

- The vortex coefficient \( \text{Ck} \) may be incorrectly set. The \( \text{Ck} \) 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 \( \text{Ck} \) value controls the adaptive filter, \( \text{fi} \), setting. During flow, view the \( f \) and \( \text{fi} \) values in the first column of the hidden diagnostics. The \( \text{fi} \) value should be approximately 10-20% higher than the \( f \) value. If you raise the \( \text{Ck} \) setting in the Calibration Menu, then the \( \text{fi} \) value will increase. The \( \text{fi} \) 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 \( \text{fi} \) value will increase to a large number - this is correct.
5.4.3 **Symptom: No Output**

1. For remote mounted electronics, carefully check all the wiring connections in the remote mount junction box. There are 18 connections that must be correct, verify each color (black and red), shield, and wire number.

2. Turn on the pressure and temperature display in the *Display Menu* and verify that the pressure and temperature are correct.

3. Using ESD precautions and hazardous area precautions, remove the electronics enclosure window cover. Disconnect the vortex sensor from the electronics stack (see Figure 78 below) or the remote feed through board (see Figure 79 below). Measure the resistance from each outside pin to the meter ground (see Figure 80 on page 118) - each should be open. Measure the resistance from the center pin to the meter ground - this should be grounded to the meter.

![Figure 78: Electronics Stack Sensor Connections](image)

![Figure 79: Remote Feed Through Board Sensor Connections](image)
5.4.3 Symptom: No Output (cont.)

4. With the sensor still disconnected, go to the first column of the hidden diagnostics and display the vortex shedding frequency, $f$. Hold a finger on the three exposed pins on the analog board. The meter should read electrical noise, 60 Hz for example. If all readings are correct, re-install the vortex sensor wires.

5. Verify all meter configuration and troubleshooting steps previously described. There are many possible causes of this problem. Consult GE if necessary.
5.4.4 Symptom: Meter Displays Temperature Fault

1. For remote mounted electronics, carefully check all the wiring connections in the remote mount junction box. There are 18 connections that must be correct. Verify each color (black and red), shield, and wire number.

2. Go to the first column of the hidden diagnostics and check the resistance of the RTD1. It should be about 1080 ohms at room temperature.

3. Using ESD precautions and hazardous area precautions, remove the electronics enclosure window cover. Disconnect the temperature sensor from the electronics stack (see Figure 78 on page 117) or the remote feed through board (see Figure 79 on page 117). Measure the resistance across the outside pins of the temperature sensor connector (see Figure 81 below). It should read approximately 1080 ohms at room temperature (higher resistance at higher temperatures).

4. Consult GE with your findings
5.4.5 Symptom: Meter Displays Pressure Fault

1. For remote mounted electronics, carefully check all the wiring connections in the remote mount junction box. There are 18 connections that must be correct. Verify each color (black and red), shield, and wire number.

2. Using ESD precautions and hazardous area precautions, remove the electronics enclosure window cover. Disconnect the pressure sensor from the electronics stack (see Figure 78 on page 117) or the remote feed through board (see Figure 79 on page 117). Measure the resistance across the outside pins of the pressure sensor connector, then across the inside pins (see Figure 82 below). Both readings should be approximately 4000 ohms.

![Figure 82: Pressure Sensor Connector](image)

3. Go to the first column of the hidden diagnostics and record the $P_e(V)$ and $P_v(V)$ values and consult GE with your findings.
5.5 Electronics Assembly Replacement (All Meters)

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

**WARNING!** Before attempting any 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 78 on page 117 or Figure 79 on page 117). The vortex sensor connection is on the left, the temperature sensor connection (if present) is second from the left, and the pressure sensor connection (if present) is on the right. Use small pliers to pull the sensor wiring connectors off of the circuit boards.
4. Locate and loosen the small set screw which locks the smaller enclosure cover in place. Unscrew the cover to expose the field wiring strip. Tag and remove the field wires.
5. Remove the screws that hold the black wiring label in place and remove the label.
6. Locate the 4 Phillips head screws which are spaced at 90-degrees around the terminal board. These screws hold the electronics stack in the enclosure. Loosen these screws (Note that these are captive screws and they will stay inside the enclosure).
7. Carefully remove the electronics stack from the opposite side of the enclosure. If the electronics stack will not come out, gently tap the terminal strip with the screw driver handle. This will loosen the rubber sealing gasket on the other side of the enclosure wall. Be careful that the stack does not become tangled on the loose sensor harnesses.
8. Repeat steps 1 through 6 in reverse order to install the new electronics stack.
5.6 Pressure Sensor Replacement (Series MV80 Only)

1. For local mounted electronics, remove the electronics stack as previously described. For remote mount electronics, remove all wires and sensor connectors from the remote feed through board in the junction box at the meter.

2. Loosen the three set screws at the center of the adapter between the meter and the enclosure.

3. Remove the top half of the adapter to expose the pressure transducer.

4. Remove the transducer and replace it with the new one using appropriate thread sealant.

5. Reassemble in reverse order.

5.7 Returning Equipment to the Factory

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

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

When requesting further troubleshooting guidance, please record the values in the tables provided in “Troubleshooting the Flow Meter” on page 114 and have this information available.
Appendix A. Product Specifications

**Accuracy**

<table>
<thead>
<tr>
<th>Process Variables</th>
<th>MV80 Series In-Line Meters</th>
<th>MV82 Series Insertion Meters1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liquids</td>
<td>Gas &amp; Steam</td>
</tr>
<tr>
<td>Mass Flow Rate</td>
<td>±1% of rate over a 30:1 range3</td>
<td>±1.5% of rate over a 30:1 range3</td>
</tr>
<tr>
<td>Volumetric Flow Rate</td>
<td>±0.7% of rate over a 30:1 range3</td>
<td>±1% of rate over a 30:1 range3</td>
</tr>
<tr>
<td>Temperature</td>
<td>±2° F (±1°C)</td>
<td>±2° F (±1°C)</td>
</tr>
<tr>
<td>Pressure</td>
<td>0.3% of transducer full scale</td>
<td>0.3% of transducer full scale</td>
</tr>
<tr>
<td>Density</td>
<td>0.3% of reading</td>
<td>0.5% of reading</td>
</tr>
</tbody>
</table>

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: ±0.2°C (±0.1°C)
Pressure: 0.05% of full scale
Density: ±0.1% of reading

**Stability Over 12 Months**

Mass Flow Rate: ±0.2% of rate maximum
Volumetric Flow Rate: Negligible error
Temperature: ±0.1°C (±0.5°C) maximum
Pressure: 0.1% of full scale maximum
Density: ±0.1% of reading maximum

**Response Time**

Adjustable from 1 to 100 seconds
**Material Capability**

Series MV80 In-Line 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 GE for sizing assistance.

<table>
<thead>
<tr>
<th>Units</th>
<th>½-inch</th>
<th>¾-inch</th>
<th>1-inch</th>
<th>1.5-inch</th>
<th>2-inch</th>
<th>3-inch</th>
<th>4-inch</th>
<th>6-inch</th>
<th>8-inch</th>
</tr>
</thead>
<tbody>
<tr>
<td>gpm</td>
<td>1</td>
<td>2.2</td>
<td>5.5</td>
<td>9.2</td>
<td>21</td>
<td>36</td>
<td>81</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>67</td>
<td>166</td>
<td>276</td>
<td>618</td>
<td>1076</td>
<td>2437</td>
<td>4270</td>
<td></td>
</tr>
<tr>
<td>m³/hr</td>
<td>0.23</td>
<td>0.5</td>
<td>1.3</td>
<td>2.1</td>
<td>4.7</td>
<td>8.1</td>
<td>18</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>15</td>
<td>38</td>
<td>63</td>
<td>140</td>
<td>244</td>
<td>554</td>
<td>970</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Nominal Pipe Size (mm)</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>40</th>
<th>50</th>
<th>80</th>
<th>100</th>
<th>150</th>
<th>200</th>
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<tbody>
<tr>
<td>0 barg</td>
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<td>3</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>13</td>
<td>19</td>
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<td>90</td>
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<td></td>
<td></td>
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<td>66</td>
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<td>847</td>
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<td>3476</td>
<td>7775</td>
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<tr>
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<td>7</td>
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<td>21</td>
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<td>337</td>
<td>764</td>
</tr>
<tr>
<td></td>
<td></td>
<td>165</td>
<td>390</td>
<td>847</td>
<td>2080</td>
<td>3476</td>
<td>7775</td>
<td>13533</td>
<td>30682</td>
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<td>9</td>
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<td>40529</td>
<td>70544</td>
<td>159942</td>
<td>280187</td>
</tr>
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</table>

**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.)

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Nominal Pipe Size (in)</th>
<th>Flow Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
<td>0.75</td>
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<tr>
<td>5 psig</td>
<td>6.5</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>122</td>
</tr>
<tr>
<td>100 psig</td>
<td>15</td>
<td>27</td>
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<tr>
<td></td>
<td>271</td>
<td>639</td>
</tr>
<tr>
<td>200 psig</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>493</td>
<td>1163</td>
</tr>
<tr>
<td>300 psig</td>
<td>24</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>716</td>
<td>1688</td>
</tr>
<tr>
<td>400 psig</td>
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<td>51</td>
</tr>
<tr>
<td></td>
<td>941</td>
<td>2220</td>
</tr>
<tr>
<td>500 psig</td>
<td>31</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>1170</td>
<td>2760</td>
</tr>
</tbody>
</table>

### Typical Saturated Steam Minimum and Maximum Flow Rates (kg/hr)

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Nominal Pipe Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>0 barg</td>
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<tr>
<td>5 barg</td>
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<td>20 barg</td>
<td>11</td>
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<tr>
<td></td>
<td>314</td>
</tr>
<tr>
<td>30 barg</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>463</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Process Connection</th>
<th>Material</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanged</td>
<td>316L SS, A105 Carbon Steel, C276 Hastelloy</td>
<td>150, 300, 600 lb, PN16, PN40, PN64</td>
</tr>
<tr>
<td>Wafer</td>
<td>316L SS, A105 Carbon Steel, C276 Hastelloy</td>
<td>600 lb, PN64</td>
</tr>
</tbody>
</table>

**MV80 Pressure Ratings**

<table>
<thead>
<tr>
<th>Probe Seal</th>
<th>Process Connection</th>
<th>Material</th>
<th>Rating</th>
<th>Ordering Code</th>
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<tbody>
<tr>
<td>Compression Fitting</td>
<td>2-inch MNPT</td>
<td>316L SS</td>
<td>ANSI 600 lb</td>
<td>CNPT</td>
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<tr>
<td></td>
<td>2-inch 150 lb flange, DN50 PN16</td>
<td>316L SS</td>
<td>ANSI 150 lb, PN16</td>
<td>C150, C16</td>
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<tr>
<td></td>
<td>2-inch 300 lb flange, DN50 PN40</td>
<td>316L SS</td>
<td>ANSI 300 lb, PN40</td>
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<tr>
<td></td>
<td>2-inch 600 lb flange, DN50 PN64</td>
<td>316L SS</td>
<td>ANSI 600 lb, PN64</td>
<td>C600, C64</td>
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<tr>
<td>Packing Gland</td>
<td>2-inch MNPT</td>
<td>316L SS</td>
<td>50 psig</td>
<td>PNPT</td>
</tr>
<tr>
<td></td>
<td>2-inch 150 lb flange, DN50 PN16</td>
<td>316L SS</td>
<td>50 psig</td>
<td>P150, P16</td>
</tr>
<tr>
<td></td>
<td>2-inch 300 lb flange</td>
<td>316L SS</td>
<td>50 psig</td>
<td>P300, P40</td>
</tr>
<tr>
<td>Packing Gland with Removable Retractor</td>
<td>2-inch MNPT</td>
<td>316L SS</td>
<td>ANSI 300 lb</td>
<td>PM, RR</td>
</tr>
<tr>
<td></td>
<td>2-inch 150 lb flange, DN50 PN16</td>
<td>316L SS</td>
<td>ANSI 150 lb</td>
<td>P150, P16, RR</td>
</tr>
<tr>
<td></td>
<td>2-inch 300 lb flange</td>
<td>316L SS</td>
<td>ANSI 300 lb</td>
<td>P300, P40, RR</td>
</tr>
<tr>
<td>Packing Gland with Permanent Retractor</td>
<td>2-inch MNPT</td>
<td>316L SS</td>
<td>ANSI 600 lb</td>
<td>PNPTR</td>
</tr>
<tr>
<td></td>
<td>2-inch 150 lb flange, DN50 PN16</td>
<td>316L SS</td>
<td>ANSI 150 lb</td>
<td>P150R, P16R</td>
</tr>
<tr>
<td></td>
<td>2-inch 300 lb flange, DN50 PN40</td>
<td>316L SS</td>
<td>ANSI 300 lb</td>
<td>P300R, P40R</td>
</tr>
<tr>
<td></td>
<td>2-inch 600 lb flange, DN50 PN64</td>
<td>316L SS</td>
<td>ANSI 600 lb</td>
<td>P600R, P64R</td>
</tr>
</tbody>
</table>
Appendix A. Product Specifications

**Pressure Transducer Ranges**

<table>
<thead>
<tr>
<th>Pressure Sensor Ranges¹, psia (bara)</th>
<th>Full Scale Operating Pressure</th>
<th>Maximum Over-Range Pressure</th>
</tr>
</thead>
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<tr>
<td></td>
<td>psia</td>
<td>bara</td>
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<tr>
<td>30</td>
<td>2</td>
<td>60</td>
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<td>300</td>
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<td>500</td>
<td>35</td>
<td>1000</td>
</tr>
<tr>
<td>1500</td>
<td>100</td>
<td>2500</td>
</tr>
</tbody>
</table>

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

**Power Requirements**

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

Class I Equipment (Grounded Type)

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

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

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

**Display**

Alphanumeric 2 x 16 LCD digital display:
Six push-button switches (UP, DOWN, RIGHT, LEFT, ENTER, EXIT) operable through explosion-proof window using hand-held magnet. Viewing at 90-degree mounting intervals.
Process Fluid and Ambient Temperature

Process Fluid:
- Standard temperature sensor: –330 to 500°F (–200 to 260°C)
- High temperature sensor: to 750°F (400°C)

Ambient:
- Operating temperature range: –40 to 140°F (–40 to 60°C)
- Storage temperature range: –40 to 185°F (–40 to 85°C)
- Maximum relative humidity: 0-98%, non-condensing conditions
- Maximum altitude: –2000 to 14,000 feet (–610 to 4268 meters)

Pollution Degree 2 for the ambient environment

Output Signals

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

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.

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.
Appendix A. Product Specifications

**Wetted Materials**

**Series MV80 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: Wafer, 150, 300, 600 lb ANSI flange, PN16, PN40, PN64 flange
Series MV82 Permanent installation: 2-inch MNPT; 150, 300, 600 lb ANSI flange, PN16, PN40, PN64 flange with compression fitting probe seal
Series MV82 Hot Tap\(^1\) Installation: 2-inch MNPT; 150, 300, 600 lb ANSI flange, PN16, PN40, PN64 flange and optional retractor with packing gland probe seal. \(^1\)Removable under line pressure

**Mounting Position**
Series MV80 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

### Feature 1: Multivariable Options
- V: Volumetric Flow Meter for liquid, gas, and steam
- VT: Velocity and Temperature Sensors
- VTP: Velocity, Temperature and Pressure Sensors
- VTEP: Velocity, Temperature, and External 4-20mA Input (T or P)
- VTICE: Velocity, External RTD Temperature Input, External 4-20mA Input (T or P)
- VI-E: Energy output options
- VTEP-E: Energy options with Pressure Sensors
- VTPE-E: Velocity, Temperature, and External 4-20mA Input (T or P)

### Feature 2: Flow Body
- 04: 1/2-inch Nominal Bore (15mm)
- 06: 3/4-inch Nominal Bore (20mm)
- 08: 1-inch Nominal Bore (25mm)
- 12: 1.5-inch Nominal Bore (40mm)
- 16: 2-inch Nominal Bore (50mm)
- 24: 3-inch Nominal Bore (80mm)
- 32: 4-inch Nominal Bore (100mm)
- 48: 6-inch Nominal Bore (150mm)
- 64: 8-inch Nominal Bore (200mm)

### 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: RF 16
- 49: RF 49
- 64: RF 64

### Feature 5: Electronics Enclosure
- L: NEMA 4X, IP65 Enclosure
- R: Remote Electronics NEMA 4X, IP65, Specify cable length in parentheses

### Feature 6: Display Option
- BD: Optical Display and Programming Buttons
- ND: No Display

### Feature 7: Input Power
- DCL: 12-26 V DC, 25mA, 1W max, required on loop powered meters, 1AH only
- DCH: 12-35 V DC, 300mA, 6W max, - use with 1AH, 1AM, 3AH, 3AM
- AC: 100-240 VAC, 50/60 Hz line power, 5W max, - use with 1AH, 1AM, 3AH, 3AM

### Feature 8: Output
- 1 AHL: Loop powered option - one analog output (4-20 mA), one alarm, one pulse, 1AH, DCL input power or only
- 1AH: One analog output (4-20 mA), one alarm, one pulse, 1AH, DCL input power or only
- 1AM: One analog output (4-20 mA), one alarm, one pulse, MODBUS Communication Protocol, DCL or AC option only
- 1AB: One analog output (4-20 mA), one alarm, one pulse, 1AH, DCL input power or only
- 3AH: Three analog outputs (4-20 mA), three alarms, one pulse, 1AH, DCL input power or only
- 3AM: Three analog outputs (4-20 mA), three alarms, one pulse, MODBUS Communication Protocol, DCL or AC option only
- 3AB: Three analog outputs (4-20 mA), three alarms, one pulse, 1AH, DCL input power or only

### Feature 9: Temperature Options
- ST: Standard Temperature
- HT: High Temperature

### Feature 10: Pressure Options
- P0: No Pressure Sensor
- P1: Maximum 100 psig (7 bara), Proof 60 psig (4 bara)
- P2: Maximum 100 psig (7 bara), Proof 200 psig (14 bara)
- P3: Maximum 200 psig (14 bara), Proof 600 psig (41 bara)
- P4: Maximum 500 psig (34 bara), Proof 1000 psig (69 bara)
- P5: Maximum 1000 psig (57 bara), Proof 2500 psig (175 bara)
**Model Number Information: Series MV82 Insertion Flow Meter**

<table>
<thead>
<tr>
<th>Parent Number Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV82</td>
</tr>
</tbody>
</table>

**Feature 1: Multivariable Options**

- V: Volumetric Flow Meter for liquid, gas, and steam
- VT: Velocity and Temperature Sensors
- VTEP: Velocity, Temperature, and External 4-20mA Input (T or P)
- VTEP: Velocity, External RTD Temperature Input, External 4-20mA Input (T or P)
- VTEP-EP: Velocity, External RTD Temperature Input, External 4-20mA Input (T or P)

**Feature 2: Probe Length**

- SL: Standard Length
- CL: Compact Length
- EL: Extended Length

**Feature 3: Electronics Enclosure**

- E: NEMA 4X, IP69 Enclosure
- R: Remote Electronics (NEMA 4X, IP66). Specify cable length in parentheses

**Feature 4: Display Option**

- DD: Digital Display and Programming Buttons
- ND: No Display

**Feature 5: Input Power**

- DCL: 12-35 VDC, 25mA, 1W max. required on loop powered meters, 1A-HL only
- DCH: 32-35 VDC, 300mA, 9W max. - use with 1A-H, 1A-M, 3A-H, 3A-M
- AC: 100-240 VAC, 50/60 Hz line power, 5W max. - use with 1A-H, 1A-M, 3A-H, 3A-M

**Feature 6: Output Signal**

- 1A-HL: Loop powered option - one analog output (4-20 mA), one alarm, one pulse, Hart, DCL input power only *
- 1A-H: One analog output (4-20 mA), one alarm, one pulse, Hart Communication Protocol, DCH or AC option only *
- 1A-M: One analog output (4-20 mA), one alarm, one pulse, MODBUS Communication Protocol, DCH or AC option only *
- 3A-H: Three analog outputs (4-20 mA), three alarms, one pulse, Hart (VT, VTEP) only, DCH or AC option only *
- 3A-M: Three analog outputs (4-20 mA), three alarms, one pulse, MODBUS (VT, VTEP) only, DCH or AC option only *
- 3A-B: Three analog outputs (4-20 mA), three alarms, one pulse, BA-Cnet Communication Protocol, DCH or AC option only *

**Feature 7: Temperature Options**

- ST: Standard Temperature: -330 to 550°F (-200 to 260°C)
- HT: High Temperature: Process temperature to 750°F (400°C)

**Feature 8: Pressure Options**

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

**Feature 9: Process Connections**

- CNPT: Compression, 2 inch NPT
- C150: Compression, 2 inch 150# Flange
- C1500: Compression, 2 inch 300# Flange
- C40: Compression, 4 inch NPT
- C600: Compression, 2 inch 600# Flange
- C64: Compression, 6 inch NPT
- CNPT: Compression, 2 inch NPT
- P300: Packing gland, 2 inch 300# Flange
- P40: Packing gland, 4 inch NPT
- P1500: Packing gland, 2 inch 150# Flange
- P150: Packing gland, 150# Flange
- P400: Packing gland, 2 inch 600# Flange
- P400: Packing gland, 6 inch NPT
- P9: Packing gland, 2 inch 150# Flange
- P9: Packing gland, 2 inch 600# Flange

---

*Includes scaled frequency output
Appendix B. Approvals

FM / FMC Approval

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

ATEX-IECEx Specifications / Approval

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

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

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

Equipment Intended for use in Potentially Explosive Atmospheres
(ATEX)

Cable entries are ¾ NPT.

ID 0344

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

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

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

[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)
- \( \rho \) = 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 (ft²)
- \( f \) = Vortex shedding frequency (pulses/sec)
- \( K_C \) = Meter factor corrected for Reynolds Number (pulses/ft)
- \( Q_V \) = Volume flow rate (ft³/sec)
- \( Q_M \) = Mass flow rate (lbm/sec)
- \( V_f \) = Flowing velocity (ft/sec)
- \( \rho \) = Density (lbm/ft³)
C.3 Fluid Calculations

C.3.1 Calculations for Steam T & P

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

C.3.1a Density

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

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

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

\[ B_0 = 1.89 - 2641.62 \cdot t \cdot 10^{80870\tau^2} \]

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

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

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

Where:

\( \tau \) is 1/ temperature in Kelvin

density = \( 1/(v/ \) standard density of water)
C.3.1b  Viscosity

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

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

Where:
T is the temperature in Kelvin.

C.3.2  Calculations for Gas ("Real Gas" and "Other Gas")

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

C.3.2a  Density

The density for real gases is calculated from the equation:

\[ \delta = \frac{GM_{w,\text{Air}}p_f}{Z_fR_0T_f} \]

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.
Appendix C. Flow Meter Calculations

C.3.2b  Viscosity

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

\[ \mu_{cP} = a T_K^n \]

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.3.3  Calculations for Liquid

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

C.3.3a  Density

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

\[ G_F = \frac{p_c M_w}{T_c} \left( \frac{0.008}{Z_c^{0.773}} - 0.01102 \frac{T_f}{T_c} \right) \]

The specific gravity can then be converted into density.
C.3.3b Viscosity

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

Andrade's equation:

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

To find A and B:

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

and

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

The temperatures are all in degrees Rankin. Do not misinterpret the subscript \( R \) to mean that they are reduced temperatures.
# Appendix D. Glossary

<table>
<thead>
<tr>
<th>A</th>
<th>Cross sectional area</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACFM</td>
<td>Actual Cubic Feet Per Minute (volumetric flow rate)</td>
</tr>
<tr>
<td>ASME</td>
<td>American Society of Mechanical Engineers</td>
</tr>
<tr>
<td>Bluff Body</td>
<td>Non-streamlined body placed into a flow stream to create vortices. Also called Shedder Bar.</td>
</tr>
<tr>
<td>BTU</td>
<td>British Thermal Unit, an energy measurement</td>
</tr>
<tr>
<td>Cenelec</td>
<td>European Electrical Code</td>
</tr>
<tr>
<td>Compressibility Factor</td>
<td>A factor used to correct for the non-ideal changes in a fluid's density due to changes in temperature and/or pressure</td>
</tr>
<tr>
<td>CSA</td>
<td>Canadian Standards Association</td>
</tr>
<tr>
<td>d</td>
<td>Width of a bluff body or shedder bar</td>
</tr>
<tr>
<td>D</td>
<td>Diameter of a flow channel</td>
</tr>
<tr>
<td>f</td>
<td>Frequency of vortices generated in a vortex flow meter, usually in Hz</td>
</tr>
<tr>
<td>Flow Channel</td>
<td>A pipe, duct, stack, or channel containing flowing fluid</td>
</tr>
<tr>
<td>Flow Profile</td>
<td>A map of the fluid velocity vector (usually non-uniform) in a cross-sectional plane of a flow channel (usually along a diameter)</td>
</tr>
<tr>
<td>FM</td>
<td>Factory Mutual</td>
</tr>
<tr>
<td>Ft</td>
<td>Foot, 12 inches, a measure of length</td>
</tr>
<tr>
<td>Ft^2</td>
<td>Square feet, measure of area</td>
</tr>
<tr>
<td>Ft^3</td>
<td>Cubic feet, measure of volume</td>
</tr>
<tr>
<td>GPM</td>
<td>Gallons Per Minute</td>
</tr>
</tbody>
</table>
### Appendix D. Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hz</td>
<td>Hertz, cycles per second</td>
</tr>
<tr>
<td><strong>In-Line Flow Meter</strong></td>
<td>A flow meter which includes a short section of piping which is put in-line with the user's piping</td>
</tr>
<tr>
<td><strong>Insertion Flow Meter</strong></td>
<td>A flow meter which is inserted into a hole in the user's pipeline</td>
</tr>
<tr>
<td>Joule</td>
<td>A unit of energy equal to one watt for one second; also equal to a Newton-meter</td>
</tr>
<tr>
<td>LCD</td>
<td>Liquid crystal display</td>
</tr>
<tr>
<td>m</td>
<td>Mass flow rate</td>
</tr>
<tr>
<td>mA</td>
<td>Milliampere, one thousandth of an ampere of current</td>
</tr>
<tr>
<td>µ</td>
<td>Viscosity, a measure of a fluid's resistance to shear stress. Honey has high viscosity, alcohol has low viscosity</td>
</tr>
<tr>
<td>nm³/hr</td>
<td>Normal cubic meters per hour (flow rate converted to normal conditions, as shipped 101 kPa and 0° C). User definable.</td>
</tr>
<tr>
<td>∆P</td>
<td>Permanent pressure loss</td>
</tr>
<tr>
<td>P</td>
<td>Line pressure (psia or bar absolute)</td>
</tr>
<tr>
<td>ρ&lt;sub&gt;act&lt;/sub&gt;</td>
<td>The density of a fluid at the actual temperature and pressure operating conditions</td>
</tr>
<tr>
<td>ρ&lt;sub&gt;std&lt;/sub&gt;</td>
<td>The density of a fluid at standard conditions (usually 14.7 psia and 20° C)</td>
</tr>
<tr>
<td><strong>Permanent Pressure Loss</strong></td>
<td>Unrecoverable drop in pressure</td>
</tr>
<tr>
<td><strong>Piezoelectric Crystal</strong></td>
<td>A material which generates an electrical charge when the material is put under stress</td>
</tr>
<tr>
<td>PRTD</td>
<td>Resistance temperature detector (RTD) with platinum element. Used because of high stability</td>
</tr>
<tr>
<td>psia</td>
<td>Pounds per square inch absolute (equals psig + atmospheric pressure). Atmospheric pressure is typically 14.696 psi at sea level</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>psig</td>
<td>Pounds per square inch gauge</td>
</tr>
<tr>
<td>$P_V$</td>
<td>Liquid vapor pressure at flowing conditions (psia or bar absolute)</td>
</tr>
<tr>
<td>$Q$</td>
<td>Flow rate, usually volumetric</td>
</tr>
<tr>
<td>Rangeability</td>
<td>Highest measurable flow rate divided by the lowest measurable flow rate</td>
</tr>
<tr>
<td>Reynolds Number</td>
<td>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., $Re = \frac{VD}{\rho}$). 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.</td>
</tr>
<tr>
<td>RTD</td>
<td>Resistance temperature detector, a sensor whose resistance increases as the temperature rises</td>
</tr>
<tr>
<td>scfm</td>
<td>Standard cubic feet per minute (flow rate converted to standard conditions, as shipped 14.696 psia and 59°F). User definable.</td>
</tr>
<tr>
<td>Shedder Bar</td>
<td>A non-streamlined body placed into a flow stream to create vortices. Also called a Bluff Body.</td>
</tr>
<tr>
<td>Strouhal Number</td>
<td>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., $St = \frac{fd}{V}$). This is an important number for vortex flow meters because it relates the vortex frequency to the fluid velocity.</td>
</tr>
<tr>
<td>Totalizer</td>
<td>An electronic counter which records the total accumulated flow over a certain range of time</td>
</tr>
<tr>
<td>Traverse</td>
<td>The act of moving a measuring point across the width of a flow channel</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>The closeness of agreement between the result of a measurement and the true value of the measurement</td>
</tr>
<tr>
<td>$V$</td>
<td>Velocity or voltage</td>
</tr>
<tr>
<td>VAC</td>
<td>Volts, alternating current</td>
</tr>
<tr>
<td>VDC</td>
<td>Volts, direct current</td>
</tr>
<tr>
<td>VORTEX</td>
<td>An eddy of fluid</td>
</tr>
</tbody>
</table>
Warranty

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

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

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

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

Return Policy

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

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

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

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

GE Sensing
1100 Technology Park Drive
Billerica, MA 01821
USA

declare under our sole responsibility that the

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

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

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

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

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

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

Billerica - September 1, 2015

Issued

Mr. Gary Kozinski
Certification & Standards, Lead Engineer
[no content intended for this page]
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