SonoPro® Professional Series Ultrasonic Flow Meter

Series S36

Instruction Manual

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Rev B

8475 W I-25 Frontage Rd
Suite 300
Longmont, CO 80504
(303) 682-9999 (888) 386-7835 Fax (303) 682-4368
http://www.vortekinst.com

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Warning!
Consult the flow meter nameplate for specific flow meter approvals.

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.

Always remove main power before disassembling any part of the flow meter.

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

Revision History

Rev. A – New Release
Rev. B – Added Missing Mounting Template

Chapter 1 Introduction

SonoPro® Ultrasonic Flow Meters

The VorTek Instruments' SonoPro® Series ultrasonic flow meters provide a reliable solution for process flow measurement. From the externally mounted transducers, volumetric flow can be calculated non-invasively.

Multi-Parameter Mass Flow Meters

Mass flow can be determined by using the volumetric flow reading from the clamp on ultrasonic transducers and measurements from the external temperature sensors.

Volumetric Flow Meters

The primary sensing elements of the volumetric flow meter are the clamp on ultrasonic sensors. The analog 4-20 mA output signals offer 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 come standard 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 frequency output are also available. SonoPro® digital electronics allows for easy reconfiguration for most liquids. The VorTek Series SonoPro® Meters' simple installation combines with an easy-to-use interface that provides quick set up, long term reliability and accurate volume or mass flow measurement over a wide range of flows, pressures, and temperatures.

Using This Manual

This manual provides information needed to install and operate the SonoPro® Professional Series (Fixed Mount) Flow Meter.

- Chapter 1 includes the introduction and product description
- Chapter 2 provides information needed for installation
- Chapter 3 describes system operation and programming
- Chapter 4 provides information on MODBUS and BACnet protocols
- Chapter 5 provides information on datalogging
- Chapter 6 briefly describes the SonoPro® app and its functionality
- Chapter 7 covers troubleshooting and repair

Appendix A - Product Specifications, Appendix B – Flow Meter Calculations, Appendix C – Sound Speed and Pipe Data, Appendix D – Quick Start-Up Guide, Appendix E – Mounting Template, Appendix F– Glossary of Terms

Note and Safety Information

We use note, caution, and warning statements throughout this book to draw your attention to important information.

Warning!
This statement appears with information that is important to protect people and equipment from damage. Pay very close attention to all warnings that apply to your application.

Caution!
This statement appears with information that is important for protecting your equipment and performance. Read and follow all cautions that apply to your application.

Note
This statement appears with a short message to alert you to an important detail.

Receipt of System Components

When receiving a VorTek ultrasonic 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 VorTek Customer Service.

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 Chapter 7 – Troubleshooting, for specific information and recommendations.

If the problem persists after following the troubleshooting procedures outlined in Chapter 7, contact VorTek Instruments, Technical Support at (888) 386-7835 or (303) 682-9999 between 8:00 a.m. and 5:00 p.m. MST. When calling Technical Support, have the following information on hand:

- the serial number and VorTek order number (all marked on the label on the inside of the enclosure)
- the problem you are encountering, and any corrective action taken
- application information (fluid, pressure, temperature, and piping configuration)

How the SonoPro® Flow Meter Operates

Velocity Measurement

The SonoPro® Fixed Mount flow meter operates on the transit time ultrasonic measurement method. This type of measurement uses the basic fact that the fluid's velocity influences the transmission speed of the ultrasonic signal. This is analogous to a person paddling a canoe with the current versus paddling against the current. The canoe can travel downstream with the current faster than it can be paddled back upstream against the current. The same is true for the sound waves as they travel with and against the direction of fluid flow.

For the measurement, two ultrasonic transducers are mounted onto the outside of the pipe. With one being downstream at a designated distance from the other. The electronics send two pulses through the pipe and into the fluid inside the pipe. One signal is sent with the direction of the flow, and the second is sent against the flow. The transducers act as both transmitters and receivers. The transit time of the ultrasonic signal moving in the direction of the flow is faster than that sent against the flow. The meter's electronics read these two times and calculate the time difference, ΔT, which can then be used to determine the average flow velocity.

The SonoPro® Professional Series electronics take into account the fluid flow profile and apply a correction to the velocity reading to determine the average flow through the pipe.

Ultrasonic Flow Path

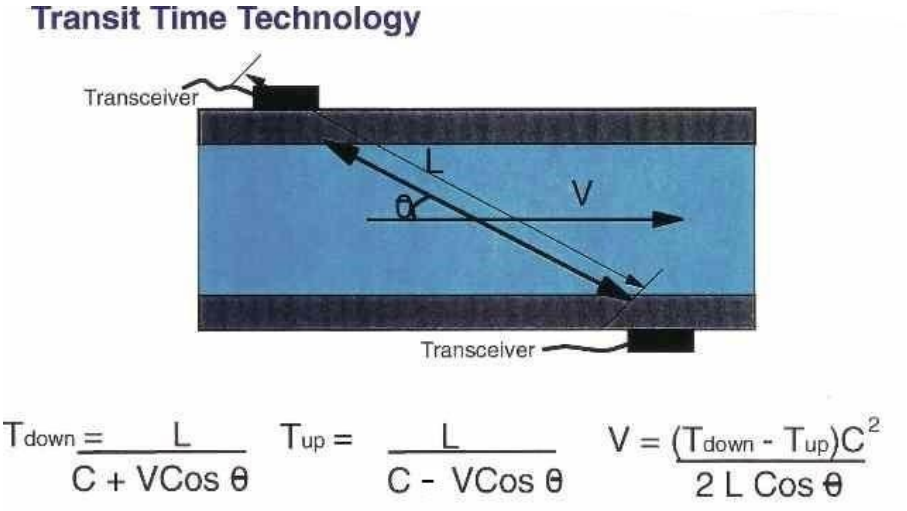


Figure 1-1. Ultrasonic Flow Path

Temperature Measurement

SonoPro® flow meters can use external 1000-ohm platinum resistance temperature detectors (PRTD) to measure transducer temperature and to adjust for changes in the speed of sound due to temperature changes.

Flow Meter Configurations

SonoPro® Ultrasonic flow meters are available with different transducer frequencies for a wide variety of applications. Typical pipe sizes for each transducer type are listed below.

- 2 MHz transducers – 1/2" (15mm) pipe to 4" (100mm) pipe typical
- 1 MHz transducers – 2" (50mm) pipe to 20" (500mm) pipe typical
- .5 MHz transducers – 12" (300mm) pipe to 200" (5000mm) pipe typical

Installation and startup are covered in the following chapters.

Multivariable Options

The SonoPro® meter is available with the following options:
V, volumetric flowmeter; VER velocity and external RTD; VERER, velocity, two external RTDs.

Line Size / Materials

The SonoPro® meter can be applied to line sizes from ½-inch (15mm) to 200-inch (5000mm), in a variety of materials and liners. The SonoPro® meter comes preloaded with 22 pipe materials and six liner materials. If the preloaded selections do not cover the intended application, a new pipe or liner material can be entered pending the speed of sound of the material is known.

Flow Meter Electronics

The SonoPro® flow meter electronics housing may be used indoors or outdoors, including wet environments. It can be powered by either AC (100-240 VAC, 50-60 Hz) or DC (16-36 VDC), with the nominal DC input being 24 Volts. Note: the flow meter will not be damaged if both AC and DC power is connected simultaneously.

As part of the standard product offering, two analog output signals are available to output any of the five process variables: mass flow rate, volumetric flow rate, energy flow rate, temperature, or fluid density. A pulse output signal for remote totalization and a scalable frequency output are also available. USB communication is standard whereas Bluetooth®, MODBUS, and BACnet communications are available only as options.

Flow meters include a local 2 x 16-character LCD display housed within the enclosure. Local operation and reconfiguration are accomplished using a tactile keypad. If local operation and reconfiguration are not desired, an Android® tablet with VorTek Instruments' SonoConfig™ In-

strument Interface Software can be purchased to communicate with the SonoPro® and provide valuable setup, diagnostic, and data logging tools.

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 flowmeters are configured for the customer's flow application.

Chapter 2 Installation

Installation Overview

VorTek's SonoPro® Ultrasonic flow meter installations are simple and straightforward. Wiring instructions begin on page 2-20.

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 the following considerations:

1. Line 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 Table 2-1.

3. Safe and convenient access with adequate clearance for maintenance purposes.

4. The degree of protection of at least IP66 to EN 60529 is only achieved if certified cable entries are used that are suitable for the application and correctly installed. Unused apertures shall be closed with suitable blanking elements (e.g., plugs).

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

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. To achieve accurate and repeatable performance, install the flow meter using the recommended number of straight run pipe diameters upstream and downstream of the sensors.

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.

Piping Conditions		
Condition	Pipe Diameters	
	Upstream	Downstream
One 90° elbow before meter	10D	5D
Two 90° elbows before meter	15D	5D
Two 90° elbows before meter, out of plane	30D	10D
Reduction before meter	10D	5D
Expansion before meter	20D	5D
Partially open valve	30D	10D

Table 2-1. Recommended Pipe Length Requirements for Installation

Series S36 Clamp-On Flow Meter Installation

Prior to installing the SonoPro® transducers, a clean pipe surface needs to be established. Remove any rust or loose paint or debris to make a smooth surface. Choose a section of sound conducting pipe for installing the transducers. The application should be checked to ensure that air bubbles and particulate are at a minimum.

Transducer Mounting Methods

There are three typical mounting methods available. These include the Z method, which is a single traverse across the pipe, the V method, which is two traverses across the pipe, and the W method, which is 4 traverses across the pipe. Each method has its own merits. The V method is by far the most common for most applications from 4-inch to 12-inch pipe. The W method is used for smaller pipes, i.e. line sizes ½-inch to 4-inch. The Z method is used when there is poor signal strength or on pipes larger than 12-inch.

V – Two Traverse – Installation Method

1MHz transducers shown.

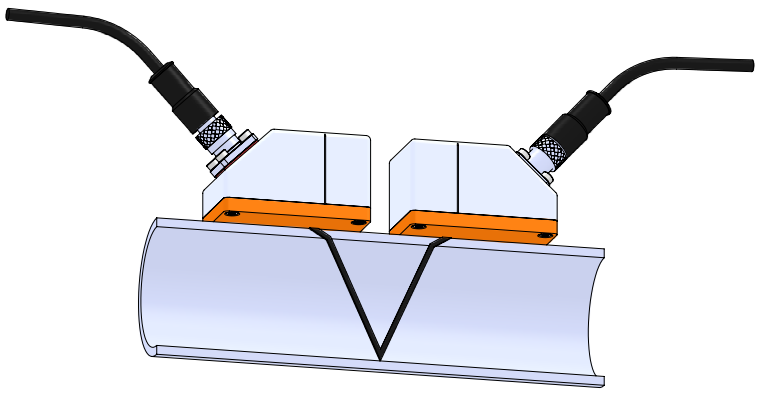


Figure 2-1. V - Two Traverses

W – Four Traverses – Installation Method

2 MHz transducers shown.

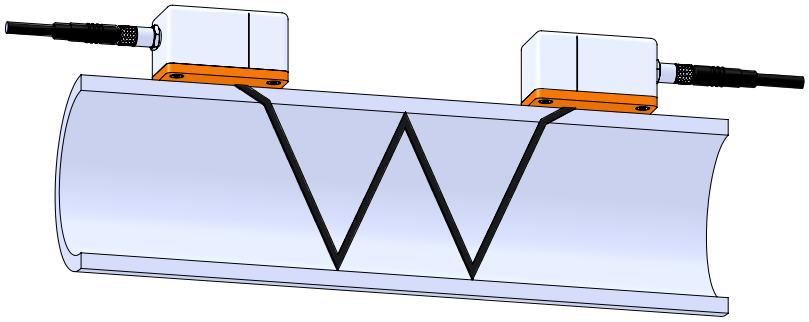


Figure 2-2. W - Four Traverses

Z – One Traverse – Installation Method

2 MHz transducers shown.

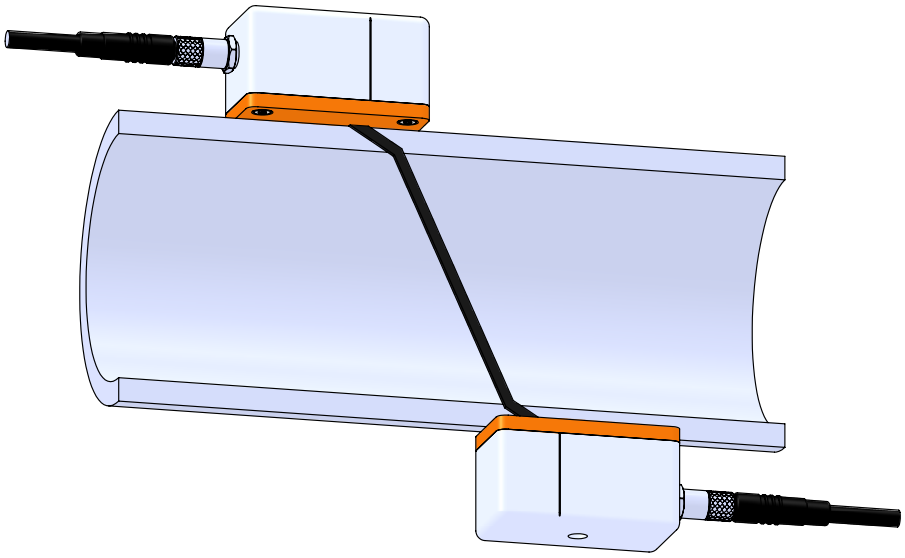


Figure 2-3. Z - One Traverse

Once the installation method is chosen, you will then need to refer to Chapter 3 for programming the unit for the actual application. The meter will calculate the appropriate distance to mount the transducers from the data provided. The transducers can then be mounted to the pipe using the mounting clamps or rail/fixture system.

Large Mounting Clamps

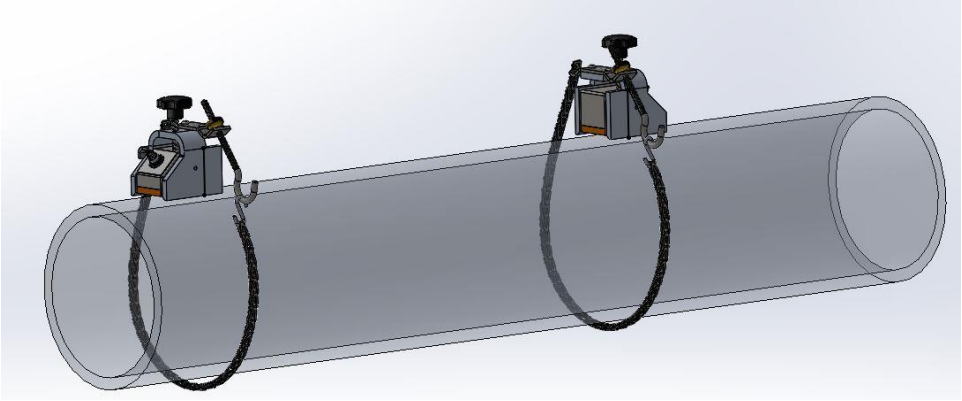


Figure 2-4. Large Mounting Clamps

Adjacent Side Transducer Installation

1. Program all the calibration menu items of the flow meter for the fluid and pipe specifics to obtain the transducer mounting locations.
2. Position the large mounting clamps on the pipe in the desired location.
3. String the mounting chains from the front adjustable hook to the rear attachment hook for both mounting clamps as shown in Figure 2-4. Start with a loose fit.
4. On the leftmost mounting clamp, tighten the chain using the thumb nut on the front adjustable hook so that it fits tight to the pipe.
5. Using a tape measure, measure the distance between the two green (scribe) lines on each of the large mounting clamps as shown in Figure 2-5 and Figure 2-6.
6. Once the distance is set, tighten the chain using the thumb nut on the front adjustable hook of the rightmost mounting clamp so that it fits tight to the pipe. Double check that the spacing did not change as the chain was being tightened. If it did, loosen the chain, set the spacing, and retighten.
7. Apply a thin coat of coupling grease to the transducers. If the coupling grease that came with your SonoPro® flow meter unit runs out, contact VorTek Instruments to order a replacement container.
8. Place the transducers in the left and right mounting clamps. Tighten the screw with plastic knob on the top of the mounting clamp so the end of the screw fits into the divot on the top of the transducer. Do not overtighten.

Figure 2-5. Spacing Locating Points on Large Clamps

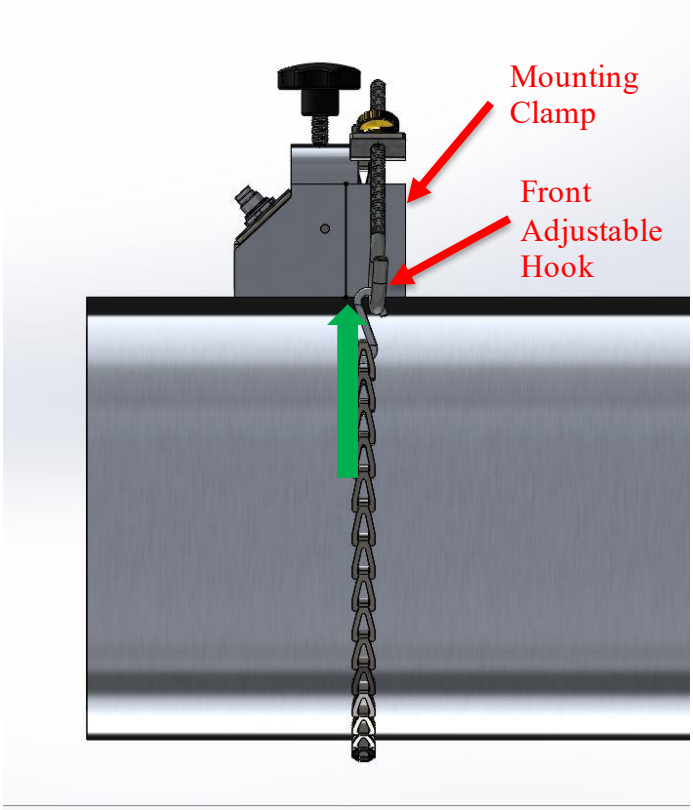


Figure 2-6. Spacing Locating Point on Large Clamp

Opposite Side Transducer Installation

1. Program all the calibration menu items of the flow meter for the fluid and pipe specifics to obtain the transducer mounting locations.
2. Position the first transducer mounting clamp on the pipe in the desired location.
3. String the mounting chain from the front adjustable hook to the rear attachment hook. Start with a loose fit.
4. Apply a thin coat of coupling grease to the first transducer. If the coupling grease that came with your SonoPro® flow meter unit runs out, contact VorTek Instruments to order a replacement container.
5. Place the transducer in the mounting clamp. Tighten the screw with plastic knob on the top of the mounting clamp so the end of the screw fits into the divot on the top of the transducer.
6. Tighten the chain using the thumb nut on the front adjustable hook so the mounting clamp fits tight on the pipe.
7. Tighten the screw with plastic knob on the top of the transducer mounting clamp so the transducer fits tight on the pipe. Do not over tighten.
8. Position the second transducer mounting clamp on the pipe at the location determined by the flow meter and 180 degrees around the pipe from the first one. See Figure 2-7, 2-8, and 2-9 for reference.
9. String the mounting chain from the front adjustable hook to the rear attachment hook. Start with a loose fit.
10. Apply a thin coat of coupling grease to the second transducer. If the coupling grease that came with your SonoPro® flow meter unit runs out, contact VorTek Instruments to order a replacement container.
11. Place the transducer in the mounting clamp. Tighten the screw with plastic knob on the top of the mounting bracket so the end of the screw fits into the divot on the top of the transducer. Do not overtighten.
12. Tighten the chain using the thumb nut on the front adjustable hook so the mounting clamp fits tight on the pipe.
13. Tighten the screw with plastic knob on the top of the transducer mounting clamp so the transducer fits tight on the pipe. Do not overtighten.

Figure 2-7. Opposite Side Transducer Installation, Front View

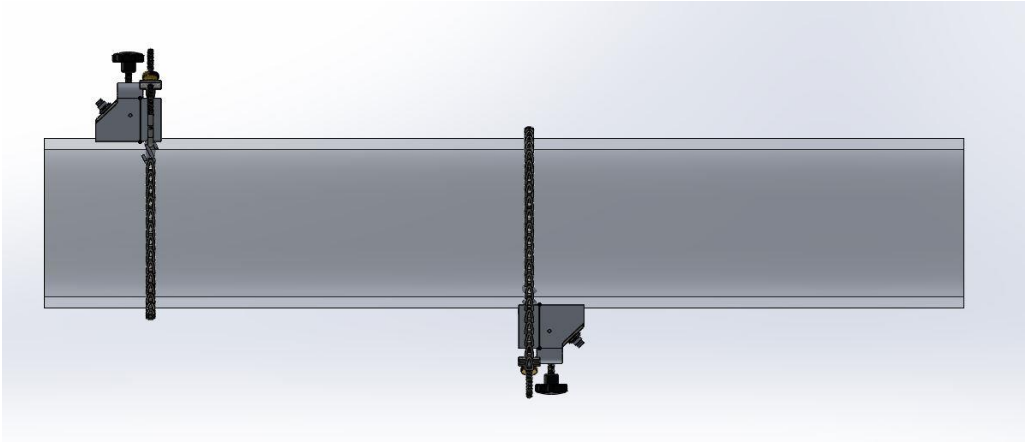


Figure 2-8. Opposite Side Transducer Installation, Side View

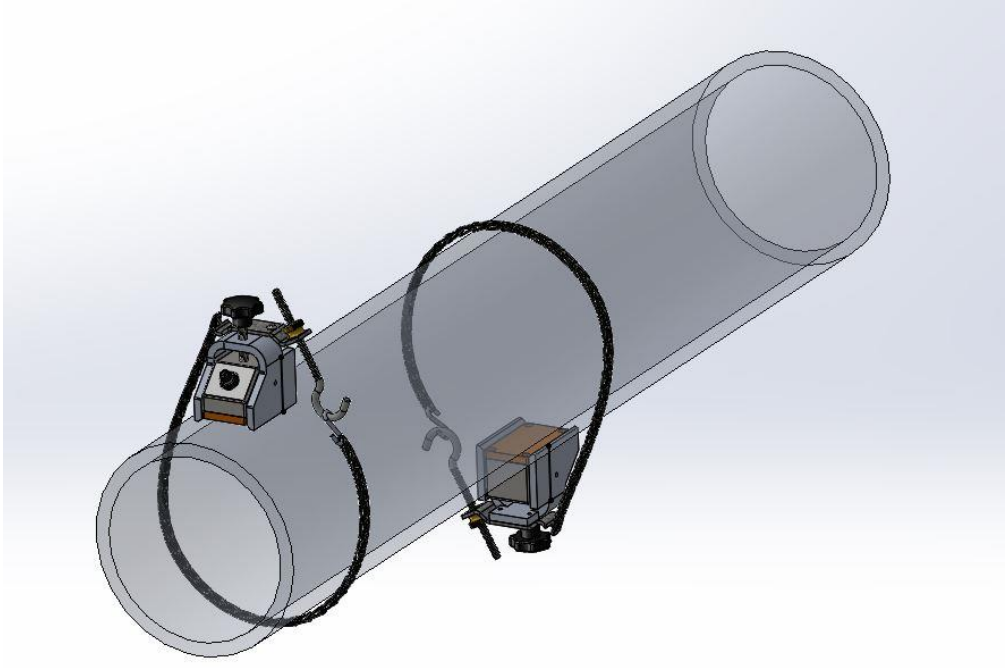


Figure 2-9. Opposite Side Transducer Installation, Angled View

Small Rail / Fixture System

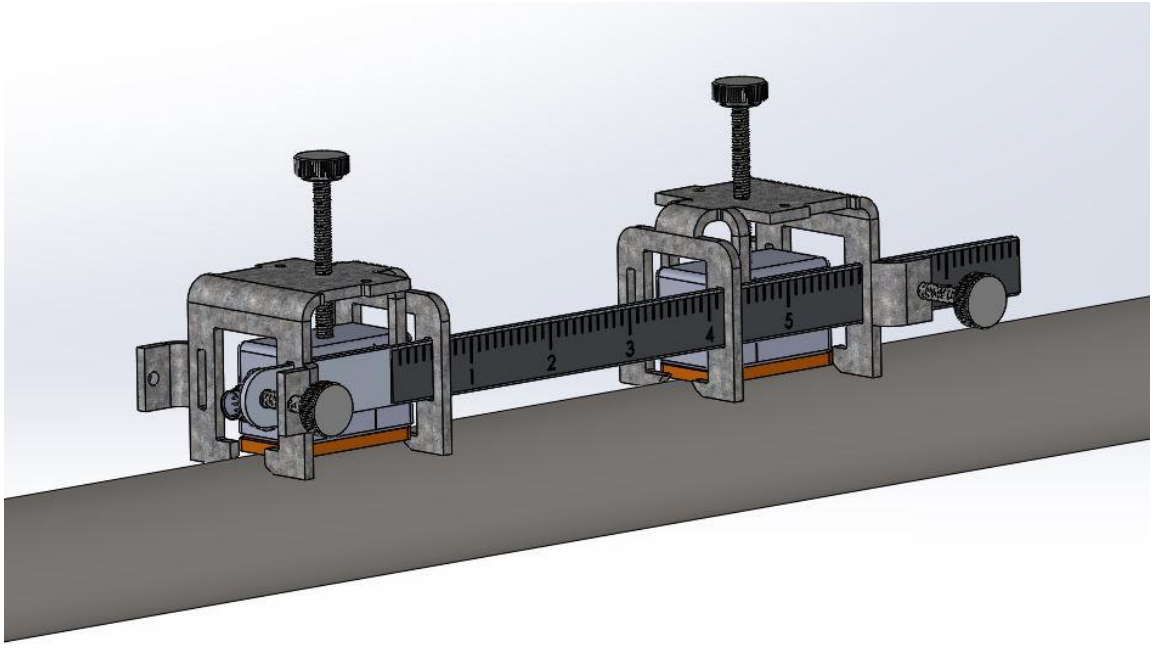


Figure 2-10. Small Rail/Fixture System

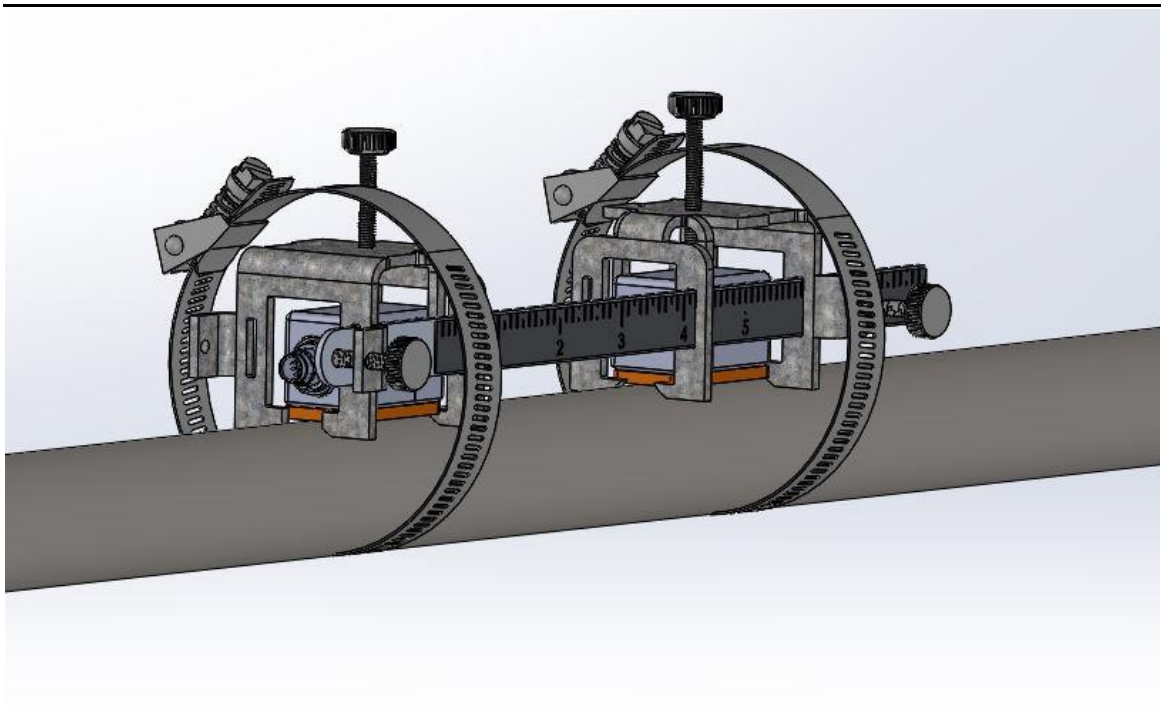


Figure 2-11. Small Rail/Fixture System with Worm-Clamps

Adjacent Side Transducer Installation

1. Program all the calibration menu items of the flow meter for the fluid and pipe specifics to obtain the transducer mounting locations.
2. Position the rail/fixture system on the pipe in the desired location.
3. String the two adjustable worm-drive clamps around the pipe and the fixture as shown in Figure 2-11. Start with a loose fit.
4. Loosen the set screw on the rightmost transducer mounting clamp and using the scale attached to the front rail, slide the clamp so that the middle of the bracket is close to the location determined by the flow meter. See Figure 2-12 for reference. Slightly tighten the set screw that was loosened in the previous step so that the clamp does not being moving when the transducer is placed inside. **Note:** the leftmost mounting clamp does not need to be moved as it is already in the correct position.
5. Connect the transducer cables to each transducer. Note that there is a key on the male connector found on each transducer while each transducer cable has a female connector with a keyway. Align the key and the keyway on the male and female connectors to ensure a proper connection of the cable.

6. With the transducer cables connected, apply a thin coat of coupling grease to the transducers. If the coupling grease that came with your SonoPro® flow meter unit runs out, contact VorTek Instruments to order a replacement container.
7. Place the transducers in the left and right mounting bracket of the rail/ fixture system. Once the rightmost transducer is fitted, move the clamp so that the scribe line on the transducer is placed at the flow meter's determined location. Refer to the green arrow in Figure 2-12 for this locating point. Tighten the set screw completely. **Note:** the transducer in the left mounting bracket does not need to be moved as the scribe line is already aligned with the scale zero.
8. Tighten the worm-drive clamps using a standard screwdriver so the rail fits tight on the pipe.
9. Tighten the screw with plastic knob on the top of each transducer mounting clamp so the transducer fits tight on the pipe. Do not overtighten.

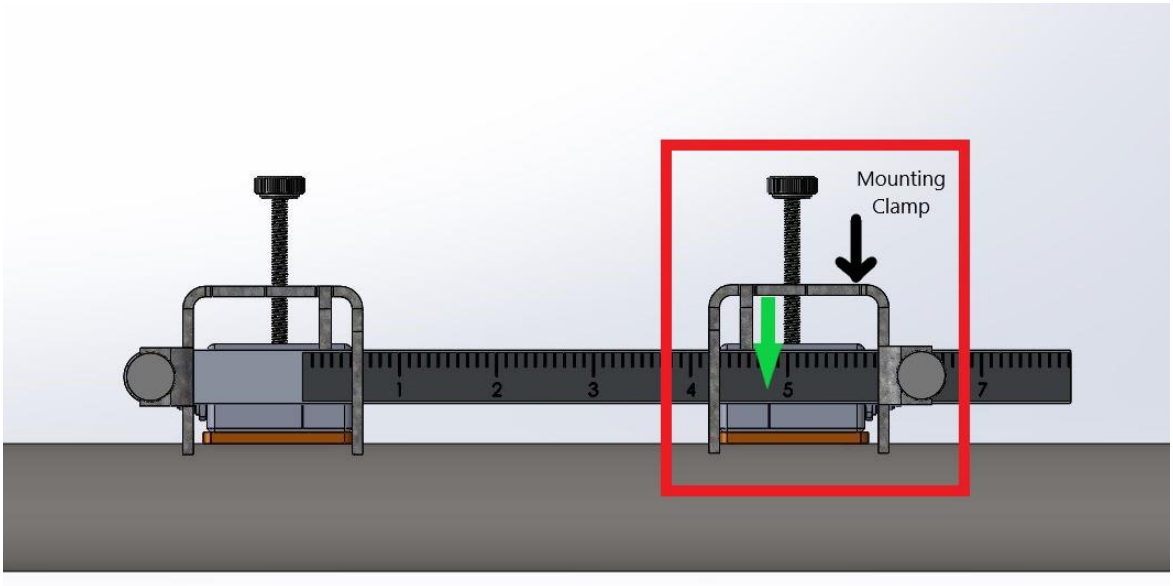


Figure 2-12. Spacing Locating Point on Small Rail/Fixture System*
* Note: Scale not shown here. Scale to be included with actual Small Transducer Rail/Fixture

Enclosure Mounting – Wall or Panel

The SonoPro® Professional Series flow meter can be mounted to a wall or panel using the four holes that pass through the enclosure. See below for a procedure on mounting the SonoPro® enclosure to a wall or panel. **Note:** mounting hardware is not provided. No. 8 screws are recommended for installation. Measure the screws intended for use to ensure that the outside dimeter of the screw threads is less than 0.177 inches (4.496mm) and the diameter of the screw head is less than 0.334 inches (8.484mm). If the screws are larger than the dimensions stated above, the screw will not fit through the hole in the enclosure.

1. To begin the mounting process, print the mounting template from Appendix E of this manual. The mounting template includes a 1:1 scale drawing of the bottom half of the enclosure with hole locations for drilling and mounting.
    a. It is required for the drawing template to be printed on 11”x17” paper for the 1:1 scale to be accurate. If the drawing template is printed on standard, 11 x 8 ½-inch paper, the scale will not be correct and the spacing of the holes for drilling and mounting will not match those found on the enclosure.
2. Determine where on the wall or panel the enclosure is to be mounted. It is up to the user to determine if a location is safe for mounting and if the wall or panel can support the weight of the enclosure. The weight of the enclosure is approximately 7.0 Lbs. (3.2 kg).
3. Tape the mounting template to the wall. Ensure the template is level as this will translate to the enclosure being level.
4. Before the holes are drilled into the wall or panel, determine if anchors are required in addition to screws. If anchors are required, select a drill bit size intended for the anchor. If anchors are not required, select a drill bit size for the screw being used.
    a. A No. 8 screw is recommended for installation of the enclosure. The maximum allowable diameter of the screw threads is 0.177 inches (4.496mm). The maximum allowable diameter of the screw head is 0.334 inches (8.484mm).
5. Drill the holes in the wall or panel with the drill bit selected in the previous step.
6. If it was determined that anchors were required for the installation, install those now. If not, proceed to Step 7.
7. To access these four holes for mounting, locate the four Phillips head screws on the lid of the enclosure which prevent the lid from opening. Unscrew the four screws and open the hinged lid to expose the four mounting holes as shown in Figure 2-13.

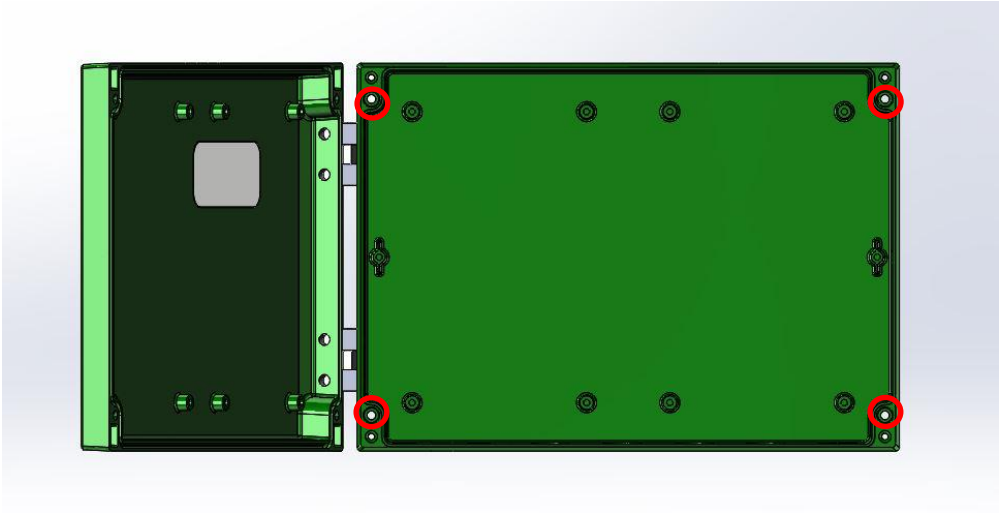


Figure 2-13. Holes for Wall or Panel Mounting

8. Align the holes on the enclosure with the holes in the wall or panel. Insert the screws through the holes in the enclosure and into the wall or panel. Tighten once all screws are in place.
    a. If mounting into a panel, access to the backside of the panel may be required. It is up to the user to determine if or when access to the backside of the panel is required.

Enclosure Mounting - Pipe Mounting Bracket

Instructions for Installation

This kit is not included with the standard offering of the product. It is an accessory option and must be ordered under the code, -PMK, for these parts to be included with your flowmeter

1. Gather the mounting bracket and two U-Bolts provided with your flowmeter. For an idea of the steps involved in this installation, refer to Figure 2-14 and 2-15.

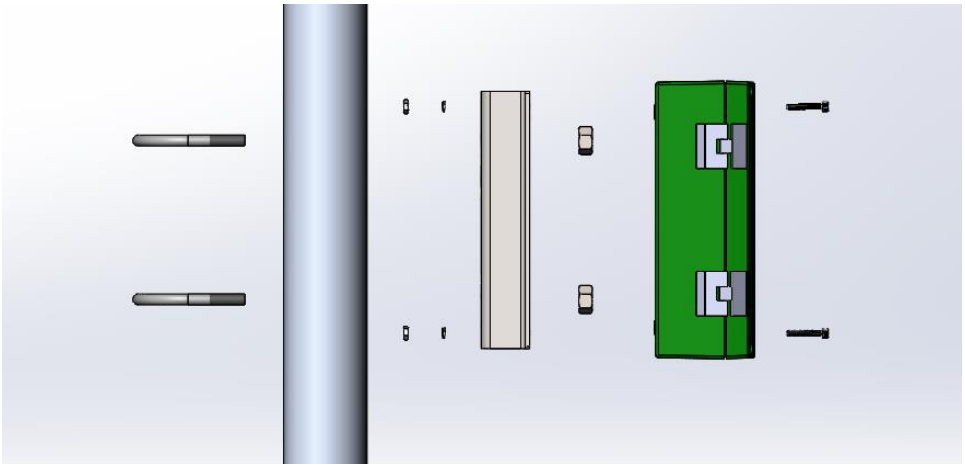


Figure 2-14: Exploded Side View of Pipe Mounting Bracket Assembly

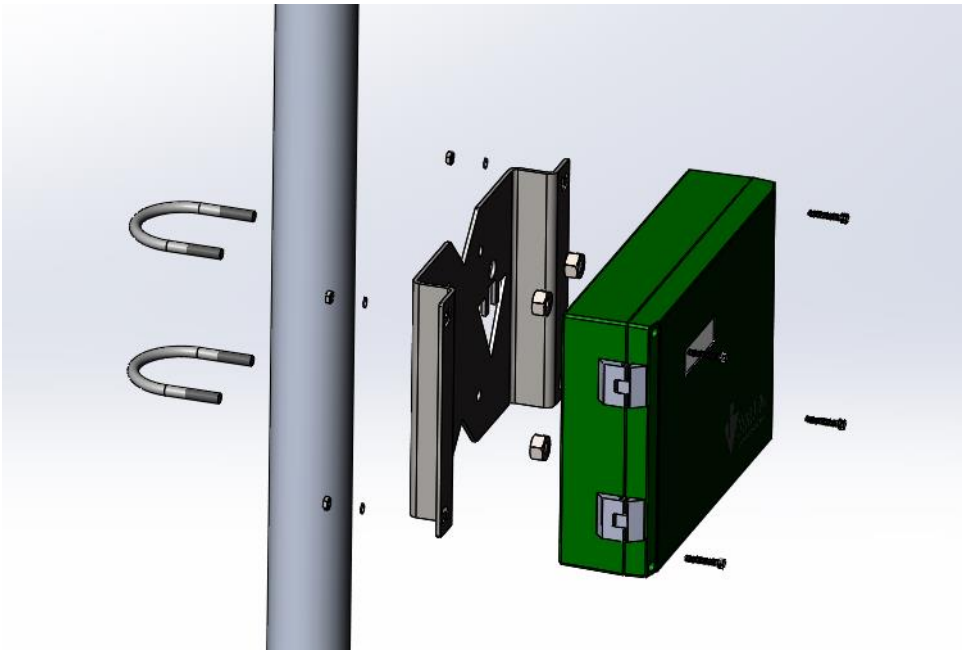


Figure 2-15: Expl. Angled View of Pipe Mounting Bracket Assembly

2. Unscrew the two nuts from each U-Bolt. The mounting bracket will need to go on before the nuts can be installed and tightened.

3. With the mounting bracket in one hand and one U-Bolt in the other hand, place the U-Bolt around the 2-inch pipe in which the flowmeter is to be mounted and through one set of holes in the center of the mounting bracket as shown in Figure 2-16.

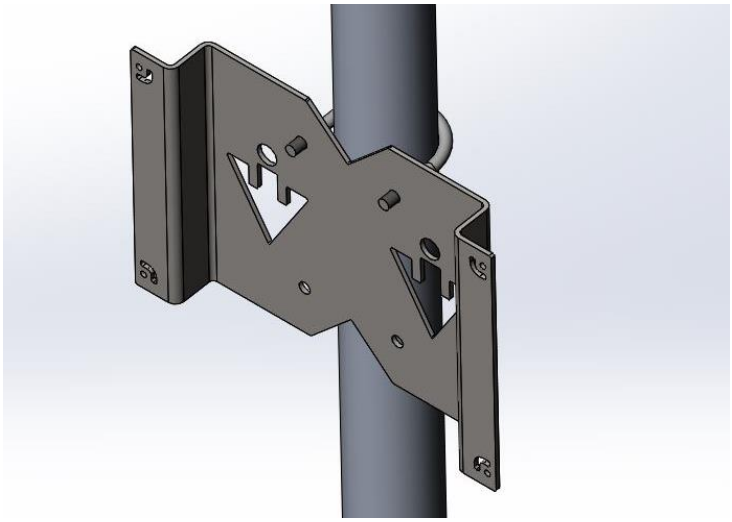


Figure 2-16. Mounting Bracket with U-Bolt

4. Thread the two nuts that were removed from the U-Bolt in Step 2 back on. Move the mounting bracket to the desired location. Tighten the nuts down fully ensuring the bracket stays straight and level. The assembly should resemble that of Figure 2-17.

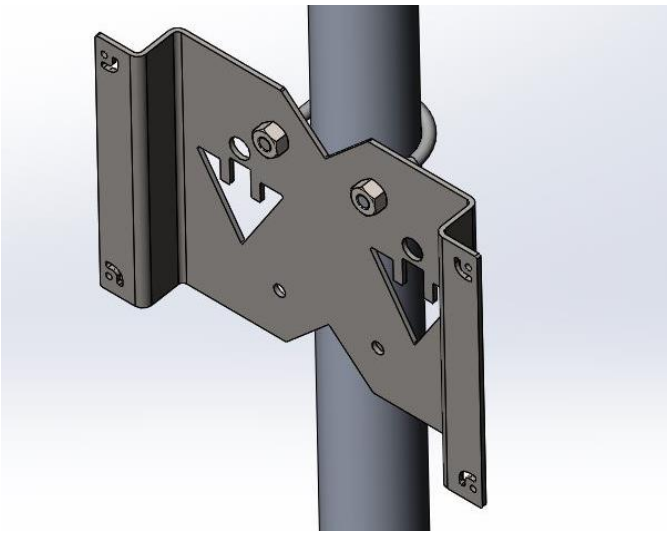


Figure 2-17. Mounting Bracket with U-Bolt and Nuts

5. Place the second U-Bolt around the pipe and through the set of holes in the center of the bracket that were not used in Step 3 (these can be either the top or bottom Holes).
6. Thread the two nuts that were removed from the U-Bolt in Step 2 back on. Tighten the nuts down fully. The assembly should now resemble that of Figure 2-18.

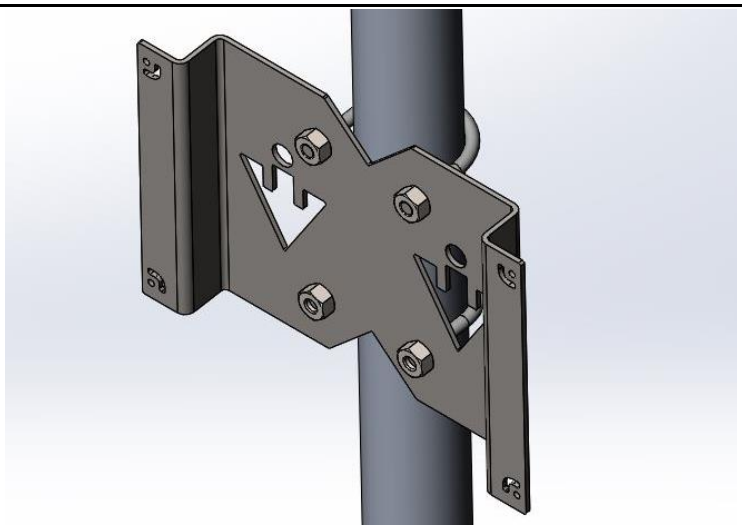


Figure 2-18. Mounting Bracket with Both U-Bolts and Nuts

7. Gather the four socket head cap screws, lock washers, and nuts provided with your flowmeter.
8. Now that the mounting bracket is fully secured to the pipe, the enclosure can be attached to the bracket. To prepare the enclosure for mounting, unscrew the four Phillips head screws from the top of the enclosure so that the lid can be opened, and the mounting holes underneath can be seen.
9. With the lid opened, align the four mounting holes on the enclosure shown in Figure 2-19 with the four mounting holes on the mounting bracket.

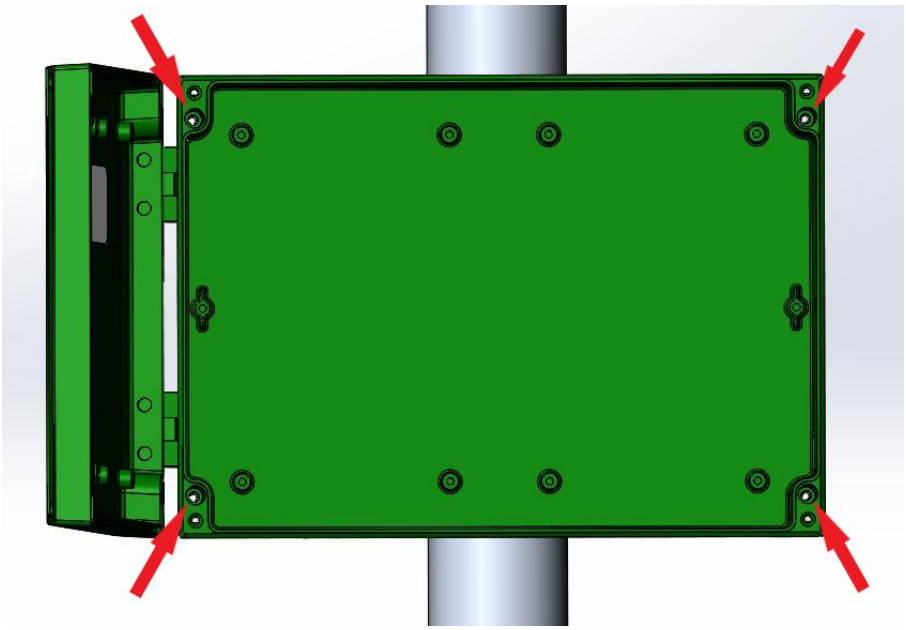


Figure 2-19. Aligning Enclosure with Mounting Bracket

10. Using the socket head cap screws provided, feed one screw through the enclosure and through the mounting bracket as shown in Figure 2-20.

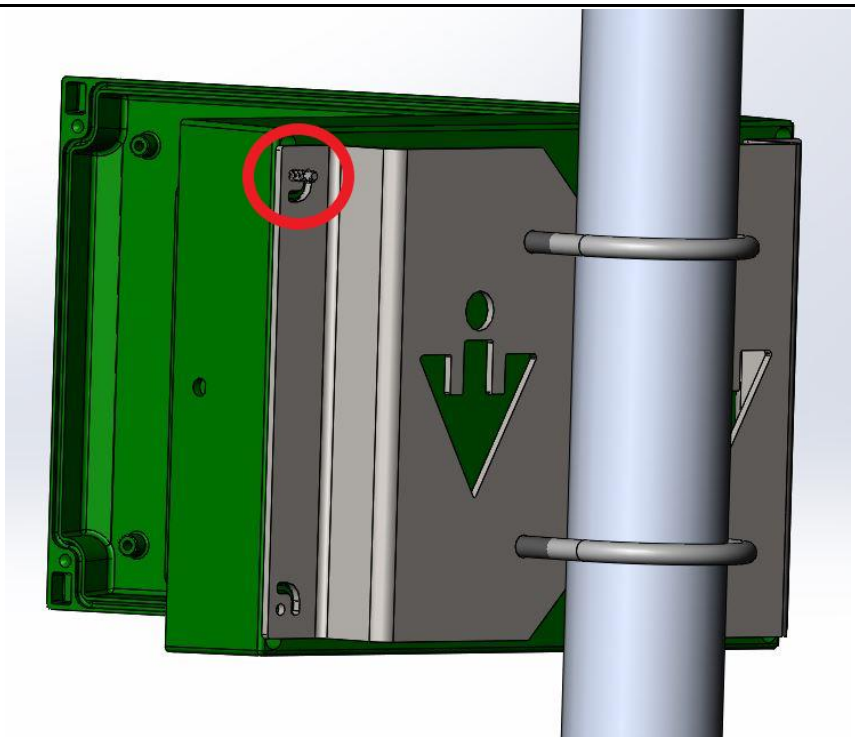


Figure 2-20. Feeding Screw Through Enclosure and Mounting Bracket

11. Using the lock washers and nuts provided, place a lock washer over the screw threads and start threading a nut on as shown in Figure 2-21. Tighten the nut by hand first to allow for the remaining screws to be installed.

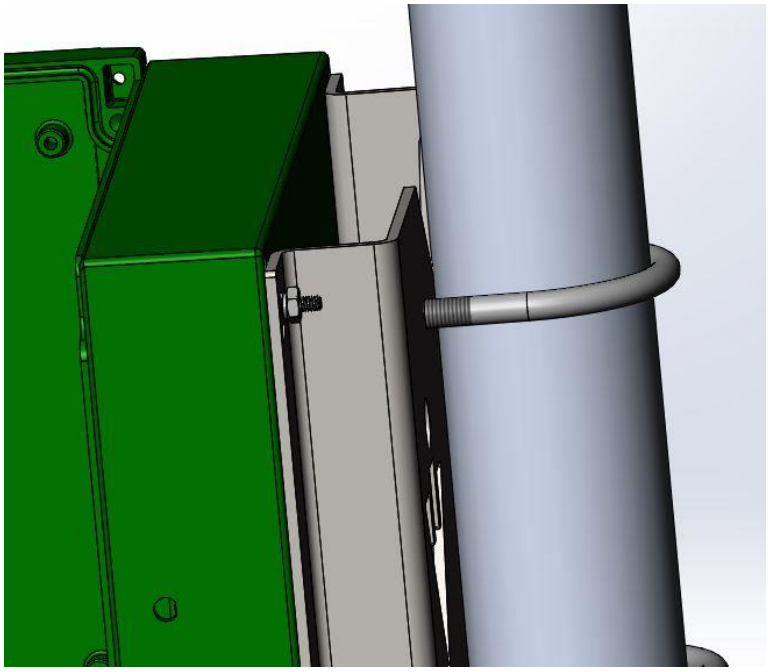


Figure 2-21. Installing Lock Washer and Nut to Screw

12. Repeat Steps 10-11 for installing the three remaining screws. The assembly should resemble that of Figure 2-22.

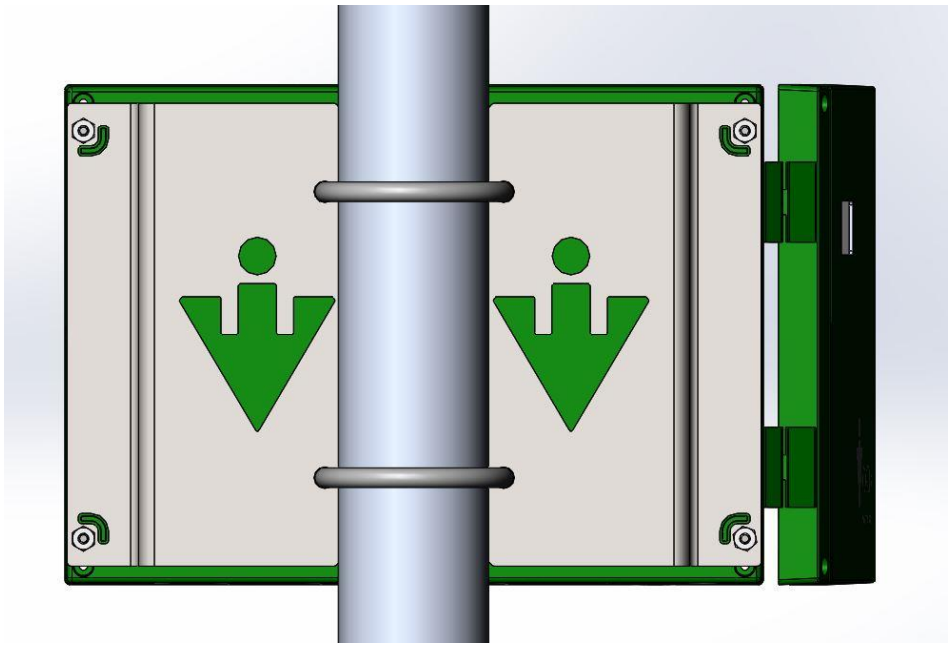


Figure 2-22. Mounting Bracket with All Screws Attached

13. Now that all hardware is installed and hand tight, go to each screw and tighten down fully using an 9/64-inch Allen wrench and an 11/32-inch wrench.
14. The enclosure is now fully attached to the mounting bracket and therefore to the pipe. The assembly should resemble that of Figure 2-23. The lid can be closed and reattached to the bottom half of the enclosure or the lid can be left open to complete the wiring which is described in the next section.

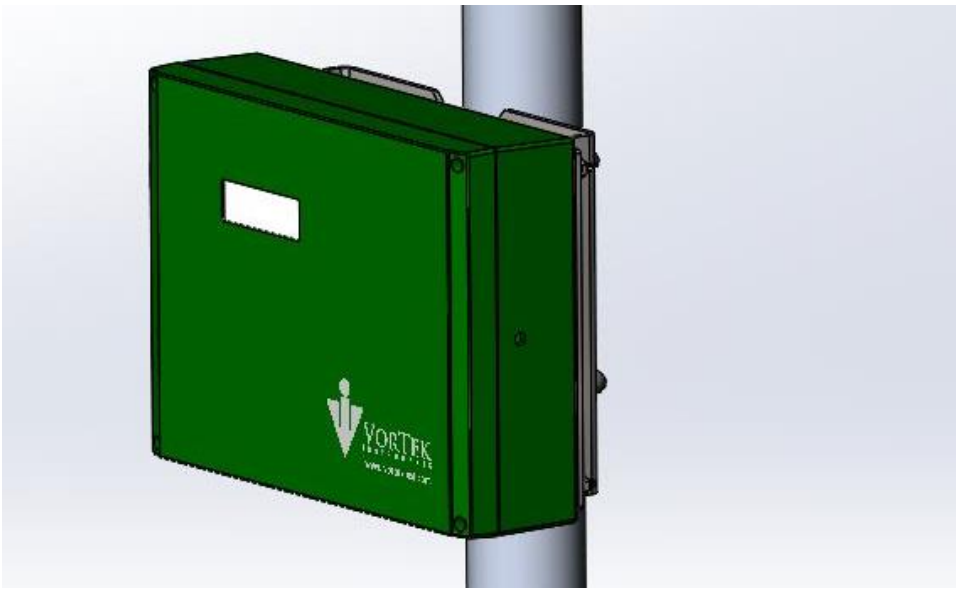


Figure 2-23. Enclosure with Pipe Mounting Bracket

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.

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

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

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

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

The IP66 hinged lid enclosure, when opened, contains an area for wiring. Included in this area are numerous push and lock terminal blocks for making all required connections. Included on the back of these terminal blocks are test points for a digital multimeter (DMM) if the need for measuring the voltage arises (i.e., a troubleshooting scenario). Five nylon cable glands are provided that will accept cable diameters of 0.24 inches to 0.47 inches (6.0 mm to 12.0 mm) for separate power and signal wiring. The degree of protection of at least IP66 to EN 60529 is only achieved if the certified cable entries used are suitable for the application and are correctly installed. Unused apertures shall be closed with suitable blanking elements. **Note:** cable glands and cable gland plugs are provided at the time of purchase.

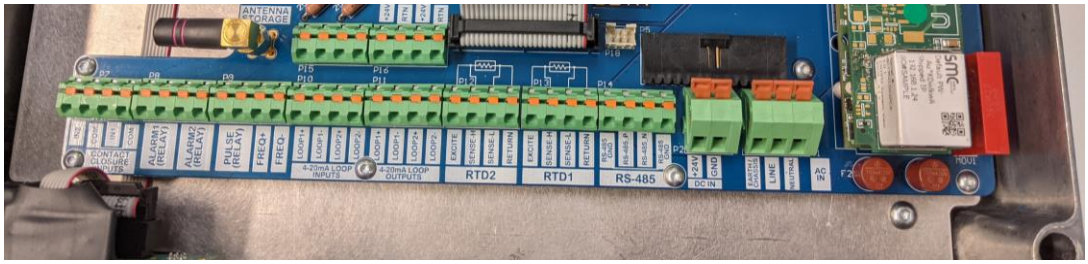


Figure 2-24. Wiring Area Inside of Enclosure

Input Power Connections

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

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

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

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

To access the wiring terminal blocks, locate the four Phillips head screws on the lid of the enclosure which prevent the lid from opening. Unscrew the four screws and open the hinged lid to expose the terminal blocks.

DC Power Wiring

The DC power wire size must be 24 to 12 AWG with the wire stripped 7.5 mm (0.295 inch). Connect 16 to 36 VDC (333 mA, 8 W maximum) to the +24V and GND terminals on the terminal block labeled DC IN.

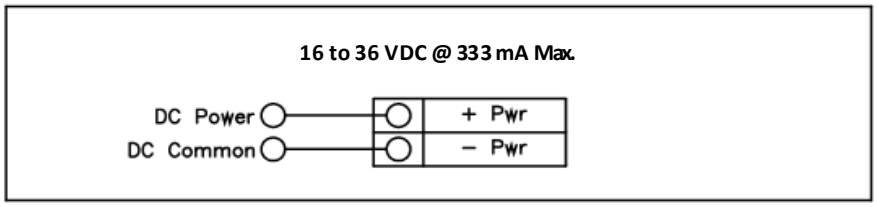


Figure 2-25. DC Power Connections

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

Warning!

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

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

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

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

Caution!

The AC wire insulation temperature rating must meet or exceed 90°C (194°F), maximum operating voltage 600 VRMS.

AC Power Wiring

The AC power wire size must be 24 to 12 AWG with the wire stripped 7.5 mm (0.295 inch). The wire insulation temperature must meet or exceed 90°C (194°F). Connect 100 to 240 VAC (8 W maximum) to the Line and Neutral terminals on the terminal block. Connect the ground wire to the terminal labeled EARTH/CHASSIS. Use a separate conduit entry for signal lines to reduce the possibility of AC noise interference.

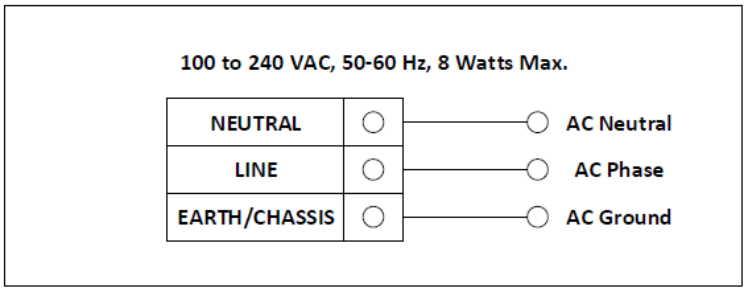


Figure 2-26. AC Power Connections

Transducer Connections

Connect the transducer cables to the transducers and the SonoPro® Professional Series Ultrasonic unit. The cable marked with blue heat shrink wrap is intended for the downstream transducer and the leftmost connector on the fixed mount enclosure. The cable marked with red heat shrink wrap is intended for the upstream transducer and the rightmost connector on the fixed mount enclosure. Cables are interchangeable but are marked for convenience. **Note:** there is a key on the male connector found on the transducer and a keyway on the female connector found on bottom of the enclosure. The key on the male end of the connector must be placed in the keyway of the female end of the connector to allow for proper alignment of the connectors.

Figure 2-27. Transducer Connection Points

4-20 mA Output Connections

The standard SonoPro® Professional Series flow meter has two 4-20 mA loop outputs. 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. For convenience, the SonoPro® comes standard with two, 250 Ohm resistors, for use with each 4-20 mA loop. The current control electronics require a minimum of 12 volts at the input terminals to operate correctly. 36 volts is the maximum. Another added convenience of the standard SonoPro® is the addition of an isolated 24 VDC power supply for powering of the 4-20 mA outputs, pulse output, frequency output, and alarm outputs (all discussed in the sections below). The 24 VDC power supply can produce 100 mA at maximum.

The maximum loop resistance (load) for the current loop output is dependent upon the supply voltage and is given in Figure 2-28. 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

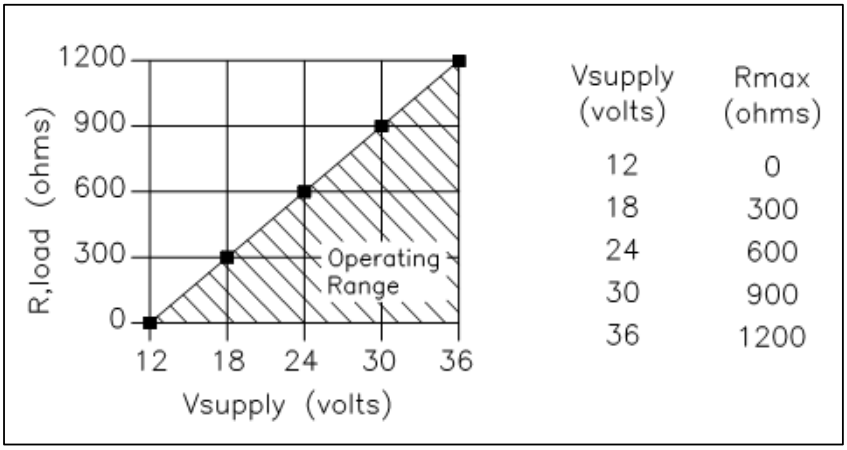


Figure 2-28. Load Resistance versus Input Voltage

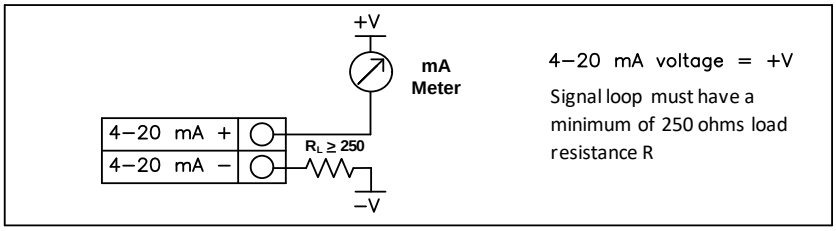


Figure 2-29. Isolated 4–20 mA Output Using External Power Supply

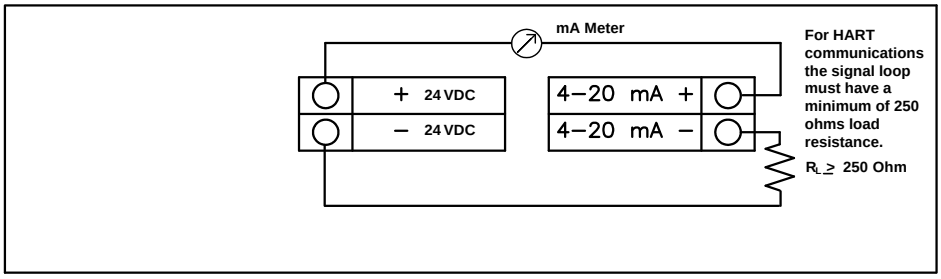


Figure 2-30. Iso. 4-20 mA Output Using Meter Provided Power Supply

Pulse Output Connections

The pulse output is used for a remote counter of the flow total. When the preset volume or mass (defined in the totalizer settings, see page 3-9) has passed the meter, the output provides a 50 millisecond square pulse.

The pulse output requires a separate 5 to 36 VDC power supply. The pulse output optical relay is a normally-open single-pole relay. The relay can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply. Additionally, the relay has no polarity. Safely connect the input wires (and resistor) to either terminal.

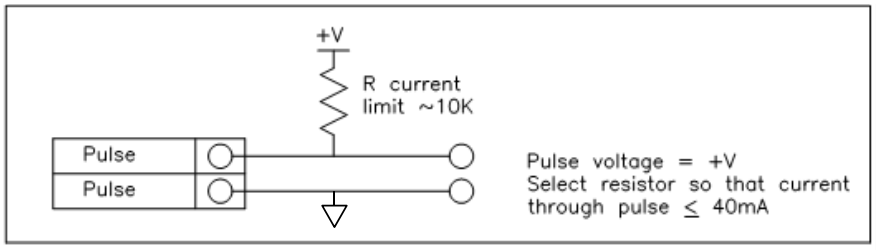


Figure 2-31. Isolated Pulse Output Using External Power Supply

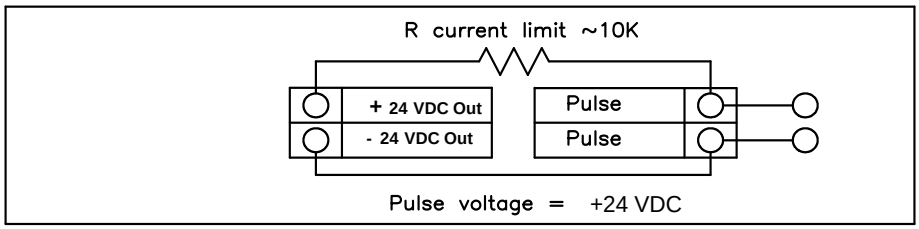


Figure 2-32. Isolated Pulse Output Using Meter Provided Power Supply

Frequency Output Connections

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

The frequency output is an optocoupler (phototransistor) that implements a normally-open switch. It is galvanically isolated from the meter electronics and power supply. The frequency output requires a power supply and pullup resistor (current-limiting resistor). Be mindful of the polarity; it is important. The optocoupler is safe up to 40V and 40mA. However, it is recommended to choose a pullup resistor value so that the current is approximately 10mA.

The choice of supply voltage and pullup resistor affect achievable output frequency and signal dynamics. If the resistor is too large (current is too small) then the optocoupler cannot switch fast enough and the maximum frequency is reduced. (In extreme cases, the achievable frequency can be less than 1kHz). If the resistor is too small (current is too high) then the optocoupler becomes deeply saturated and the logic low level is raised significantly above zero volts. (Example: Using a 24V supply and a 600 ohm resistor results in a switch current of 40mA. With this setup, the low level was measured to be about 8.3V, not 0V as desired). Another concern with small resistors (high current) is the power rating of the resistor.

There is a sweet spot compromise between these two extremes: 10mA. Switching at 10kHz is achievable while keeping logic low levels reasonably close to 0V. To determine what resistor value is needed, divide the supply voltage by 10mA (R = V/I).

Here are recommended values for common voltages:

- 5V supply → use 500 ohms (499 or 470 ohms is okay)
- 12V supply → use 1.2kohms (1kohms is okay)
- 24V supply → use 2.4kohms

It is up to the user to verify correct operation with their setup.

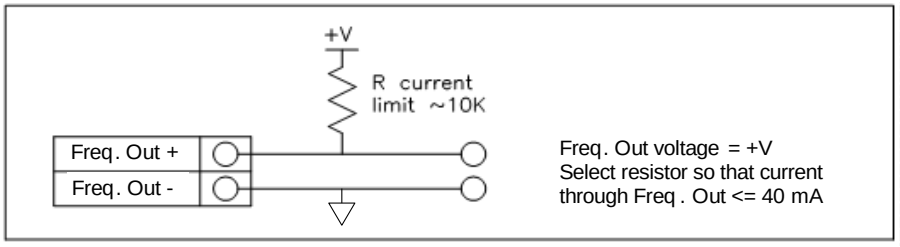


Figure 2-33. Isolated Frequency Output Using External Power Supply

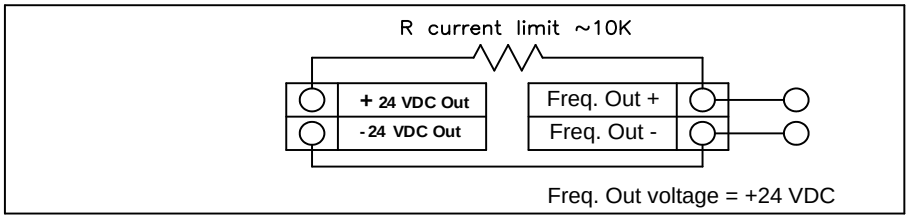


Figure 2-34. Iso. Freq. Output Using Meter Provided Power Supply

Alarm Output Connections

Two alarm outputs (Alarm 1 and Alarm 2) are included on the standard SonoPro® Professional Series Ultrasonic flow meter. The alarm output requires a separate 5 to 36 VDC power supply. The alarm output optical relay is a normally open single-pole relay. The relay can conduct a current up to 40 mA. It is isolated from the meter electronics and power supply. Additionally, the relay has no polarity. Safely connect the input wires (and resistor) to either terminal. When the alarm relay is closed, the current draw will be constant. Make sure to size R_{load} appropriately.

There are two connection options for the alarm output–the first with a separate power supply (Figure 2-34) and the second with the meter provided power supply (Figure 2-35). 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 a 24 VDC, 100 mA Max, power supply is acceptable for the alarm output. In either 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 3-8).

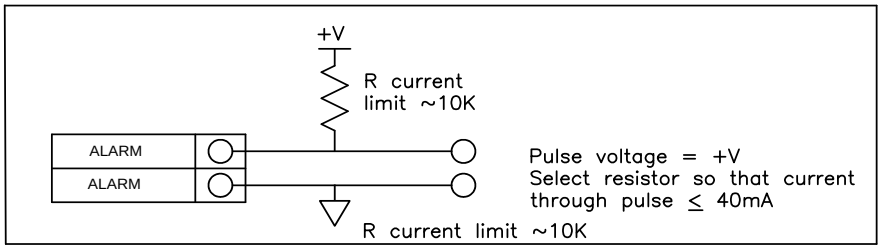


Figure 2-35. Isolated Alarm Output Using External Power Supply

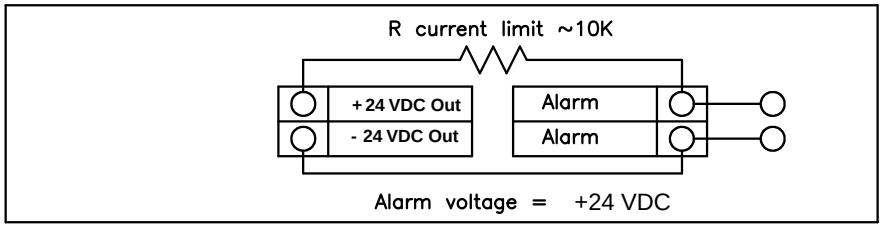


Figure 2-36. Iso. Alarm Output Using Meter Provided Power Supply

RTD Input Connections

The SonoPro® VER/VERER-EM models include inputs for up to two RTD inputs. With these inputs, a 3 or 4-wire RTD may be used. To connect a 3-wire RTD, split the single wire into two separate wires (see the circle in Figure 2-37) and connect these to the EXCITE and SENSE-H terminals on either the RTD1 or RTD2 four pin connectors. Any other connection using a 3-wire RTD will result in increased measurement error. To connect a 4-wire RTD, refer to Figure 2-37.

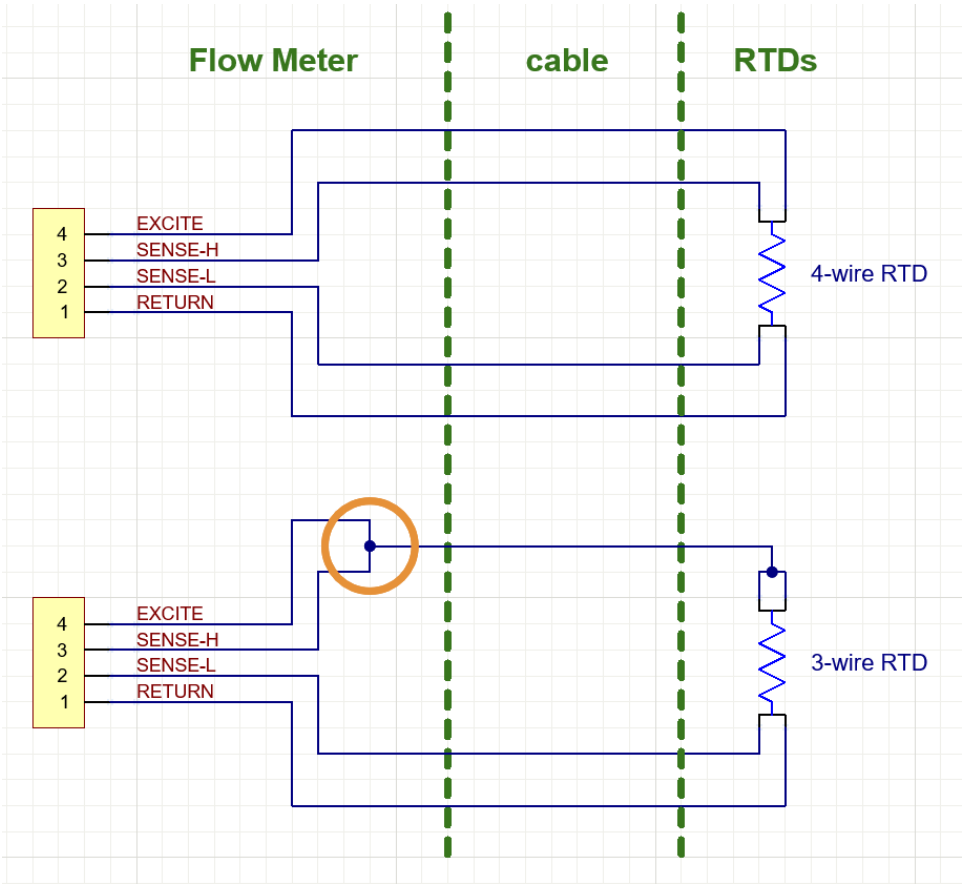


Figure 2-37. 3 and 4-Wire RTD Input Wiring

Chapter 3 Operating Instructions

After choosing the installation orientation of the SonoPro® Fixed Mount Ultrasonic flow meter, you are ready to begin operation. The sections in this chapter explain the display/keypad commands, meter start-up, and programming. To enter parameters and system settings unique to your operation, see the following pages for instructions on using the setup menus.

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 tactile membrane keypad makes it easy to read the measured parameters or program the meter.

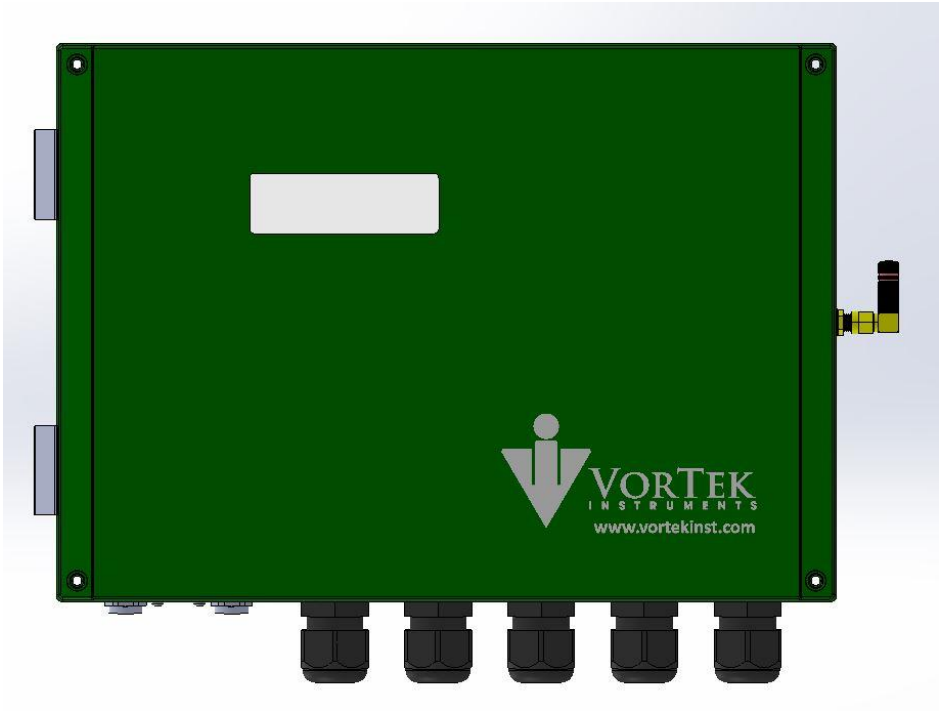


Figure 3-1. Flow Meter Enclosure and Display

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

Start Up

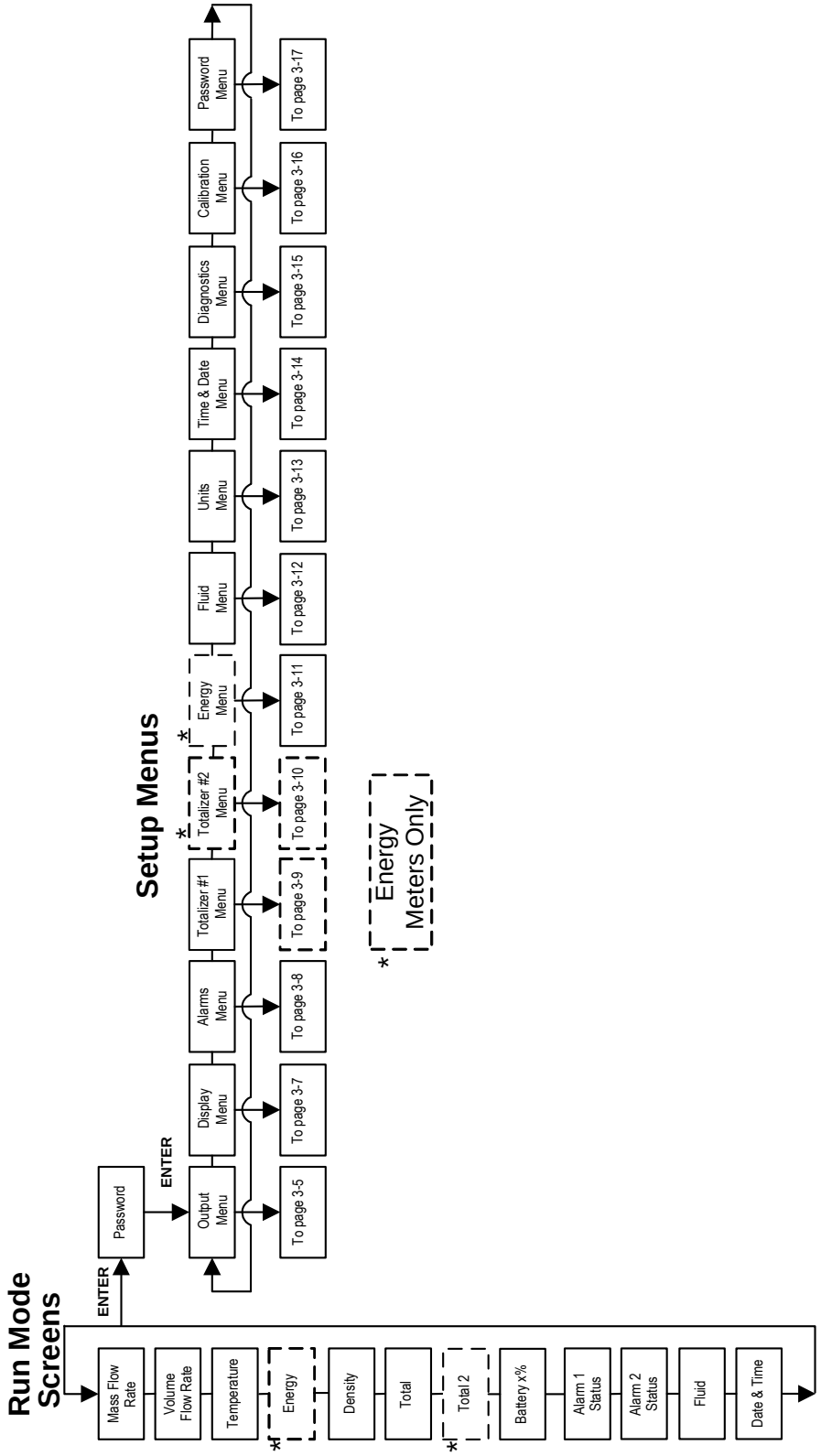
To begin flow meter operation:

1. Turn on 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.

2. 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.

3. Press the ENTER key from any Run Mode screen to access the Setup Menus. Enter the factory configured password 1234. Use the Setup Menus to configure the meter's multi-parameter features to fit your application.

Using the Setup Menus



Programming the Flow Meter

1. Enter the Setup Menu by pressing the ENTER key until prompted for a password. Note: all outputs are disabled while using the Setup Menus.

2. Use the keypad to select the password characters (1234 is the factory-set password). When the password is correctly displayed, press ENTER to continue.

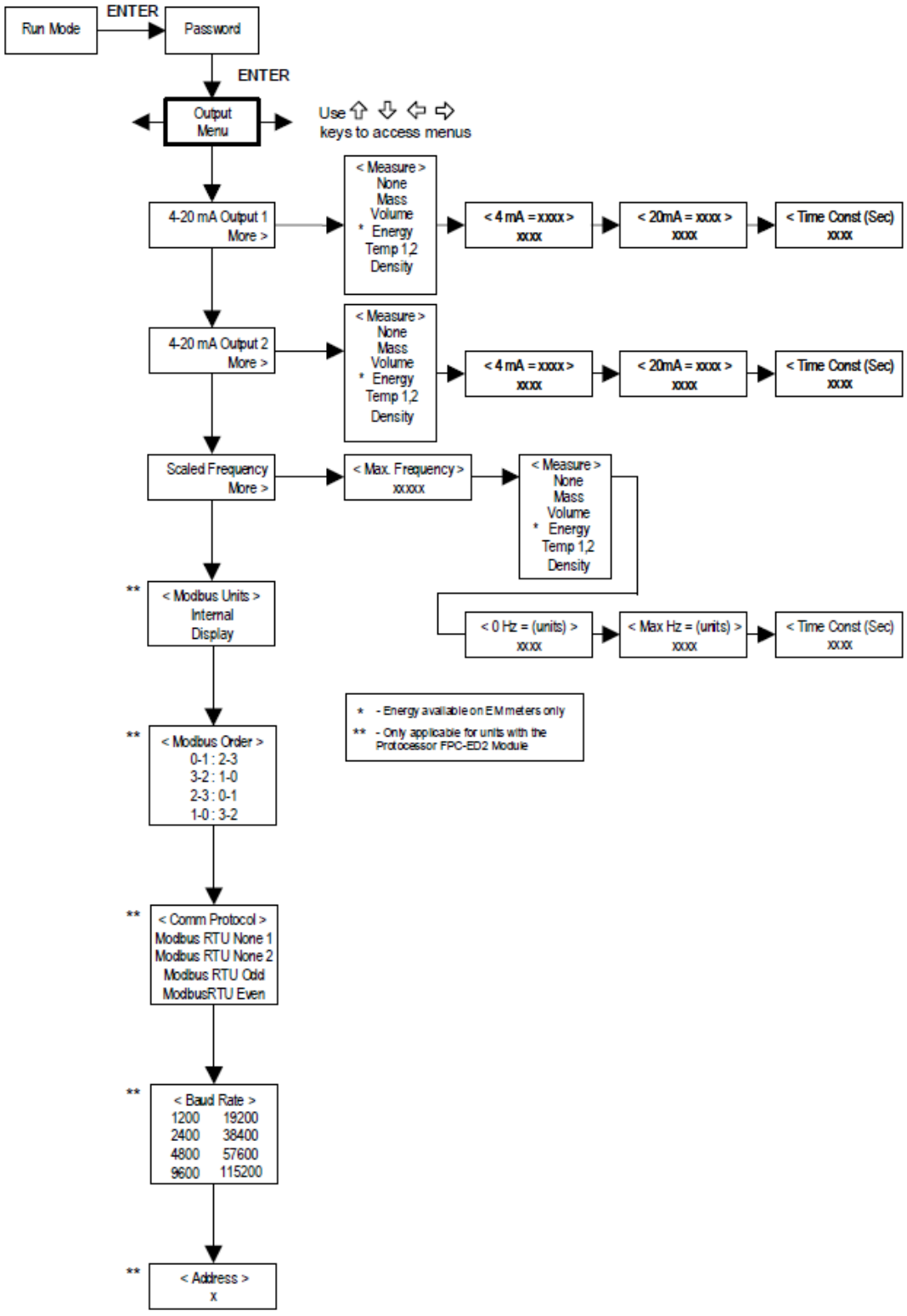
3. Use the Setup Menus described on the following pages to customize the multi-parameter features of your SonoPro® Flow Meter. (The entire lower display line is available for entering parameters.) Some items depicted in the graphic on the preceding page may not be displayed based on flow meter configuration settings.

4. To activate a parameter, press ENTER. Use the keypad to make selections. Press ENTER to continue. Press EXIT to save or discard changes and return to the Run Mode screen.

5. **Program the UNITS menu first because later menus will be based on the units selected.**

6. **Next program the Calibration menu to obtain information needed for installing the transducers as described in Chapter 2.**

Output Menu


Run Mode
ENTER
Password
ENTER
Output Menu
Use ⇧ ⇩ ⇦ ⇨ keys to access menus
4-20 mA Output 1 More >
4-20 mA Output 2 More >
Scaled Frequency More >
** < Modbus Units > Internal Display
** < Modbus Order > 0-1 : 2-3 3-2 : 1-0 2-3 : 0-1 1-0 : 3-2
** < Comm Protocol > Modbus RTU None 1 Modbus RTU None 2 Modbus RTU Odd ModbusRTU Even
** < Baud Rate > 1200 19200 2400 38400 4800 57600 9600 115200
** < Address > x
< Measure > None Mass Volume * Energy Temp 1,2 Density
< 4 mA = xxxx > xxxx
< 20mA = xxxx > xxxx
< Time Const (Sec) xxxx
< Max. Frequency > xxxxx
< 0 Hz = (units) > xxxx
< Max Hz = (units) > xxxx
* - Energy available on EM meters only
** - Only applicable for units with the Protocessor FPC-ED2 Module

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 5 seconds. Note: all outputs are disabled while using the Setup Menus.

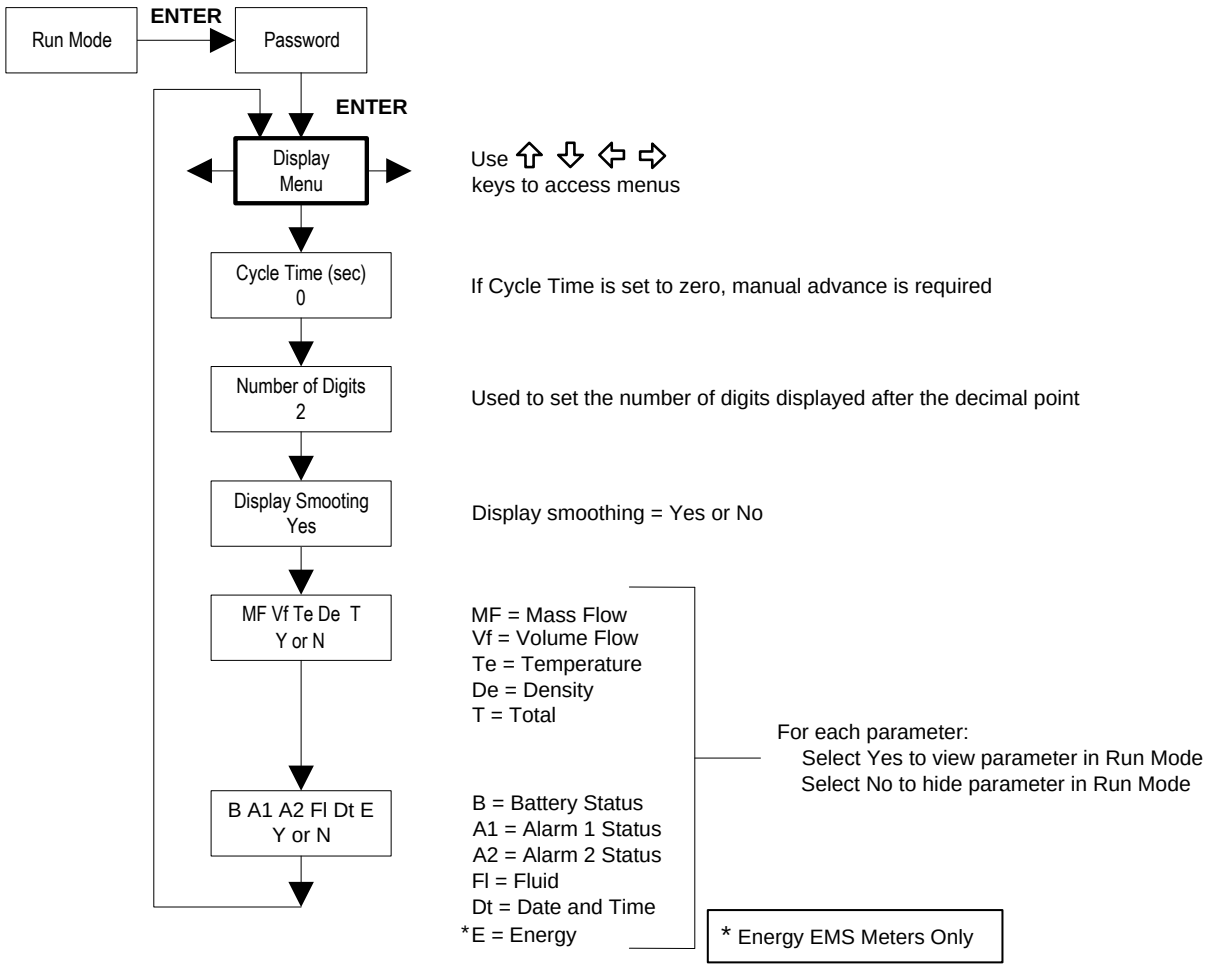
First, set the desired units of measurement:

1. Use ⇦⇨ keys to move to the Units Menu (see page 3-13).
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 then ENTER to save changes and return to the Run Mode screen..

Display Menu



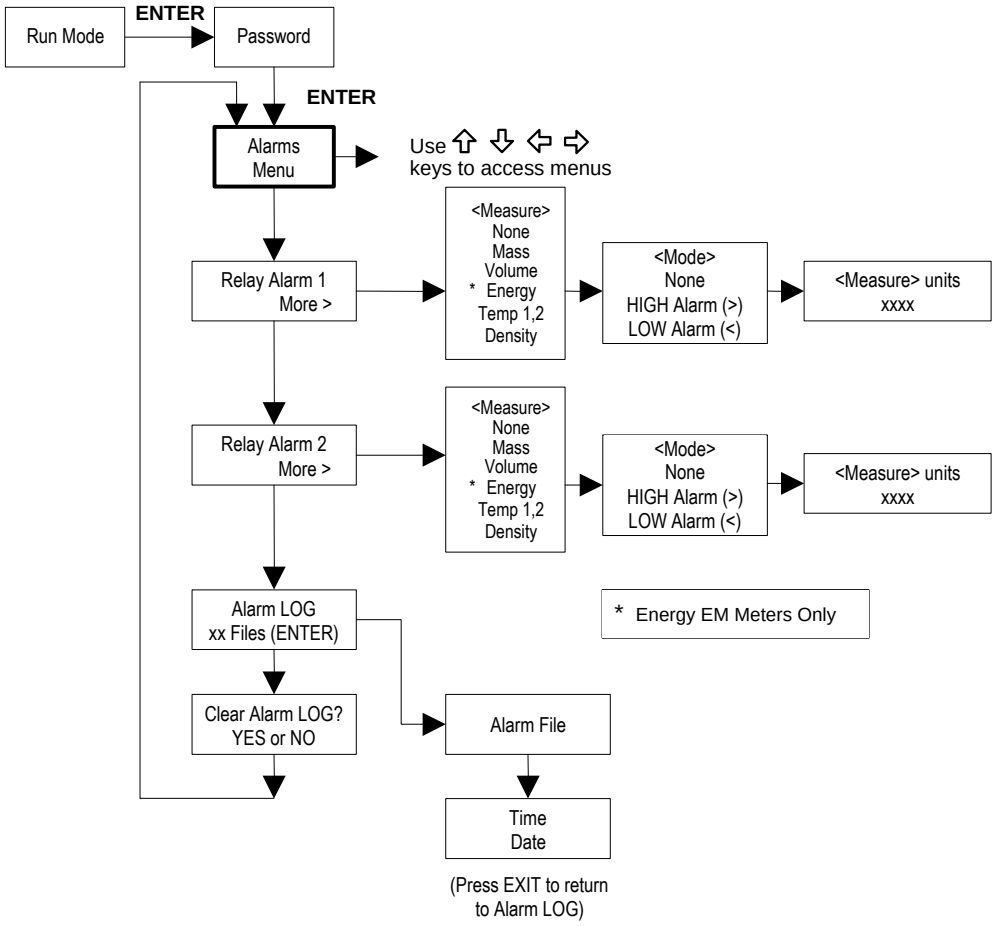
Use the Display Menu to set the cycle time for automatic screen sequencing used in the Run Mode, change the precision of displayed values, smooth the values or enable or disable each item displayed in the Run Mode screens.

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 Setup Menus.

1. Use ⇦⇨ keys to move to the Display Menu.
2. Press ⇩ key until Mf Vf 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 the EXIT key and then ENTER to save changes and return to the Run Mode screen.

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 Setup Menus.

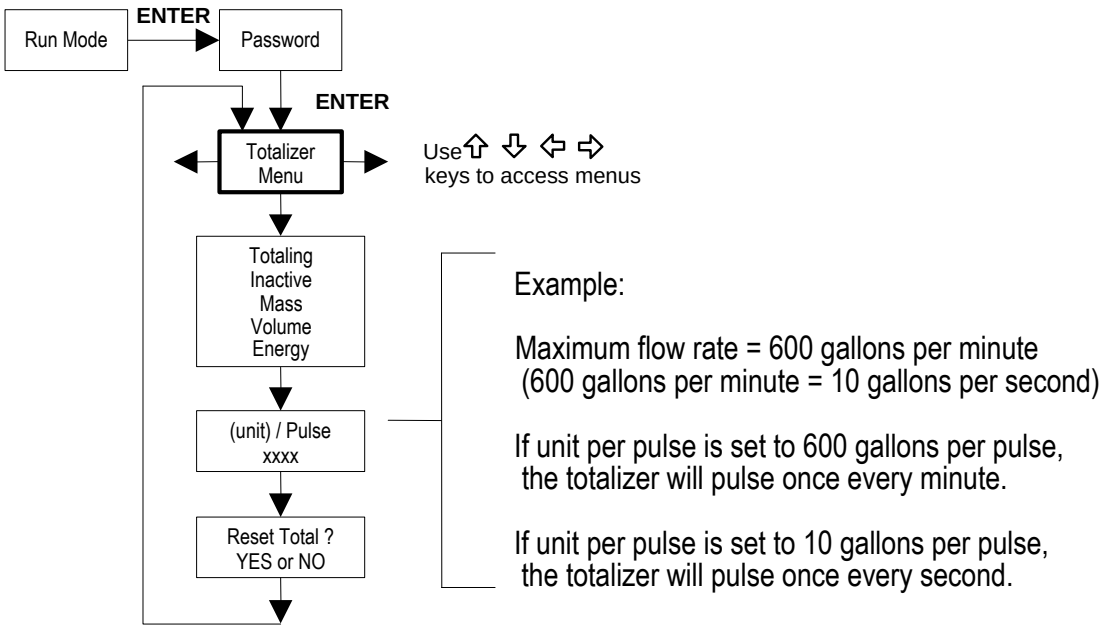
First, set the desired units of measurement:

1. Use ⇦ ⇨ keys to move to the Units Menu (see page 3-13).
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 the keypad to set 100 or 100.0. Press ENTER.
6. Press the EXIT key and then ENTER to save changes and return to the Run Mode screen. (Alarm changes are always permanently saved.)

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 milliseconds (.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. Note: all outputs are disabled while using the Setup Menus.

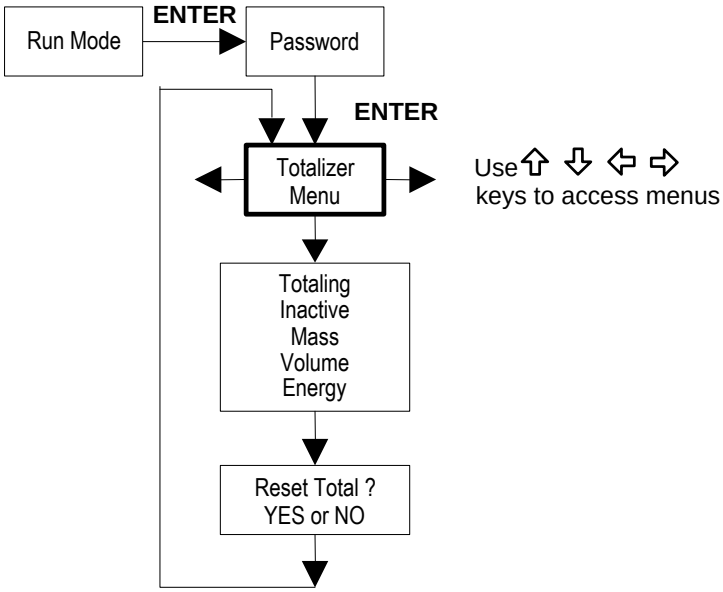
First, set the desired units of measurement:

1. Use ⇦⇨ keys to move to the Units Menu (see page 3-13).
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:

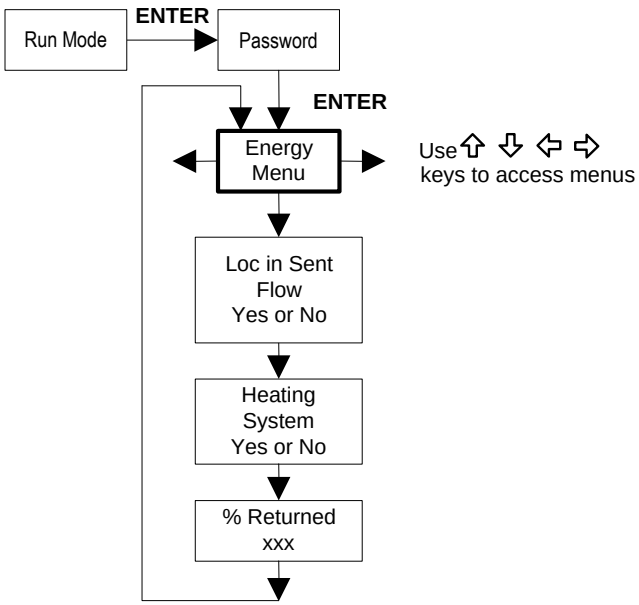
1. Use ⇦⇨ keys to move to the Totalizer Menu.
2. Press the ⇩ key until Totaling appears.
3. Press ENTER and press the ⇩ key to select Mass. Press ENTER.
4. Press ⇩ key to set the pulse output in the units you have selected for mass flow of kg/sec. Press ENTER and use the keypad to set the pulse value 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 then ENTER to save changes and return to the Run Mode screen.

Totalizer #2 Menu



Use the Totalizer #2 to Monitor Flow or Energy. Note: Totalizer #2 does not operate a relay, it is for monitoring only.

Energy Menu – For EMS Energy Meters Only



Configuration:

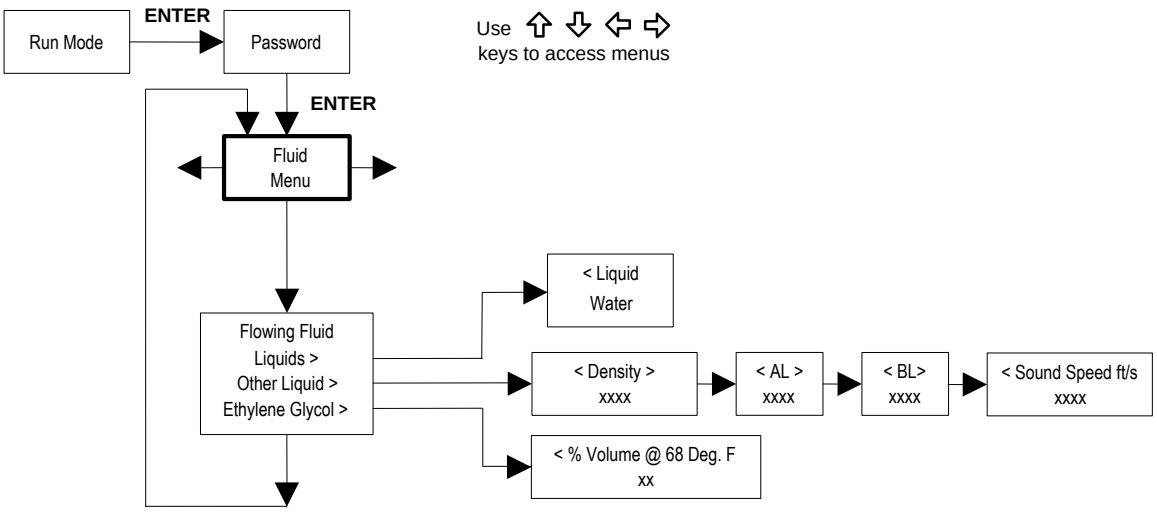
There are several possibilities regarding the measurement of water energy given the location of the meter and the use of a second RTD. The table below summarizes the possibilities:

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

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

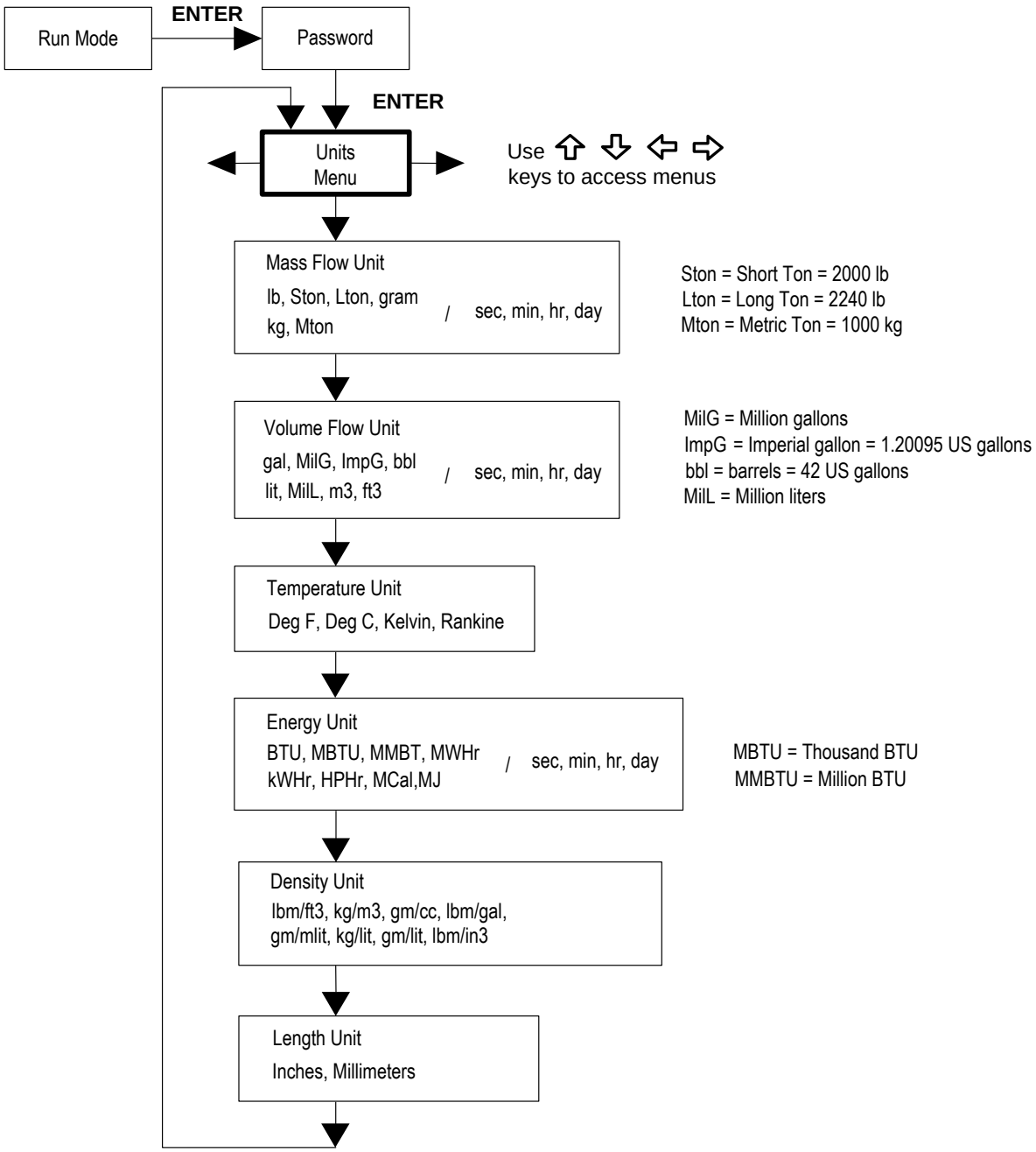
1. Loc in Sent Flow? Select Yes or No based on where the meter is located. Refer to the above table.
2. Heating System? Select Yes for a hot water system used for heating. Select No for a chilled water system used for cooling.
3. % Returned. Select a number between 0% and 100%. Estimate the amount of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

Fluid Menu



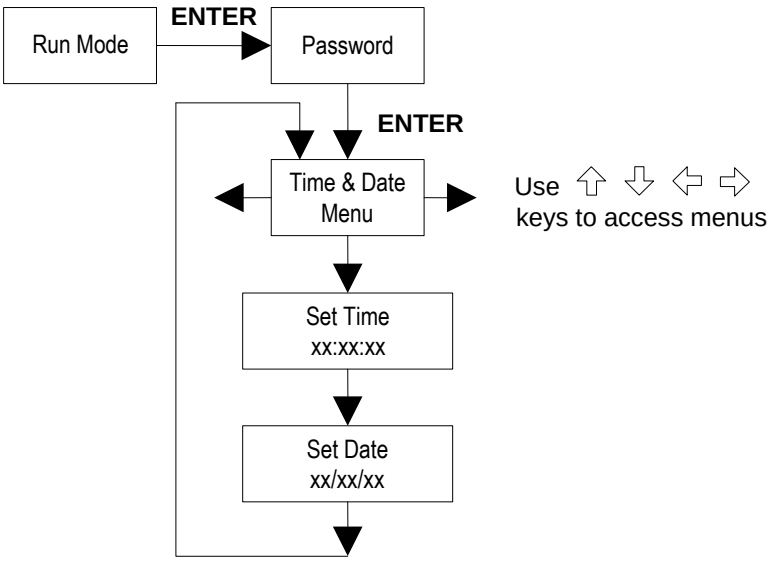
The units of measurement used in the Fluid Menu for density are = lbm/ft^3.

Units Menu



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

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.

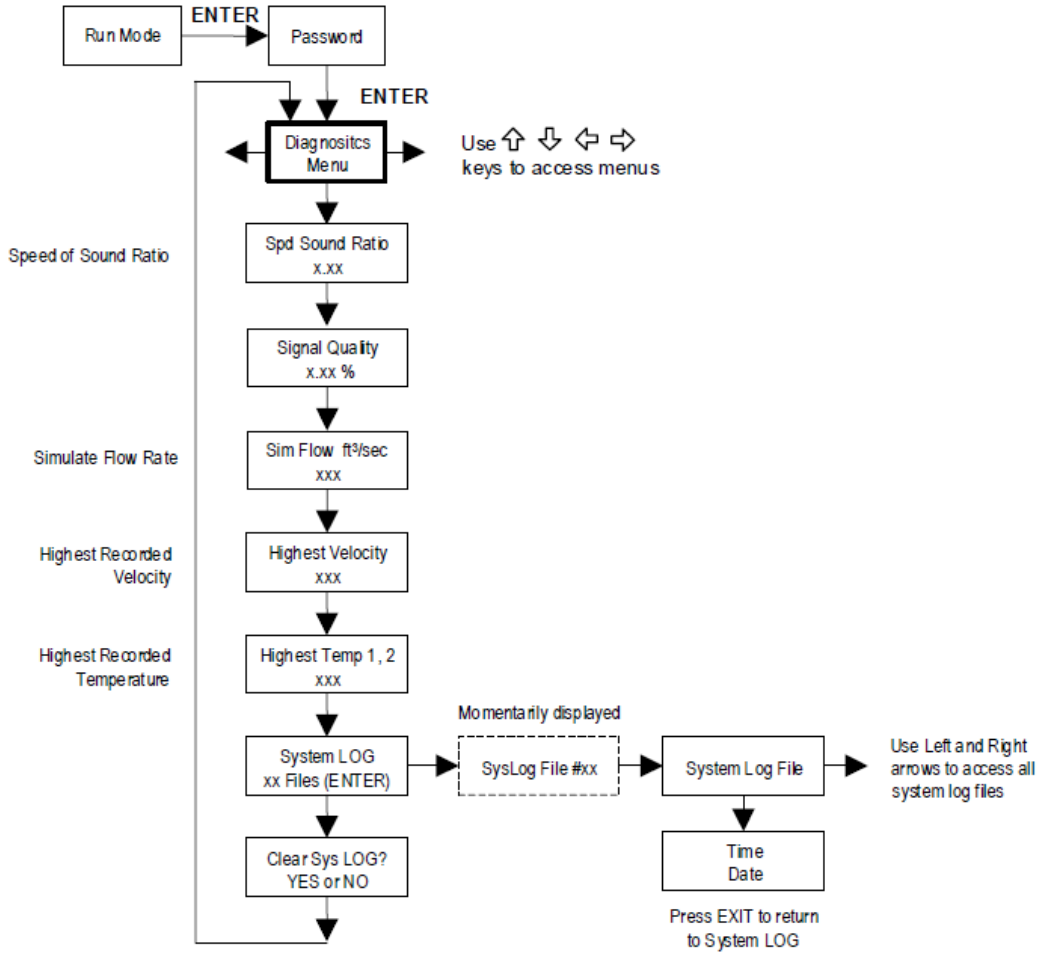
Note: time is displayed in AM/PM format, but military format is used to set the time. For example, 1:00 PM is entered as 13:00:00 in the Set Time menu.

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 Setup Menus.

1. Use ⇦⇨ keys to move to the Time and Date Menu.
2. Press ⇩ key until Set Time appears. Press ENTER.
3. Use the keypad to enter a 1. Use the keypad to enter a 2. 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.

Diagnostics Menu



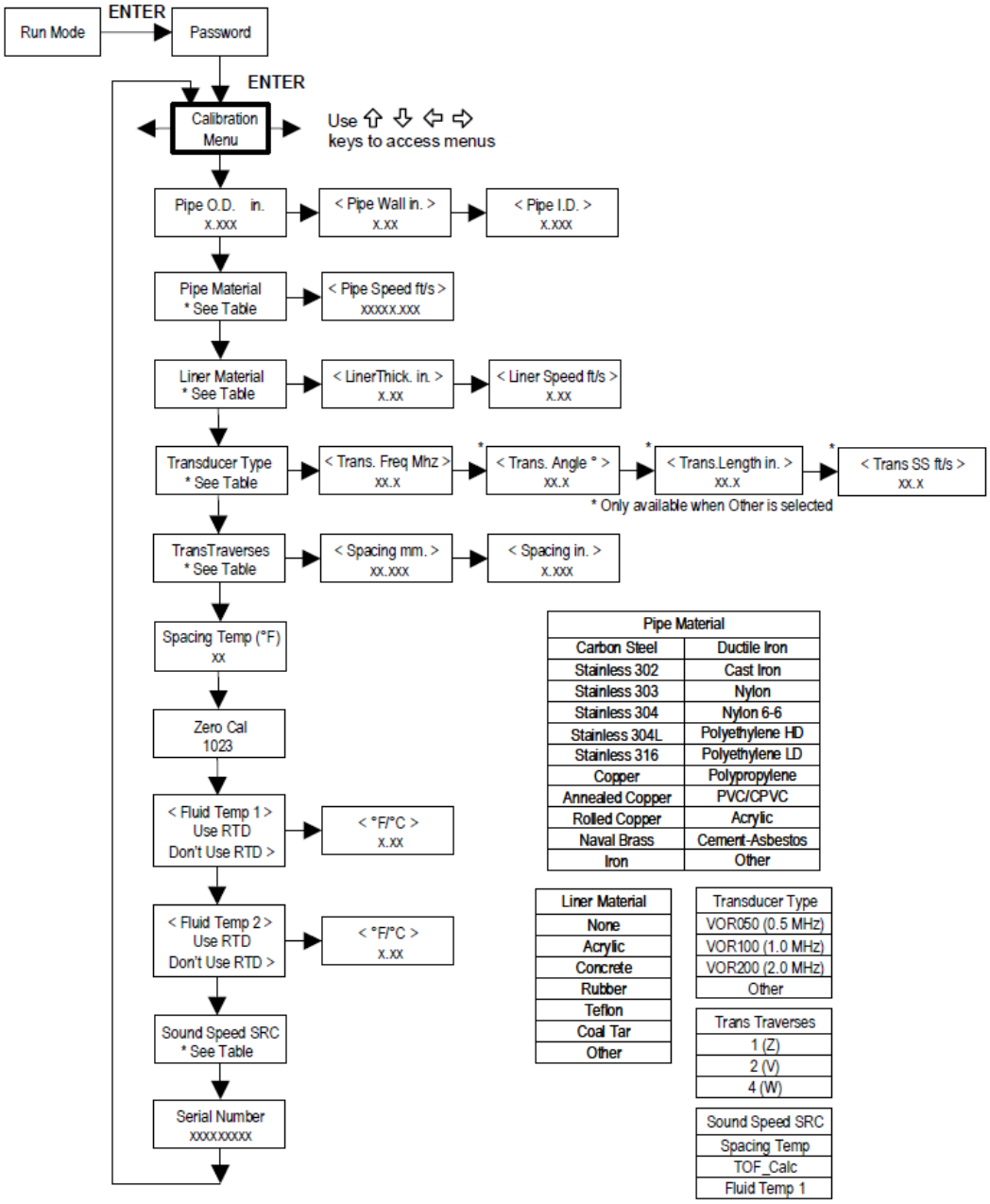
Use the Diagnostics Menu to evaluate signal integrity, simulate operation, and review the system files. The system log files contain time/date stamped messages including power on, power off, programming time outs, parameter faults, incorrect password entry, and other various information relative to system operation and programming. See below for a description of the items in this menu that evaluate signal integrity and simulate operation.

Spd Sound Ratio, is a unitless measure between 0 and 1 that compares the *Fluid Temp 1* speed of sound to the *TOF_Calc* speed of sound. The closer the value is to 1, the stronger the correlation.

Signal Quality, is a measure of the amplitude of the ultrasonic signal from 0 to 100%, that is normalized for gain, fluid, and pipe materials. A value of 85% or higher is considered acceptable. A value below 85% is considered unacceptable and Chapter 6 of the manual should be referenced for steps on how to troubleshoot the application.

Sim Flow, is an input used for testing the meter to verify that the programming is correct. Simulated Flow allows you to enter a flow rate, and in turn, the meter will update all analog outputs. 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 value to zero to allow the electronics to use the actual transducer values.

Calibration Menu



The Calibration Menu contains the calibration information needed for programming the meter and calculating the transducer scribe to scribe spacing. If provided at the time of order, the application information will be preconfigured in the meter, otherwise it is needed at the time of installation to properly program the unit. Note: once the information is programmed, the meter will calculate the proper transducer scribe to scribe spacing. Set the spacing accordingly and the meter is ready to read flow. See below for a description of the items in this menu that are required to be defined for calculating the transducer scribe to scribe spacing and accurately measuring the flow rate.

Pipe O.D. in. and *Pipe Wall in.*, are the dimensions of the pipe in which the transducers will be installed and are required to calculate the flow rate. The Pipe I.D. does not need to be entered as it is calculated by the flow meter electronics. Appendix C contains typical pipe wall and outside diameter (OD) information.

Pipe Material and *Liner Material*, if applicable, are the materials of the pipe in which the transducers will be installed. Appendix C contains speed of sound information for various pipe materials.

Transducer Type, defines the frequency of the transducer being used for measurement of the liquid inside the pipe. The three transducer frequencies to choose from include 0.5 MHz, 1 MHz, or 2 MHz.

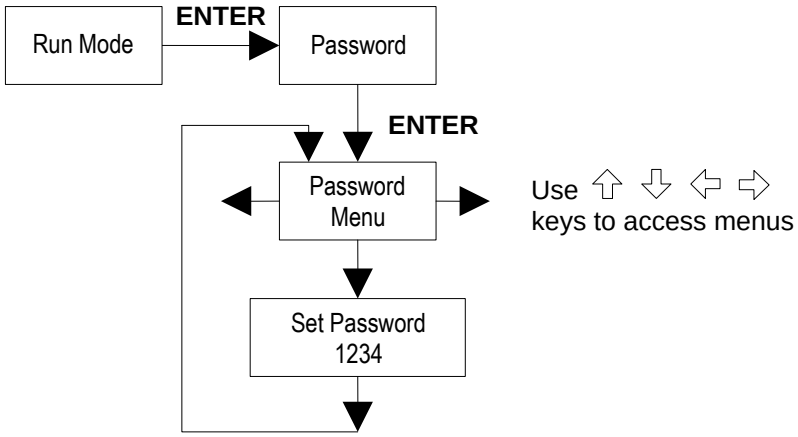
TransTraverses, defines the path of the ultrasonic sound wave that is being used for measurement of the liquid inside the pipe. The selections include 1 path (Z), 2 path (V), or 4 path (W).

Spacing Temp, is used in calculations to determine the distance (spacing) between the scribe lines of the transducers. Enter the temperature of the liquid being measured at the time the transducers are being installed for measurement.

Fluid Temp 1, is the temperature of the liquid inside the pipe. The temperature can be entered manually by selecting *Don't Use RTD*. It can also be measured with a resistance temperature detector (RTD) by selecting *Use RTD*. If *Use RTD* is selected and the meter display indicates a temperature 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. This is accomplished by selecting *Don't Use RTD* and entering the temperature of the liquid being measured. The units of measure of the displayed values are the same as the units configured for the flow meter. Note: if a V only model was purchased, select *Don't Use RTD* and enter the temperature of the fluid being measured.

Sound Speed SRC, provides the user with three options for calculating the speed of sound of the liquid being measured. Select *Spacing Temp* to use the temperature programmed for determining the distance (spacing) between the scribe lines of the transducers to calculate the speed of sound. Select *TOF_Calc* to use the measured time of flight (TOF) of the liquid being measured to calculate the speed of sound. Select *Fluid Temp 1* to use either the programmed or measured temperature of the liquid to calculate the speed of sound.

Password Menu



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

Chapter 4 Serial Communications

Standard Communications

Standard communication with the SonoPro® Professional Series Flow Meter comes in the form of direct wire communication. The USB port on the bottom of the enclosure for use with direct wire communication can be seen in Figure 4-1. Connect a phone or tablet to this USB port on the flow meter when using SonoConfig™ Instrument Interface software to assist with setup, diagnostic, and data logging features. Refer to Chapter 5 for more information on SonoConfig™ Instrument Interface software.

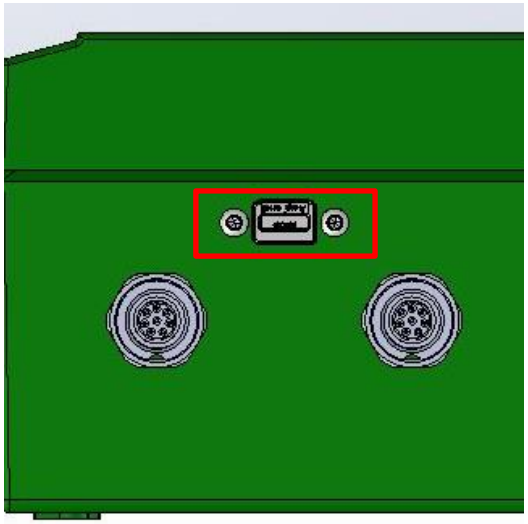


Figure 4-1. USB Port on SonoPro® Professional Series

Connect a Device

To connect your SonoPro® to the SonoConfig™ Instrument Interface Software using direct wire communication, refer to the procedure, Instruction Manual - SonoConfig™, available at www.vortekinst.com.

Bluetooth® Communications

Applicable Flow Meter Models Only

In addition to the standard, direct wire communication, the SonoPro® Professional Series Flow Meter can be ordered with optional Bluetooth® wireless communication. The antenna for Bluetooth® communication is shown in Figure 4-2. With this the user has the ability to wirelessly connect a phone or tablet to the

flow meter using SonoConfig™ Instrument Interface software to assist with setup, diagnostic, and data logging features. Refer to Chapter 5 for more information on SonoConfig™ Instrument Interface software.

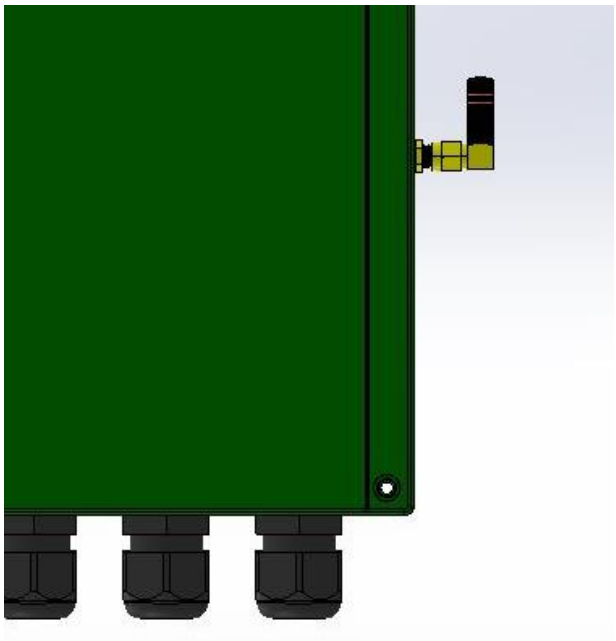


Figure 4-2. Bluetooth® Antenna on SonoPro® Professional Series

Connect to a Device

To connect your SonoPro® to the SonoConfig™ Instrument Interface Software using Bluetooth® wireless communication, refer to the procedure, Instrument Manual - SonoConfig™, available at www.vortekinst.com.

Modbus Communications

Refer to the document, Start-up Guide – ProtoCessor FPC-ED2, for all information relating to the ProtoCessor and how to configure the ProtoCessor to communicate via Modbus. This document can be found at www.vortekinst.com.

Applicable Flow Meter Models Only

The SonoPro® Professional Series Flow Meter utilizes an MSA Safety ProtoCessor that provides a TTL to RS-485 and Ethernet connection for Modbus RTU or Modbus TCP/IP communication depending on the model code configuration ordered. The MSA Safety ProtoCessor will leave the factory configured for the communication protocol selected at the time of order. If later the communication protocol needs to be changed (e.g., from Modbus

TCP/IP to RTU), the procedure (Start-up Guide - ProtoCessor FPC-ED2) to do so can be found at www.vortekinst.com. The MSA Safety ProtoCessor can be seen in Figure 4-3.

Figure 4-3: MSA Safety ProtoCessor Module

Overview

This document describes the preliminary implementation of the Modbus communication protocol for use in monitoring common process variables in the VorTek SonoPro® Professional Series 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

Wiring

An RS485 daisy chained network configuration as depicted below is recommended. Do not use a star, ring, or cluster arrangement.

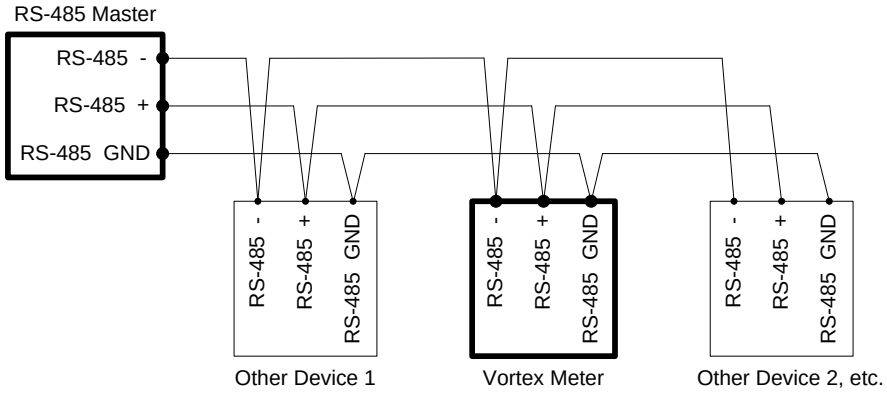


Figure 4-4. RS-485 Wiring (MODBUS)

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"

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 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 what units, where applicable, the meter's variables will be displayed in. Internal – these are the base units of the meter, °F, 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 order in which

registers representing floating point or long integer data and/or the byte order within the registers may be reversed for compatibility with some PLCs and PC software.

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

Table 4-1. Byte Order (MODBUS)

Note that all 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 9600 baud. Depending upon the Modbus protocol selected, data are 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. It is very important that all devices communicating via Modbus do so at the same baud rate.

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 that is 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 0000-9999
30001-39999	03, 04	Read-only 16-bit registers 0000-9998
40001-49999	03, 06, 16	Read/write 16-bit registers 0000-9998

Register Definitions

The meter serial number and those variables that are commonly monitored (mass, volume and energy flow rates, total, temperature, density, viscosity, Reynolds number, and diagnostic variables such as signal quality, speed of sound, speed of sound ratio, and time of flight) 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, 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 2 characters of the string, and the strings may be 2 to 12 characters in length with unused characters set to zero. Note that the byte order affects the order in which the strings are transmitted. If the Modbus Order menu (see page 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	—
48501-48512	Tag	string	—	03, 06, 16	8500-8511
30545-30546	Net Volume Flow Totalizer	unsigned long	display units*	03, 04	544-545
30501-30502	Forward Volume Flow Totalizer	unsigned long	display units*	03, 04	500-501
30549-30550	Reverse Volume Flow Totalizer	unsigned long	display units*	03, 04	548-549
30547-30548	Net Mass Flow Totalizer	unsigned long	display units*	03, 04	546-547
30503-30504	Forward Mass Flow Totalizer	unsigned long	display units*	03, 04	502-503
30551-30552	Reverse Mass Flow Totalizer	unsigned long	display units*	03, 04	550-551
30009-30010	Mass flow	float	display units*	03, 04	8-9
30007-30008	Volume flow	float	display units*	03, 04	6-7
30001-30002	Temperature #1	float	display units*	03, 04	0-1
32555-32556	Velocity	float	display units*	03, 04	2554-2555
30029-30030	Velocity (ft/sec)	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
32501-32502	Time of Flight	float	uS	03, 04	2500-2501
32553-32554	Delta Time Filtered (ns)	float	ns	03, 04	2552-2553
43193-43194	Low Flow Cutoff	float	ft/sec	03, 06, 16	3192-3193
45159-45160	Zero	float	counts	03, 06, 16	5158-5159
32551-32552	Signal Quality	float	%	03, 04	2550-2551
32537-32538	Speed of Sound	float	—	03, 04	2536-2537
32549-32550	Speed of Sound Ratio	float	—	03, 04	2548-2549
34564	Transducer	byte	—	03, 04	4563
34567	Transducer Mounting	byte	—	03, 04	4566
32557-32558	Transducer Spacing	float	—	03, 04	2556-2557
33159-33160	Pipe Inside Diameter	float	—	03, 04	3158-3159
30017-30018	Enthalpy #1	float	BTU/lbm	03, 04	16-17
30019-30020	Enthalpy #2	float	BTU/lbm	03, 04	18-19
—	Reset Totalizers	—	—	05	coil 9
—	Clear Alarm History	—	—	05	coil 12
—	Reboot Device	—	—	05	coil 8
—	Set Zero	—	—	05	coil 21

The following registers are available with energy meter firmware:

Registers	Variable	Data type	Units	Function code	Addresses
30003-30004	Temperature #2	float	display units*	03, 04	2-3
30191-30192	Delta Temperature	float	display units*	03, 04	190-191
30011-30012	Energy Flow	float	display units*	03, 04	10-11
30505-30506	Forward Energy Flow Totalizer	Unsigned Long	display units*	03, 04	504-505
30507-30508	Reverse Energy Flow Totalizer	Unsigned Long	display units*	03, 04	506-507
30543-30544	Net Energy Flow Totalizer	Unsigned Long	display units*	03, 04	542-543

The following registers contain the display unit's string:

Registers	Variable	Data type	Units	Function code	Addresses
32007-32012	Volume Units	string	—	03, 04	2006-2011
32001-32006	Mass Units	string	—	03, 04	2000-2005
32025-32030	Temperature Units	string	—	03, 04	2024-2029
32073-32078	Velocity Units	string	—	03, 04	2072-2077
32079-32084	Length Units	string	—	03, 04	2078-2083
32055-32060	Volume Total Units	string	—	03, 04	2054-2059
32061-32066	Mass Total Units	string	—	03, 04	2060-2065
32013-32018	Energy Units	string	—	03, 04	2012-2017
32067-32072	Energy Total Units	string	—	03, 04	2066-2071

Table 4-2. Register Definitions (MODBUS)

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 these data are 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 #00008 (function code 5, address 7, 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	Not used
3	Not used
4	Not used
5	Not used
6	Not used
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 writeable 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 7 through 9, respectively, (register #00008 through #00010). 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 8 bits, 1…247	Function Code 8 bits	Start Address 16 bits, 0…9998	N = Number of Registers 16 bits, 1…125	CRC 16 bits

Normal Response Message Format

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

Exception Response Message Format

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

Examples

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

```
01 07 41 E2


01 Device address
07 Function code, 07 = read exception status
41 E2 CRC
```

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
5C 38 CRC
```

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 09 00 00 1D C8


01 Device address
05 Function code 5 = write single coil
00 09 Coil address = 9
00 00 Data to “turn off coil” does not reset totalizer
1D C8 CRC
```

BACnet MS/TP Communications

Refer to the document, Start-up Guide – ProtoCessor FPC-ED2, for all information relating to the ProtoCessor and how to configure the ProtoCessor to communicate via BACnet. This document can be found at www.vortekinst.com.

Applicable Flow Meter Models Only

The SonoPro® Professional Series Flow Meter utilizes an MSA Safety ProtoCessor that provides a TTL to RS-485 and Ethernet connection for BACnet MS/TP or BACnet/IP communication depending on the model code configuration ordered. The MSA Safety ProtoCessor will leave the factory configured for the communication protocol selected at the time of order. If later the communication protocol needs to be changed (e.g., from BACnet MS/TP to BACnet/IP), the procedure (Start-up Guide - ProtoCessor FPC-ED2) to do so can be found at www.vortekinst.com. The MSA Safety ProtoCessor comes standard with BTL (BACnet Testing Laboratories) certification. For a copy of the BTL certificate, see www.vortekinst.com. The MSA Safety ProtoCessor can be seen in Figure 4-3.

1. Baud Rates

The baud rate settings available on the SonoPro® Professional Series Flow Meters for BACnet communication are 9600 (Default), 19200, 38400, and 76800.

Chapter 5 Datalogging

Datalogging Overview

VorTek Instruments SonoPro® Ultrasonic Flow Meter can log data internally. The procedure for programming the unit to log data can be found below. To download data that has already been logged, see Chapter 6: SonoConfig™ Instrument Interface Software – The SonoPro® App.

Programming the Unit to Log Data

1. Press "ENTER" on the keypad of your fixed mount ultrasonic unit. The text in Figure 5-1 will be displayed.

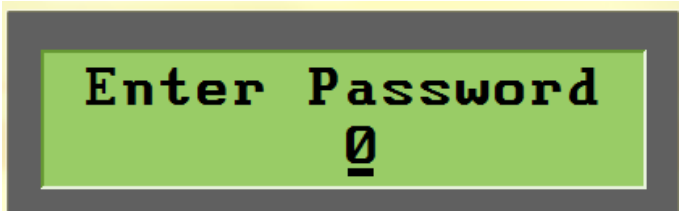


Figure 5-1. Password Screen

2. Using the numbers on the keypad, type the password "16363" and then press "ENTER". The text in Figure 5-2 will be displayed.

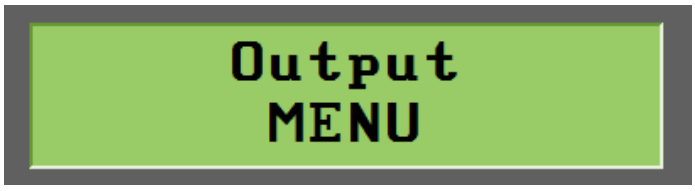


Figure 5-2. Output Menu

3. Using the left or right arrow key, navigate to the Diagnostics menu as shown in Figure 5-3.

Figure 5-3. Diagnostics Menu

4. Press "Enter" to access the first level of the hidden Diagnostics menu. The text in Figure 5-4 will be displayed.

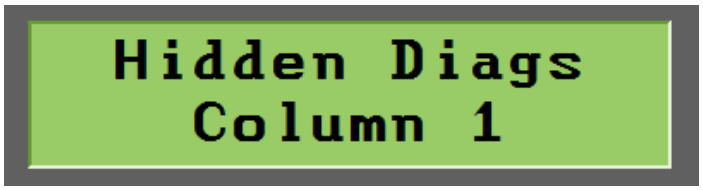


Figure 5-4. First Level of Hidden Diagnostics Menu

5. Press the right arrow to access the second level of the hidden Diagnostics menu. The text in Figure 5-5 will be displayed.
   a. **Note:** The number represented in this image may not match your unit. This is normal.

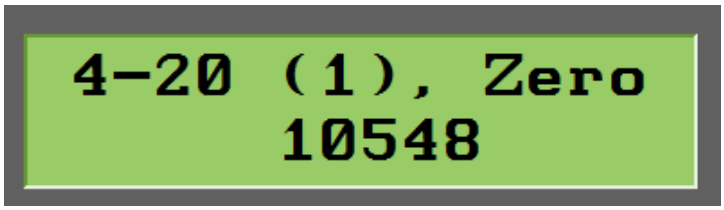


Figure 5-5: Second Level of Hidden Diagnostics Menu

6. Using the up or down arrow, scroll to find the Logging submenu as shown in Figure 5-6.

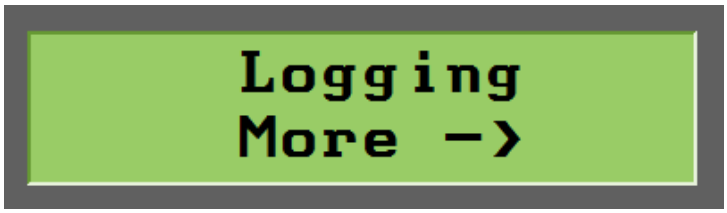


Figure 5-6. Logging Submenu

7. Scroll to the right to set the first parameter. The first parameter, or logging interval, determines how often the unit records the variables defined in the following four submenus. The smallest interval that can be defined is 1 second. If this parameter is set to 0, the unit will not log data. See Figure 5-7 for reference.

Figure 5-7. Logging Interval

8. The next four parameters define the variables that will be recorded during a logging session. A logging session is defined as an entire day. The unit will record all defined variables, at the interval selected above, and save them to a file with the format of YYYYMMDD.log at the end of each day. You have the option to select four variables from the following list. See Figure 5-8 for a screen capture of how these menus will look on the SonoPro® Fixed Mount unit.
    a. Mass Flow
    b. Volume Flow
    c. Energy Flow
    d. Fwd Volume Total
    e. Rev Volume Total
    f. Fwd Mass Total
    g. Rev Mass Total
    h. Energy Total
    i. Fwd Energy Total
    j. Rev Energy Total
    k. Temperature 1
    l. Temperature 2
    m. RTD 1
    n. RTD 2
    o. Density
    p. Enthalpy 1
    q. Enthalpy 2
    r. Viscosity
    s. Velocity
    t. Reynolds
    u. Speed of Sound

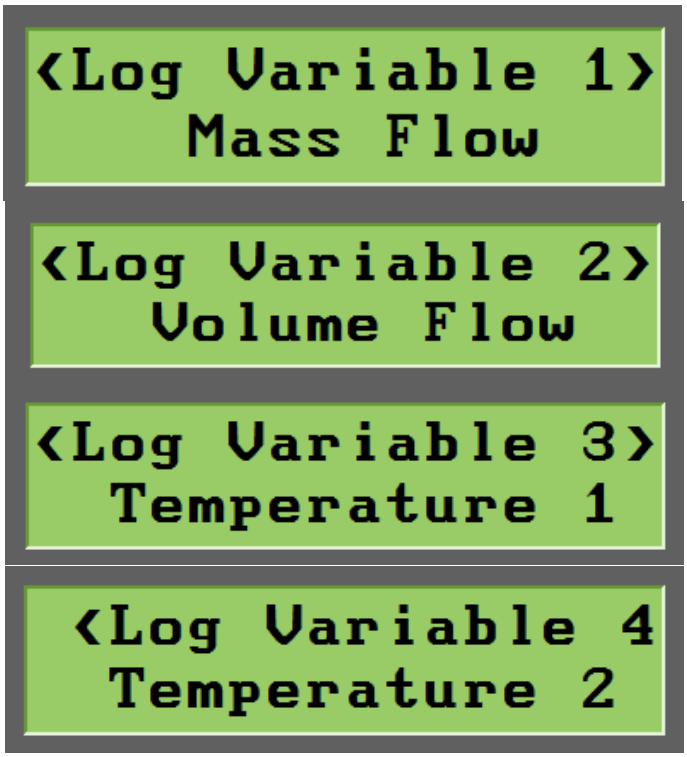


Figure 5-8. Logging Variables

9. Once the four variables are defined, press the “EXIT” button until you are prompted to “Save Changes?”. Select “YES” or “NO”, press “ENTER”, and you will be returned to the run mode screen. The device is now set up to log data.

Chapter 6 SonoConfig™ Instrument Interface Software

SonoConfig™ Instrument Interface Software – The SonoPro® App

SonoConfig™ Instrument Interface software works in conjunction with the SonoPro® Fixed Mount Ultrasonic Flow Meter to provide valuable setup, diagnostic, and data logging tools. Communicate with SonoPro® Fixed Mount through Bluetooth® wireless or direct wire communication. SonoConfig™ is available for download through VorTek Instruments, LLC website, vortekinst.com. An image of the SonoConfig™ app icon can be seen in Figure 6-1. SonoConfig™ can also be provided preloaded on a tablet from VorTek Instruments, LLC. For a preview of what can be seen on the Waveforms tab of SonoConfig™, see Figure 6-2. For more information on features of the app and how to use them, see the SonoConfig™ Instruction and Operation Manual.

Figure 6-1. SonoConfig™ App Icon

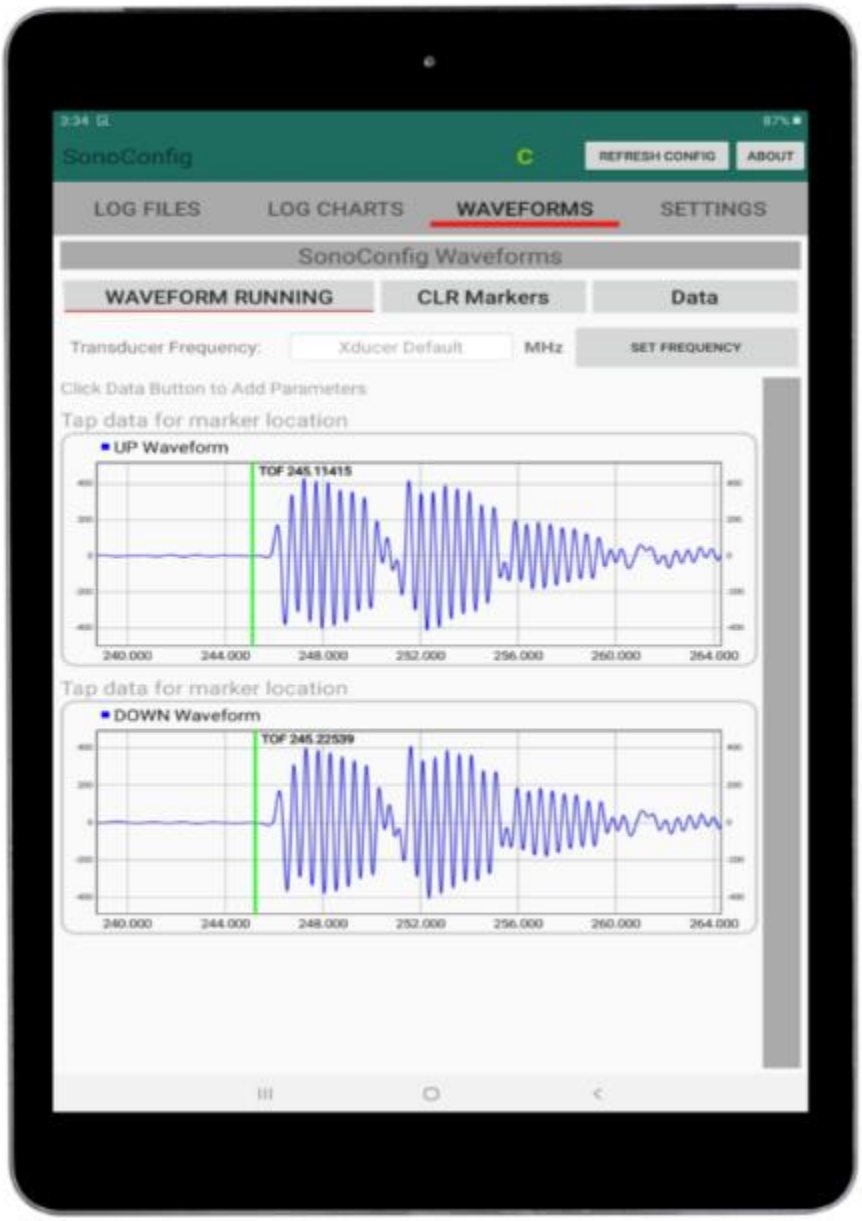


Figure 6-2. Screenshot of Waveforms Tab on SonoConfig™

Warning!
Always turn off power and remove main power before disassembling any part of the flow meter.

Chapter 7 Troubleshooting and Repair

Hidden Diagnostics Menus

The menus shown on the following page can be accessed using the password 16363, then moving to the display that reads "Diagnostics Menu" and pressing ENTER (rather than one of the arrow keys).

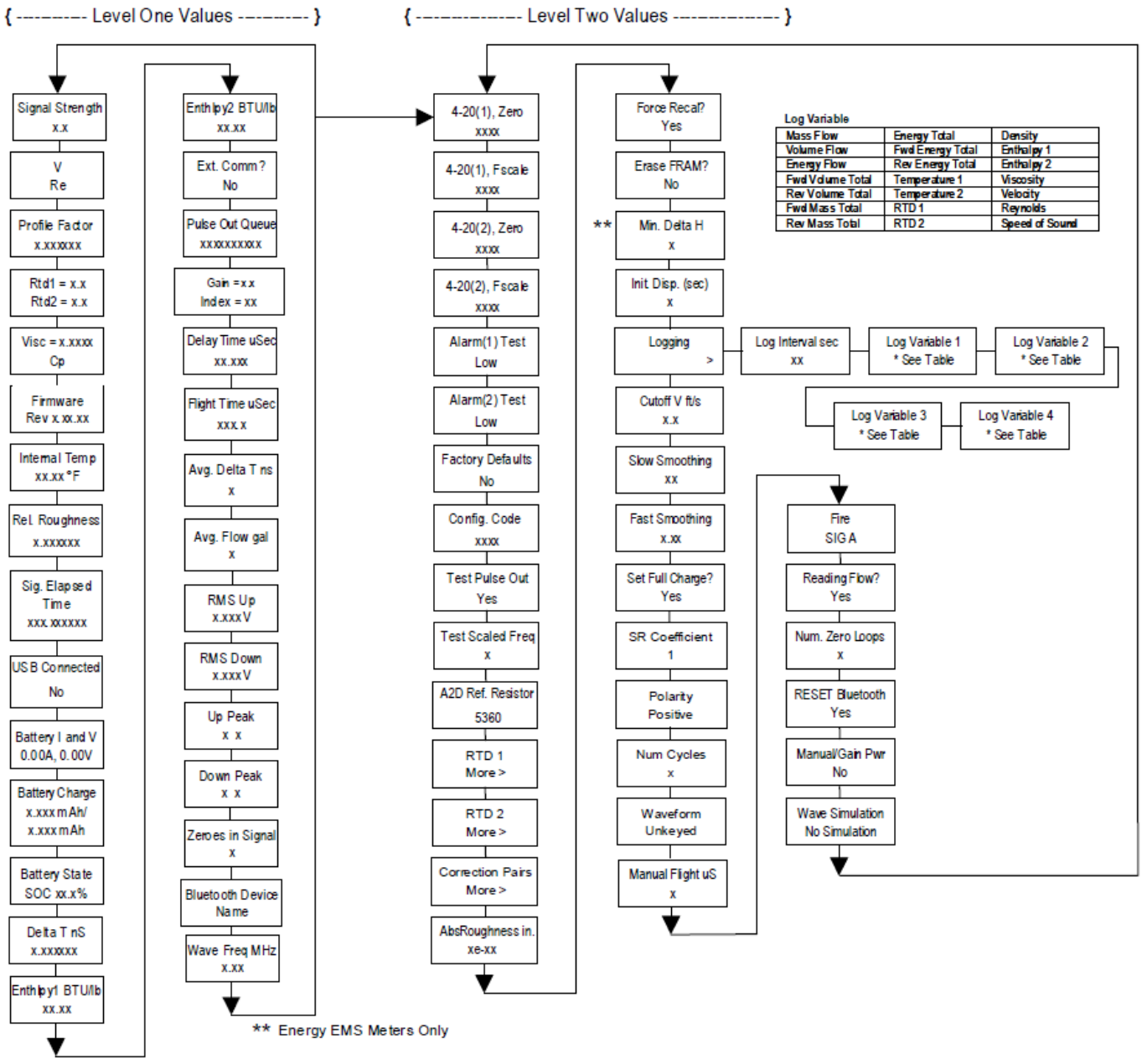
Use the right arrow key to move to the second level. Press EXIT to move from the second level back to the first, press EXIT while in the first level to return to the setup menus.

Caution: password 16363 will allow full access to the configuration and should be used carefully to avoid changes that can adversely alter the function of the meter.

Each of the menus on the following page will first be defined followed by specific troubleshooting steps.

Additional items for troubleshooting can be found in Chapter 3 on pages 3-15 through 3-17

Hidden Diagnostics Menus



Level One Hidden Diagnostics Values

- **Signal Strength** = A unitless measure of the amplitude of the received ultrasonic signal displayed as a percentage (0 to 100). A value of 0 means there is no signal being received. A value of 100 means the maximum amount of signal is being received but a saturation state has not yet been met. Values over 100 mean that the signal is attenuated to avoid being in a saturation state. Pipe size, material, fluid, etc. affect this value.
- **V** = Calculated average pipe velocity (ft/sec).
- **Re** = Calculated Reynolds number.
- **Profile Factor** = Factory use only.
- **RTD1** = Optional RTD resistance in ohms.
- **RTD2** = Optional second RTD resistance value in ohms.
- **Viscosity** = Calculated viscosity of flowing fluid (cP).
- **Firmware** = Current revision of Firmware. This will match the firmware revision that is displayed on the LCD screen when power is turned on to the handheld unit.
- **Internal Temperature =** Internal electronics temperature.
- **Rel. Roughness =** Factory use only.
- **Sig. Elapsed Time =** The amount of time between processing ultrasonic samples. It helps to give an idea of how many samples can be processed in a second.
- **USB Connected** = Yes or no.
- **Battery I and V =** Current and voltage of the internal battery. Positive current is battery charging. Negative current is battery discharging. Note: Not applicable for Fixed Mount units.
- **Battery Charge =** Total and remaining capacity of the battery in mAh. Note: Not applicable for Fixed Mount units.
- **Battery State =** State of charge of the battery (i.e., battery percentage remaining). Note: Not applicable for Fixed Mount units.
- **Delta T nS =** The difference in time in nanoseconds (nS) of the most recent sound wave that was sent downstream compared to the sound wave that was sent upstream.
- **Enthalpy1 BTU/hr** = Factory use only.
- **Enthalpy2 BTU/hr** = Factory use only.
- **Ext. Comm =** External communications active. Yes or no.
- **Pulse Out Queue** = Pulse output queue. This value will accumulate if the totalizer is accumulating faster than the pulse output hardware can function. The queue will allow the pulses to "catch up" later if the flow rate decreases. A better practice is to slow down the totalizer pulse by increasing the value in the (unit)/pulse setting in the totalizer menu.
- **Gain** = Gain (applied to ultrasonic signal amplitude). Gain is typically set automatically by the meter depending on the application. This value can be less than 1 at times as the meter can attenuate if the signal becomes saturated.

- **Index =** The number of the Gain setting being applied to the signal. The range of numbers in the Index is 48 to 215. An index value of 48 is displayed at the largest gain value. An index value of 215 is displayed at the smallest gain value.
- **Delay Time uS =** An amount of time in microseconds (uS) set by the flow meter software after determining the Flight Time of the ultrasonic sound wave through the pipe and process fluid. This amount of time is then used to determine the window in which the flow meters looks for the signal.
- **Flight Time uS =** The amount of time in microseconds (uS) that it takes for the ultrasonic sound wave to travel from the transmitting transducer, through the process fluid, and to the receiving transducer. Note: both transducers act as transmitters and receivers.
- **Avg Delta T nS =** The average of the difference in time in nanoseconds (nS) of the sound wave that was sent downstream compared to the sound wave that was sent upstream.
- **Avg Flow gal =** The average flow rate in GPM (gallons per minute).
- **RMS Up =** The root mean square (RMS) voltage of the up waveform.
- **RMS Down =** The root mean square (RMS) voltage of the down waveform.
- **Up Peak =** The A/D counts of the upstream sound wave representing the amplitude of the signal. Each stage has a maximum value of 511. The A/D counts will increase or decrease depending on the strength of the signal. This value is used in conjunction with the Gain to calculate the Signal Strength.
- **Down Peak =** The A/D counts of the downstream sound wave representing the amplitude of the signal. Each stage has a maximum value of 511. The A/D counts will increase or decrease depending on the strength of the signal. This value is used in conjunction with the Gain to calculate the Signal Strength.
- **Zeros in Signal =** Diagnostic value that details how many waveforms have an ADC reading of zero. A good signal should have none. These waveforms are then ignored.
- **Bluetooth Device Name =** Name of the device for Bluetooth communication.
- **Wave Freq MHz =** The actual driving frequency of the transducer. This value can be adjusted in the *Calibration* Menu under the *Transducer Type* submenu.

Level Two Hidden Diagnostics Values

- **4-20(1) Zero** = Analog counts to calibrate zero on analog output 1.
- **4-20(1) FScale** = Analog counts to cal. full scale on analog output 1.
- **4-20(2) Zero** = Analog counts to calibrate zero on analog output 2.
- **4-20(2) FScale** = Analog counts to cal. full scale on analog output 2.
- **Alarm (1) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.

- **Alarm (2) Test** = Used as a test to verify that the alarm circuit is functioning. When low is selected the alarm will initiate a low alarm on the output. When High is selected it will give a high alarm on the output.
- **Factory Defaults** = Reset factory defaults. If you change this to Yes and press Enter, all the factory configuration is lost and you must reconfigure the entire program. Consult the factory before performing this process, it is required only in very rare cases.
- **Config Code =** Factory use only.
- **Test Pulse Out** = Force totalizer pulse. Set to Yes and press enter to send one pulse. Very useful when needing to test totalizer counting equipment.
- **Test Scaled Freq** = Enter a frequency value in order to test the scaled frequency output. Return to 0 to stop the test.
- **A2D Ref. Resistor =** Factory use only.
- **RTD1.** Press the RIGHT ARROW to access:
  - **Ro** = RTD resistance at 0°C (1000 ohms).
  - **A** = RTD coefficient A
  - **B** = RTD coefficient B
  - **RTD1 Max Deg. F =** 356
  - **RTD1 Min Deg. F =** -40
- **RTD2** = Second RTD configuration, for special applications only.
- **Correction Pairs**
  - **Frequency** (1 through 10)
  - **Velocity** (1 through 10)
- **Absolute (Abs) Roughness in.** = Factory use only.
- **Force Recal?** = Factory use only.
- **Erase FRAM?** = Factory use only.
- **Min. Delta H =** Energy EMS meters only. Sets the deadband for totalization to begin. Must be greater than this number (1 default) to initiate the totalizer.
- **Init. Disp. (sec)** = Enter a value in seconds to initialize the display every X seconds. Enter a value of 0 to disable initializing the display.
- **Logging =** Defines the parameters associated with internal data logging.
  - **Log Interval Sec** = The time, in seconds, determining when the unit records the variables defined in the following four submenus.
  - **Log Variable 1** = The first variable to be recorded during a logging session.
  - **Log Variable 2** = The second variable to be recorded during a logging session.
  - **Log Variable 3** = The third variable to be recorded during a logging session.
  - **Log Variable 4** = The fourth variable to be recorded during a logging session.
- **Cutoff V ft/s** = The minimum velocity of an application before the software filters off any value below this set value.

- **Slow Smoothing** = Slow time constant if smoothing is enabled in the *Display* Menu under the *Display Smooth?* Submenu.
- **Fast Smoothing** = Fast time constant if smoothing is enabled in the *Display* Menu under the *Display Smooth?* submenu.
- **Set Full Charge?** = YES or NO. If YES is selected, then the "Battery State" will change from the current value to a value of 100%. The default value is NO. As long as this is selected the "Battery State" will not be reset.
- **SR Coefficient** = Flow rate multiplier. This parameter has a default value of 1. It should not be changed unless directed by the factory.
- **Polarity** = Polarity of the drive signal (i.e. charge on the piezoelectric crystal).
- **Num Cycles** = The number of sound wave pulses that are being sent through the pipe and fluid and received by the transducers.
- **Waveform** = Unkeyed or keyed.
- **Manual Flight uS** = A manual adjustment for the Time of Flight. Zero will use the value calculated by the application (i.e. value calculated from transducer, pipe size, fluid, setup temp, etc.) This is used when the received waveform is not in the sampling window, especially the wave front.
- **Fire** = Factory use only.
- **Reading Flow?** = YES or NO.
- **Num. Zero Loops =** Number of samples (loops) of up/down waveforms, taken at no flow, to calculate the *Zero Cal.* average found in the *Calibration* menu.
- **RESET Bluetooth =** YES or NO. Default value is YES.
- **Manual Gain/Pwr =** YES or NO. Default value is NO.
- **Wave Simulation =** This feature simulates actual waveforms but is for demonstration purposes only. If there are simulation files stored in the flash, it will have a selection other than *No Simulation*. Normal operation resumes if the power is cycled or *No Simulation* is selected. Units operating as a flow meter should never use this feature. Simulation reprograms the application. Simulation files should be provided for training and sales purposes only.

Analog Output Calibration

To check the 4–20 mA circuit, connect a DVM in series with the output loop. Select zero or full scale (from the second level of the hidden Diagnostics menu) and then actuate the *ENTER* key. This action will cause the meter to output its 4 mA or 20 mA condition. If the DVM indicates a current greater than ± 0.006 mA from 4 or 20 mA, adjust the setting up or down until the output is calibrated.

Note: these settings are not for adjusting the output zero and span to match a flow range, that function is located in the Output Menu.

Troubleshooting the Flow Meter

Warning!
Always turn off power and remove main power before disassembling any part of the flow meter.

First Check Items:

- ☐ Installation Programming Correct
- ☐ Installation Spacing Correct
- ☐ Power and Wiring Correct
- ☐ Application Fluid Correct
- ☐ Meter Range Correct for the Application
- ☐ Meter Configuration Correct
- ☐ Describe Installation Geometry i.e. upstream diameters, valve position, downstream diameters, etc.

Record Values:

Record the following values from the Run Menu with the meter installed in order to determine the operating state of the flow meter:

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

Record the following values from the Hidden Diagnostics Menu with the meter installed:
(Use password 16363 to access.)

	With Flow	With No Flow (if possible)
Spd Sound Ratio =		
Signal Quality =		
Signal Strength =		
V =		
RTD1/RTD2 =		
Firmware =		
Sig. Elapsed Time =		
Pulse Out +/- VDC =		
Gain/Index =		
Flight Time =		

Record values - Hidden Diagnostics Menu continued:

	With Flow	With No Flow (if possible)
Avg. Delta T=		
Up Peak =		
Down Peak =		
Zeros in Signal =		
Wave Freq. =		
Cutoff V =		
SR Coefficient =		
Num Cycles =		
Waveform =		
Manual Flight =		
Wave Simulation =		

Record the following values from the Calibration Menu.

Pipe OD =	
Pipe Wall =	
Pipe Material =	
Liner Material =	
Transducer Type =	
Transducer Mounting Pattern (V, W, Z) =	
Transducer Spacing =	
Serial Number =	

Determine the Fault

Symptom: Output at No Flow

1. The programming values defined in the *Calibration* menu may not match the actual hardware being used at the time of measurement, leading to erroneous flow rate readings. Verify that the programmed values match the hardware that is being used with the handheld unit.

Symptom: Erratic Output

1. Mechanical installation may be incorrect. Verify the straight run is adequate as described in chapter 2 of the manual.
2. The meter may be reacting to actual changes in the flow stream. The output can be smoothed using a time constant. The displayed values can be smoothed using the time constant in the *Display* menu. The analog outputs can be smoothed using the time constant in the *Output* menu. A time constant of 1 will result in the change in value reaching 63% of its final value in one second. A time constant of 4 is 22%, 10 is 9.5%, and 50 is 1.9% of the final value in one second. The time constant equation is shown below (TC= Time Constant).

$$\%\ change\ to\ final\ value\ in\ one\ second = 100\ (1 - e^{\left(-\frac{1}{TC}\right)})$$

Symptom: No Output or Empty Pipe Detected

1. Verify that there is fluid in the pipe and that there is a full pipe condition. The flow meter will not read depending on the mounting position of the transducer in a partially full pipe condition.
2. Are there air bubbles in the pipe? If so, where are the transducers mounted? If the transducers are not generating a measurement when mounted on the top/bottom of the pipe, try moving them so that they are in the 3 O'clock or 9 O'clock position on the outside of the pipe. This will eliminate interference from entrained air bubbles traveling in the upper portion of the pipe or solids traveling in the lower portion of the pipe.
3. Carefully check all the wiring connections between the fixed mount unit and transducers. There are four connections that must be correct. Each female connector has a keyway, and each male connector has a key. These must be aligned properly when connecting the two for a valid connection to result. If there are additional wires connected to the terminal blocks on the inside of the enclosure, ensure all wires are secured by lightly tugging on the insulated part of the wire to verify it will not pull out. Next, verify that the metal conductors of the wire are contacting the conductive body of the terminal block.
4. The velocity cutoff (*Cutoff V)* is set too high. Go to the *First Level of the Hidden Diagnostics* menu and record the *V* Value. The *Cutoff V* must be set below this value.

5. Verify all meter configuration and troubleshooting steps previously described. There are many possible causes of this problem, consult factory if necessary.

Symptom: Inaccurate Flow Rate Reading

1. If the flow rate you are measuring is negative, the transducers/cables may have been installed incorrectly. Verify the placement of the upstream and downstream transducers and that the transducer cables are properly connected. The cable with the red tag (upstream) must be connected to the upstream transducer and the connector on the left of the top of the handheld unit labeled *UP*. The cable with the blue tag (downstream) must be connected to the downstream transducer and the connector on the right of the top of the handheld unit labeled *DN*.
2. The first parameter to check when measuring a flow rate that is above/below the expected flow rate of your system is the *SR Coefficient*. This can be found in the *Second Level of the Hidden Diagnostics* menu.
    a. This parameter should be set to a value of 1.0 by default. If this value is not set to 1.0 and you have not been instructed to change it, please change it back to a value of 1.0. This value acts as a multiplier and will either increase or decrease the flow rate displayed on the unit.
    b. If this value is set to 1.0 and the flow rate is still above/below the expected flow rate, continue to the next step for additional parameters to consider.
3. The next parameter to consider is the *Speed of Sound Source*. This can be found in the *Calibration* menu. The SonoPro® gives the user the ability to select from three different speed of sound sources which are used in the calculation to determine the flow rate of the liquid inside the pipe.
    a. *Spacing Temp* – This *Speed of Sound Source* uses the temperature programmed for determining the distance (spacing) between the scribe lines of the transducers, *Spacing Temp*, to calculate the speed of sound.
    b. *Fluid Temp 1* – This *Speed of Sound Source* uses either a manual temperature input (*Don't Use RTD*) or measures the temperature from an RTD (*Use RTD*) to calculate the speed of sound. *Use RTD* is a dynamic value and will change with the change in temperature of the fluid. **Note:** This value can only be used if the user has a model that is compatible with external RTD inputs (i.e., VER or VERER-EM).
    c. *TOF_Calc* – This *Speed of Sound Source* is measured with the two transducers that are installed on the pipe. This is a dynamic value and will change with a change in the measured up and down time of flight.
4. The next parameter to consider is the *Waveform* which can be found in the *Second Level of the Hidden Diagnostics* menu. This parameter is used to define the waveform of the driving circuit and can help with refining the transmit and receive signals.
    a. *Unkeyed* – When this type of signal is selected, the driving circuit sends a waveform in the form of a square wave with equal minimum/maximum

amplitudes and a steady frequency and period**.** With an *Unkeyed* signal you can define the number of cycles (*Num Cycles*) parameter which is used to define the number of cycles (or pulses) being sent by the driving circuit. More on *Num Cycles* can be found below.

b. *Keyed* – When this type of signal is selected, the driving circuit sends a waveform in the form of a square wave with equal minimum/maximum amplitudes but alternating frequencies and periods. In a keyed signal you cannot set the number of cycles (*Num Cycles)* as it is locked at a value of 8.

5. The third parameter to consider is the *Num Cycles* which can be found in the *Second Level of the Hidden Diagnostics* menu.
   a. *Num Cycles* – This parameter is used to define the number of cycles (or pulses) being sent by the driving circuit to try and determine the flow rate of the fluid in the pipe. You can select between 1 and 8 pulses. Depending on the number that is selected, the transmit and receive waveforms will increase or decrease in width to account for the increase or decrease in the number of cycles being sent and received.

Symptom: Unsatisfactory Correlation

1. If the upstream and downstream signals do not generate a correlation that is considered satisfactory, an inaccurate flow rate may be displayed. To start troubleshooting this issue, verify that a thin layer of coupling grease has been applied to the bottom of the upstream and downstream transducers. If not, apply a thin layer of the coupling grease (included in your kit) and try visualizing the signals again. Visualization of the signals can be accomplished using the SonoConfig™ app.
2. Verify that the spacing calculated in the *Calibration* Menu matches the actual spacing on the rail assembly of the set of transducers being used. If the spacing has been increased or decreased compared to the calculated value, an inaccurate correlation will result.
3. Verify that the transducers have been secured to the outside face of the pipe via the wing screw on the top of the transducer clamp.

If your problem persists, run through the *First Check Items* in the beginning of this chapter, fill in the *Record Values* Section, and contact the factory if necessary.

Returning Equipment to the Factory

Before returning any SonoPro® Fixed Mount Ultrasonic flow meter to the factory, you must request a Return Material Authorization (RMA) number. To obtain an RMA number and the correct shipping address, submit a request through VorTek Instruments, LLC website, vortekinst.com, or contact Customer Service at:

888-386-7835 or 303-682-9999 in the USA,

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

Please see the Meter Troubleshooting Checklist for additional items which may help with problem isolation. When requesting further troubleshooting guidance, please record the values on the checklist at no flow and during flow if possible.

Appendix A Product Specifications

Accuracy
≤1-inch Line Size: +/- 2% of rate
>1-inch Line Size: +/- 1% of rate
Accuracy is dependent on several variables including pipe characteristics and transducer mounting configuration. Special calibration can improve accuracy. Contact factory if needed.

Repeatability
+/- 0.2% of rate typical

Velocity: English Units: +/-.25 ft/sec of reading to +/-30 ft/sec
SI Units: +/- 0.08 m/s of reading to +/- 9.1 m/s

Pipe Sizes
Clamp-On Transducers:
2MHz – 1/2" (15mm) to 4" (100mm)
1MHz – 2" (50mm) to 20" (500mm)
0.5MHz – 12" (300mm) to 200" (5000mm)
Installation conditions can affect transducer selection

Measurement Parameters
Volume Flow, Mass Flow, Density, Temperature, Energy Units

Temperature Range
Standard Temperature -4°F to 248°F (-20°C to 120°C)

Electronics Specifications
Power Requirements
16 to 36 VDC, 333 mA, 8 W max.
100 to 240 VAC, 50-60 Hz, 8 W max.

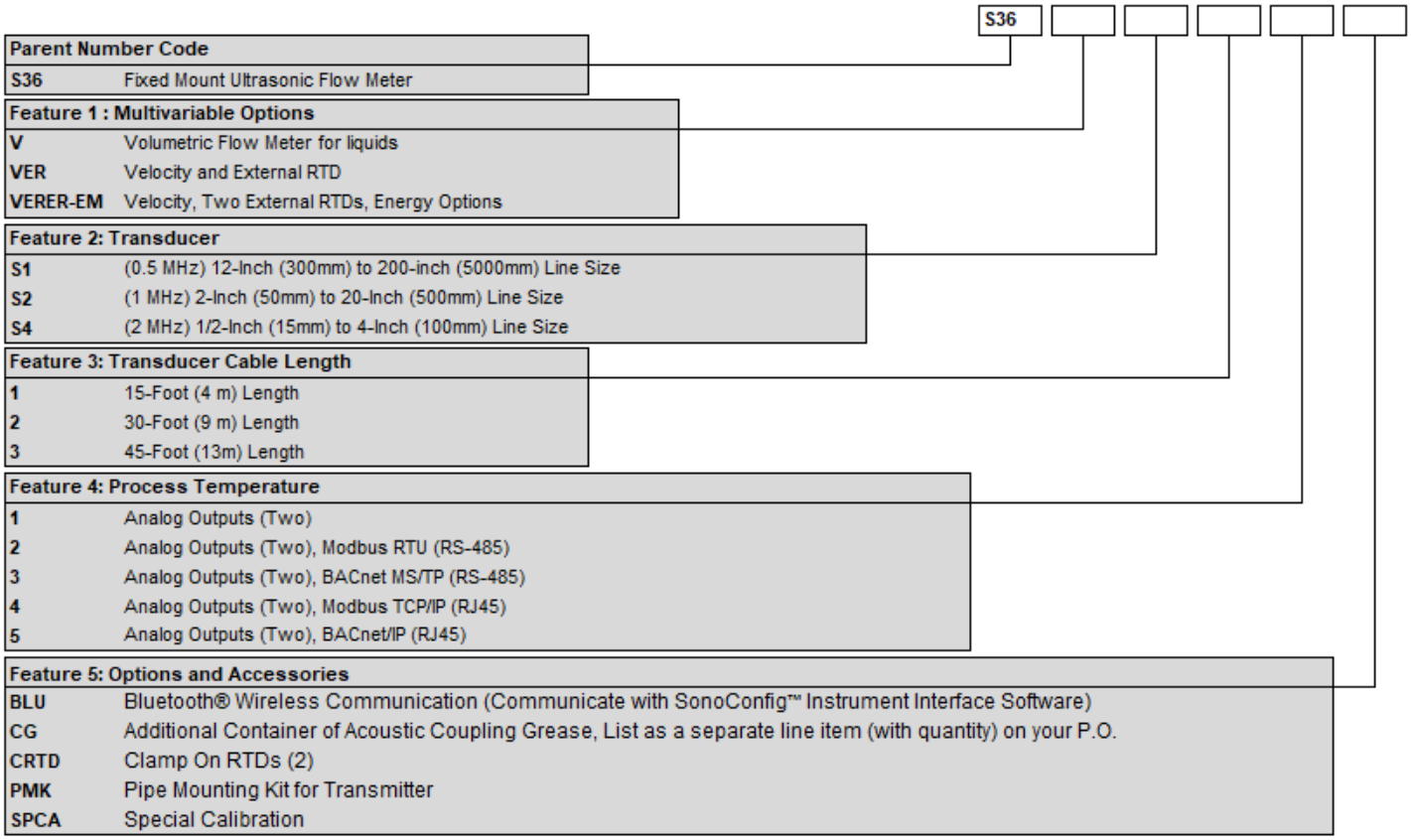
Display
Display – 2x16 character LCD with backlight

Output Signals
Output Standard – 2 analog 4-20mA, 2 alarms, 1 pulse output, 1 scaled frequency

Optional Output – Energy output with the addition of optional RTD inputs

Fluid Types
Acoustically conductive fluids, including most clean fluids and many liquids with entrained solids or gas bubbles. Some examples are: Refined Hydrocarbons, Petroleum products, Crude oil, Hydraulic fluids, Diesel and fuel oils, water, wastewater, Hot and chilled water, Glycol water solutions, Other liquids.

Model Number Information - SonoPro® Model S36 Fixed Mount Ultrasonic Flow Meter



Parent Number Code	
S36	Fixed Mount Ultrasonic Flow Meter

Feature 1 : Multivariable Options	
V	Volumetric Flow Meter for liquids
VER	Velocity and External RTD
VERER-EM	Velocity, Two External RTDs, Energy Options

Feature 2: Transducer	
S1	(0.5 MHz) 12-Inch (300mm) to 200-inch (5000mm) Line Size
S2	(1 MHz) 2-Inch (50mm) to 20-Inch (500mm) Line Size
S4	(2 MHz) 1/2-Inch (15mm) to 4-Inch (100mm) Line Size

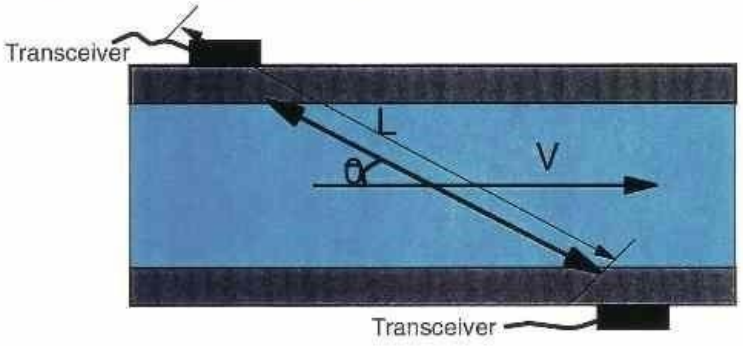
Feature 3: Transducer Cable Length	
1	15-Foot (4 m) Length
2	30-Foot (9 m) Length
3	45-Foot (13m) Length

Feature 4: Process Temperature	
1	Analog Outputs (Two)
2	Analog Outputs (Two), Modbus RTU (RS-485)
3	Analog Outputs (Two), BACnet MS/TP (RS-485)
4	Analog Outputs (Two), Modbus TCP/IP (RJ45)
5	Analog Outputs (Two), BACnet/IP (RJ45)

Feature 5: Options and Accessories	
BLU	Bluetooth® Wireless Communication (Communicate with SonoConfig™ Instrument Interface Software)
CG	Additional Container of Acoustic Coupling Grease, List as a separate line item (with quantity) on your P.O.
CRTD	Clamp On RTDs (2)
PMK	Pipe Mounting Kit for Transmitter
SPCA	Special Calibration

Appendix B Flow Meter Calculations

Transit Time Technology



$$T_{down} = \frac{L}{C + V\cos\theta} \qquad T_{up} = \frac{L}{C - V\cos\theta} \qquad V = \frac{(T_{down} - T_{up})C^2}{2L\cos\theta}$$

Volume Flow Rate

$$Q_V = V\,A$$

Mass Flow Rate

$$Q_M = Q_V \rho$$

Where:
A = Cross sectional area of the pipe (ft^2)
C = speed of sound
L = sound path length
Q_M = Mass flow rate (lbm / sec)
Q_v = Volume flow rate (ft^3 / sec)
V = Flowing velocity (ft / sec)
ρ = Density (lbm / ft^3)

Fluid Calculations

Density

The liquid density is found using the International Association for the Properties of Water and Steam, IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam.

Viscosity

The liquid viscosity is found using the International Association for the Properties of Water and Steam, The IAPS Formulation 1985 for the Viscosity of Ordinary Water Substance.

Appendix C Sound Speed and Pipe Data

Pipe Sound Speeds

Material	Shear Wave (ft/sec)	Long Wave (ft/sec)
Carbon Steel	10598	19325
Stainless 302	10236	18525
Stainless 303	10236	18525
Stainless 304	10305.12	19094.49
Stainless 304L	10073	19000
Stainless 316	10735	18750
Copper	7415	15291.67
Annealed Copper	7628	0.0
Rolled Copper	7448	0.0
Naval Brass	6923	14533.33
Iron 10630	19358.33	
Ductile Iron	9843	0.0
Cast Iron	8203	14925
Nylon 3772	7875	
Nylon 6-6	3510	0.0
Polyethylene HD	0.0	7575
Polyethylene LD	1772	6366.67
Polypropylene	3937.01	8530.18
PVC/CPVC	3477	7387
Acrylic	8958.33	
Cement-Asbestos	0.0	7216.67

Pipe Chart

Pipe Size (inches)	Outside Diameter (inches)	Identification			Wall Thickness (inches)	Inside Diameter (inches)
		Steel		Stainless Steel		
		Iron Pipe Size	Schedule No.	Schedule No.		
		.	.	5S	0.065	0.71
		.	.	10S	0.083	0.674
		STD	40	40S	0.109	0.622
		XS	80	80S	0.147	0.546
		.	160	.	0.187	0.466
1/2	0.84	XXS	.	.	0.294	0.252
		.	.	5S	0.065	0.92
		.	.	10S	0.083	0.884
		STD	40	40S	0.113	0.824
		XS	80	80S	0.154	0.742
		.	160	.	0.219	0.612
3/4	1.05	XXS	.	.	0.308	0.434
		.	.	5S	0.065	1.185
		.	.	10S	0.109	1.097
		STD	40	40S	0.133	1.049
		XS	80	80S	0.179	0.957
		.	160	.	0.25	0.815
1	1.315	XXS	.	.	0.358	0.599
		.	.	5S	0.065	1.53
		.	.	10S	0.109	1.442
		STD	40	40S	0.14	1.38
		XS	80	80S	0.191	1.278
		.	160	.	0.25	1.16
1 1/4	1.66	XXS	.	.	0.382	0.896
		.	.	5S	0.065	1.77
		.	.	10S	0.109	1.682
		STD	40	40S	0.145	1.61
		XS	80	80S	0.2	1.5
		.	160	.	0.281	1.338
1 1/2	1.9	XXS	.	.	0.4	1.1
		.	.	5S	0.065	2.245
		.	.	10S	0.109	2.157
		STD	40	40S	0.154	2.067
		XS	80	80S	0.218	1.939
		.	160	.	0.344	1.689
2	2.375	XXS	.	.	0.436	1.503

		.	.	5S	0.083	2.709
		.	.	10S	0.12	2.635
		STD	40	40S	0.203	2.469
		XS	80	80S	0.276	2.323
		.	160	.	0.375	2.125
2 1/2	2.875	XXS	.	.	0.552	1.771
		.	.	5S	0.083	3.334
		.	.	10S	0.12	3.26
		STD	40	40S	0.216	3.068
		XS	80	80S	0.3	2.9
		.	160	.	0.438	2.624
3	3.5	XXS	.	.	0.6	2.3
		.	.	5S	0.083	3.834
		.	.	10S	0.12	3.76
		STD	40	40S	0.226	3.548
3 1/2	4	XS	80	80S	0.318	3.364
		.	.	5S	0.083	4.334
		.	.	10S	0.12	4.26
		STD	40	40S	0.237	4.026
		XS	80	80S	0.337	3.826
		.	120	.	0.438	3.624
		.	160	.	0.531	3.438
4	4.5	XXS	.	.	0.674	3.152
		.	.	5S	0.109	5.345
		.	.	10S	0.134	5.295
		STD	40	40S	0.258	5.047
		XS	80	80S	0.375	4.813
		.	120	.	0.5	4.563
		.	160	.	0.625	4.313
5	5.563	XXS	.	.	0.75	4.063
		.	.	5S	0.109	6.407
		.	.	10S	0.134	6.357
		STD	40	40S	0.28	6.065
		XS	80	80S	0.432	5.761
		.	120	.	0.562	5.501
		.	160	.	0.718	5.187
6	6.625	XXS	.	.	0.864	4.897
		.	.	5S	0.109	8.407
		.	.	10S	0.148	8.329
		.	20	.	0.25	8.125
		.	30	.	0.277	8.071
		STD	40	40S	0.322	7.981
		.	60	.	0.406	7.813
		XS	80	80S	0.5	7.625
		.	100	.	0.594	7.437
		.	120	.	0.719	7.187
		.	140	.	0.812	7.001
		XXS	.	.	0.875	6.875
8	8.625	.	160	.	0.906	6.813

		.	.	5S	0.134	10.482
		.	.	10S	0.165	10.42
		.	20	.	0.25	10.25
		.	30	.	0.307	10.136
		STD	40	40S	0.365	10.02
		XS	60	80S	0.5	9.75
		.	80	.	0.594	9.562
		.	100	.	0.719	9.312
		.	120	.	0.844	9.062
		.	140	.	1	8.75
10	10.75	.	160	.	1.125	8.5
		.	.	5S	0.156	12.438
		.	.	10S	0.18	12.39
		.	20	.	0.25	12.25
		.	30	.	0.33	12.09
		STD	.	40S	0.375	12
		.	40	.	0.406	11.938
		XS	.	80S	0.5	11.75
		.	60	.	0.562	11.626
		.	80	.	0.688	11.374
		.	100	.	0.844	11.062
		.	120	.	1	10.75
		.	140	.	1.125	10.5
12	12.75	.	160	.	1.312	10.126
		.	.	5S	156	13.688
		.	.	10S	0.188	13.624
		.	10	.	0.25	13.5
		.	20	.	0.312	13.376
		STD	30	.	0.375	13.25
		.	40	.	0.438	13.124
		XS	.	.	0.5	13
		.	60	.	0.594	12.812
		.	80	.	0.75	12.5
		.	100	.	0.938	12.124
		.	120	.	1.094	11.812
		.	140	.	1.25	11.5
14	14	..	160	.	1.406	11.188
		.	.	5S	0.165	15.67
		.	.	10S	0.188	15.624
		.	10	.	0.25	15.5
		.	20	.	0.312	15.376
		STD	30	.	0.375	15.25
		XS	40	.	0.5	15
		.	60	.	0.656	14.688
		.	80	.	0.844	14.312
		.	100	.	1.031	13.938
		.	120	.	1.219	13.562
		.	140	.	1.438	13.124
16	16	.	160	.	1.594	12.812

		.	.	5S	0.165	17.67
		.	.	10S	0.188	17.624
		.	10	.	0.25	17.5
		.	20	.	0.312	17.376
		STD	.	.	0.375	17.25
		.	30	.	0.438	17.124
		XS	.	.	0.5	17
		.	40	.	0.562	16.876
		.	60	.	0.75	16.5
		.	80	.	0.938	16.124
		.	100	.	1.156	15.688
		.	120	.	1.375	15.25
		.	140	.	1.562	14.876
18	18	.	160	.	1.781	14.438
		.	.	5S	0.188	19.624
		.	.	10S	0.218	19.564
		.	10	.	0.25	19.5
		STD	20	.	0.375	19.25
		XS	30	.	0.5	19
		.	40	.	0.594	18.812
		.	60	.	0.812	18.376
		.	80	.	1.031	17.938
		.	100	.	1.281	17.438
		.	120	.	1.5	17
		.	140	.	1.75	16.5
20	20	.	160	.	1.969	16.062
		.	.	5S	0.188	21.624
		.	.	10S	0.218	21.564
		.	10	.	0.25	21.5
		STD	20	.	0.375	21.25
		XS	30	.	0.5	21
		.	60	.	0.875	20.25
		.	80	.	1.125	19.75
		.	100	.	1.375	19.25
		.	120	.	1.625	18.75
		.	140	.	1.875	18.25
22	22	.	160	.	2.125	17.75
		.	.	5S	0.218	23.564
		.	10	10S	0.25	23.5
		STD	20	.	0.375	23.25
		XS	.	.	0.5	23
		.	30	.	0.562	22.876
		.	40	.	0.688	22.624
		.	60	.	0.969	22.062
		.	80	.	1.219	21.562
		.	100	.	1.531	20.938
		.	120	.	1.812	20.376
		.	140	.	2.062	19.876
24	24	.	160	.	2.344	19.312
		.	10	.	0.312	25.376
		STD	.	.	0.375	25.25
26	26	XS	20	.	0.5	25

		.	10	.	0.312	27.376
		STD	.	.	0.375	27.25
		XS	20	.	0.5	27
28	28	.	30	.	0.625	26.75
		.	.	5S	0.25	29.5
		.	10	10S	0.312	29.376
		STD	.	.	0.375	29.25
		XS	20	.	0.5	29
30	30	.	30	.	0.625	28.75
		.	10	.	0.312	31.376
		STD	.	.	0.375	31.25
		XS	20	.	0.5	31
		.	30	.	0.625	30.75
32	32	.	40	.	0.688	30.624
		.	10	.	0.344	33.312
		STD	.	.	0.375	33.25
		XS	20	.	0.5	33
		.	30	.	0.625	32.75
34	34	.	40	.	0.688	32.624
		.	10	.	0.312	35.376
		STD	.	.	0.375	35.25
		XS	20	.	0.5	35
		.	30	.	0.625	34.75
36	36	.	40	.	0.75	34.5
		STD	.	.	0.375	41.25
		XS	20	.	0.5	41
		.	30	.	0.625	40.72
42	42	.	40	.	0.75	

Pipe Size	Pipe O.D.	Standard to XXHY	Wall Thickness	Pipe I.D.
48	48		0.25	47.5
			0.281	47.438
			0.312	47.376
			0.344	47.312
		STD.	0.375	47.25
			0.406	47.188
			0.438	47.188
			0.469	47.062
		XHY	0.5	47
			0.562	46.876
			0.625	46.75
			0.688	46.621
			0.75	46.5
			0.875	46.25
			1	46

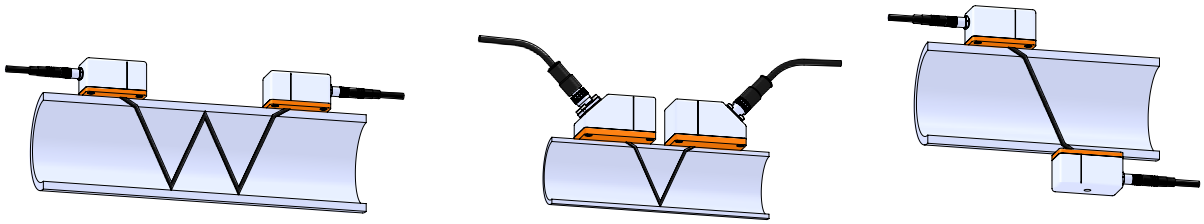
54	54		0.25	53.5
			0.281	53.438
			0.312	53.376
			0.344	53.312
		STD.	0.375	53.25
			0.406	53.188
			0.438	53.124
			0.469	53.062
		XHY	0.5	53
			0.562	52.876
			0.625	52.75
			0.688	52.624
			0.75	52.5
			0.875	52.25
			1	52
60	60		0.25	59.5
			0.312	59.376
		STD.	0.375	59.25
			0.438	59.121
		XHY	0.5	59
			0.562	58.876
			0.625	58.75
			0.688	58.621
			0.75	58.5
			0.875	58.25
			1	58
66	66		0.25	65.5
			0.312	65.376
		STD.	0.375	65.25
			0.438	65.124
		XHY	0.5	65
			0.562	64.876
			0.625	64.75
			0.688	64.624
			0.75	64.5
			0.875	64.25
			1	64
72	72		0.25	71.5
		STD.	0.375	71.25
		XHY	0.5	71
			0.75	70.5
			1	70
78	78		0.25	77.5
		STD.	0.375	77.25
		XHY	0.5	77
			0.75	76.5
			1	76
84	84		0.25	83.5
		STD.	0.375	83.25
		XHY	0.5	83
			0.75	82.5
			1	82

90	90	STD. XHY	0.25 0.375 0.5 0.75 1	89.5 89.25 89 88.5 88
96	96	STD. XHY	0.25 0.375 0.5 0.75 1	95.5 95.25 95 94.5 94
102	102	STD. XHY	0.25 0.375 0.5 0.75 1	101.5 101.25 101 100.5 100
108	108	STD. XHY	0.25 0.375 0.5 0.75 1	107.5 107.25 107 106.5 106
120	120	STD. XHY	0.25 0.375 0.5 0.75 1	119.5 119.25 119 118.5 118.5
144	144	STD. XHY	0.375 0.5 0.75 1	143.25 143 142.5 142

Refer to ASTM A530, ASME SA530 for pipe tolerances.

Appendix D Quick Start-Up Guide

1. Turn on power to the fixed mount ultrasonic unit by pressing the "POWER" button after the input power wire connections have been made.
2. Press "ENTER". A screen with "Enter Password" will be displayed.
    a. Enter the "User Password" of 1234.
3. Using the left/right arrow, navigate to the "Fluid" menu.
    a. Press the up/down arrow to access the "Flowing Fluid" sub-menu.
    b. Press "Enter" and select the type of liquid to be measured.
        i. Use the up/down arrow to scroll through the list of fluids.
        ii. **Note:** If the liquid used in your system is not represented in this list use the "Other Liquid" category and input the necessary parameters.
    c. Press "Enter" after selecting the type of liquid.
        i. This will save the current configuration.
    d. Press the up/down arrow to return to the "Fluid" menu.
4. Using the right arrow, navigate to the "Units" menu.
    a. Using the up/down arrow, define the required units.
5. Using the right arrow, navigate to the "Calibration" menu.
    a. Enter the "Pipe OD" and the "Wall Thickness".
        i. **Note:** "Pipe ID" will be calculated.
    b. Enter "Pipe Material" and "Liner Material".
    c. Enter the "Transducer Type".
        i. 2 MHz
            1. Typical pipe sizes: ½" to 4"
        ii. 1 MHz
            1. Typical pipe sizes: 2" to 20"
        iii. ½ MHz
            1. Typical pipe sizes: 12" to 200"
    d. Enter the "Trans Traverse".
        i. W method – Typically used with pipe sizes ranging from ½" to 4"
        ii. V method – Typically used with pipe sizes ranging from 4" to 12"
        iii. Z method – Typically used with pipe sizes ranging from 12" and up



    e. Enter "Spacing Temp (°F)".
        i. Note: this is the temperature of the liquid at the time of transducer installation.
    f. Enter "Fluid Temp. 1".
        i. Select:
            1. "Use RTD"
            2. "Don't Use RTD"

a. Enter temperature of liquid being measured

g. Enter "Fluid Temp. 2". **Note:** Only for models with Energy.

6. Now that all parameters have been set, navigate to the "Trans Traverse" sub-menu within the "Calibration" menu.

a. Press the right arrow to access the "Spacing" parameter.

b. This number is the required spacing, in units of length, that will need to be set between the scribe lines of the two transducers before measurements within the pipe can be taken.

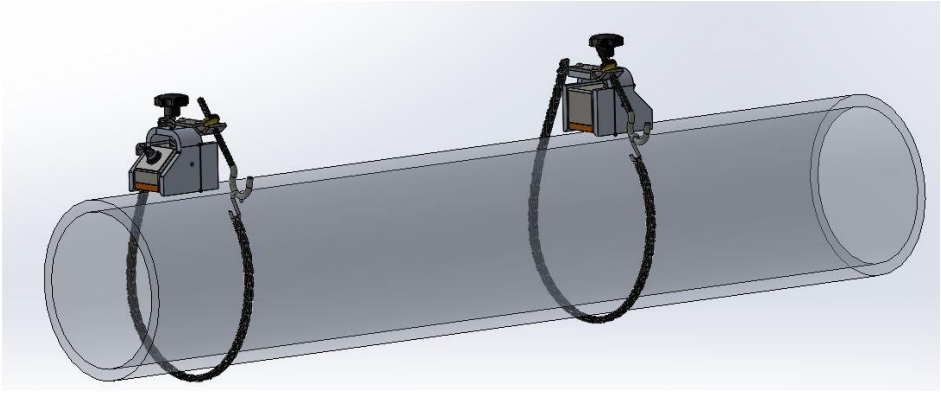
7. Exit and "Save Changes".

8. Install the Large Mounting Clamps or Small Rail/Fixture System on to the pipe.

a. Adjacent side transducer installation method.

i. V and W methods of measurement.

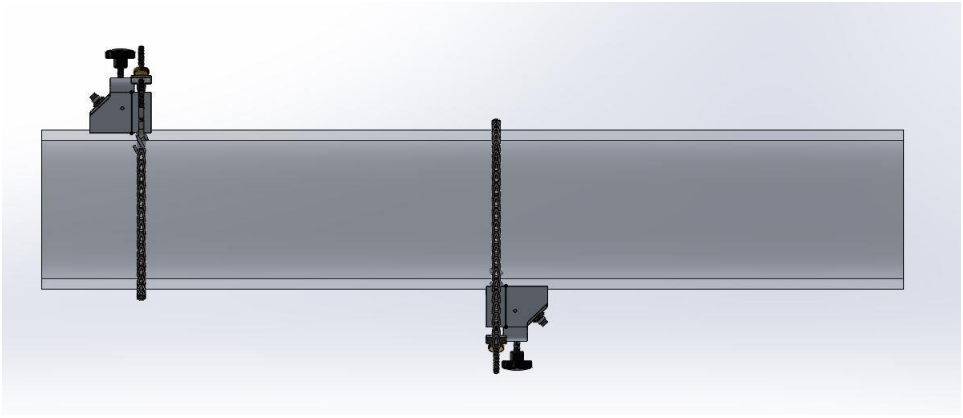
1. Refer to page 2-5 in the manual for detailed installation instructions.



b. Opposite side transducer installation method.

i. Z method of measurement.

1. Refer to page 2-7 in the manual for detailed installation instructions.



9. **Optional:** With no flow, navigate to the "Zero Cal" sub-menu within the "Calibration" menu.

a. Press "Enter", scroll to the left two places, and place a zero in that location using the up/down arrow. Press "Enter" again.

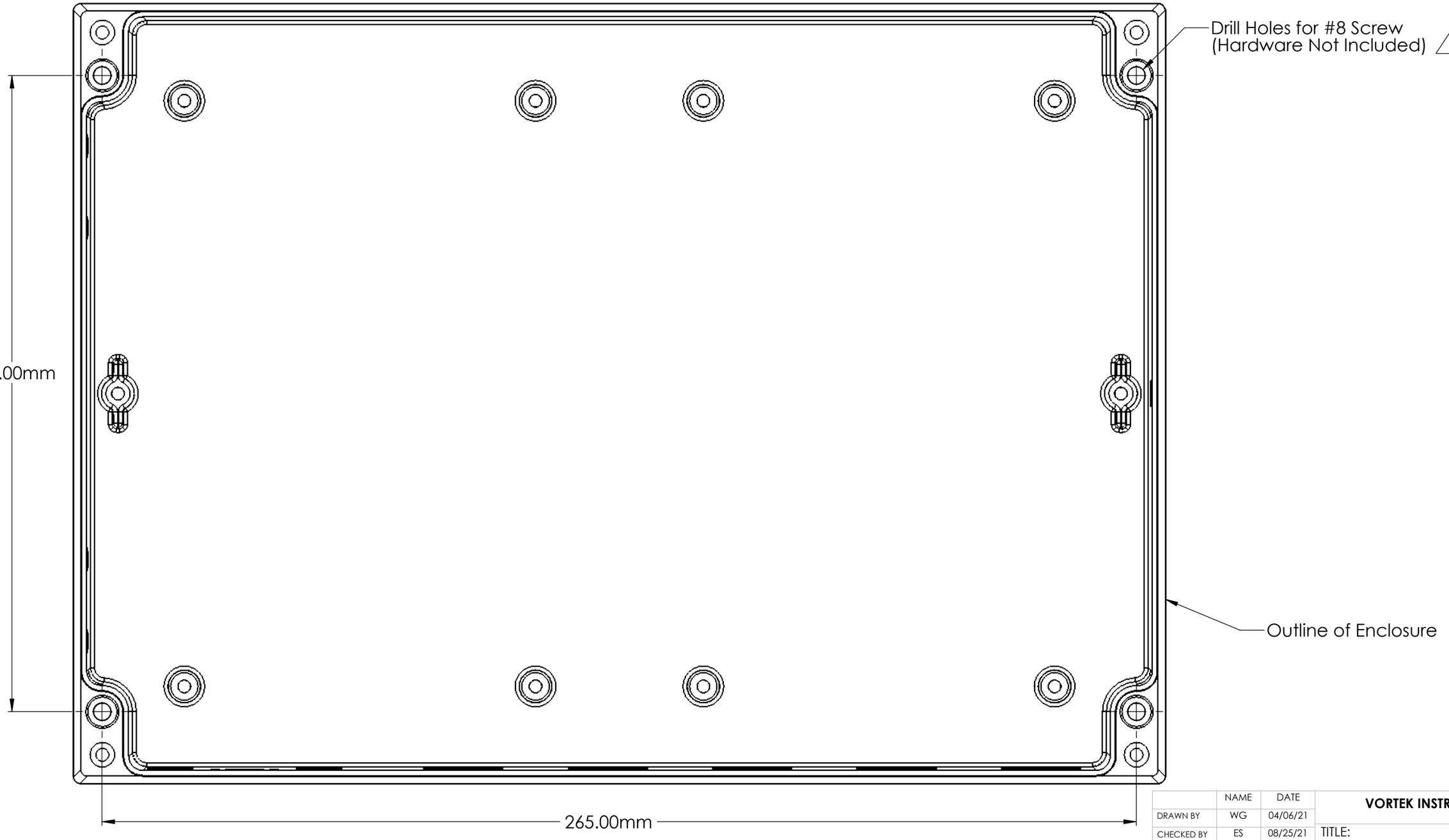
b. This will calculate the internal error factor of the transducers.

10. The fixed mount ultrasonic unit is now ready to take readings.

Appendix E Mounting Template

The SonoPro® fixed mount ultrasonic flow meter can be mounted to a wall or panel by using the procedure outlined in Chapter 2. To assist with the mounting of the enclosure, a mounting template is provided as mentioned in Chapter 2. The mounting template can be found on the next page. Print the mounting template on 11x17-inch paper.

REV	ECO	DESCRIPTION	APPRV.	DATE
A	888	New Release.	WG	08/25/2021



	NAME	DATE
DRAWN BY	WG	04/06/21
CHECKED BY	ES	08/25/21
APPROVED BY	SD	08/25/21

VORTEK INSTRUMENTS, LLC

TITLE:

Mounting Template, SonoPro F.M. Encl

SIZE	DWG. NO.	REV
B	800122	A
SCALE: 1:1		SHEET 1 OF 1

Notes

1. Maximum Allowable Diameter of Screw is 0.177 Inches. Maximum Allowable Diameter of Screw Head is 0.334 Inches.

Appendix F Glossary of Terms

A B C D

A	Cross sectional area.
ACFM	Actual Cubic Feet Per Minute (volumetric flow rate).
ASME	American Society of Mechanical Engineers.
BTU	British Thermal Unit, an energy measurement.
Compressibility Factor	A factor used to correct for the non-ideal changes in a fluid's density due to changes in temperature and/or pressure.
CSA	Canadian Standards Association.
D	Diameter of a flow channel.

E F G H

Flow Channel	A pipe, duct, stack, or channel containing flowing fluid.
Flow Profile	A map of the fluid velocity vector (usually non-uniform) in a cross-sectional plane of a flow channel (usually along a diameter).
FM	Factory Mutual.
Ft	Foot, 12 inches, a measure of length.
Ft^2	Square feet, measure of area.
Ft^3	Cubic feet, measure of volume.
GPM	Gallons Per Minute.
Hz	Hertz, cycles per second.

I J K L

Joule	A unit of energy equal to one watt for one second. Also equal to a Newton-meter.
LCD	Liquid crystal display.

M N O P

$\dot{m}$	Mass flow rate.

mA	Milli-amp, one thousandth of an ampere of current.
μ	Viscosity, a measure of a fluid's resistance to shear stress. Honey has high viscosity, alcohol has low viscosity.
P	Line pressure (psia or bar absolute).
ρ	The density of the liquid.

Q R S T

Q	Flow rate, usually volumetric.
Rangeability	Highest measurable flow rate divided by the lowest measurable flow rate.
Reynolds Number or Re	A dimensionless number equal to the density of a fluid times the velocity of the fluid times the diameter of the fluid channel, divided by the fluid viscosity (i.e., $Re = \rho VD/\mu$). The Reynolds number is an important number for vortex flow meters because it is used to determine the minimum measurable flow rate. It is the ratio of the inertial forces to the viscous forces in a flowing fluid.
RTD	Resistance temperature detector, a sensor whose resistance increases as the temperature rises.
Totalizer	An electronic counter which records the total accumulated flow over a certain range of time.
Traverse	The act of moving a measuring point across the width of a flow channel.

U V W X Y Z

Uncertainty	The closeness of agreement between the result of a measurement and the true value of the measurement.
V	Velocity or voltage.
VAC	Volts, alternating current.
VDC	Volts, direct current.