F-1500 Series Insertion Turbine Flow Meter
Installation and Operation Guide

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SAFETY INFORMATION

This meter was calibrated at the factory before shipment. To ensure correct use of the meter, please read this manual thoroughly.

Regarding this manual:

- This manual should be passed on to the end user.
- Before use, read this manual thoroughly to comprehend its contents.
- The contents of this manual may be changed without prior notice.
-
- ONICON makes no warranty of any kind with regard to this material, including, but not limited to, implied warranties of merchantability and suitability for a particular purpose.
- All reasonable effort has been made to ensure the accuracy of the contents of this manual. However, if any errors are found, please inform ONICON.
- ONICON assumes no responsibilities for this product except as stated in the warranty.
- If the customer or any third party is harmed by the use of this product, ONICON assumes no responsibility for any such harm owing to any defects in the product which were not predictable, or for any indirect damages.

Safety Precautions:

The following general safety precautions must be observed during all phases of installation, operation, service, and repair of this product. Failure to comply with these precautions or with specific WARNINGS given elsewhere in this manual violates safety standards of design, manufacture, and intended use of the product. ONICON Incorporated assumes no liability for the customer's failure to comply with these requirements. If this product is used in a manner not specified in this manual, the protection provided by this product may be impaired.

The following symbols are used in this manual:

WARNING

Messages identified as "WARNING" contain information regarding the personal safety of individuals involved in the installation, operation or service of this product.

CAUTION

Messages identified as "CAUTION" contain information regarding potential damage to the product or other ancillary products.

IMPORTANT NOTE

Messages identified as "IMPORTANT NOTE" contain information critical to the proper operation of the product.

WARNINGS AND CAUTIONS

WARNING

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

Hot tapping must be performed by a trained professional. U.S. 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.

All flow meter connections, isolation valves and fittings for cold/hot tapping must have the same or higher pressure rating as the main pipeline.

For F-1500 series insertion flow meter installations, an insertion tool must be used for any installation where a flow meter is inserted under pressure greater than 50 psig.

To avoid serious injury, DO NOT loosen a compression fitting under pressure.

To avoid potential electric shock, follow National Electric Code or your local code when wiring this unit to a power source. 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.

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

CAUTION

Calibration must be performed by qualified personnel. ONICON Incorporated, strongly recommends that you return your flow meter to the factory for calibration.

In order to achieve accurate and repeatable performance, the flow meter must be installed with at least the specified minimum length of straight pipe upstream and downstream of the flow meter's location.

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.

For F-1500 series insertion flow meter installations, the sensor alignment pointer must point downstream in the direction of flow.

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

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SECTION 1.0: INTRODUCTION

We at ONICON Incorporated, would like to thank you for purchasing our quality, U.S. made, Turbine Flow Meter. As our valued customer, our commitment to you is to provide fast reliable service and assistance, while continuing to offer you new products to meet your growing flow measurement needs.

1.1 PURPOSE OF THIS GUIDE

We have written this guide to provide the persons responsible for the installation, operation and maintenance of your turbine flow meter with the most specific equipment information they will need. This is NOT an electrical or plumbing trade manual.

WARNING

Please do not permit any persons to install, operate or maintain this equipment unless they have a complete knowledge of their trade skills and are competent to work on high pressure hot and cold water, steam or pressurized gas systems, according to their individual trades. Death or permanent injury may result from accidents with these systems.

This guide is the basic reference tool for ONICON F-1500 Series Turbine Flow Meters. If you have not purchased all of the options, there will be references in this manual which are not applicable to your meter(s).

1.2 ONICON F-1500 SERIES INSERTION TURBINE FLOW METERS

The ONICON F-1500 Insertion Turbine Flow Meters provide a reliable solution for process flow measurement. From a single entry point in the pipeline, F-1500 meters offer precise measurements of mass or volumetric flow rates.

Multi-Parameter Mass Flow Meters
Mass flow meters utilize three primary sensing elements: a rotating turbine velocity sensor, an RTD temperature sensor, and an optional 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. BACnet MS/TP and MODBUS RTU RS485 interface options are also available.

Volumetric Flow Meters
The primary sensing element of a volumetric flow meter is a rotating turbine velocity sensor. Meters are loop powered. 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 are provide 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 BACnet MS/TP, MODBUS RTU RS485 or HART communications are also available.

Digital electronics allow for easy reconfiguration for most gases, liquids and steam. ONICON 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.

1.2.1 Using This Manual

This manual provides information needed to install and operate the F-1500 insertion style flow meter.

Section 1 includes the introduction and product description.
Section 2 provides information needed for installation.
Section 3 describes system operation and programming.
Section 4 provides information on HART, MODBUS and BACnet protocols.
Section 5 covers troubleshooting and repair.

Appendix A - Product Specifications
Appendix B– Flow Meter Calculations
Appendix C – Glossary of Terms
Appendix D – Terms & Conditions

1.2.2 Receipt of System Components

When receiving an ONICON flow meter, carefully check the outside packing carton for damage incurred in shipment. If the carton is damaged, notify the local carrier and submit a report to the factory or distributor. Remove the packing slip and check that all ordered components are present. Make sure any spare parts or accessories are not discarded with the packing material. Do not return any equipment to the factory without first contacting ONICON Customer Service.

1.2.3 Technical Assistance

If you encounter a problem with your flow meter, review the configuration information for each step of the installation, operation and set up procedures. Verify that your settings and adjustments are consistent with factory recommendations. Refer to Section 5, Troubleshooting, for specific information and recommendations.

If the problem persists after following the troubleshooting procedures outlined in Section 5, contact ONICON Incorporated Technical Support at
(727) 447-6140 between 8:00AM and 5:00PM EST.

When calling Technical Support, have the following information on hand:
The serial number and model number (shown on the meter nameplate)
The problem you are encountering and any corrective action taken
Application information (fluid, pressure, temperature and piping configuration)

1.2.4 Warranty

Warranty ONICON's complete warranty is included in Appendix D of this manual as part of the "Conditions of Sale". ONICON provides a two-year warranty.

1.3 HOW THE ONICON INSERTION TURBINE MASS FLOW METER OPERATES

ONICON F-1500 Series Insertion Turbine Mass Flow Meters are designed to monitor mass flow rate by directly measuring fluid velocity, temperature and when required, pressure. The built-in flow computer calculates the mass flow rate and volumetric flow rate based on these direct measurements. The sensing head is built into the insertion turbine meter's flow body. To measure fluid velocity, the flow meter incorporates a rotating turbine in the flow stream. The rotation is converted into an electrical output that is proportional to the fluid velocity. Temperature is measured using a platinum resistance temperature detector (PRTD). When require, pressure measurement is achieved using an integral solid state pressure transducer.

1.3.1 Velocity Measurement

Fluid passing through the turbine causes its rotor to spin. The rotor is fabricated from 17-4PH stainless steel which is slightly magnetic, and is positioned in close proximity to a passive magnetic pickup coil. As each blade rotates by the pickup coil, a small sinusoidal voltage is generated. This sinusoidal voltage is then amplified, filtered, and shaped by the measurement electronics. The frequency of the signal is proportional to the flowing velocity.

Flow Velocity Range

To ensure trouble-free operation, turbine flow meters must be correctly sized so that the flow velocity range through the meter lies within the measurable velocity range.

The measurable range is defined by the minimum and maximum velocity using the following table.

Gas or Steam				
	Minimum Velocity		Maximum Velocity	
	ft/sec	m/sec	ft/sec	m/sec
R40	3.5	1.07	43.0	13.11
R30	4.0	1.22	62.5	19.05
R25	5.0	1.52	80.0	24.38
R20	7.0	2.13	100.0	30.48
R15	8.5	2.59	134.6	41.03
R10	12.0	3.66	205.0	62.48

Table 1. Measurable Range

The pressure drop for F-1500 Series insertion meters is negligible.

1.3.2 Temperature Measurement

This flow meter uses a 1000 ohm platinum resistance temperature detector (PRTD) to measure fluid temperature.

1.3.3 Pressure Measurement

The F-1500 incorporates a solid-state pressure transducer isolated by a 316 SS 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° C to 60° C). Thermal isolation of the pressure transducer ensures the same accuracy across the allowable process fluid temperature range of -200° F to 750° F (-128° C to 400° C).

1.4 Flow Meter Configuration

The F-1500 Insertion Turbine Mass Flow Meter has a sensing head which contains the turbine rotor, temperature sensor, and pressure tap. The pressure sensor, if provided, is located in the pressure transducer housing between the stem and electronics housing.

The meter is installed through a full block valve and mounting adapter having a clear, cylindrical port diameter of 1.875” diameter. It can be installed during system downtime or using standard “Hot Tap” procedures.

The meter directly monitors the velocity at a point in the cross-sectional area of a pipe, duct, or stack. The velocity at a point in the pipe varies as a function of the Reynolds number. When a fluid flows through a pipe, the velocity generated is not constant across the diameter. The fluid velocity varies across the diameter of the pipe creating a “Velocity Profile”. That is, velocities near the center of the pipe are faster than those nearer to the wall. In addition, the velocity profile varies in concert with flow rate from the lowest to the highest flows. Mathematical descriptions of this profile have been developed for over 100 years. By knowing the velocity profile and the flow rate at a single point, the average flow rate can be determined. The accuracy of the flow rate computation depends on adherence to the piping installation requirements given in Chapter 2. If adherence to those guidelines cannot be met, contact the factory for specific installation advice.

1.4.1 Multivariable Options

Different versions of the meter are capable of providing the following flow measurement options: Volumetric flow; Mass flow with temperature compensation; Mass flow with temperature and pressure compensation; Steam energy flow with temperature compensation; Steam energy flow with temperature and pressure compensation, Mass or Energy flow with temperature and external pressure compensation and Net Energy using a second temperature sensor.

1.4.2 Line Size / Process Connections / Materials

The F-1500 can be used in line sizes 2” and greater and is built with a 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 is available with a permanent or removable retractor.

1.4.3 Flow Meter Electronics

The flow meter electronics are available mounted directly to the flow body, or mounted remotely. 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 BACnet, MODBUS or HART communications is also available.

Each meter includes a local 2 x 16 character LCD display housed within the enclosure. Local operation and reconfiguration is accomplished using six push-button operated via finger touch. For hazardous locations, the six buttons can be operated with the electronics enclosure sealed using a hand-held magnet, thereby maintaining 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.

SECTION 2.0 INSTALLATION

2.1 INSTALLATION OVERVIEW

ONICON F-1500 Insertion Turbine Flow Meter installations are simple and straightforward. After reviewing the installation requirements given below, see page 24 for installation instructions. Wiring instructions begin on page 38.

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 the installation site allows for these considerations:

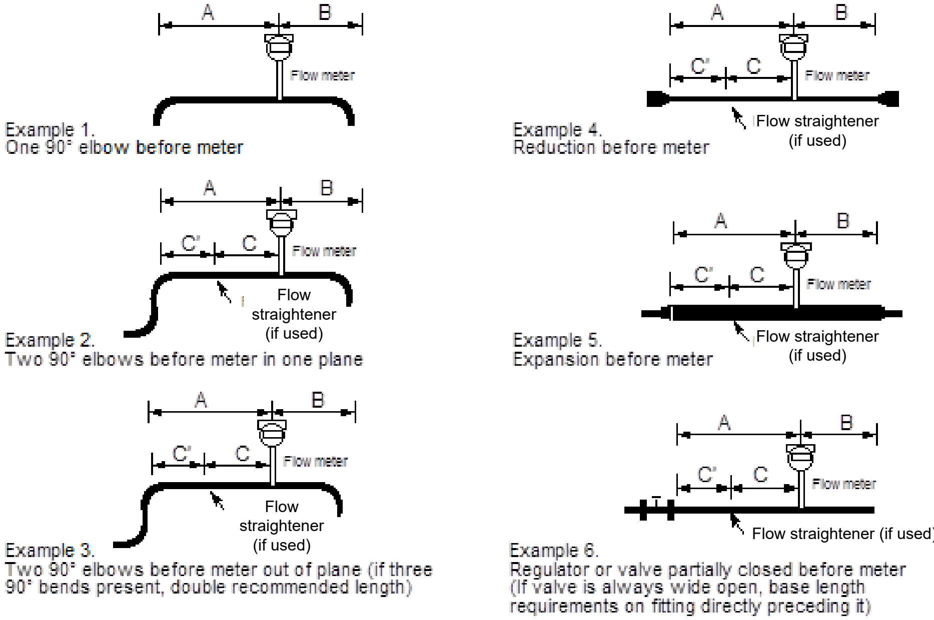
1. Line pressure and temperature will not exceed the flow meter rating.
2. The location meets the required minimum number of pipe diameters upstream and downstream of the sensor head as illustrated in Figure 4.
3. Safe and convenient access with adequate overhead clearance for maintenance purposes.
4. 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 that could create disturbances in the flow profile that might cause unexpected flow rate indications
- Avoid areas where high RF, EMI, or other electrical interference may be present. Devices such as VFD's (variable frequency drives), large AC motors, etc

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 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.



	Minimum Required Upstream Diameters				Minimum Required Downstream Diameters	
	No Flow Straightener	With Flow Straightener			No Flow Straightener	With Flow Straightener
Example	A	A	C	C’	B	B
1	10 D	N/A	N/A	N/A	5 D	5 D
2	15 D	10 D	8 D	2 D	5 D	5 D
3	30 D	15 D	13 D	2 D	5 D	5 D
4	10 D	N/A	N/A	N/A	5 D	5 D
5	20 D	10 D	8 D	2 D	5 D	5 D
6	50 D	25 D	23 D	2 D	5 D	5 D
D = Internal diameter of channel.						

2.2 FLOW METER INSTALLATION

Prepare the pipeline for installation using either a standard or hot tap method described on the following pages. 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 below.

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

Isolation Valve Selection
Always install an isolation valve. If you supply the isolation valve, it must meet the following requirements:

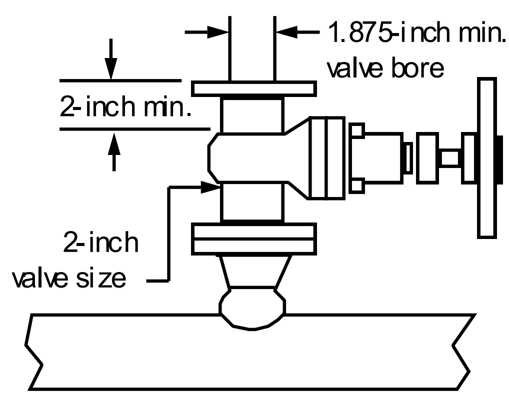


Figure 1. Isolation Valve Requirements

1. A minimum valve bore diameter of 1.875” is required, and the valve’s body size should be 2”. 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 two inches existing 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.

2.2.1 Standard Installation Guidelines

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.

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

1. Confirm that the installation site meets the minimum upstream and downstream pipe diameter requirements. See Figure 4.
2. Turn off the flow of process gas, liquid or steam. Verify that the line is not pressurized.
3. Use a cutting torch or sharp cutting tool to tap into the pipe. The pipe opening must be at least 1.875” in diameter. (Do not attempt to insert the sensor probe through a smaller hole.)
4. Remove all burrs from the hole. 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.

After cutting, measure the thickness of the cut-out and record this number for calculating the insertion depth.

5. Weld the flow meter pipe connection onto the pipe. Make sure this connection is within ± 5° perpendicular to the pipe center line.
   Install the isolation valve.
6. 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 re-test.
7. The first time the sensor is inserted, install the check-disc tool on the flow meter rather than the rotor.
8. Open the isolation valve and insert the check-disc tool. After successful insertion, retract the sensor and remove the flow meter.
9. Install the rotor and 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.

2.2.2 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.

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

1. Confirm that the installation site meets the minimum upstream and downstream pipe diameter requirements.
2. Weld a 2" mounting adapter on the pipe. Make sure the mounting adapter is within ± 5° perpendicular to the pipe center line (see previous page). The pipe opening must be at least 1.875" in diameter.
3. Connect a 2" 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" 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" diameter hole.
7. Retract the drill, close the isolation valve, and remove the hot tapping equipment.
8. The first time the sensor is installed, install the check-disc tool on the flow meter rather than the rotor.
9. Open the isolation valve and insert the check-disc tool. After successful insertion, retract the sensor, close the isolation valve and remove the flow meter.
10. Install the rotor, connect the flow meter to the isolation valve and open the isolation valve.
11. Calculate the sensor probe insertion depth and insert the sensor probe into the pipe as described on the following pages.

> **WARNING**
>
> All flow meter connections, isolation valves, and fittings for hot tapping must have the same or higher pressure rating as the main pipeline.

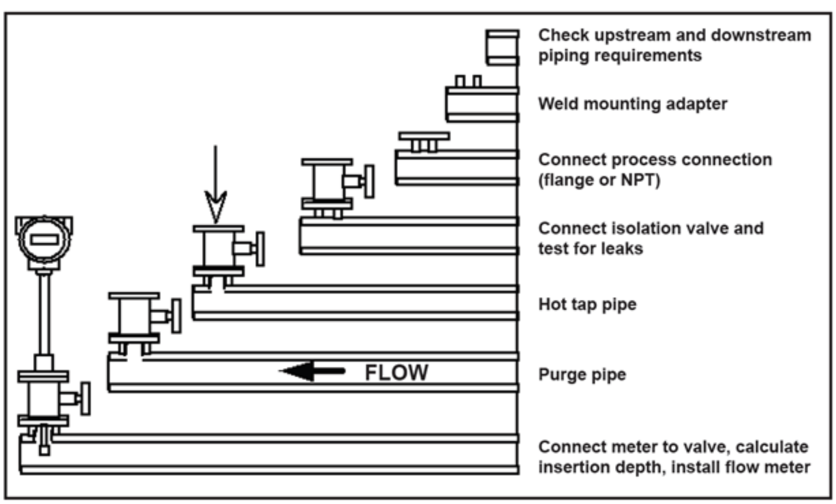


Figure 2. Hot Tap Sequence

2.3 FLOW METER INSERTION

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” and larger. For pipe sizes 10” and smaller, the center line of the meter’s sensing head is located at the pipe’s center line. For pipe sizes larger than 10”, the center line of the sensing head is located in the pipe’s cross section 5” from the inner wall of the pipe; i.e., its “wetted” depth from the wall to the center line of the sensing head is 5”.

Insertion flow meters are available in two probe lengths:

- Standard Probe configuration is used with most flow meter process connections. The length, S, of the stem is 28.67”.
- 12-Inch Extended Probe configuration is used with exceptionally lengthy flow meter process connections. The length, S, of the stem is 40.67”.

Use the Correct Insertion Formula
Depending on your flow meter’s process connection, use the applicable insertion length formula and installation procedure as follows:

- Flow meters with a packing gland type connection (NPT or flanged) configured with an insertion tool, follow the instructions beginning on page 29.
- Flow meters with a packing gland type connection (NPT or flanged) without an insertion tool, follow the instructions beginning on page 32.

WARNING

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

2.3.1 Installing Flow Meters *

Use the formula below to determine the insertion depth for flow meters (NPT and flanged) equipped with an insertion tool. To install, see the next page for instructions for meters with a permanent insertion tool. For meters with a removable insertion tool, see page 17.

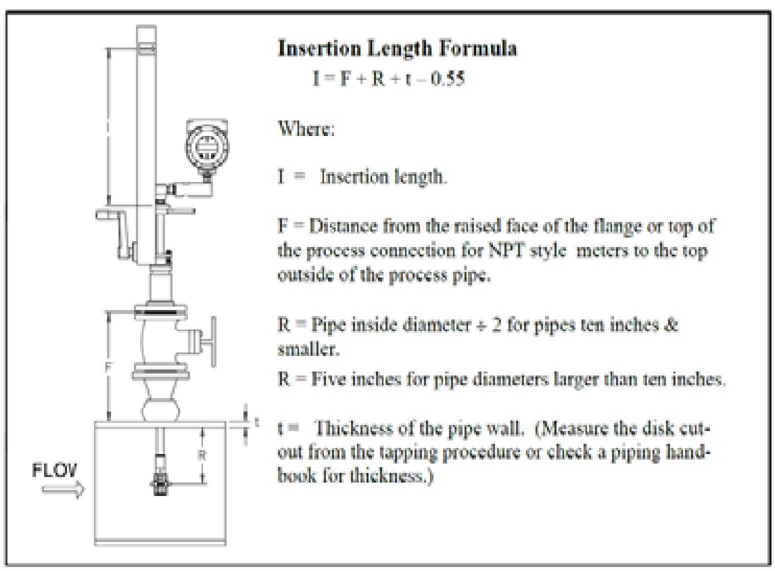


Figure 3. Insertion Calculation (Meters with Insertion Tool)

Example 1: Flange Style Meters:
To install an F-1500 flow meter into a 14 inch schedule 40 pipe, the following measurements are taken:
F = 12 inches
R = 5 inches
t = 0.438 inches

The example insertion length is 16.89 inches.

Example 2: NPT Style Meters:
The length of thread engagement on the NPT style meters is also subtracted in the equation. The length of the threaded portion of the NPT meter is 1.18 inches. Measure the thread portion still showing after the installation and subtract that amount from 1.18 inches. This gives you the thread engagement length. If this cannot be measured use .55 inch for this amount.
F = 12 inches
R = 5 inches
t = 0.438 inches

The example insertion length is 16.34 inches.

*All dimensions are in inches.

2.3.2 Insertion Procedure for Flow Meters with Permanent Insertion Tool

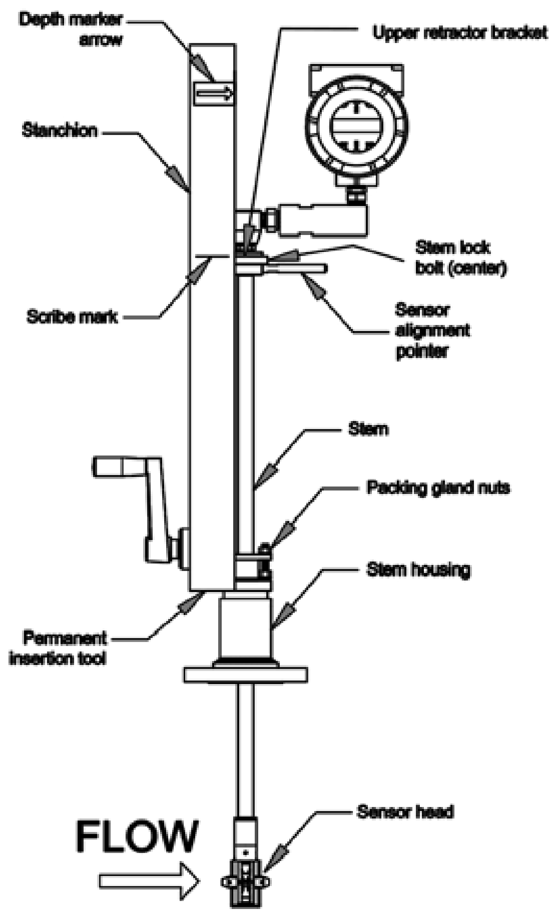


Figure 4. Flow Meter with Permanent Insertion Tool

1. Calculate the required sensor probe insertion length (see previous page). 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 full-port isolation valve. Use Teflon tape or pipe sealant to improve seal and prevent seizing on NPT style.
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 torque over 20 ft-lb.

CAUTION

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

IMPORTANT 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.

2.3.3 Insertion Procedure for Flow Meters with Removable Insertion Tool

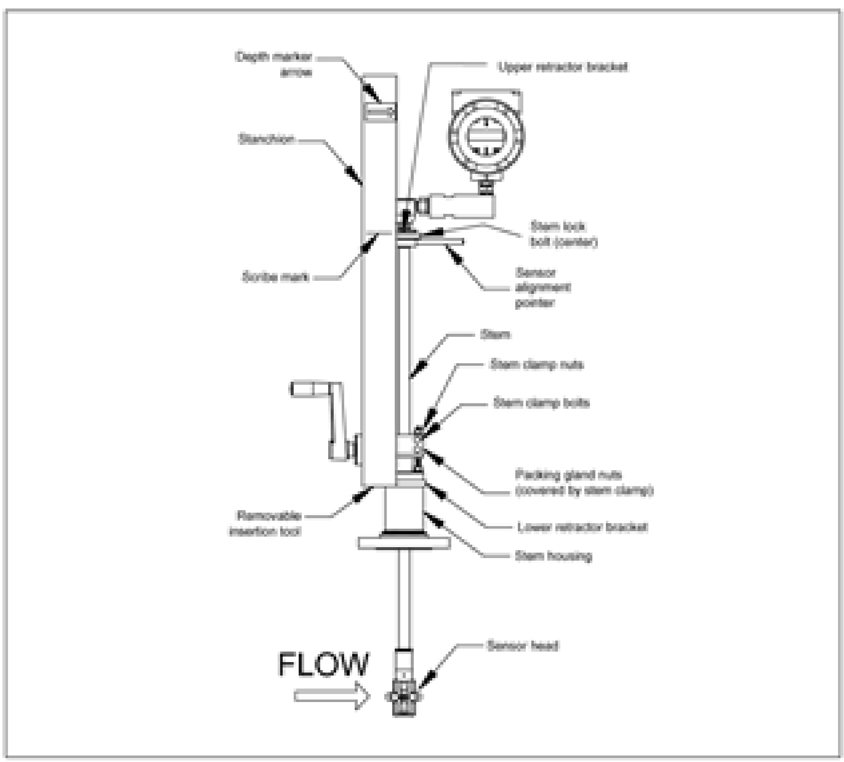


Figure 5. Flow Meter with Removable Insertion Tool

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 full-port isolation valve. Use Teflon tape or pipe sealant to improve seal and prevent seizing on NPT style.
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.

CAUTION

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

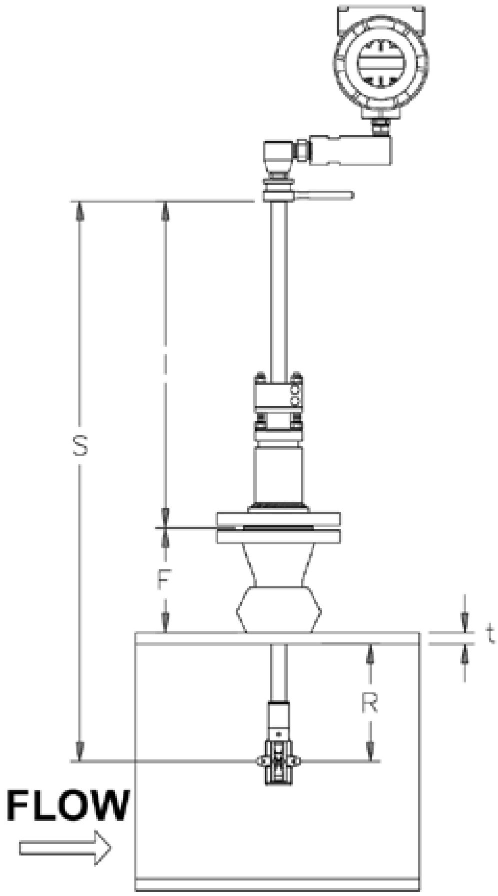
IMPORTANT NOTE

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.

7. Tighten the packing gland nuts to stop leakage around the stem. Do not torque over 20 ft-lbs.
8. Slide the stem clamp back into position. Torque stem clamp bolts to 15 ft-lbs. Replace the stem clamp nuts and torque to 10-15 ft-lbs.
9. To separate the insertion tool from the flow meter, remove four socket head cap bolts securing the upper and lower retractor brackets. Remove the insertion tool.

2.3.4 Installation of Meters with Packing Gland Connection (No Insertion Tool)*

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



Insertion Length Formula

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

Where:

I = Insertion length.

S = Stem length – the distance from the center of the sensor head to the base of the enclosure adapter (S = 28.67 inches for standard probes; S = 40.67 inches for 12 inch extended probes).

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

R = Pipe inside diameter ÷ 2 for pipes ten inches & smaller.

R = 5 inches for pipe diameters larger than ten inches.

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

Figure 6. Flow Meter with Removable Insertion Tool

Example:
To install the F-1500 flow meter with a standard probe (S = 28.67) into a 14 inch schedule 40 pipe, the following measurements are taken:
F = 3 inches
R = 5 inches
t = 0.438 inches
The example insertion length is 20.23 inches.

*All dimensions are in inches.

2.3.5 Insertion Procedure for Flow Meters with No Insertion Tool

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.
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 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 torque over 20 ft-lbs.
6. Slide the stem clamp back into position. Torque stem clamp bolts to 15 ft-lbs. Replace the stem clamp nuts and torque to 10-15 ft-lbs.

WARNING

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

CAUTION

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

2.4 ADJUSTING THE DISPLAY ORIENTATION

Depending on installation requirements, you may need to rotate the position of the LCD display / keypad. The orientation of the display / keypad may be changed in 90 degree increments for easier viewing.

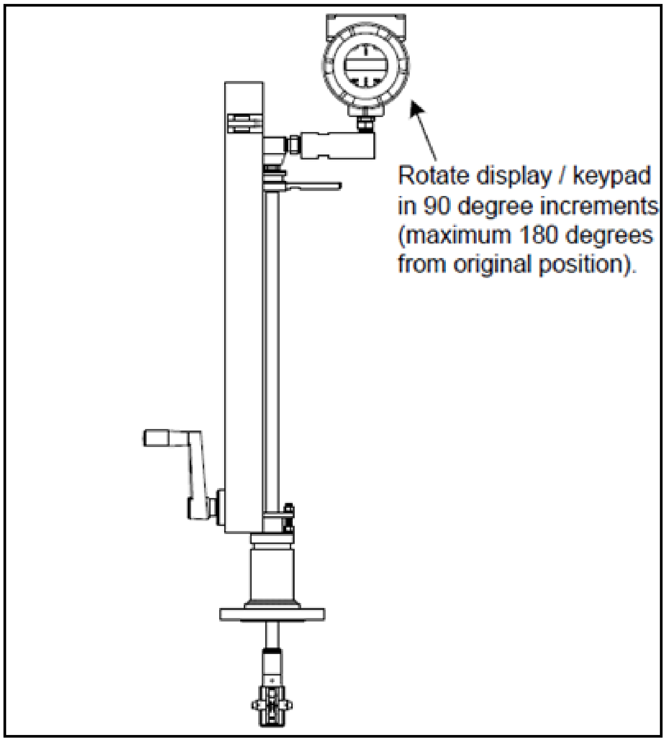


Figure 7. Display/Keypad Viewing Adjustment

The electronics boards are electrostatically sensitive. Wear a grounding wrist strap and make sure to observe proper handling precautions required for static-sensitive components. To adjust the display:

1. Disconnect power to the flow meter.
2. Loosen the small set screw which secures the electronics enclosure cover. Unscrew and remove the cover.
3. Loosen the four captive screws.
4. Carefully pull the display/microprocessor board away from the meter standoffs. Make sure not to damage the connected ribbon cable.
5. Rotate the display/microprocessor board to the desired position. Maximum turn, two positions left or two positions right (180°).
6. Align the board with the captive screws. 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. Restore power to the meter.

2.5 LOOP-POWERED 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 NEMA 4X enclosure contains an integral wiring compartment with one dual strip terminal block (located in the smaller end of the enclosure). Two ¾" 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" (457 mm) of the enclosure.

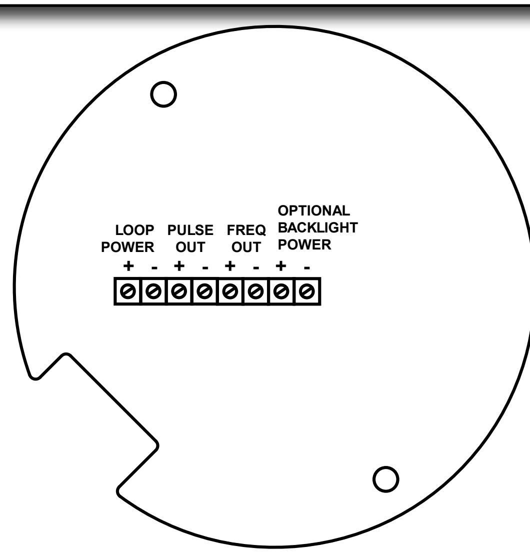


Figure 8. Wiring Terminals for Loop-Powered Version

2.5.1 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.

DC Power Wiring

Connect 4-20 mA loop power (12 to 36 VDC at 25 mA, 1W max.) to the +Loop Power and – Loop Power terminals on the terminal block. Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm). The DC power wire size must be 20 to 10 AWG with the wire stripped ¼" (7 mm).

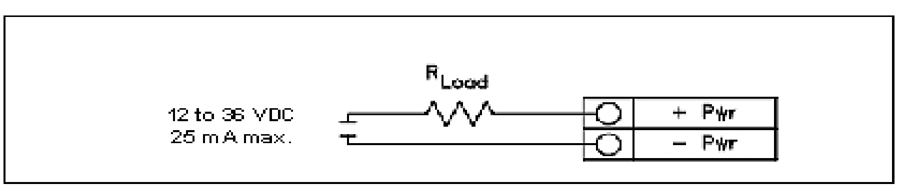


Figure 9. DC Power Connections

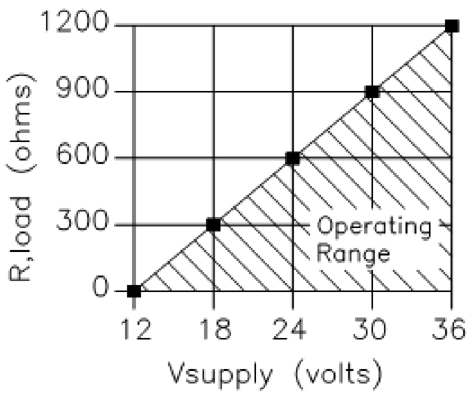
2.5.2 4-20 mA OUTPUT CONNECTIONS

The loop powered meter has a single 4-20 mA loop. The 4-20 mA loop current is controlled by the meter electronics. The electronics must be wired in series with the sense resistor or current meter. The current control electronics requires at least 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 18. The 4-20 mA loop is optically isolated from the flow meter electronics.

R_{load} is the total resistance in the loop, including the wiring resistance ($R_{load} = R_{wire} + R_{sense}$). To calculate R_{max}, the maximum Rl_{oad} for the loop, subtract the minimum terminal voltage from the supply voltage and divide by the maximum loop current, 20 mA. Thus:

The maximum resistance $R_{load} = R_{max} = (V_{supply} – 12V) / 0.020$ A



Vsupply (volts)	Rmax (ohms)
12	0
18	300
24	600
30	900
36	1200

Figure 10. Load Resistance Versus Input Voltage

2.5.3 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 and there are current and power specifications that must be observed when using this output. The output can conduct a current up to 40 mA and can dissipate up to 200 mW. The output is isolated from the meter electronics and power supply.

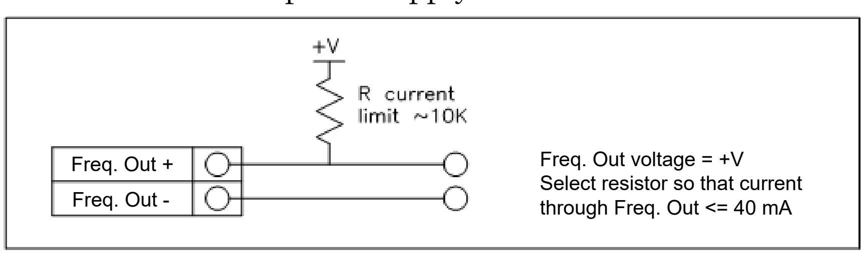


Figure 11. Isolated Frequency Output Using External Power Supply

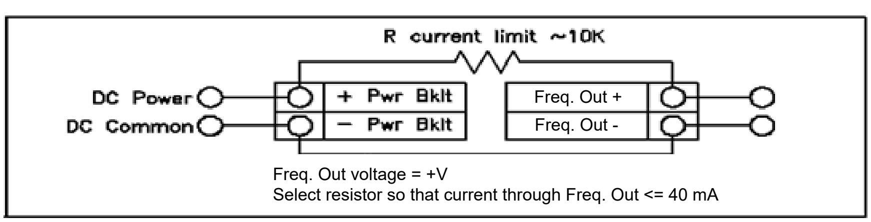


Figure 12. Non-Isolated Frequency Output Using External Power Supply

2.5.4 Optional Backlight Connection

The loop power meter has an optional backlight connection provided. It is intended to be powered by a separate 12 to 36 VDC at 35 mA max. power supply or by the pulse power input. Both options are shown below.

Figure 13. Backlight Using External Power Supply

2.5.5 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 terminations 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 - not at the remote electronics enclosure. Remove both glands and install appropriate conduit entry glands and conduit. When installation is complete, re-connect each labeled wire to the corresponding terminal position on the junction box terminal block. Make sure to connect each wire pair's shield. Note: Incorrect connection will cause the meter to malfunction.

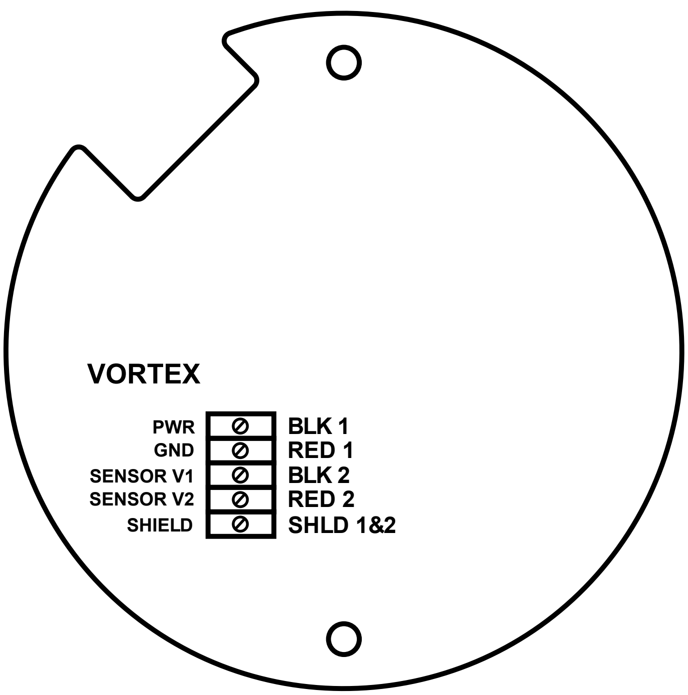


Figure 14. Loop-Powered Volumetric Flowmeter Junction Box Sensor Connections

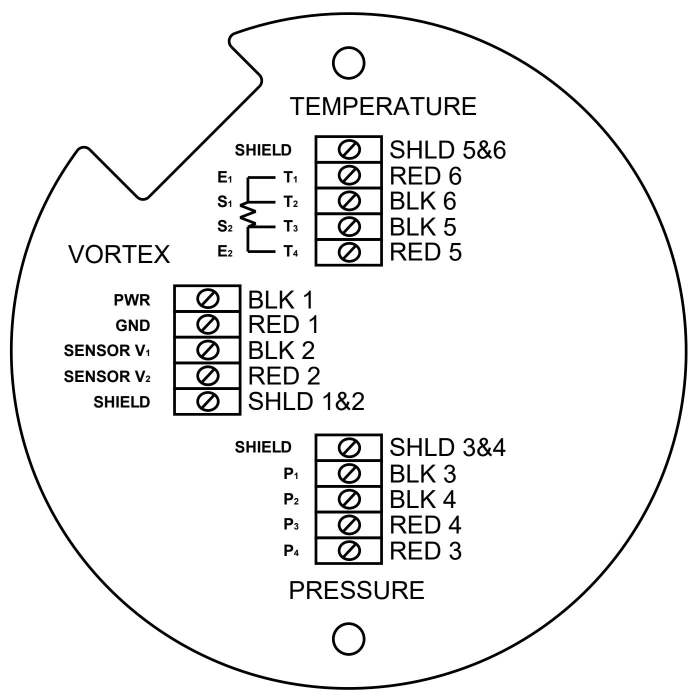


Figure 15. Loop-Power Mass Flowmeter Junction Box Sensor Connections

IMPORTANT NOTE

Numeric code in junction box label matches wire labels.

2.6 HIGH 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 NEMA 4X enclosure contains an integral wiring compartment with multiple dual strip terminal blocks (located in the smaller end of the enclosure). Two 3/4" 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" (457 mm) of the enclosure.

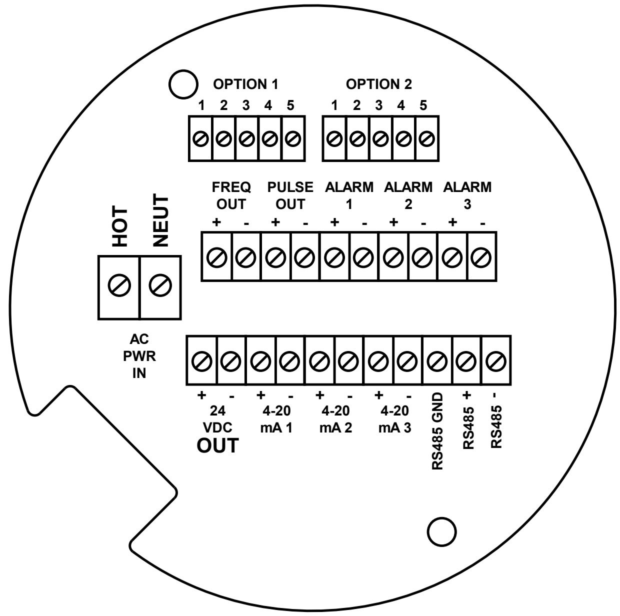


Figure 16. AC Wiring Terminals

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 blocks.

CAUTION

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

AC Power Wiring

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

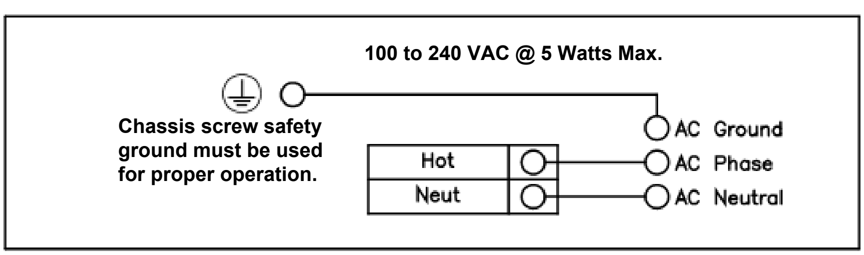


Figure 17. AC Power Connections

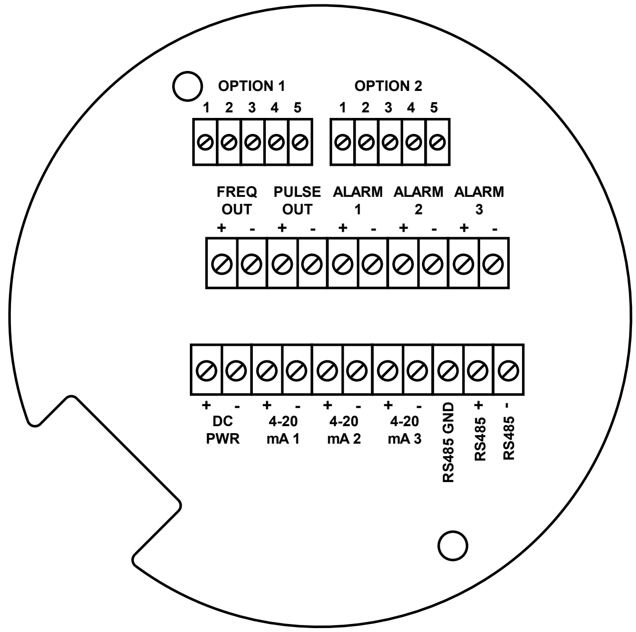


Figure 18. DC Wiring Terminals

DC Power Wiring

The DC power wire size must be 20 to 10 AWG with the wire stripped 1/4" (7 mm). Connect 18 to 36 VDC (300 mA, 9 W maximum) to the +DC Pwr and –DC Pwr terminals on the terminal block. Torque all connections to 4.43 to 5.31 in-lbs (0.5 to 0.6 Nm).

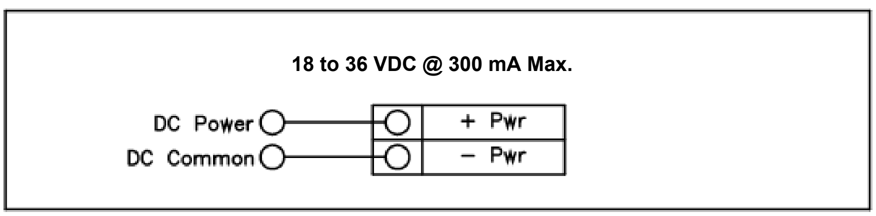


Figure 19. DC Power Connections

CAUTION

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

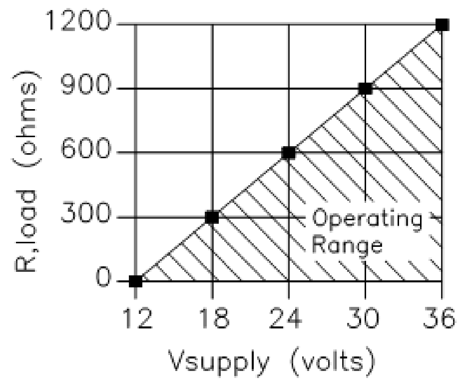
2.6.2 4-20 mA OUTPUT CONNECTIONS

The externally powered versions of the meters have a single 4-20 mA loop powered output. 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 sense resistor or current meter. The current control electronics require a minimum of 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 30. The 4-20 mA loop is optically isolated from the flow meter electronics.

R_{load} is the total resistance in the loop, including the wiring resistance ($R_{load} = R_{wire} + R_{sense}$). To calculate R_{max}, the maximum R_{load} for the loop, subtract the minimum terminal voltage from the supply voltage and divide by the maximum loop current, 20 mA. Thus:

The maximum resistance $R_{load} = R_{max} = (V_{supply} - 12V) / 0.020$ A



Vsupply (volts)	Rmax (ohms)
12	0
18	300
24	600
30	900
36	1200

Figure 20. Load Resistance Versus Input Voltage

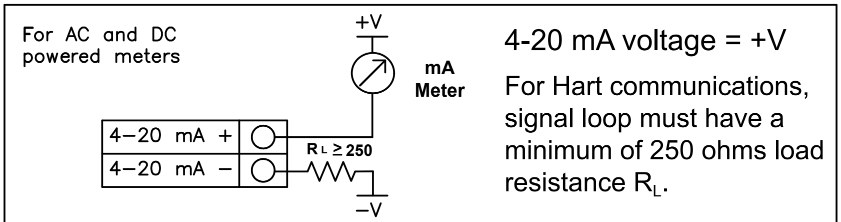


Figure 21. Isolated 4–20 mA Output Using External Power Supply

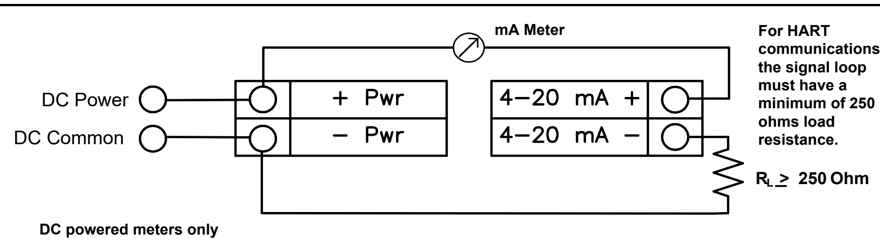


Figure 22. Non-Isolated 4–20 mA Output Using Meter Input Power Supply

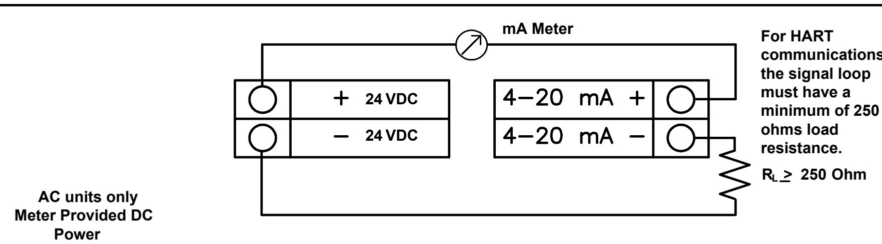


Figure 23. Isolated 4–20 mA Output Using Meter Provided Power Supply

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. The output is isolated from the meter electronics and power supply.

There are three connection options for the frequency output. The first has a separate power supply (Figure 36). The second uses the flow meter power supply (Figure 37) (DC powered units only), and the third uses the internal 24 VDC power supply (Figure 38)(AC powered units only). Use the first option with a separate power supply (5 to 36 VDC) if a specific voltage is needed for the frequency output. Use the second configuration if the voltage at the flow meter power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by the frequency load comes from the meter's power supply). Use the third configuration if you have an AC powered unit only. In any case, the voltage of the frequency output is the same as the voltage supplied to the circuit.

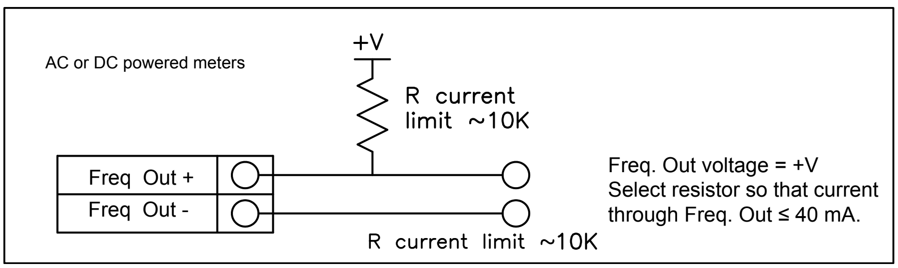


Figure 24. Isolated Frequency Output Using External Power Supply

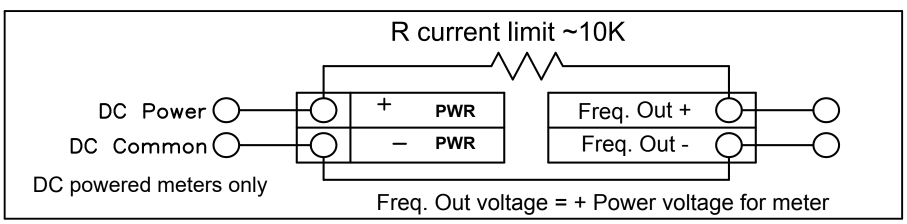


Figure 25. Non-Isolated Frequency Output Using Input Power Supply

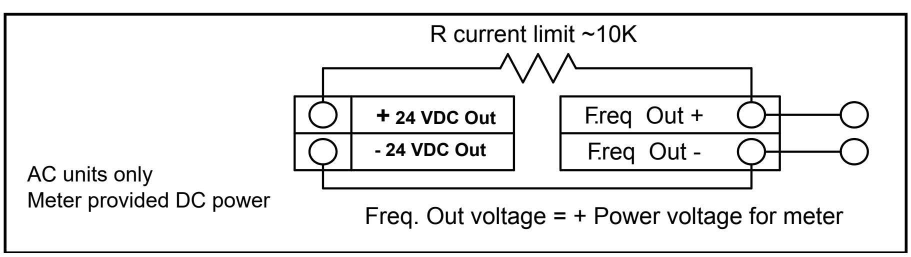


Figure 26. Isolated Frequency Output Using Meter Provided Power Supply

2.6.4 Pulse Output Connections

The pulse output is used for a remote counter. When the preset volume or mass (defined in the totalizer settings, on page 62) has passed the meter, the output provides a 50 millisecond square pulse.

The pulse output optical relay is a normally-open single-pole relay. The relay has a nominal 200 V / 160 ohm rating. This means that it has a nominal on-resistance of 160 ohms, and the largest voltage that it can withstand across the output terminals is 200 V. 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. The relay output is isolated from the meter electronics and power supply.

There are three connection options for the pulse output. The first has a separate power supply (Figure 37). The second uses the flow meter power supply (Figure 38) (DC powered units only), and the third uses the internal 24 VDC power supply (Figure 39)(AC powered units only). Use the first option with a separate power supply (5 to 36 VDC) if a specific voltage is needed for the pulse output. Use the second configuration if the voltage at the flow meter power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by the pulse load comes from the meter's power supply). Use the third configuration if you have an AC powered unit only. In any case, the voltage of the pulse output is the same as the voltage supplied to the circuit.

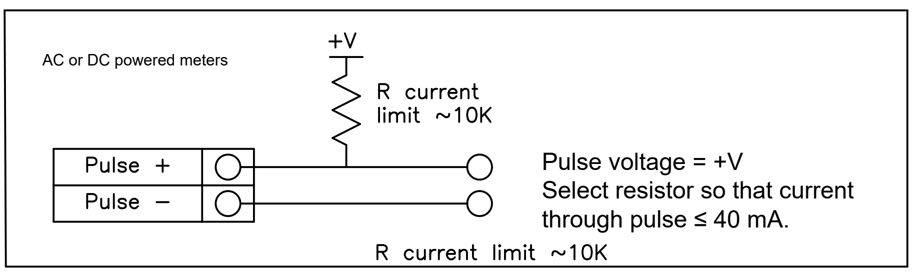


Figure 27. Isolated Pulse Output Using External Power Supply

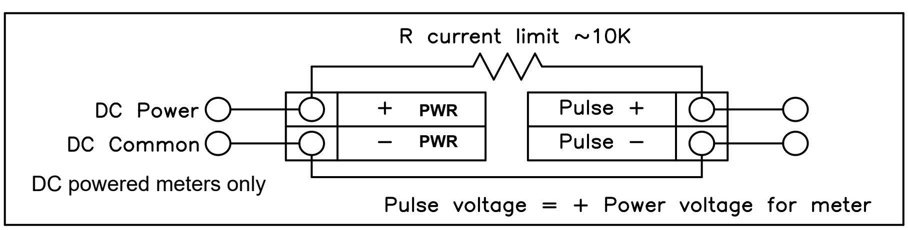


Figure 28. Non-Isolated Pulse Output Using Input Power Supply

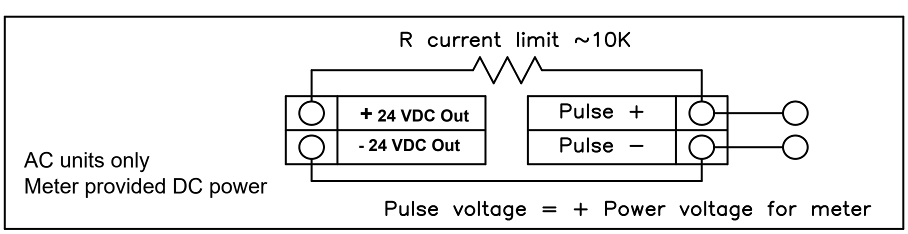


Figure 29. Isolated Pulse Output Using Meter Provided Power Supply

2.6.5 Alarm Output Connections

One alarm output (Alarm 1) is included on the standard meter. Two or more alarms (Alarm 2 and Alarm 3) are included on the optional communication board. The alarm output optical relays are normally open single-pole relays. The relays have a nominal 200 V / 160 ohm rating. This means that each relay has a nominal on-resistance of 160 ohms and the largest voltage that it can withstand across the output terminals is 200 V. 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. The relay output is isolated from the meter electronics and power supply. When the alarm relay is closed, the current draw will be constant. Make sure to size Rload appropriately.

There are three connection options for the alarm output. The first has a separate power supply (Figure 40). The second uses the flow meter power supply (Figure 41) (DC powered units only) and the third uses the meter provided power supply (Figure 42)(AC powered units only). Use the first option with a separate power supply (5 to 36 VDC) if a specific voltage is needed for the alarm output. Use the second configuration if the voltage at the flow meter power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by the alarm load comes from the meter's power supply). Use the third if you have an AC powered unit only. In any case, the voltage of the alarm output is the same as the voltage supplied to the circuit.

The alarm output is used for transmitting high or low process conditions as defined in the alarm settings (see page 45).

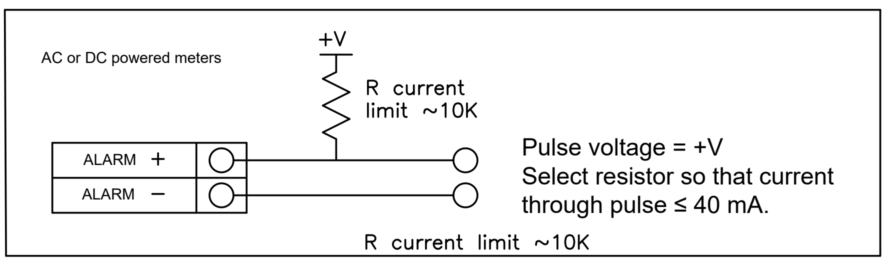


Figure 30. Isolated Alarm Output Using External Power Supply

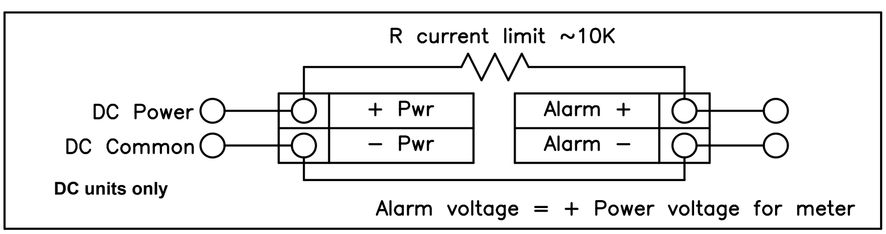


Figure 31. Non-Isolated Alarm Output Using Internal Power Supply

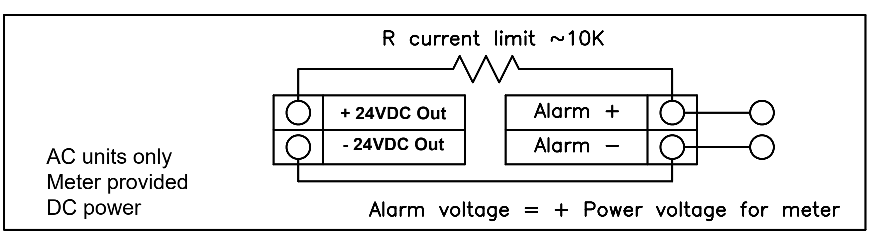


Figure 32. Isolated Alarm Output Using Meter Provided Power Supply

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 terminations 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, not at the remote electronics (where the LCD display is located) after enclosure. Remove both glands and install appropriate conduit entry glands and conduit. When installation is complete, reconnect each labeled wire to the corresponding terminal position on the junction box terminal block. Make sure to connect each wire pair's shield. Note: Incorrect connection will cause the meter to malfunction.

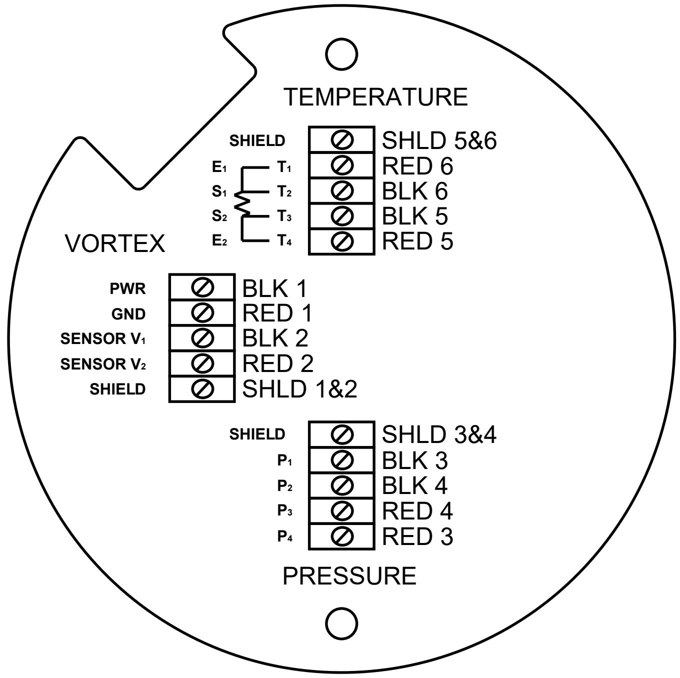


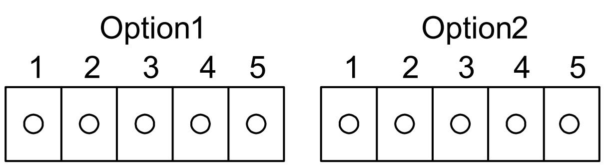
Figure 33. High Power Flow Meter Junction Box Sensor Connections

IMPORTANT NOTE

Numeric code in junction box label matches wire labels.

2.6.7 Optional Input Electronics Wiring

The meter has two optional input wiring terminals. These can be used to input a remote or second RTD input in the case of an energy monitoring meter, for the input of a remote pressure transducer, to pass a contact closure or for a remote density measurement to name a few. In any case, the wiring diagram will be included with the meter if any of the options are specified. Otherwise, the optional terminal blocks will be left blank and non-functional.



2.6.8 OPTIONAL ENERGY EMS RTD INPUT WIRING

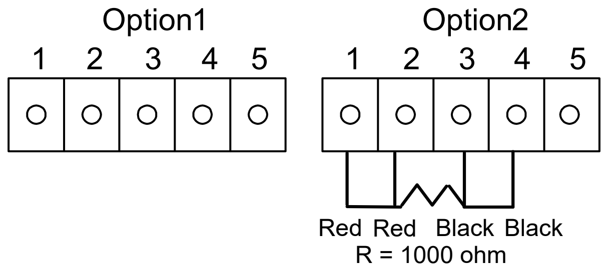


Figure 34. Optional Energy EMS RTD Input Wiring

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.

2.6.9 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 the Hidden Diagnostics Menu in section 5.

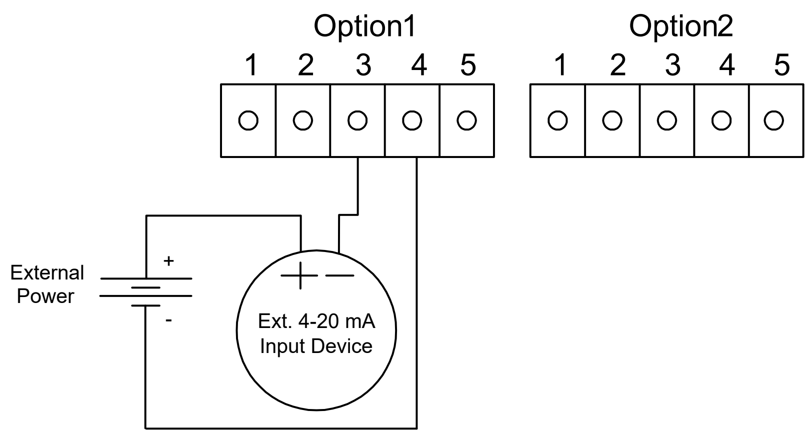


Figure 35. External 4-20 mA Input Wiring - External Power Supply

Follow the above diagram to wire the external 4-20 mA input into the flow meter using an external power supply.

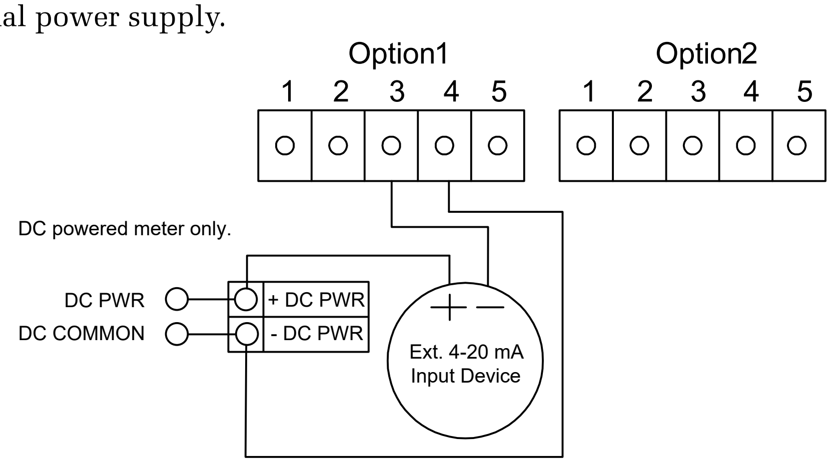


Figure 36. External 4-20 mA Input Wiring - DC Powered Meter

Follow the above diagram to wire the external 4-20 mA input into the flow meter using power supplied to the input of a DC powered meter.

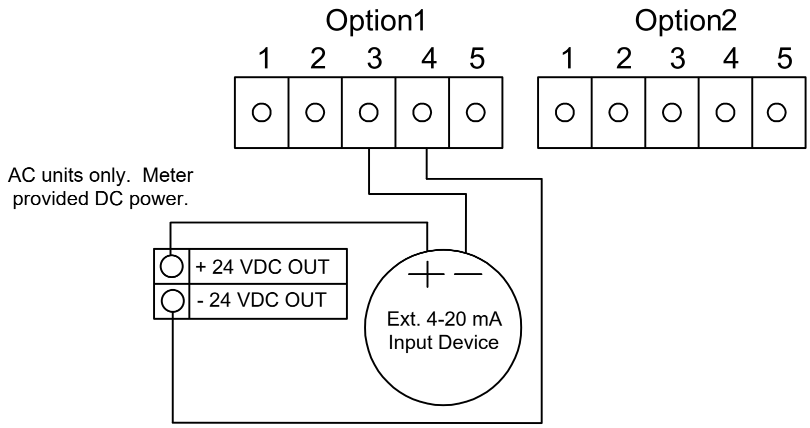


Figure 37. External 4-20 mA Input Wiring - AC Powered Meter

Follow the above diagram to wire the external 4-20 mA input into the flow meter using power from the 24 VDC output of an AC powered meter.

2.6.10 OPTIONAL CONTACT CLOSURE INPUT WIRING

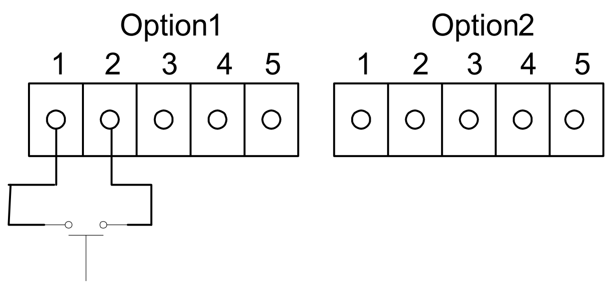


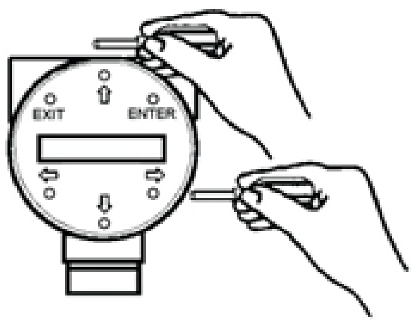
Figure 38. Optional Contact Closure Input Wiring

Follow the above diagram 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 push-button switch with a momentary contact closure is recommended.

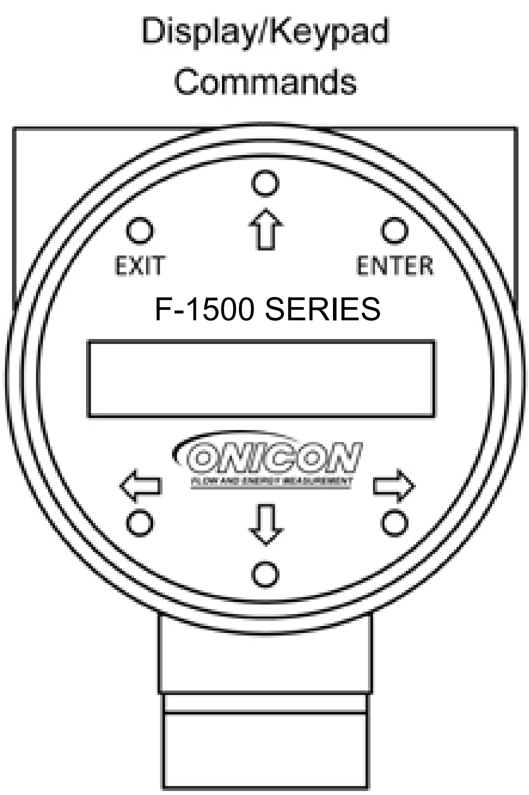
SECTION 3: OPERATING INSTRUCTIONS

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

3.1 FLOW METER DISPLAY/KEYPAD



The flow meter's digital electronics allow you to set, adjust and monitor system parameters and performance. A full range of commands are available through the display/keypad. The LCD display gives 2 x 16 characters for flow monitoring and programming. The six push-buttons can be operated with the enclosure cover removed. Or, the explosion proof cover can remain in place and the keypad operated with a hand-held magnet positioned at the side of the enclosure as shown in the illustration at the left.



From the Run Mode, the **ENTER** key allows access to the Set-up Menus (through a password screen). Within the Set-up Menus (through a password screen). Within the Set-up 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. Press **ENTER** to continue. (If change is not allowed, **ENTER** has no effect.) All outputs are disabled when using the Set-up Menus.

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

The ⇑ ⇓ ⇐ ⇒ keys advance through each screen of the current menu. When changing a system parameter, all ⇑ ⇓ ⇐ ⇒ keys are available to enter new parameters.

Figure 39. Flow Meter Display / Keypad

3.2 START-UP

To begin flow meter operation:

1. Verify the flow meter is installed and wired as described in Section 2.

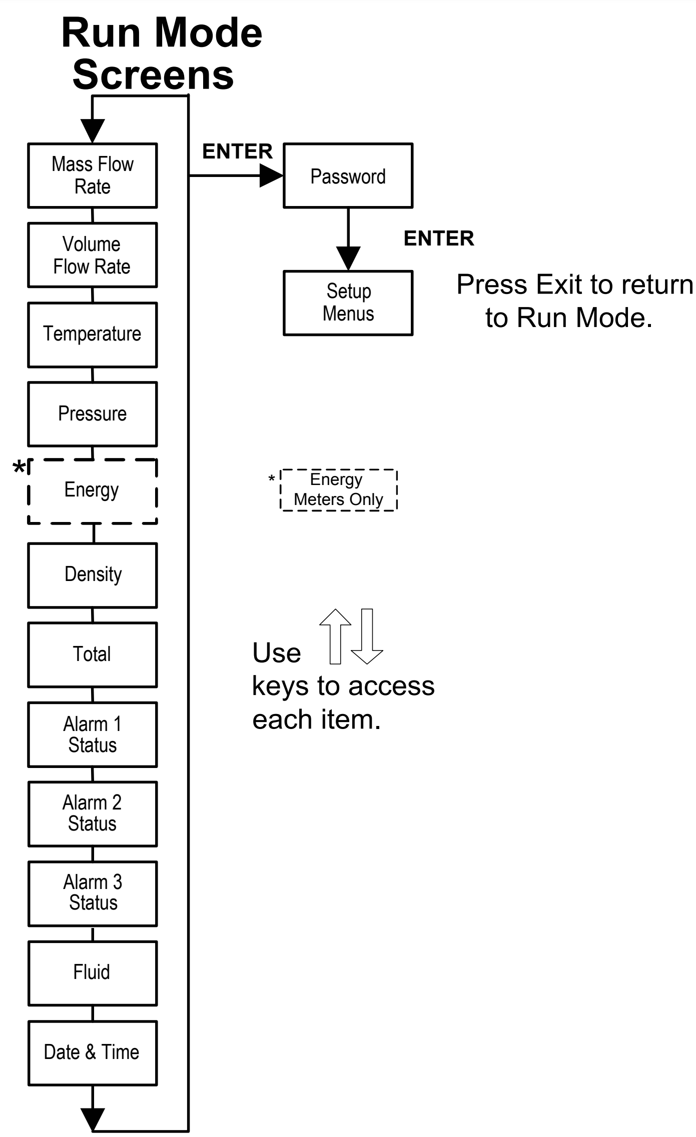
2. Apply power to the meter. At start-up, the unit runs a series of self-tests that check the RAM, ROM, EPROM and all flow sensing components. After completing the self-test sequence, the Run Mode screens appear.

3. The Run Mode displays flow information as determined by system settings. Some screens depicted on the next page may not be displayed based on these settings. Press the ⇑⇓ arrow keys to view the Run Mode screens.

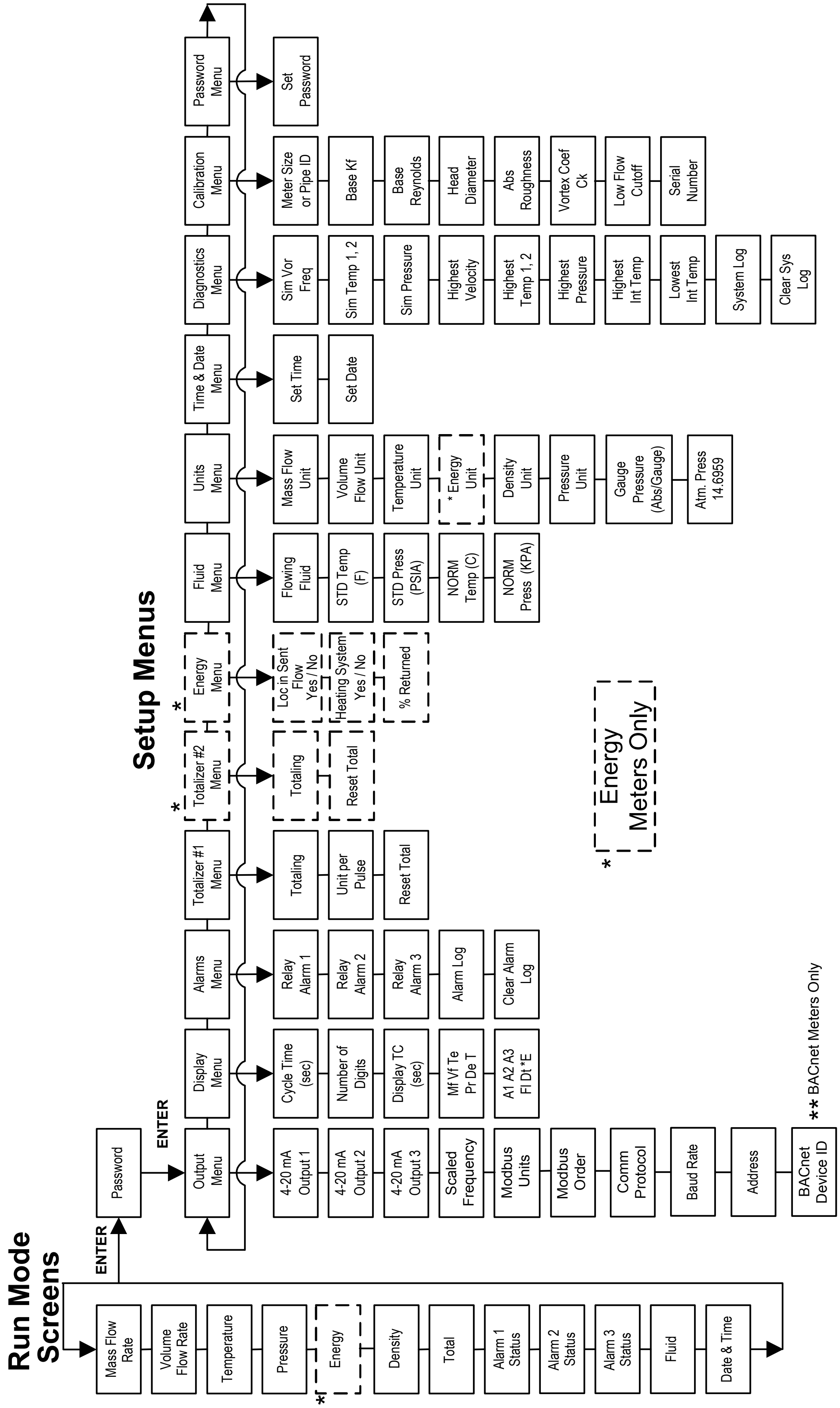
4. Press the ENTER key from any Run Mode screen to access the Set-up Menus. Use the Set-up Menus to configure the meter's multi-parameter features to fit your application.

IMPORTANT NOTICE

Starting the flow meter or pressing EXIT will always display the Run Mode screens.



3.3 USING THE SET-UP MENUS



3.3.1 Programming the Flow Meter

1. Enter the Set-up Menu by pressing the ENTER key until prompted for a password. (All outputs are disabled while using the Set-up Menus.)

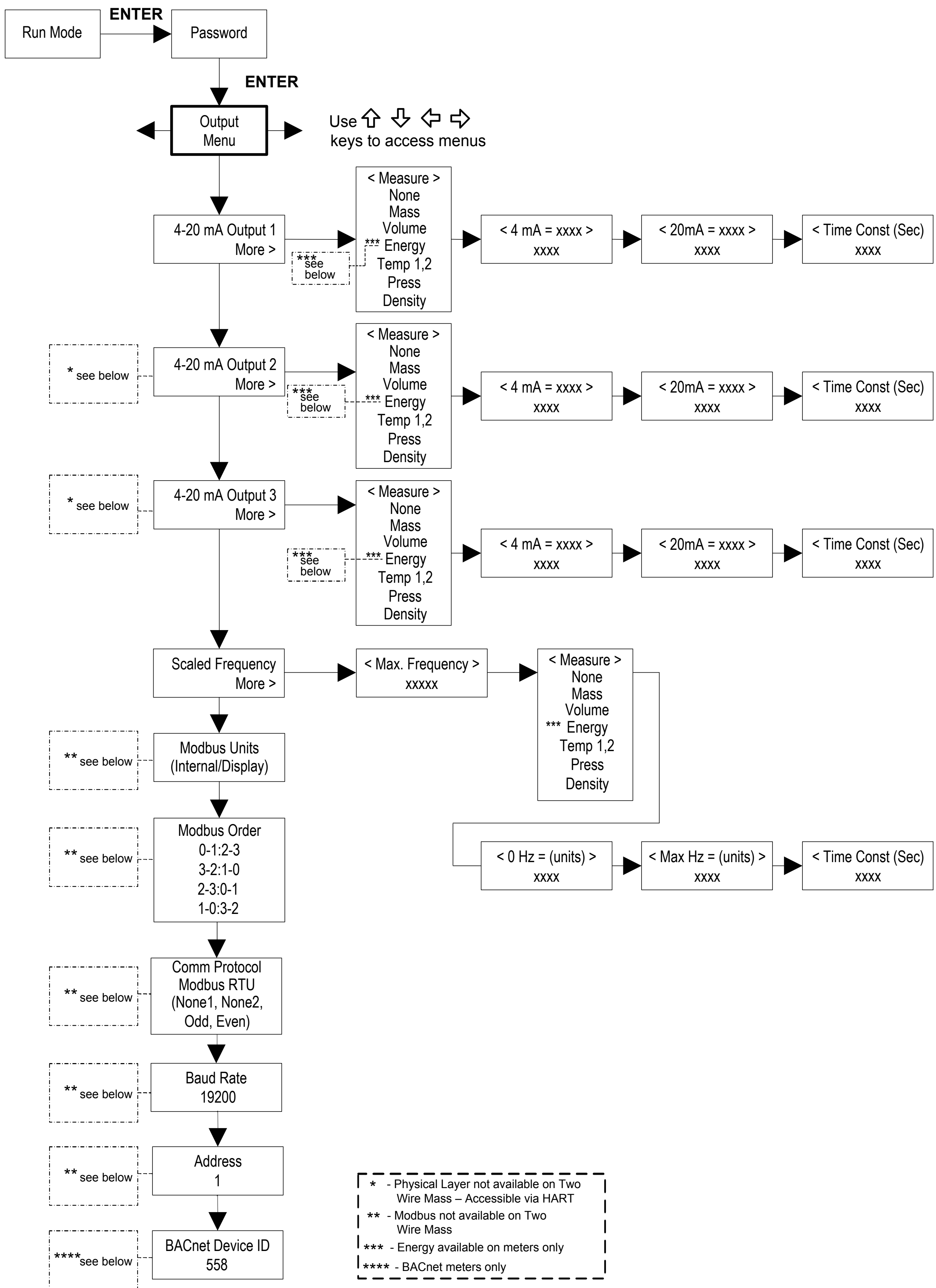
2. Use the ⇑⇓⇐⇒keys to select the password characters (1234 is the factory-set password). When the password is correctly displayed, press ENTER to continue.

3. Use the Set-up Menus described on the following pages to customize the multiparameter features of F-1500 Flow Meters (The entire lower display line is available for entering parameters.) Some items depicted in the graphic on the preceding page 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.

3.3.2 Output Menu



Example for Setting an Output

The following 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 five seconds. (All outputs are disabled while using the Set-up Menus.)

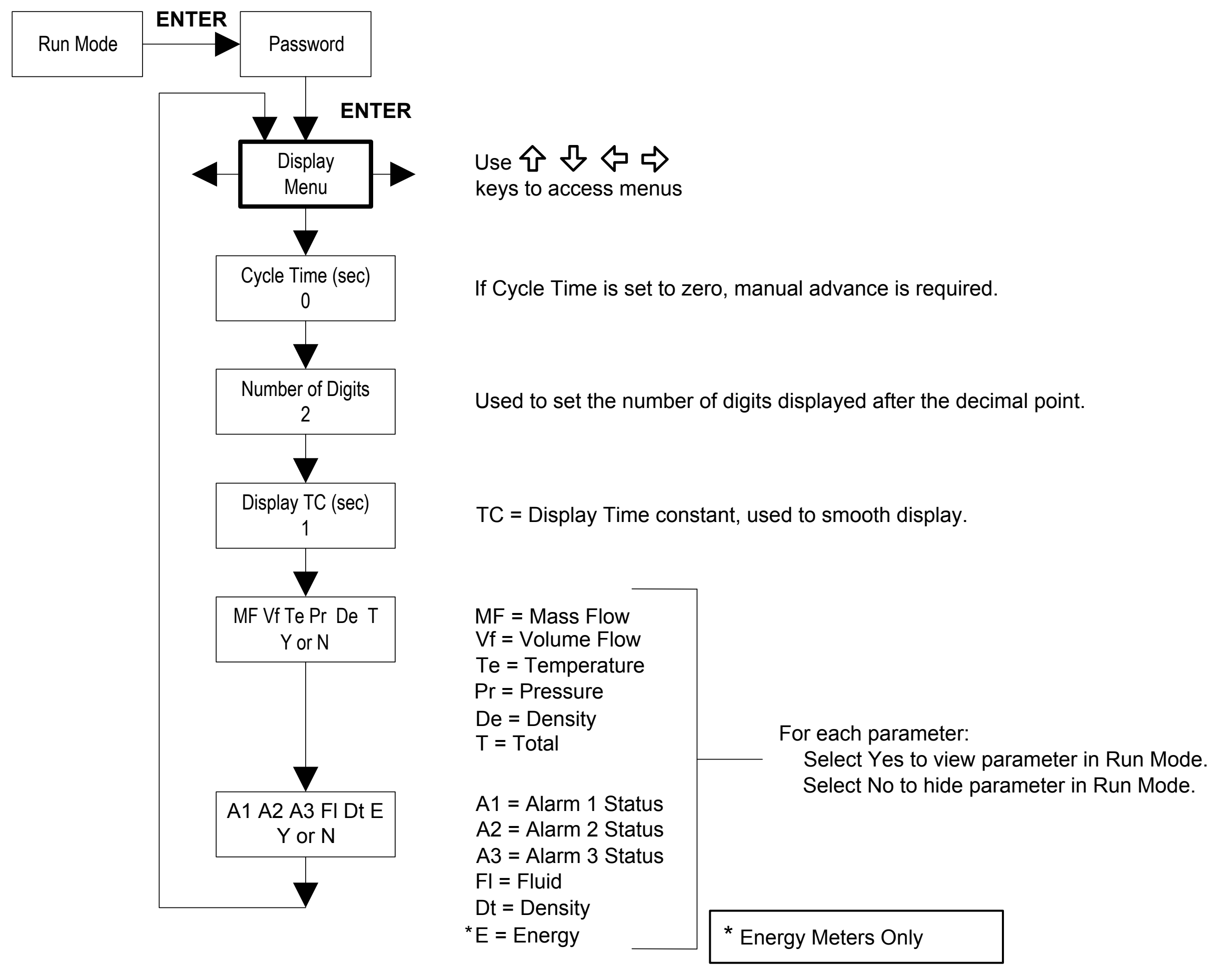
First, set the desired units of measurement:

1. Use ⇐ ⇒keys to move to the Units Menu (see page 64).
2. Press ⇓ key until Mass Flow Unit appears. Press ENTER.
3. Press ⇓ key until lb appears in the numerator. Press ⇒ key to move the underline cursor to the denominator. Press the ⇓ key until hr appears in the denominator. Press ENTER to select.
4. Press ⇑ key until Units Menu appears.

Second, set the analog output:

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

3.3.3 Display Menu



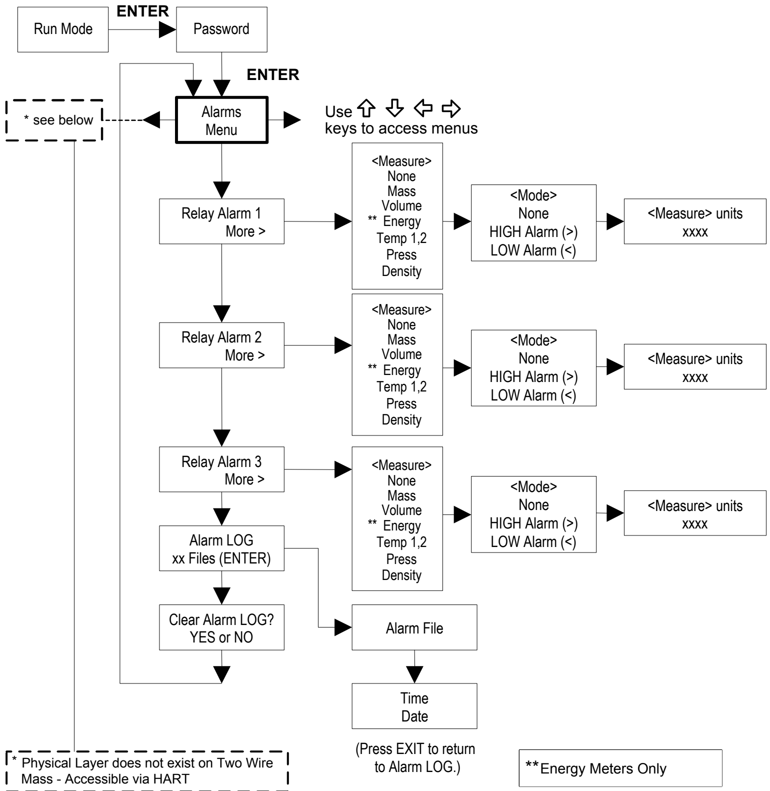
Use the Display Menu to set the cycle time for automatic screen sequencing used in the Run Mode, change the precision of displayed values, smooth the values or enable or disable each item displayed in the Run Mode screens.

Example for Changing a Run Mode Display Item

The following shows how to remove the temperature screen from the Run Mode screens. Note: All outputs are disabled while using the Set-up Menus.

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

3.3.4 Alarms Menu



Example for Setting an Alarm

The following 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 the 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 Set-up Menus.

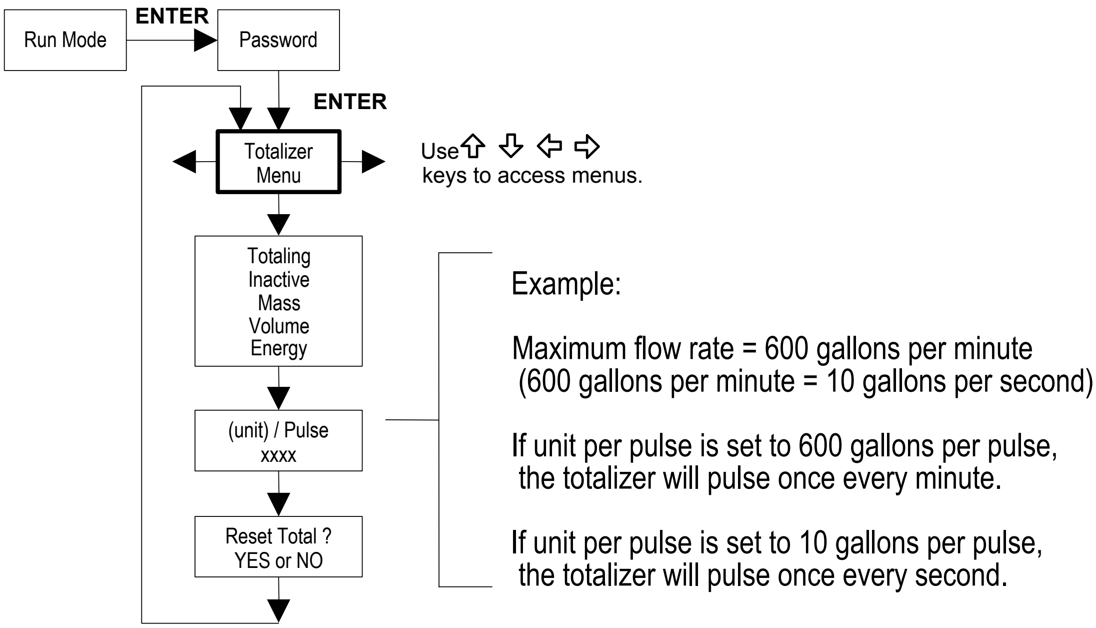
First, set the desired units of measurement:

1. Use ⇐ ⇒ keys to move to the Units Menu (see to page 64).
2. Press ⇓ key until Mass Flow Unit appears. Press ENTER.
3. Press ⇓ key until lb appears in the numerator. Press ⇒ key to move the underline cursor to the denominator. Press the ⇓ key until hr appears in the denominator. Press ENTER to select.
4. Press ⇑ 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 ⇒ key to access Measure selections. Press ENTER and use the ⇓ key to select Mass. Press ENTER.
4. Press ⇒ key to select the alarm Mode. Press ENTER and use ⇓ key to select HIGH Alarm. Press ENTER.
5. Press ⇒ 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. Up to three relay alarm outputs are available depending on meter configuration.)

3.3.5 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.

Example for Setting the Totalizer

The following shows how to set the totalizer to track mass flow in kg/sec. (All outputs are disabled while using the Set-up Menus.)

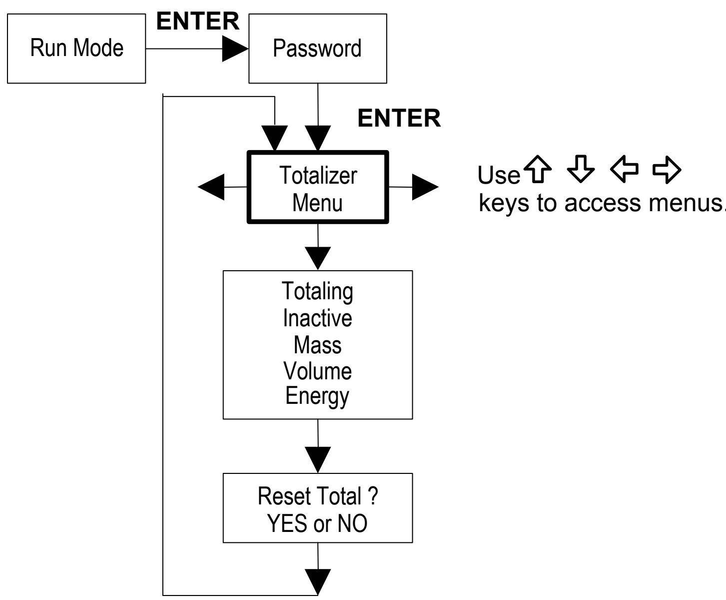
First, set the desired units of measurement:

1. Use ⇐ ⇒ keys to move to the Units Menu (see to page 64).
2. Press ⇓ key until Mass Flow Unit appears. Press ENTER.
3. Press ⇓ key until kg appears in the numerator. Press ⇒ key to move the underline cursor to the denominator. Press the ⇓ key until sec appears in the denominator. Press ENTER to select.
4. Press ⇑ key until Units Menu appears.

Second, set the pulse output:

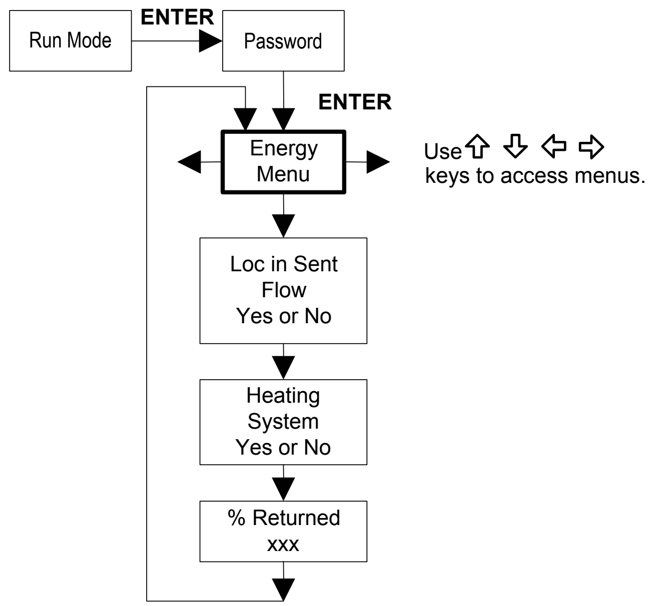
1. Use ⇐ ⇒ keys to move to the Totalizer Menu.
2. Press the ⇓ key until Totaling appears.
3. Press ENTER and press the ⇓ key to select Mass. Press ENTER.
4. Press ⇓ key to set the pulse output in the units you have selected for mass flow of kg/sec. Press ENTER and use ⇑ ⇓ ⇐ ⇒ keys to set the pulse value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

3.3.6 Totalizer #2 Menu



Use the Totalizer #2 to monitor flow or energy. Note that Totalizer #2 does not operate a relay. It is for monitoring only.

3.3.7 Energy Menu – For Energy Meters Only



Configuration:

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. The table below summarizes the possibilities:

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

As above, you must properly configure the meter in the Energy Menu.

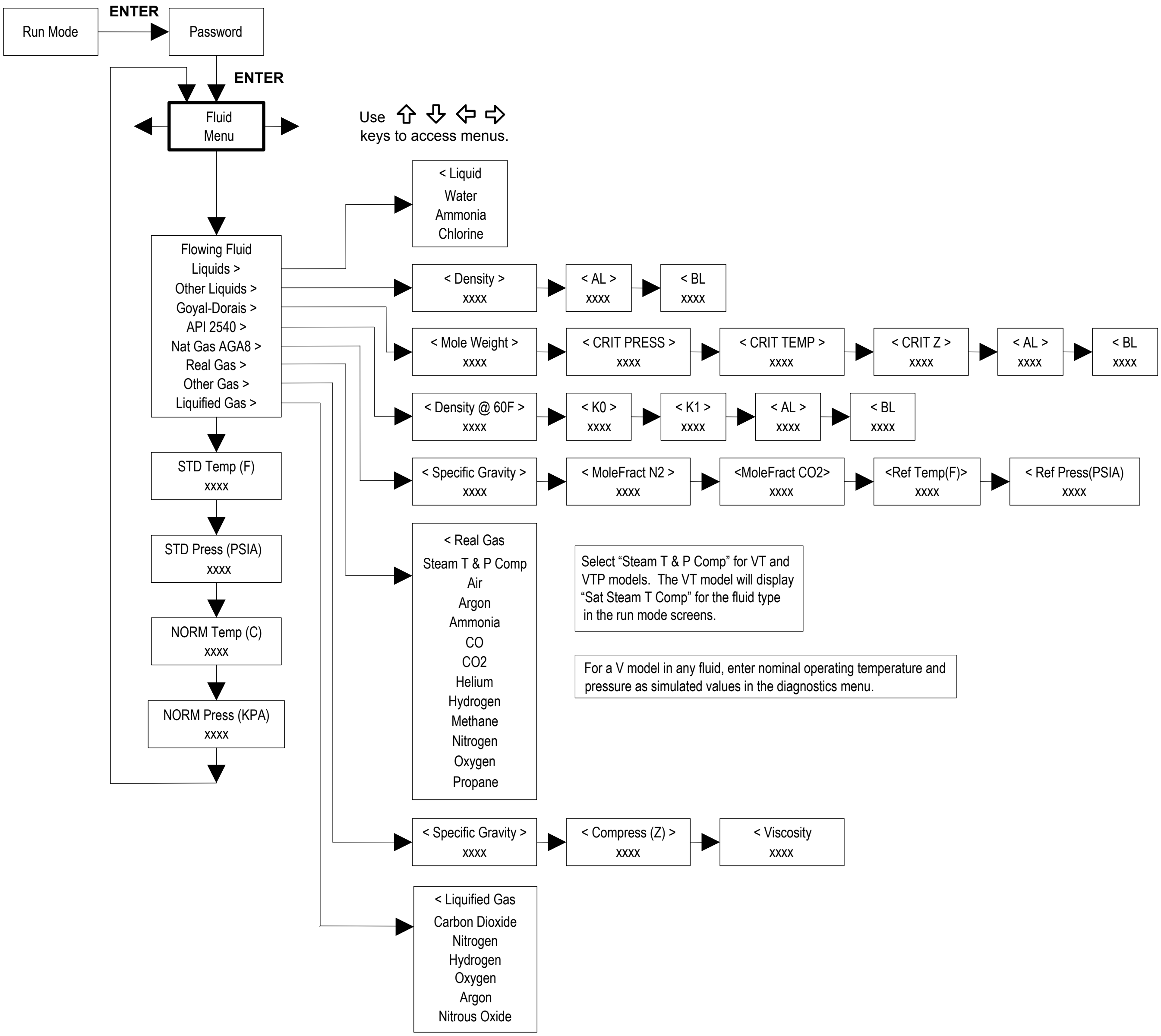
1. Loc in Sent Flow? Select Yes or No based on where the meter is located. Refer to the above table.
2. Heating System? Select Yes for a hot water system used for heating. Select No for a chilled water system used for cooling. Always select Yes for a steam system.
3. % Returned. Select a number between 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).

i

IMPORTANT NOTICE

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

3.3.8 Fluid Menu

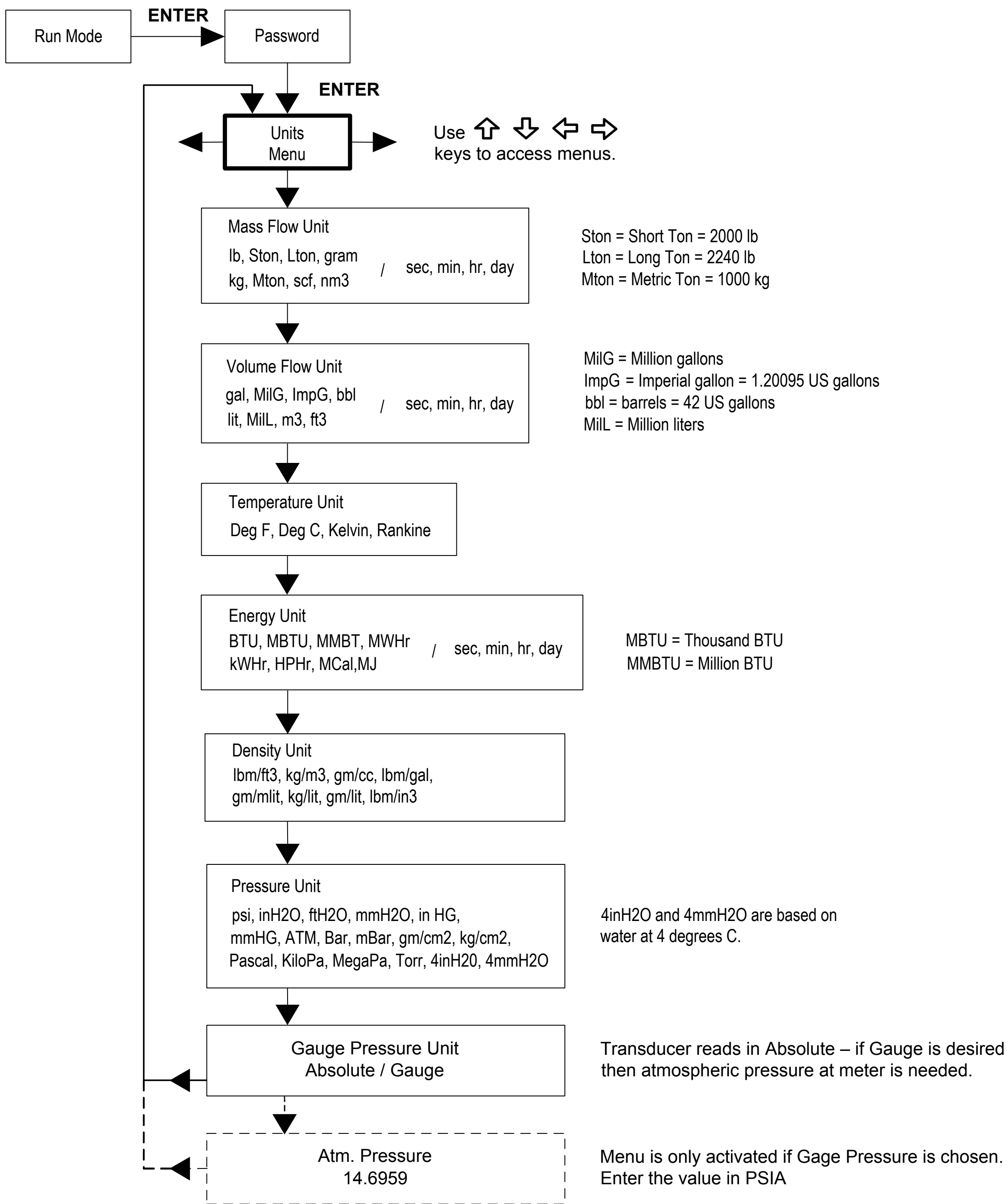


Use the Fluid Menu to configure the flow meter for use with common gases, liquids and steam. Your flow meter is pre-programmed at the factory for your application's process fluid.

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

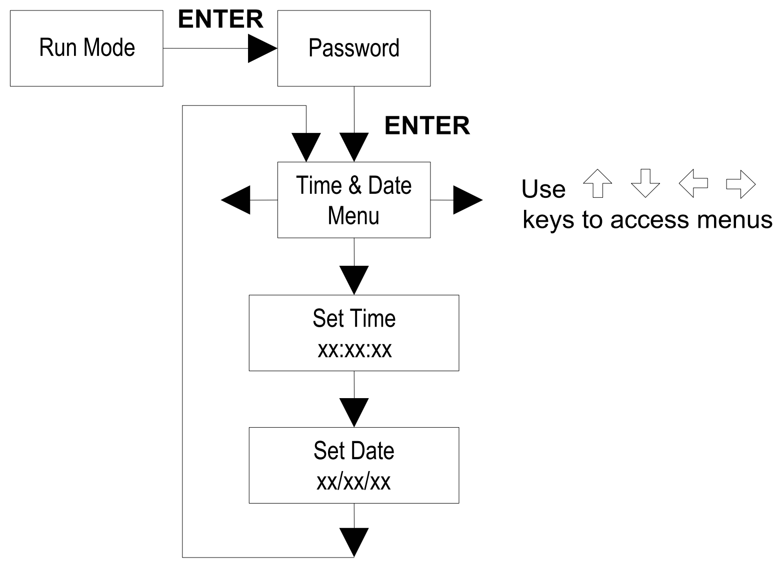
The units of measurement used in the Fluid Menu are preset and are as follows:
Mole Weight = lbm/(lbm•mol), CRIT PRESS = psia, CRIT TEMP = °R, Density = kg /m3 and Viscosity = cP (centipoise).

3.3.9 UNITS MENU



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

3.3.10 TIME & DATE MENU



Use the Time and Date Menu 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.

IMPORTANT NOTICE

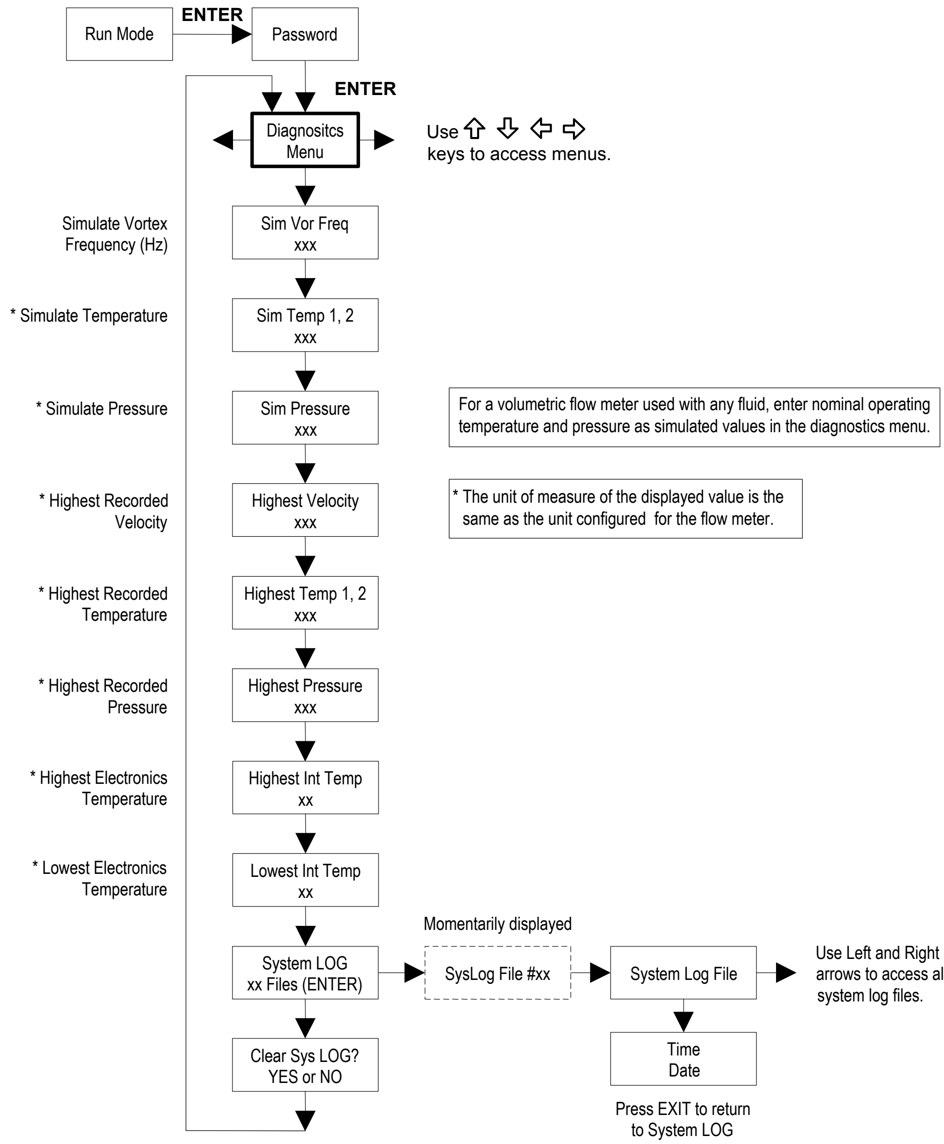
Time is displayed in AM/PM format, but military format is used to set the time. For example; 1:00 PM is entered as 13:00:00 in the Set Time menu.

Example for Setting the Time

How to set the time to 12:00:00. You can check the time in the Run Mode by pressing the ⇑⇓ keys until the Time & Date screen appears. Note: All outputs are disabled while using the Set-up Menus.

1. Use ⇐ ⇒ keys to move to the Time and Date Menu.
2. Press ⇓ key until Set Time appears. Press ENTER.
3. Press ⇓ key until 1 appears. Press ⇒ 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 the Run Mode.

3.3.11 Diagnostics Menu

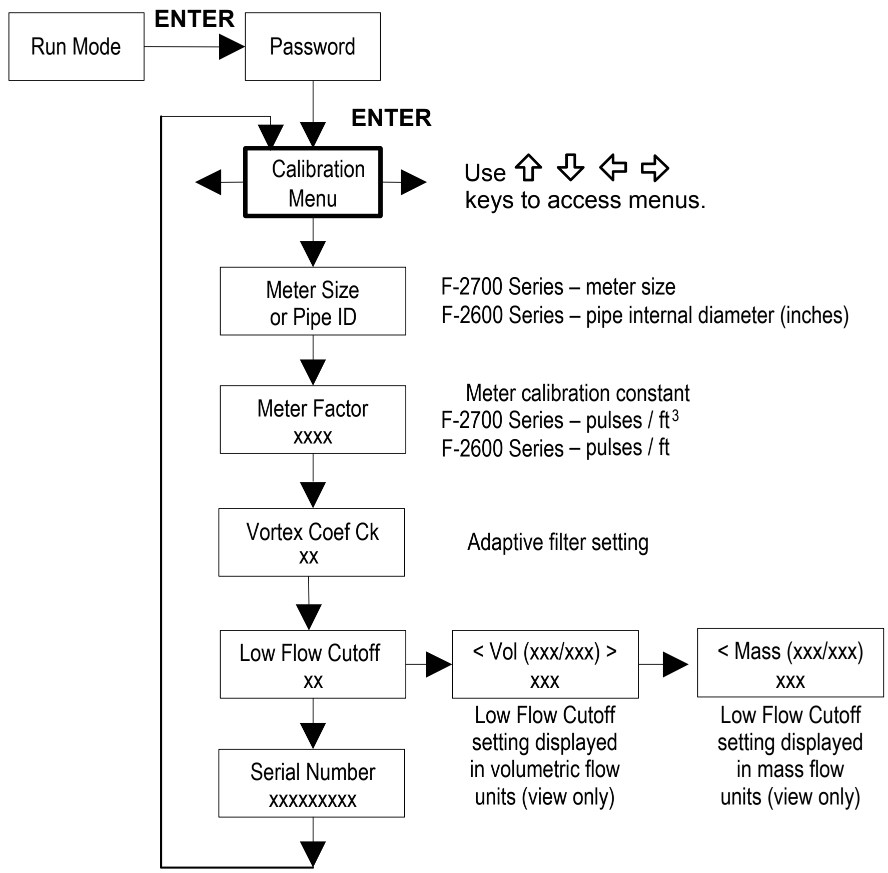


Use the Diagnostics Menu to simulate operation and review the system files. The system log files contain time/date stamped messages including: power on, power off, programming time outs, parameter faults, incorrect password entry and other various information relative to system operation and programming.

The simulated inputs are for testing the meter to verify that the programming is correct. They are also used to enter nominal operating temperature and pressure for the V (volumetric) 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.**

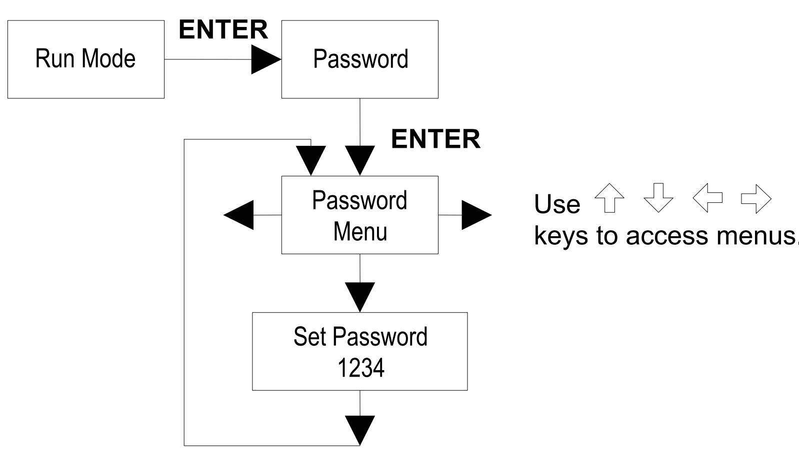
3.3.12 Calibration Menu

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.



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

3.3.13 Password Menu



Use the Password Menu to set or change the system password. The factory-set password is 1234.

SECTION 4.0: 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 4-20 mA Output 1. Peer-to-peer (analog / digital) and multi-drop (digital only) modes are supported.

4.1.1 WIRING

The diagrams below detail the proper connections required for HART communications:

Loop Powered Meter Wiring

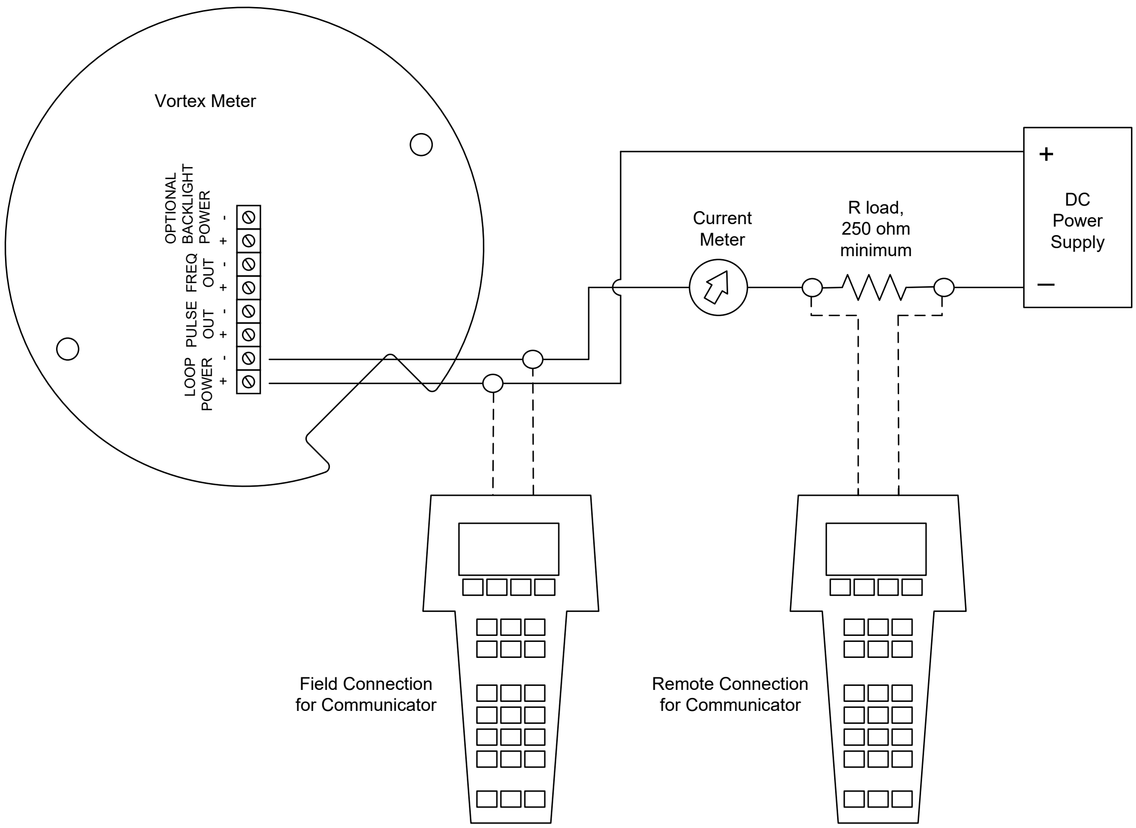


Figure 40. Loop Powered Meter Wiring (HART)

WARNING

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

DC Powered Meter Wiring

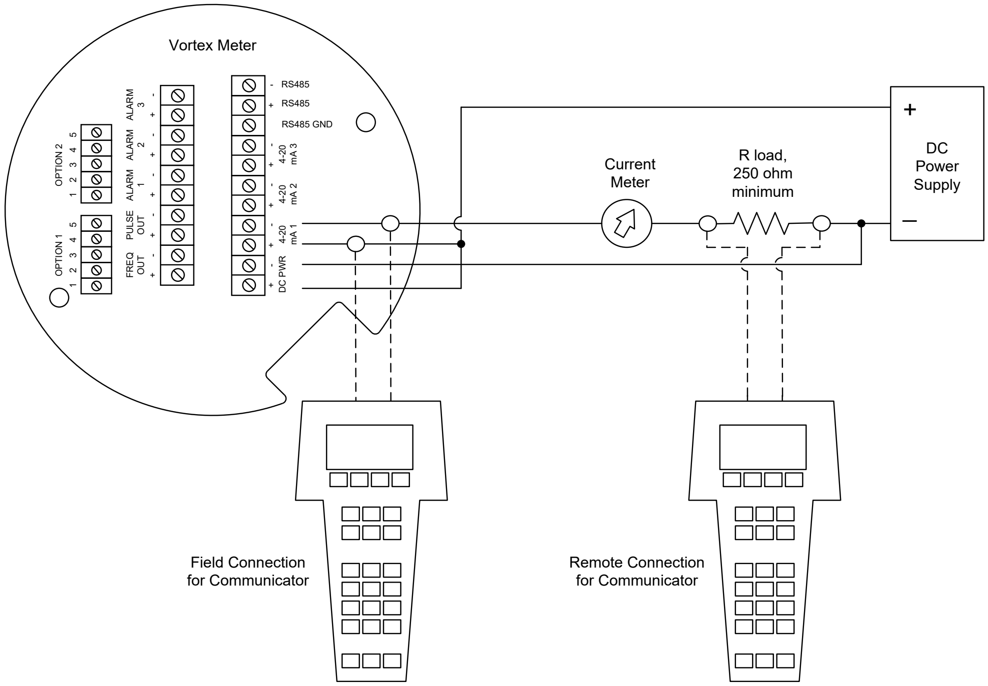


Figure 41. DC Powered Meter Wiring (HART)

AC Powered Meter Wiring

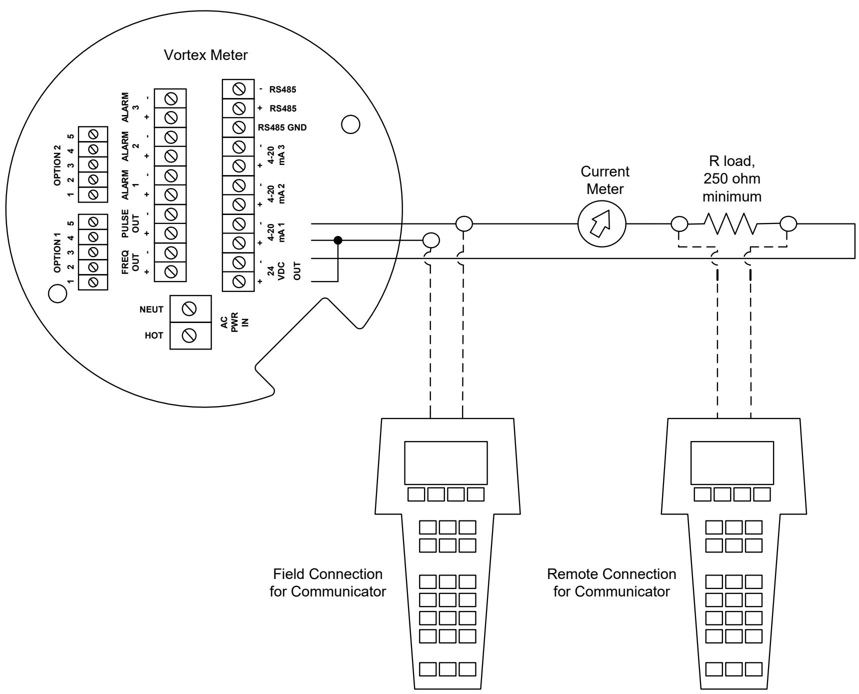
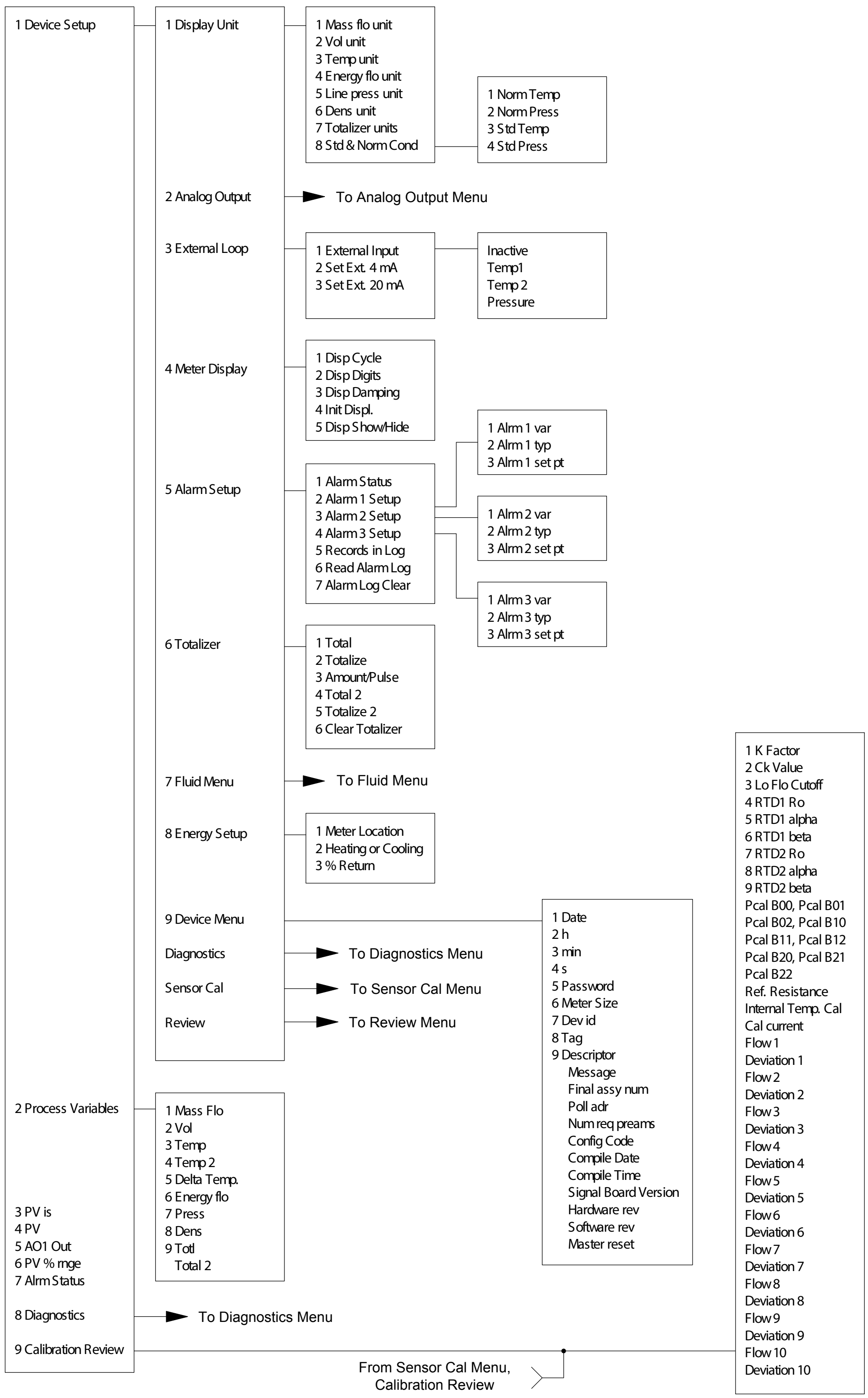


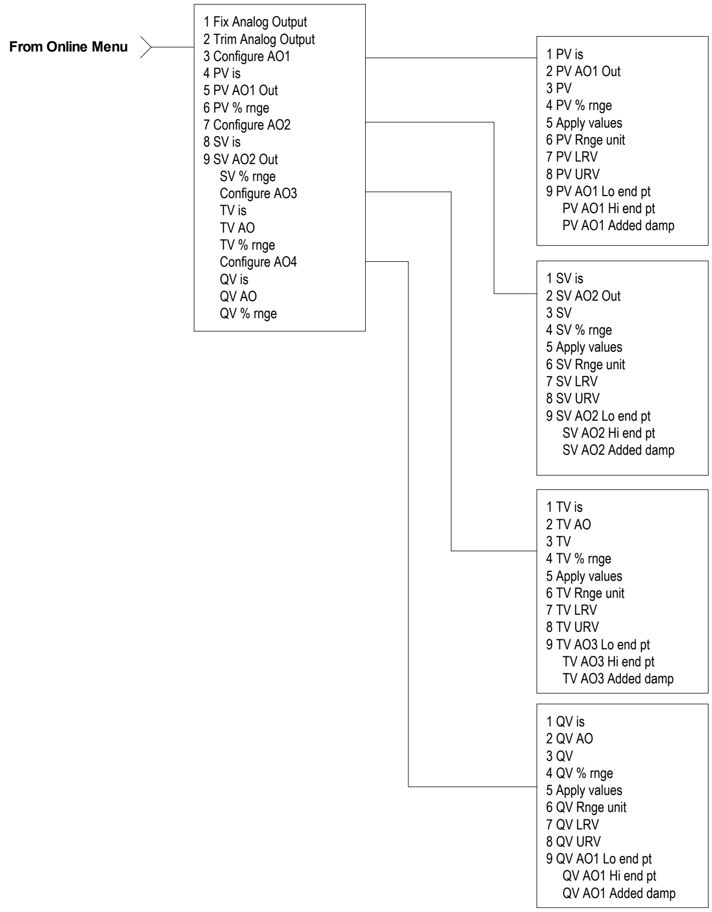
Figure 42. AC Powered Meter Wiring (HART)

4.1.2 HART Commands with the DD Menu

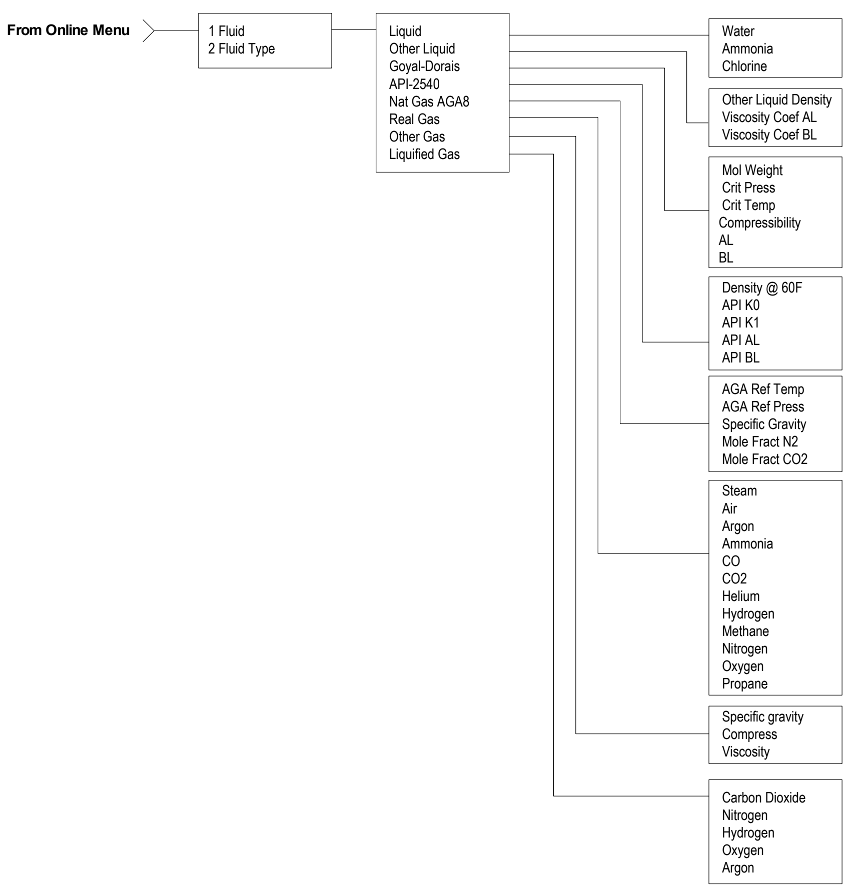
Online Menu



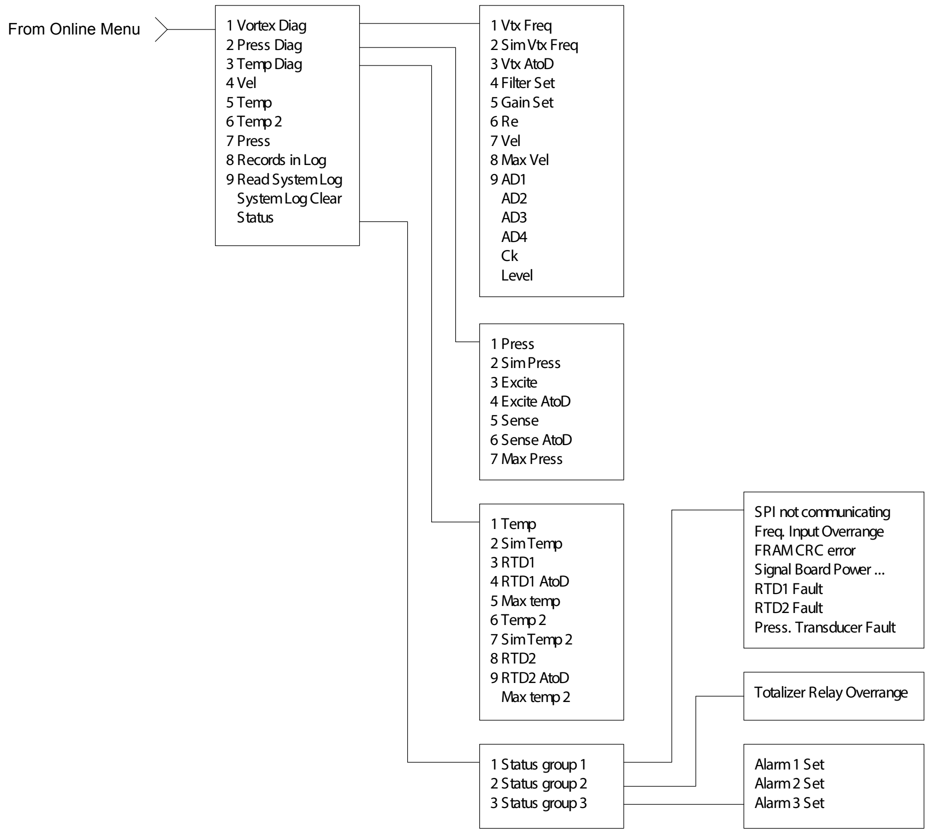
Analog Output Menu



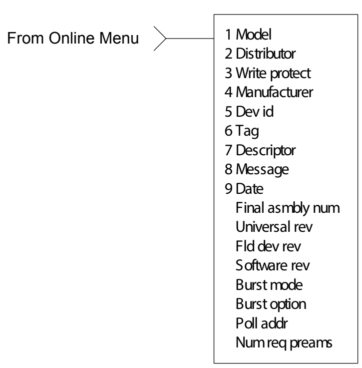
Fluid Menu

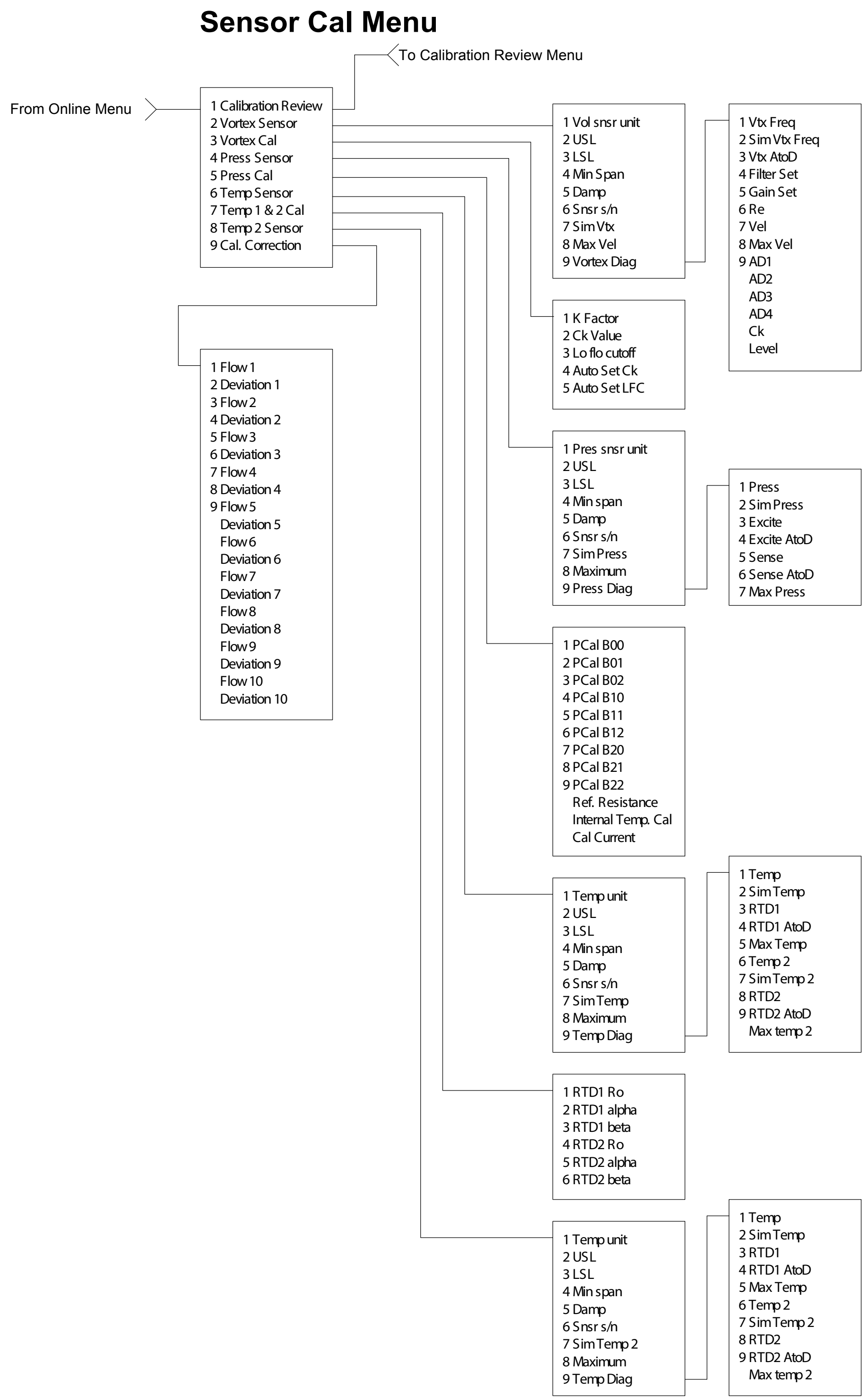


Diagnostics Menu

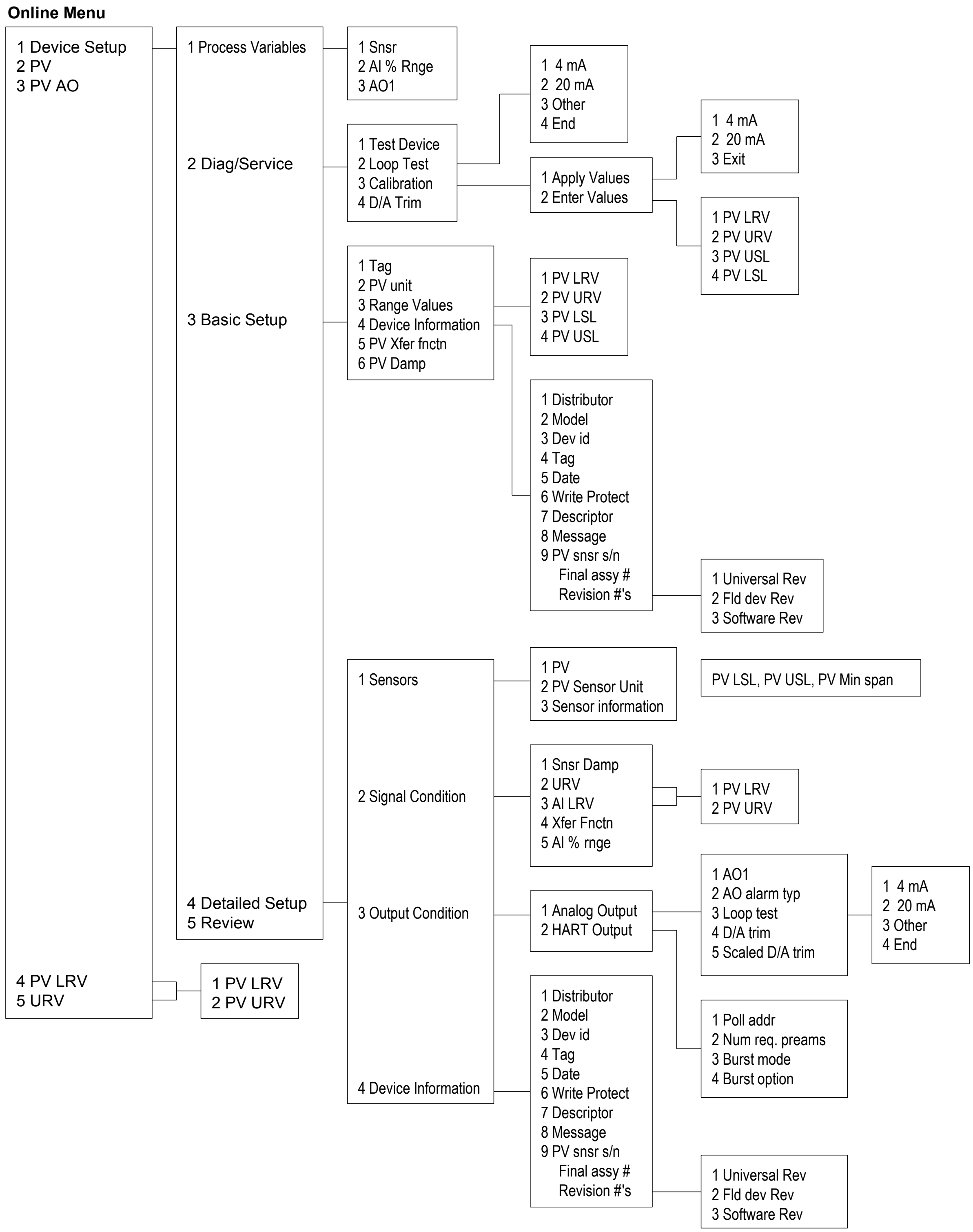


Review Menu




Sensor Cal Menu
To Calibration Review Menu
From Online Menu
1 Calibration Review
2 Vortex Sensor
3 Vortex Cal
4 Press Sensor
5 Press Cal
6 Temp Sensor
7 Temp 1 & 2 Cal
8 Temp 2 Sensor
9 Cal. Correction
1 Vol snsr unit
2 USL
3 LSL
4 Min Span
5 Damp
6 Snsr s/n
7 Sim Vtx
8 Max Vel
9 Vortex Diag
1 Vtx Freq
2 Sim Vtx Freq
3 Vtx AtoD
4 Filter Set
5 Gain Set
6 Re
7 Vel
8 Max Vel
9 AD1
AD2
AD3
AD4
Ck
Level
1 K Factor
2 Ck Value
3 Lo flo cutoff
4 Auto Set Ck
5 Auto Set LFC
1 Flow 1
2 Deviation 1
3 Flow 2
4 Deviation 2
5 Flow 3
6 Deviation 3
7 Flow 4
8 Deviation 4
9 Flow 5
Deviation 5
Flow 6
Deviation 6
Flow 7
Deviation 7
Flow 8
Deviation 8
Flow 9
Deviation 9
Flow 10
Deviation 10
1 Pres snsr unit
2 USL
3 LSL
4 Min span
5 Damp
6 Snsr s/n
7 Sim Press
8 Maximum
9 Press Diag
1 Press
2 Sim Press
3 Excite
4 Excite AtoD
5 Sense
6 Sense AtoD
7 Max Press
1 PCal B00
2 PCal B01
3 PCal B02
4 PCal B10
5 PCal B11
6 PCal B12
7 PCal B20
8 PCal B21
9 PCal B22
Ref. Resistance
Internal Temp. Cal
Cal Current
1 Temp unit
2 USL
3 LSL
4 Min span
5 Damp
6 Snsr s/n
7 Sim Temp
8 Maximum
9 Temp Diag
1 Temp
2 Sim Temp
3 RTD1
4 RTD1 AtoD
5 Max Temp
6 Temp 2
7 Sim Temp 2
8 RTD2
9 RTD2 AtoD
Max temp 2
1 RTD1 Ro
2 RTD1 alpha
3 RTD1 beta
4 RTD2 Ro
5 RTD2 alpha
6 RTD2 beta
1 Temp unit
2 USL
3 LSL
4 Min span
5 Damp
6 Snsr s/n
7 Sim Temp 2
8 Maximum
9 Temp Diag
1 Temp
2 Sim Temp
3 RTD1
4 RTD1 AtoD
5 Max Temp
6 Temp 2
7 Sim Temp 2
8 RTD2
9 RTD2 AtoD
Max temp 2

4.1.3 HART Commands with Generic DD Menu



Use password 16363.

Fast Key Sequence

Use password 16363.

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

Continued on next page.

Sequence	Description	Access	Notes
1,4,3,1,3,1	4 mA	View	Loop test, fix analog output at 4 mA
1,4,3,1,3,2	20 mA	View	Loop test, fix analog output at 20 mA
1,4,3,1,3,3	Other	Edit	Loop test, fix analog output at mA value entered
1,4,3,1,3,4	End		Exit loop test
1,4,3,1,4	D/A trim	Edit	Calibrate electronics 4mA and 20mAvalues
1,4,3,1,5	Scaled D/A trim	N/A	Not used
1,4,3,2,1	Poll addr	Edit	Poll address
1,4,3,2,2	Num req. preams	View	Number of required preambles
1,4,3,2,3	Burst mode	N/A	Not used
1,4,3,2,4	Burst option	N/A	Not used
1,4,4,1	Distributor	N/A	Not used
1,4,4,2	Model	N/A	Not used
1,4,4,3	Dev id	View	Device identification
1,4,4,4	Tag	Edit	Tag
1,4,4,5	Date	Edit	Date
1,4,4,6	Write Protect	View	Write protect
1,4,4,7	Descriptor	Edit	Turbine flow meter
1,4,4,8	Message	Edit	32 character alphanumeric message
1,4,4,9	PV snsr s/n	View	Primary variable sensor serial number
1,4,4,menu	Final assy #	Edit	Final assembly number
1,4,4,menu,1	Universal Rev	View	Universal revision
1,4,4,menu,2	Fld dev Rev	View	Field device revision
1,4,4,menu,3	Software Rev	View	Software revision
1,5	Review	N/A	Not used
2	PV	View	Primary variable value
3	PV AO	View	Analog output, mA
4,1	PV LRV	Edit	Primary variable lower range value
4,2	PV URV	Edit	Primary variable upper range value
5,1	PV LRV	Edit	Primary variable lower range value
5,2	PV URV	Edit	Primary variable upper range value

4.2 MODBUS COMMUNICATIONS

Applicable Flow Meter Models: ONICON F-1500 Series Turbine Flow Meters with Modbus communication protocol and firmware version 4.00.58 and above.

WARNING

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

Overview

This document describes the preliminary implementation of the Modbus communication protocol for use in monitoring common process variables in the ONICON F-1500 Series Turbine Flow Meter. The physical layer utilizes the half-duplex RS-485 port and the Modbus protocol.

Reference Documents

The following documents are available online from www.modbus.org.
Modbus Application Protocol Specification V1.1
Modbus Over Serial Line Specification & Implementation Guide V1.0
Modicon Modbus Protocol Reference Guide PI–MBUS–300 Rev. J

4.2.1 Wiring

An RS-485 daisy chained network configuration as depicted below is recommended. Do not use a star, ring, or cluster arrangement.

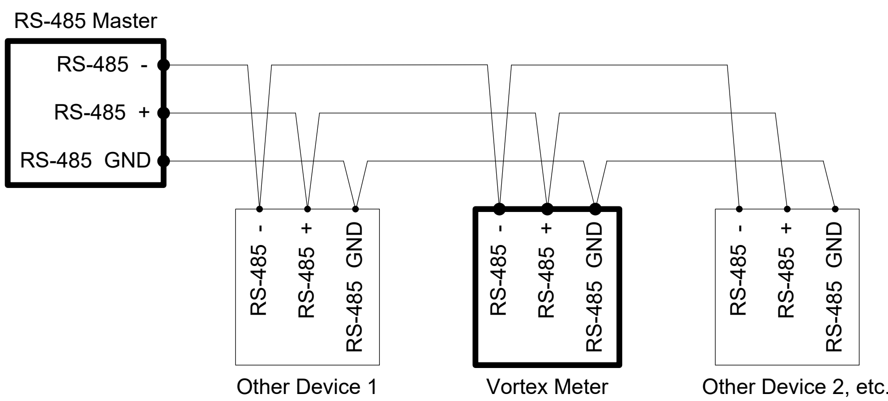


Figure 43. RS-485 Wiring (MODBUS)

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"

4.2.2 Menu Items

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

Address

When the Modbus protocol is selected, the Modbus address is equal to the user's 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.

Comm Protocol

The Comm Protocol menu allows selection of "Modbus RTU Even," "Modbus RTU Odd," or "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.

Modbus Units

The Modbus Units menu is to control which units, where applicable, the meter's variables will be displayed in. Internal – (these are the base units of the meter, °F, psia, lbm/sec , ft3/sec, Btu/sec , lbm/ft3 Display) – variables are displayed in user selected display unit.

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 word order and byte order for floating point and long integer values may be reversed to accommodate different Modbus operating systems.

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

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

Table 2. Byte Order

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

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, but there is an informal register numbering convention derived from the original (now obsolete) Modicon Modbus protocol specification which is still used by many vendors of Modbus capable products.

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

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

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

4.2.3 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 Output Menu's "Modbus Units" item. The display units strings may be examined by accessing their associated registers. Each of these units string registers contain two characters of the string, and the strings may be two 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 Section 4.2.2) is set to 0-1:2-3 or 2-3:0-1, then the characters are transmitted in the correct order. If set to 1-0:3-2 or 3-2:1-0, then each pair of characters will be transmitted in reverse order.

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

Table 3. Register Definitions

The following registers are available with the energy meter firmware:

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

The following registers contain the display units strings:

Registers	Variable	Data Type	Units	Function Code	Addresses
32007-32012	Volume flow units	string	—	03, 04	2006-2011
32001-32006	Mass flow units	string	—	03, 04	2000-2005
32025-32030	Temperature units	string	—	03, 04	2024-2029
32019-32024	Pressure units	string	—	03, 04	2018-2023
32031-32036	Density units	string	—	03, 04	2030-2035
32013-32017	Energy flow units	string	—	03, 04	2012-2017

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

Exception Status Definitions

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

Bit(s)	Definition
0-1	Byte order (see Modbus Order on page 2) 0 = 3-2:1-0 1 = 2-3:0-1 2 = 1-0:3-2 3 = 0-1:2-3
2	Temperature sensor fault
3	Pressure sensor fault
4	A/D converter fault
5	Period overflow
6	Pulse overflow
7	Configuration changed

Discrete Input Definitions

The status of the three alarms may be monitored via the Modbus Read Discrete Input command (function code 02). 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.

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

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.

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 as follows:

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

If the first byte of a message is not equal to the unit's Modbus address, 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.

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.

Device Address	Function Code	Start Address	N=Number of Registers	CRC
8 bits, 1...247	8 bits	16 bits, 0...9998	16 bits, 1...125	16 bits

Normal Response Message Format

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

Exception Response Message Format

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

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: *Note these are the older register definitions.

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

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

Results in an error response as follows:

01 84 02 C2 C1

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

Request the state all three alarms:

01 02 00 00 00 03 38 0B

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

And the unit responds with:

01 02 01 02 20 49

01 Device address
02 Function code
01 Number of data bytes = 1
02 Alarm #2 on, alarms #1 and #3 off
20 49 CRC

To reset the totalizer:

01 05 00 00 FF 00 8C 3A

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

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

01 05 00 00 00 00 CD CA

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

4.3 BACnet MS/TP Communications

4.3.1. BACnet MS/TP Description

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

4.3.2. Baud Rates on the MS/TP Bus

An MS/TP bus can be configured to communicate at one of four different baud rates. It is very important that all of the devices on an MS/TP bus communicate at the same baud rate. The baud rate setting determines the rate at which devices communicate data over the bus. The available baud rate settings available on F-1500 Flow Meters are 9600, 19200 , 38400 and 76800.

4.3.2.1. Baud Rate and MAC address configuration

1. Power on the meter
2. Press Enter to go configuration menu
3. Give the factory password 16363 (Use Up and Down arrows to enter the digits)
4. Navigate to Diagnostics menu
5. Press Enter and press right button immediately
6. Navigate to Config Code screen by continuous pressing down button
7. After reaching config code screen, press right to navigate to 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 reach Diagnostics menu back
10. Navigate to Output Menu by using right or left arrow buttons
11. Press Down button and reach Baud Rate and MAC address screens
12. Change the required settings and press Exit & Enter buttons to save the configuration
13. Do steps from b to g, and change the comm. Type as Hart.
14. Reboot the device by power off and on.

Note:

a. Baud rates are 9600, 19200, 38400 or 76800
b. MAC address range is 0-127

4.3.3. Supported BACnet Objects

A BACnet object represents physical or virtual equipment information, as a digital input or parameters. ONICON F-1500 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 by properties that allow the access to the object information. The below table shows the implemented properties for each Mass Flow Meters object type.

Properties	Object Type			
	Device	Analog Input	Binary Input	Binary Value
Object_Identifier	✓	✓	✓	✓
Object_Name	✓	✓	✓	✓
Object_Type	✓	✓	✓	✓
System_Status	✓			
Vendor_Name	✓			
Vendor_Identifier	✓			
Model_Name	✓			
Firmware_Revision	✓			
Application-Software-Version	✓			
Protocol_Version	✓			
Protocol_Revision	✓			
Protocol_Services_Supported	✓			
Protocol_Object_Types_Supported	✓			
Object_List	✓			
Max_ADPU_Length_Accepted	✓			
Segmentation_Supported	✓			
ADPU_Timeout	✓			
Number_Of_ADPU_Retries	✓			
Max_Masters	✓			
Max_Info_Frames	✓			
Device_Address_Binding	✓			
Database_Revision	✓			
Status_Flags				
Event_State		✓	✓	✓
Reliability				
Out_Of_Service		✓(W)	✓(W)	✓(W)
Units		✓		
Polarity			✓(W)	
Priority_Array				
Relinquish_Default				
Status_Flag		✓	✓	✓
Present_Value		✓(W)	✓(W)	✓(W)
Inactive_Text				
Active_Text				

(W) – Writable Property.

4.3.3.1. Device Object:

The Device object default property values are as follows –

Property Name	Default Values
object-identifier	7
object-name	Device,1
object-type	Device
system-status	operational
vendor-name	ONICON Incorporated
vendor-identifier	206
model-name	Turbine Meter
firmware-revision	N/A
application-softwareversion	1.07
protocol-version	1
protocol-revision	4
protocol-servicessupported	{F,F,F,F,F,F,F,F,F,F,F,F,T,F,T,T,T,T,F,F,F,F,F,F,F,F,F,F,F,F,T,T,F,F,F,F,F}
protocol-object-types-supported	{T,F,F,T,F,T,F,F,T,F,F,F,F,F,F,F,F,F,F,F,F,F,F,F}
object-list	{(analog-input,1), (analog-input,2), (analog-input,3), (analog-input,4), (analog-input,5), (analog-input,6), (analog-input,7), (analog-input,8) (analog-input,9), (analog-input,10), (analog-input,11), (analoginput,12), (analog-input,13), (analog-input,14), (analoginput, 15), (analog-input,16), (analog-input,17), (analoginput, 18), (analog-input,19), (binary-input,1), (binary-input,2), (binaryinput,3), (binary-input,4), (binary-value,1), (device,7) }
max-apdu-lengthaccepted	300
segmentation-supported	no-segmentation
apdu-timeout	3000
number-of-APDU-retries	1
max-master	127
max-info-frames	1
device-address-binding	()
database-revision	0

Note - Device Communication Control: Password – “vortek”

4.3.3.2. Analog Input Object:

Mass Flow Meters Analog Input type objects are described in the table below.

Object Instance	Object Name	Unit	Description
1	Volume Flow	cubic-feet-per-second, cubic-feet-per-minute, us-gallons-per-minute, imperial-gallons-perminute, liters-per-minute, liters-per-second, liters-per-hour, cubic-meters-per-second, cubic-meters-per-minute, cubic-meters-per-hour	This AI object is used to measure volume flow.
2	Mass Flow	pounds-mass-per-second, grams-per-second, kilograms-per-second, kilograms-per-minute, kilograms-per-hour, pounds-mass-per-minute, pounds-mass-per-hour, tons-per-hour, grams-per-second , grams-per-minute	This AI object is used to measure mass flow.
3	Temperature 1	degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit	This AI object measures Temperature in one of the given Unit.
4	Temperature 2	degrees-Celsius, degrees-Kelvin, degrees-Fahrenheit	This AI object measures Temperature in one of the given Unit.
5	Pressure	pounds-force-per-squareinch, inches-of-water, inches-of-mercury, millimeters-of-mercury, bars, millibars, pascals, kilopascals	TBD
6	Density	kilograms-per-cubic-meter	TBD
7	Energy Flow	Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	TBD
8	Totalizer 1 & Totalizer 2	If Totalizer selection for Mass measure– pounds-mass-per-second, grams-per-second, kilograms-per-second, kilograms-per-minute, kilograms-per-hour, pounds-mass-per-minute, pounds-mass-per-hour, tons-per-hour, grams-per-second, grams-per-minute If Totalizer selection for Volume measure – cubic-feet-per-second, cubic-feet-per-minute, us-gallons-per-minute, imperial-gallons-per-minute, liters-per-minute, liters-per-second, liters-per-hour, cubic-meters-per-second, cubic-meters-per-minute, cubic-meters-per-hour If Totalizer selection for Energy measure – Kilowatts, Horsepower, btus-per-hour, kilo-btus-per-hour, megawatts	An electronic counter which records the total accumulated flow over a certain range of time.
10	StatusRegister	NO UNITS	TBD
11	Channel 1 (4-20 mA)	milliamperes	TBD
12	Channel 2 (4-20 mA)	milliamperes	TBD
13	Channel 3 (4-20 mA)	milliamperes	TBD
14	Scaled Freq	hertz	TBD
15	Flow Velocity	feet-per-second	TBD
16	Viscosity	centipoises	TBD
17	Frequency	hertz	TBD
18	Turbine Amp	millivolts	TBD
19	FilterSetting	hertz	TBD

4.3.3.3. Binary Input Object:

Mass Flow Meters Binary Input type objects are described in the table below.

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

Note - Binary Input 4, Present value always read zero, because no information available from client, so the polarity property doesn't impact on present value property when the out of service property is false.

4.3.3.4. Binary Value Object:

Mass Flow Meters Binary Value type objects are described in the table below.

Object Instance	Object Name	Description
1	Reset	Reset's Totalizer

4.3.4. ANNEX - BACnet PROTOCOL IMPLEMENTATION CONFORMANCE STATEMENT

Date: 19-April-2012
Vendor Name: ONICON Incorporated
Product Name: F-1500 Series Turbine Meter
Product Model Number: F-1500
Applications Software Version: 1.07
Firmware Revision: N/A
BACnet Protocol Revision: 4
Product Description: 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)

List all BACnet Interoperability Building Blocks Supported (Annex K):

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

Services Supported	
Read Property	Execute
Write Property	Execute
Read Property Multiple	Execute
Write Property Multiple	Execute
Who-Is	Execute
I-AM	Initiate
Who-Has	Execute
I-Have	Initiate
Device Communication Control	Execute

Segmentation Capability:

Able to transmit segmented messages No
Able to receive segmented messages No

Standard Object Types Supported:

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

Standard Object Types - Supported Writable Properties			
Object Type	**Properties**		
Analog Input (AI)	Present Value	Out-Of-Service	
Binary Input (BV)	Present Value	Out-Of-Service	Polarity
Binary Value	Present Value	Out-Of-Service	
Device			

Properties of Analog Input/Value Objects Type						
ID	**Name**	**Present Value**	**Status Flags**	**Event State**	**Out of Service**	**Units**
AI1	Volume Flow	?	F,F,F,F	Normal	False	?
AI2	Mass Flow	?	F,F,F,F	Normal	False	?
AI3	Temperature 1	?	F,F,F,F	Normal	False	?
AI4	Temperature 2	?	F,F,F,F	Normal	False	?
AI5	Pressure	?	F,F,F,F	Normal	False	?
AI6	Density	?	F,F,F,F	Normal	False	?
AI7	Energy Flow	?	F,F,F,F	Normal	False	?
AI8	Totalizer 1	?	F,F,F,F	Normal	False	?
AI9	Totalizer 2	?	F,F,F,F	Normal	False	?
AI10	StatusRegister	?	F,F,F,F	Normal	False	?
AI11	Channel 1 (4-20 mA)	?	F,F,F,F	Normal	False	?
AI12	Channel 2 (4-20 mA)	?	F,F,F,F	Normal	False	?
AI13	Channel 3 (4-20 mA)	?	F,F,F,F	Normal	False	?
AI14	Scaled Freq	?	F,F,F,F	Normal	False	?
AI15	Flow Velocity	?	F,F,F,F	Normal	False	?
AI16	Viscosity	?	F,F,F,F	Normal	False	?
AI17	Frequency	?	F,F,F,F	Normal	False	?
AI18	Turbine Amp	?	F,F,F,F	Normal	False	?
AI19	FilterSetting	?	F,F,F,F	Normal	False	?

Properties of Analog Input/Value Objects Type						
ID	**Name**	**Present Value**	**Status Flags**	**Event State**	**Out of Service**	**Polarity**
BI1	Alarm1	?	F,F,F,F	Normal	False	?
BI2	Alarm2	?	F,F,F,F	Normal	False	?
BI3	Alarm3	?	F,F,F,F	Normal	False	?
BI4	External	?	F,F,F,F	Normal	False	?

Properties of Analog Input/Value Objects Type						
ID	**Name**	**Present Value**	**Status Flags**	**Event State**	**Out of Service**	**out-of-service**
BV1	Reset	?	F,F,F,F	Normal	False	False

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, 76800
 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)

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/networks(s) that the gateway supports:
- N/A

4.3.5. Acronyms and Definitions

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

APPENDIX

A-1 APPENDIX A

F-1500 SERIES ORDERING INFORMATION

Insertion Turbine Meter Codification = F-1500-ABCD-EFGH

A = Connection Type
0 = 2” Male NPT threads with retractor
1 = 2” ANSI class 150 flange with retractor
3 = 2” ANSI class 300 flange with retractor
6 = 2” ANSI class 600 flange with retractor
7 = 2” Male NPT threads without retractor (≤50 psig maximum pressure)
8 = 2” ANSI class 150 flange without retractor (≤50 psig maximum pressure)
9 = 2” ANSI class 300 flange without retractor (≤50 psig maximum pressure)

B = Integral or Remote Mount Transmitter
1 = Integral Mount
2 = Remote Mount

C = Temperature / Pressure Compensation
0 = Integral temperature compensation
1 = Integral temperature & pressure sensor, 30 psia maximum
2 = Integral temperature & pressure sensor, 100 psia maximum
3 = Integral temperature & pressure sensor, 300 psia maximum
4 = Integral temperature & pressure sensor, 500 psia maximum
5 = Integral temperature & pressure sensor, 1500 psia maximum
9 = None

D = Rotor Type (nominal range)
0 = Liquid
1 = R40 (steam or gas)
2 = R30 (steam or gas)
3 = R25 (steam or gas)
4 = R20 (steam or gas)
5 = R15 (steam or gas)
6 = R10 (steam or gas)

E = Input Power
0 = Loop powered (Only available with Output Signals option F=0)
1 = External 12-36 VDC powered
2 = External 85-240 VAC powered

F = Output Signals
0 = 4-20 mA output*, pulse output & frequency output
1 = 4-20 mA output, pulse output & frequency output, alarm output & MODBUS
2 = 4-20 mA output, pulse output & frequency output, alarm output & BACnet
3 = (3) 4-20 mA outputs, (3) alarm outputs, (1) pulse output (1) frequency output & MODBUS
4 = (3) 4-20 mA outputs, (3) alarm outputs, (1) pulse output (1) frequency output & BACnet
5 = (3) 4-20 mA outputs*, (3) alarm outputs, (1) pulse output (1) frequency output

G = Maximum Operating Temperature
0 = 450° F
1 = 850° F

H = Energy Meter
0 = None
1 = Gross energy meter
2 = Net energy meter (requires additional remote temperature sensor.)

* Available with HART® serial communications

REMOTE TEMPERATURE SENSOR AND THERMOWELL INSTALLATION KIT

(Required for Net Energy Meter)

Part Number	Description
20100	Remote Temperature Sensor, 1,000 Ohm 4-wire Class A Platinum RTD
20101	Remote Thermowell Kit for 1½" Welded Steel Pipe
20102	Remote Thermowell Kit for 2 - 5" Welded Steel Pipe
20103	Remote Thermowell Kit for 6 - 14" Welded Steel Pipe

Note: Net energy meter requires 1 temperature sensor and 1 thermowell installation kit sized to pipe.