 **TM500** Thermal Mass Flow Meter
Instruction Manual

Document: S-IM-TM500 | Rev B_PN 110069

GLOBAL SUPPORT LOCATIONS: WE ARE HERE TO HELP!

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TRADEMARKS

TM500™, TM-Cal™, Gas-Mix™, FlowTrak™, TM500-View Software™ and DigiSense™ are trademarks of Sierra Instruments, Inc. Other product and company names listed in this manual are trademarks or trade names of their respective manufacturers.

Warning and Cautions

General Safety Information

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

Symbol Key		
Symbol	Symbol Meaning	Description
	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/Note	This statement appears with information that is important for protecting your equipment's performance. Read and follow all cautions that apply to your application.



WARNING

- **Warning!** Agency approval for hazardous location installations varies between flow meter models. Consult the flow meter nameplate for specific flow meter approvals before any hazardous location installation.
- **Warning!** Hot tapping must be performed by a trained professional. U.S. regulations often require a hot tap permit. The manufacturer of the hot tap equipment and/or the contractor performing the hot tap is responsible for providing proof of such a permit
- **Warning!** All wiring procedures must be performed with the power Off.
- **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.
- **Warning!** Before attempting any flow meter repair, verify that the line is de-pressurized.
- **Warning!** Always remove main power before disassembling any part of the mass flow meter.

**CAUTION**

- **Caution!** Before making adjustments to the TM500, verify the flow meter is not actively monitoring or reporting to any master control system. Adjustments to the electronics will cause direct changes to flow control settings.
- **Caution!** All flow meter connections, isolation valves and fittings for hot tapping must have the same or higher pressure rating as the main pipeline.
- **Caution!** The flow meter electronics and sensor probe have been manufactured and calibrated to operate as a unit. The flow meter will not operate properly if parts are replaced from another meter.
- **Caution!** Printed circuit boards are sensitive to electrostatic discharge. To avoid damaging the board, follow these precautions to minimize the risk of damage:
 - before handling the assembly, discharge your body by touching a grounded, metal object
 - handle all cards by their edges unless otherwise required
 - when possible, use grounded electrostatic discharge wrist straps when handling sensitive components

Receipt of System Components

When receiving a Sierra mass 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 Sierra 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 setup procedures. Verify that your settings and adjustments are consistent with factory recommendations. Installation information can be found in Chapter 2 of this manual.

If the problem persists, contact Sierra Instruments by e-mail (see inside front cover). For urgent phone support you may call (831) 373-0200 between 8:00 a.m. and 5:00 p.m. PST. In Europe, contact Sierra Instruments Europe at +31 72 5071400. In the Asia-Pacific region, contact Sierra Instruments Asia at +8621 5879 8521. When contacting Technical Support, make sure to include this information:

- The serial number (marked on the meter's label)
- The firmware version (visible on the display at startup)
- The problem you are encountering and any corrective action taken
- Application information (flow range, gas, pressure, temperature and piping configuration)

Using This Manual

This manual provides information needed to install and operate the Series TM500 Mass Flow Meter.

Additional Resources

Visit Sierrainstruments.com for additional resources. Note: the most current versions of the TM500 documents can be found at <https://www.sierrainstruments.com/products/downloads.html>.

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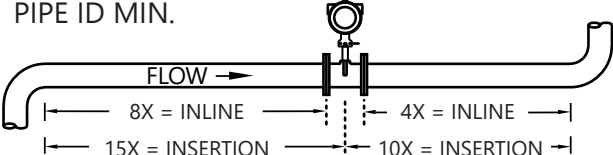
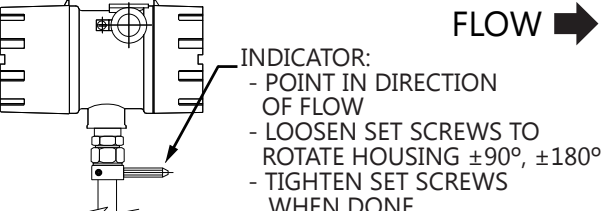
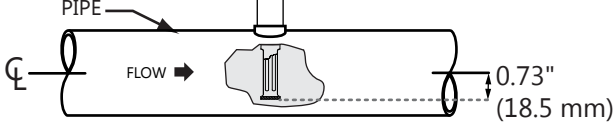
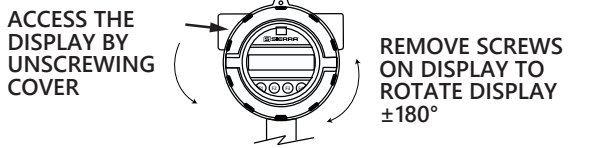
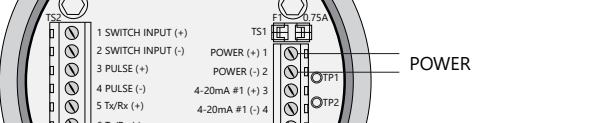
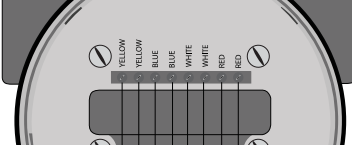
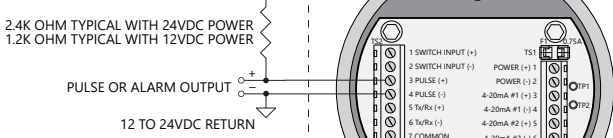

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Quick Start Guide

Use the table below as a guide while using the worksheet on the next page to record your notes.

NOTE! Please read the entire quick-start procedure before beginning installation.

<p>1.</p>	<p>Record inside diameter (ID). Ensure the actual pipe ID matches the pipe ID shown on the factory calibration certificate. If IDs do not match, refer to "Pipe Diameter" on page 61.</p>	
<p>2.</p>	<p>Record up/downstream straight-pipe requirements based on Pipe ID and meter style (insertion or inline). [refer to p. 23]</p>	
<p>3.</p>	<p>The Flow Direction Indicator must point in the direction of flow. The housing can be rotated for a better view of the meter's display. Note that the 2 set screws must be loosened before the housing will turn. [refer to p. 29]</p>	 <p>INDICATOR: - POINT IN DIRECTION OF FLOW - LOOSEN SET SCREWS TO ROTATE HOUSING ±90°, ±180° - TIGHTEN SET SCREWS WHEN DONE</p>
<p>4.</p>	<p>Ensure correct probe depth setting. If using 1 1/2" size pipe, please see note on p. 26.</p>	
<p>5.</p>	<p>If needed, the orientation of display can be rotated in 90° increments for a better view. [refer to p. 30 for more information]</p>	 <p>ACCESS THE DISPLAY BY UNSCREWING COVER</p> <p>REMOVE SCREWS ON DISPLAY TO ROTATE DISPLAY ±180°</p>
<p>6.</p>	<p>Ensure power wiring [p. 37] and 4-20mA wiring [p. 39 - p. 40] properly connected. [refer to Wiring section p. 35 for more information]</p>	
<p>7.</p>	<p>Ensure remote wiring is correct if remote option ordered. [refer to p. 46 - p. 48 for more information]</p>	
<p>8.</p>	<p>Verify you have the proper output signal wiring [refer to p. 39 - p. 45 for more information]</p>	 <p>2.4K OHM TYPICAL WITH 24VDC POWER 1.2K OHM TYPICAL WITH 12VDC POWER</p>
<p>9.</p>	<p>Apply power to the flow meter.</p>	
<p>10.</p>	<p>Check the remaining flow meter settings by accessing the meter settings either through the front panel of the display or by using the TM500-View™ software. Record the settings in the spaces given for items A - F on the following page.</p>	

Before applying power to your meter, use this worksheet to record your notes.

	Item to verify	Serial Number:	Serial Number:	Serial Number:	Serial Number:
1.	What is the Pipe ID?	ID =	ID =	ID =	ID =
2.	Calculate the Upstream/Downstream straight-pipe requirements	UP = DN =	UP = DN =	UP = DN =	UP = DN =
3.	Is the flow indicator pointed in direction of flow?	Y / N	Y / N	Y / N	Y / N
	Must the housing be rotated for easy viewing?	Y / N	Y / N	Y / N	Y / N
4.	Is the probe depth setting correct?	Y / N	Y / N	Y / N	Y / N
5.	Have you rotated the display for easier viewing?	Y / N	Y / N	Y / N	Y / N
6.	Verify proper power wiring				
7.	Verify proper remote wiring (if ordered)				
8.	Verify proper input/output wiring				

After applying power to your meter, check items A - F below by accessing the meter settings either through the front panel of the meter's display or by using the TM500-View™ Software.

A.	Which flow units have been set in meter? (SCFM, KG/H, etc..)				
B.	Correct values for reference temperature and pressure?	Y / N	Y / N	Y / N	Y / N
C.	Confirm the pipe ID listed above same as "Pipe_id="				
D.	Verify the 1st 4mA and 20mA meter settings	4mA = 20mA =	4mA = 20mA =	4mA = 20mA =	4mA = 20mA =
E.	Verify the 2nd 4mA and 20mA meter settings	4mA = 20mA =	4mA = 20mA =	4mA = 20mA =	4mA = 20mA =
F.	Confirm the correct gas is selected for your application in the Gas-Mix™ menu				

Your Notes:

If you are experiencing any problems after completing this procedure, please call the Sierra Instruments Service Department at 831-373-0200 to review this information.

Fig. 1.1: TM500 Menu Tree - Main Menu

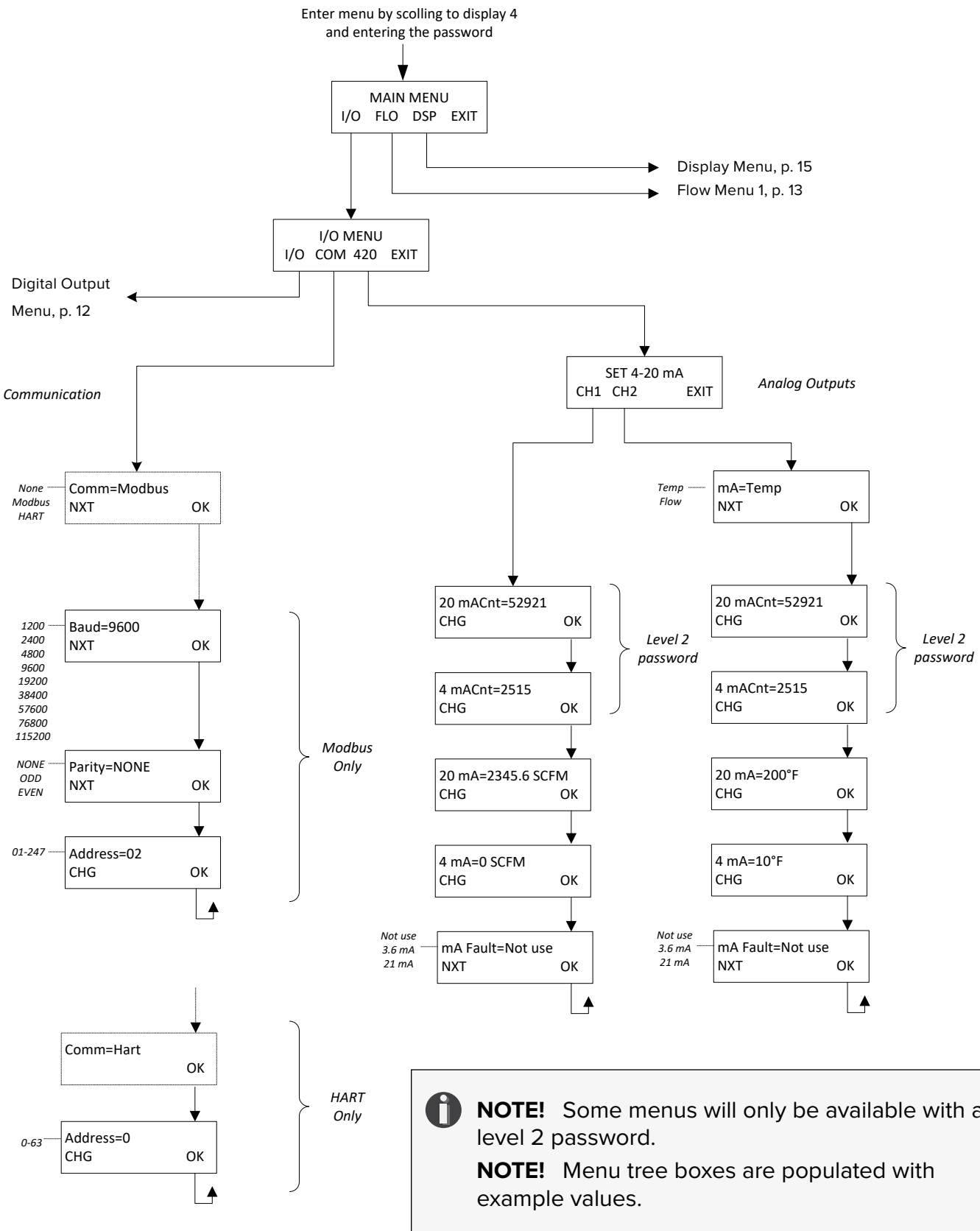


Fig. 1.2: TM500 Menu Tree - Digital Outputs and Input

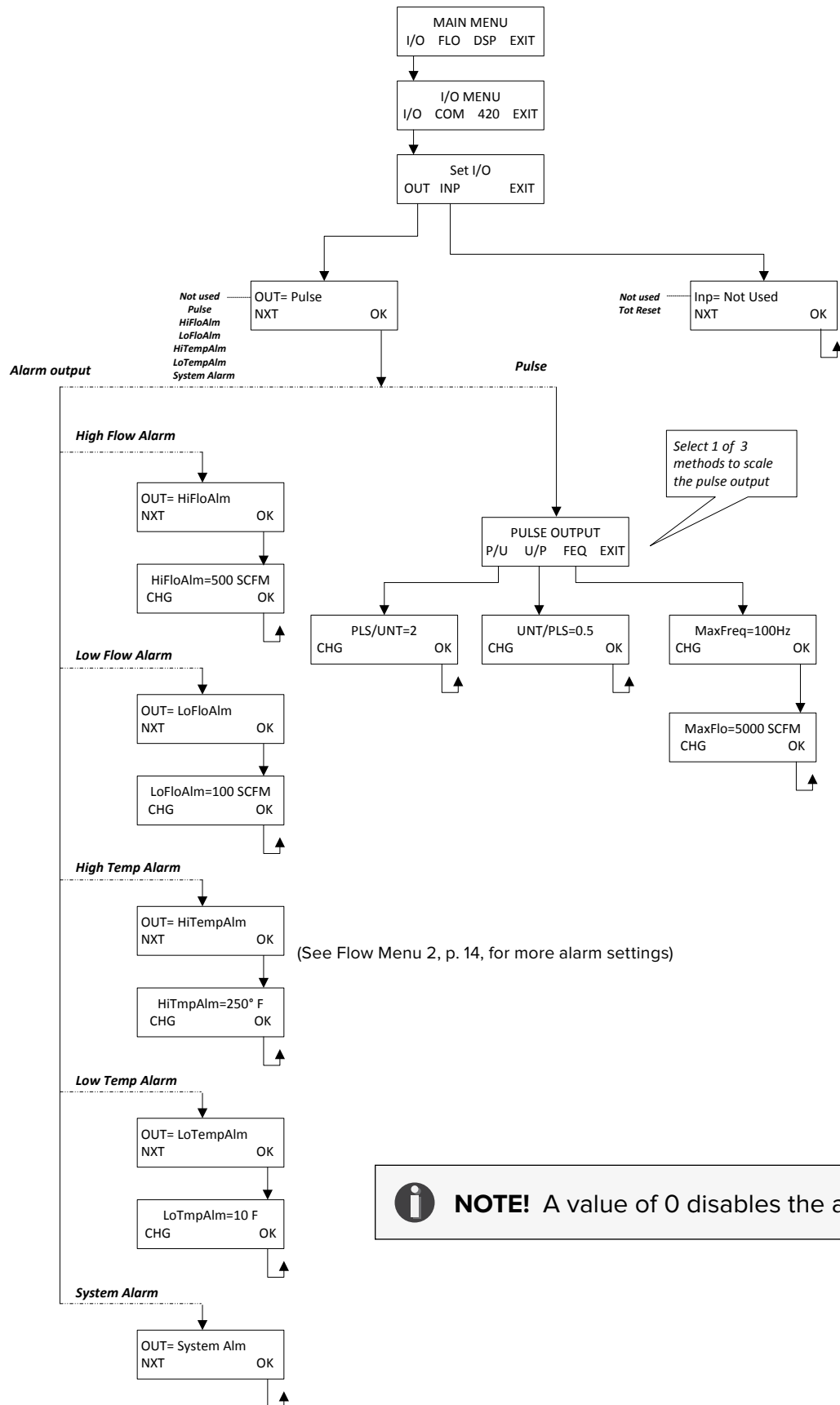


Fig. 1.3: TM500 Menu Tree - Flow Menu 1

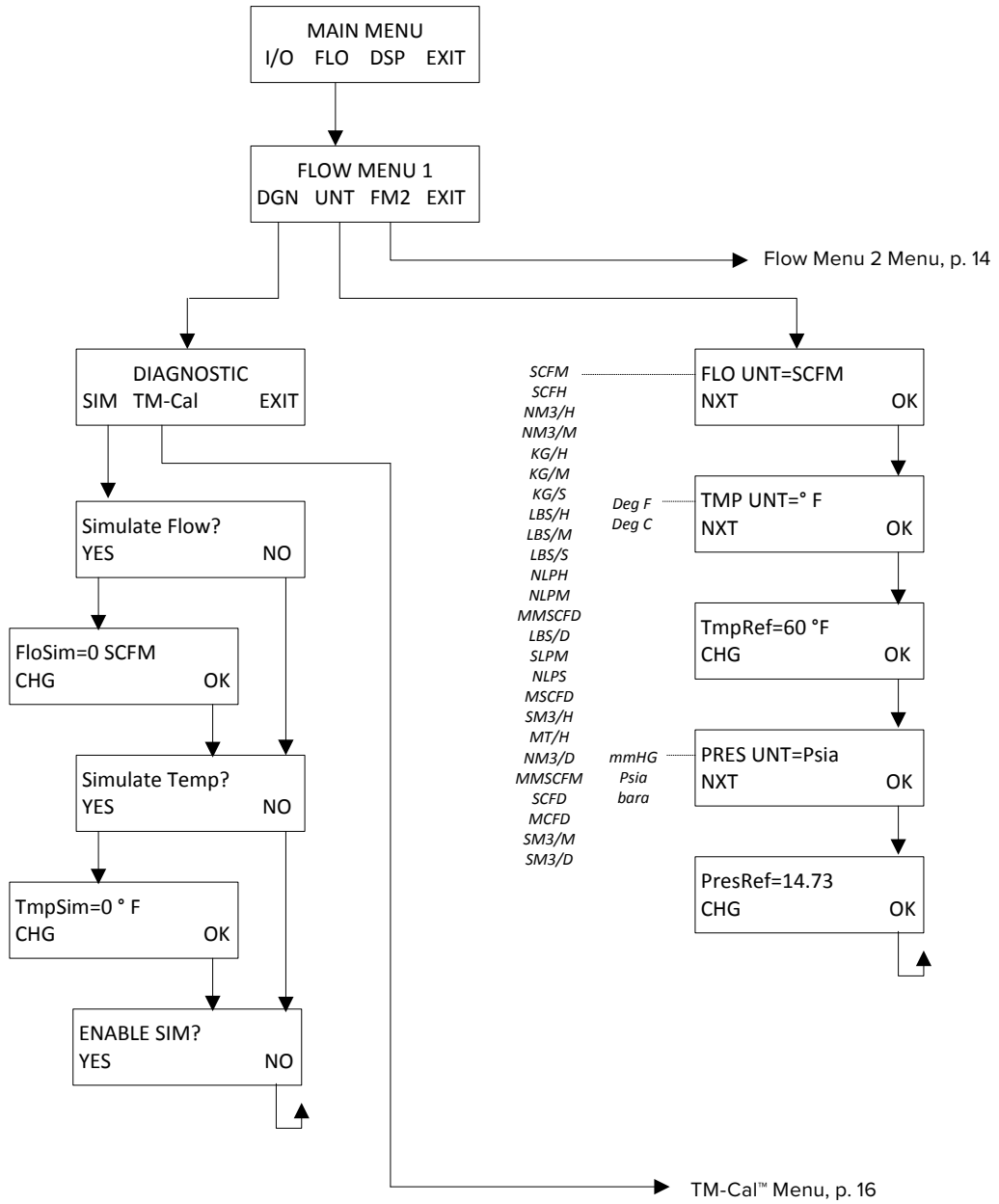
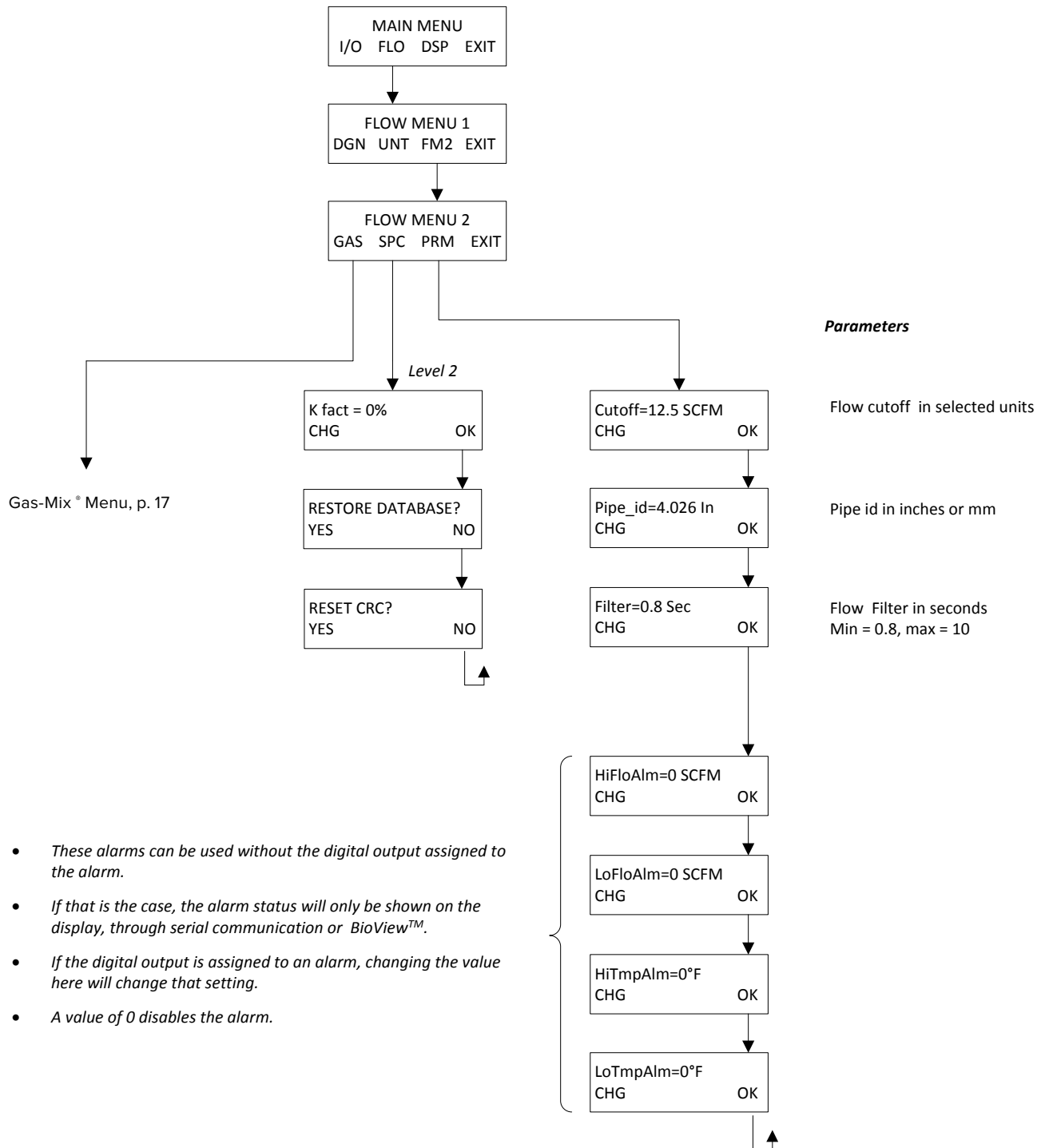
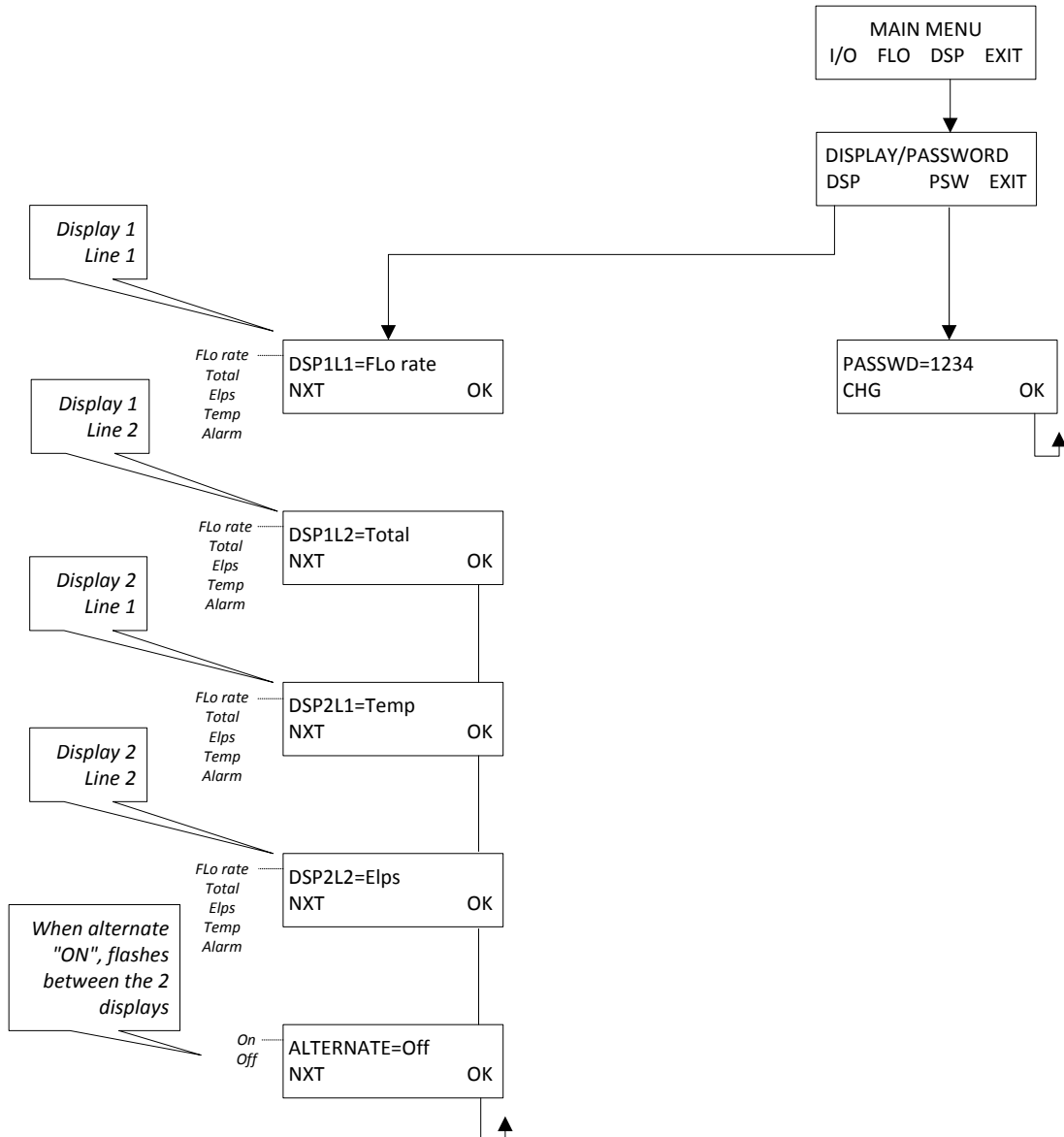


Fig. 1.4: TM500 Menu Tree - Flow Menu 2



- These alarms can be used without the digital output assigned to the alarm.
- If that is the case, the alarm status will only be shown on the display, through serial communication or BioView™.
- If the digital output is assigned to an alarm, changing the value here will change that setting.
- A value of 0 disables the alarm.

Fig. 1.5: TM500 Menu Tree - Display Menu



NOTE! All readings updated every second

- Flo Rate = Flow rate of process gas
- Total = Total flow of process gas
- Elps = Elapsed time since reset of flow total
- Temp = Temperature of process gas
- Alarm = Notification of errors; diagnostic errors

Fig. 1.6: TM500 Menu Tree - TM-Cal™ Menu

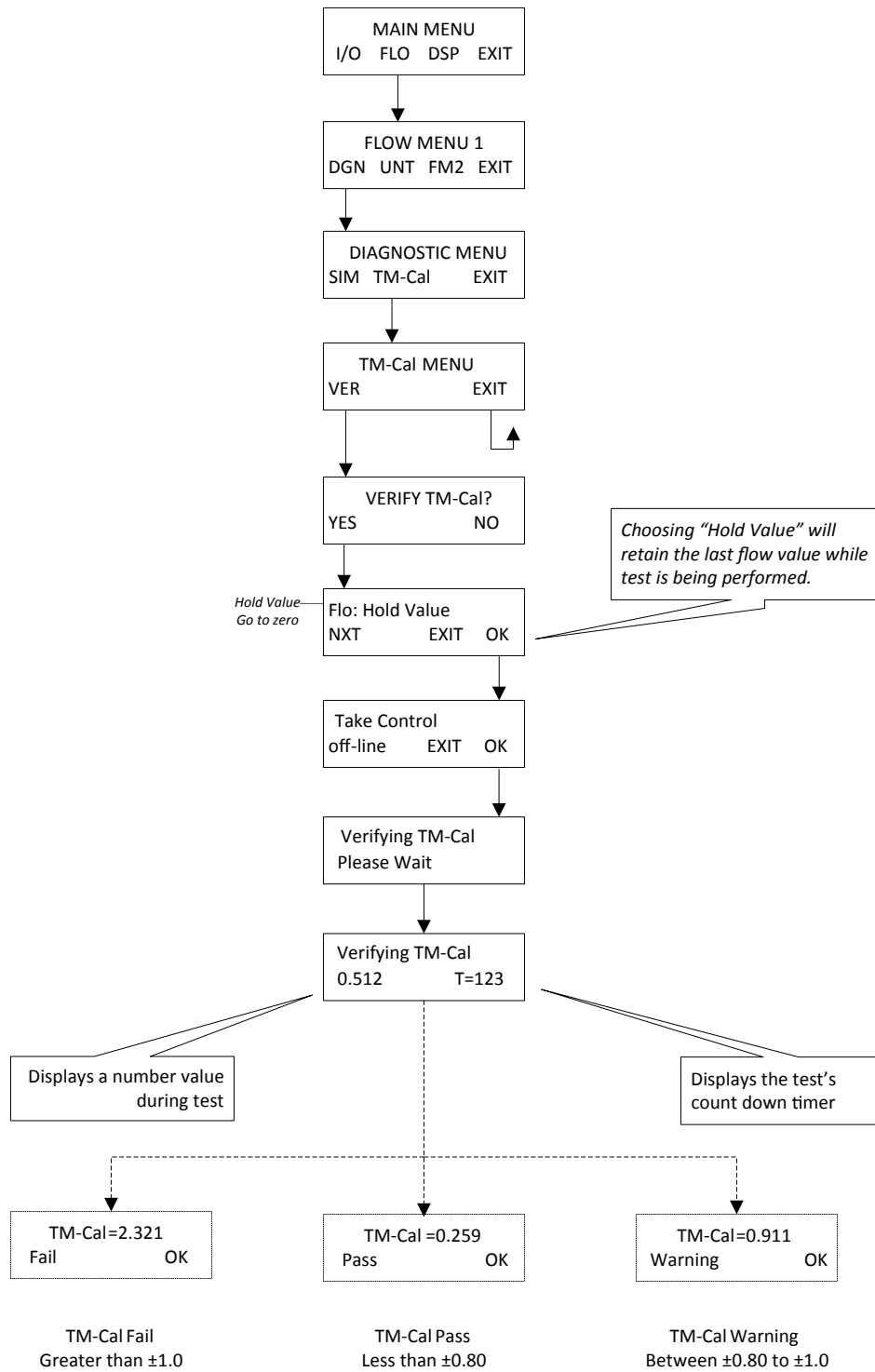
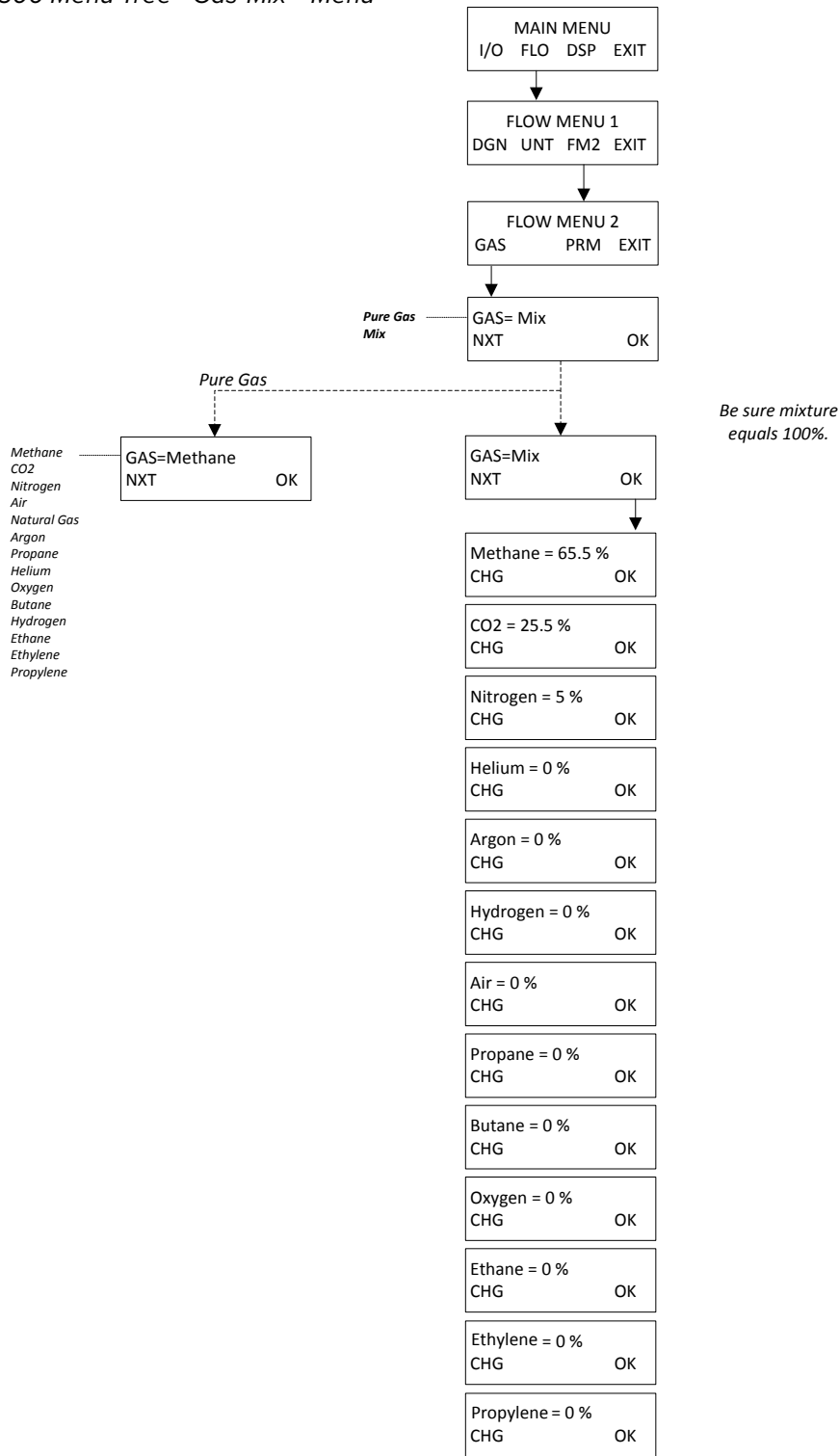


Fig. 1.7: TM500 Menu Tree - Gas-Mix™ Menu



Err: Mix= 96%
CHG

OR

Gas Mix 100%
CHG OK

Shows only if gas mix does not equal 100.0%.

Shows only if no error is detected. Pressing OK allows exit to menu.

Fig. 1.8: TM500 Menu Tree - Engineering Screens

Press F1 and F2 at the same time to enter the Engineering Screens
 Press F4 to return to normal mode

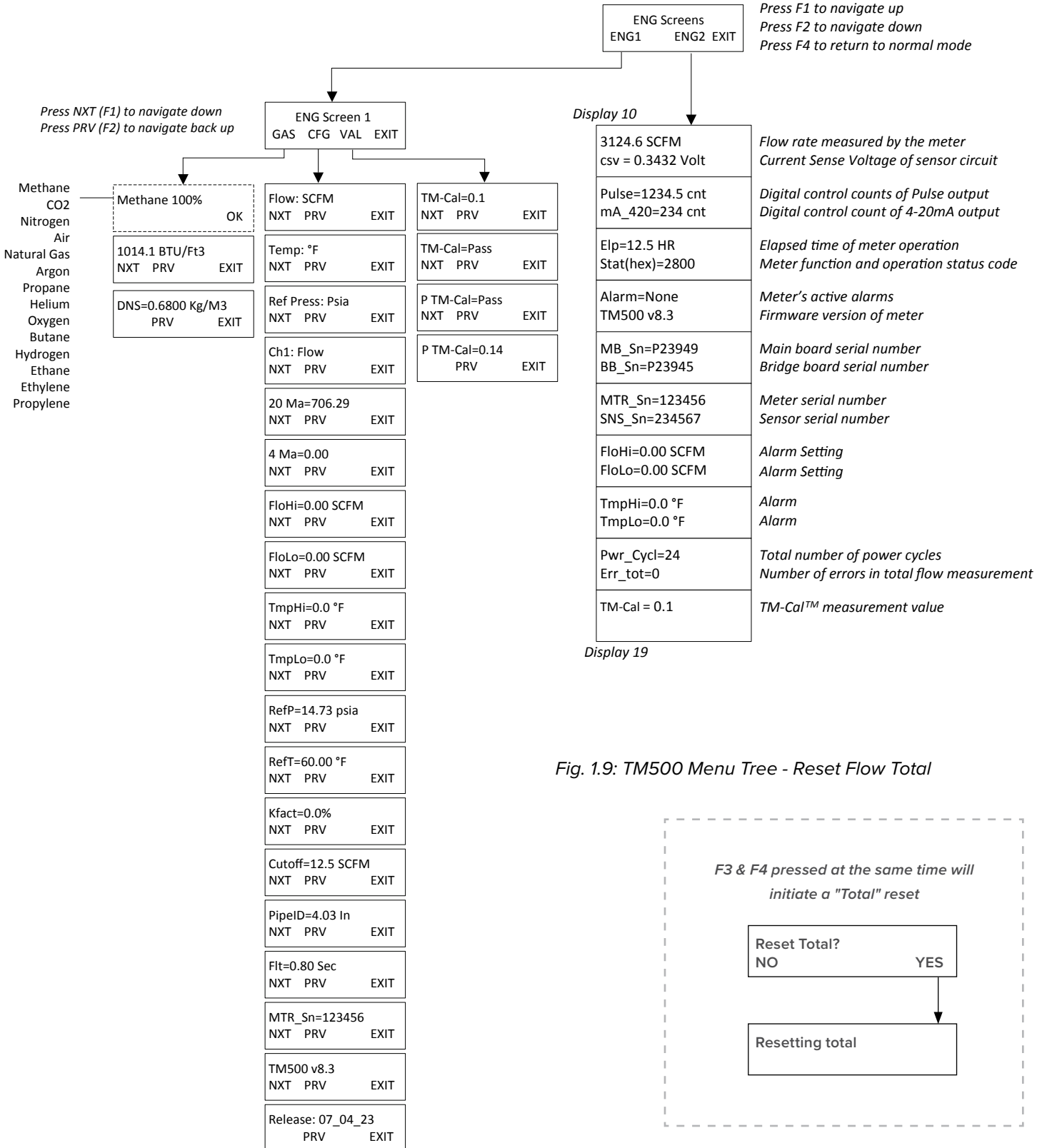


Fig. 1.9: TM500 Menu Tree - Reset Flow Total

Welcome

Thank you for purchasing the TM500 Thermal Gas Mass Flow Meter from Sierra Instruments. The TM500 is one of the most technically advanced flow meters in the world. Extensive engineering effort has been invested to deliver advanced features, accurate measurement performance and outstanding reliability.

This instruction manual contains the electrical and mechanical installation instructions as well as details for programming, maintaining and troubleshooting the meter. This manual is divided into the following sections: Introduction, Installation, Wiring, Operation, Communications, Maintenance, Appendices, Definitions, and Index.

Theory of Operation

The TM500 is an innovative thermal mass gas flow meter and temperature transmitter. It is microprocessor-based and field programmable. The TM500 thermal sensor operates on the law that gases absorb heat. A heated sensor placed in an air or gas stream transfers heat in proportion to the stream's mass velocity. There are two sensor elements. One sensor element detects the gas temperature and a second element is maintained at a constant temperature above the gas temperature. The energy transferred from the heated element is proportional to the mass flow velocity. The TM500 flow meter maintains accurate flow measurement over a large temperature and pressure range.

Mass Flow

The TM500 measures mass flow; an advantage over other flow meters which measure volumetric flow rate. Volumetric flow is incomplete because temperature and pressure are unknown and must be measured separately. For example, the mass flow of a gas depends on its temperature and pressure. As temperature and pressure changes, the gas volume changes but not its mass. Therefore a device measuring mass flow is independent of temperature and pressure changes. The TM500 provides a direct measurement of gas flow in Mass units (kg/hr, lb/hr), standard units (SCFM, SLPM) or normal units (NM³/hr, NLPM) with no additional temperature or pressure measurements required.

Calibration Validation

Validate the calibration of the TM500 in the field using the TM-Cal™ test. The goal of Calibration Validation is to provide operators with the ability to verify that the meter is capturing accurate data at scheduled recalibration times - or at any time - instead of sending the meter back to the factory for recalibration. By performing TM-Cal™ in the field, operators can verify that the meter is running accurately by testing the functionality of the sensor and its associated signal processing circuitry. This test can be done in the pipe under normal process conditions.

Flow Calibration

Every Sierra Instruments flow meter is set to the customer's configuration at the factory using an App ID which is generated by the on-line configurator. The App ID specifies the gas type, flow range, serial communication and other settings in the meter. If these settings match the final customer application, the meter is ready to use. Sierra maintains instrument calibration data on every flow meter. Calibration files include details on process conditions, customer gas, line size and other information. All NIST-traceable equipment utilized for the calibration procedure is identified on the Calibration Certificate, which is sent with every flow meter.

I/O Description

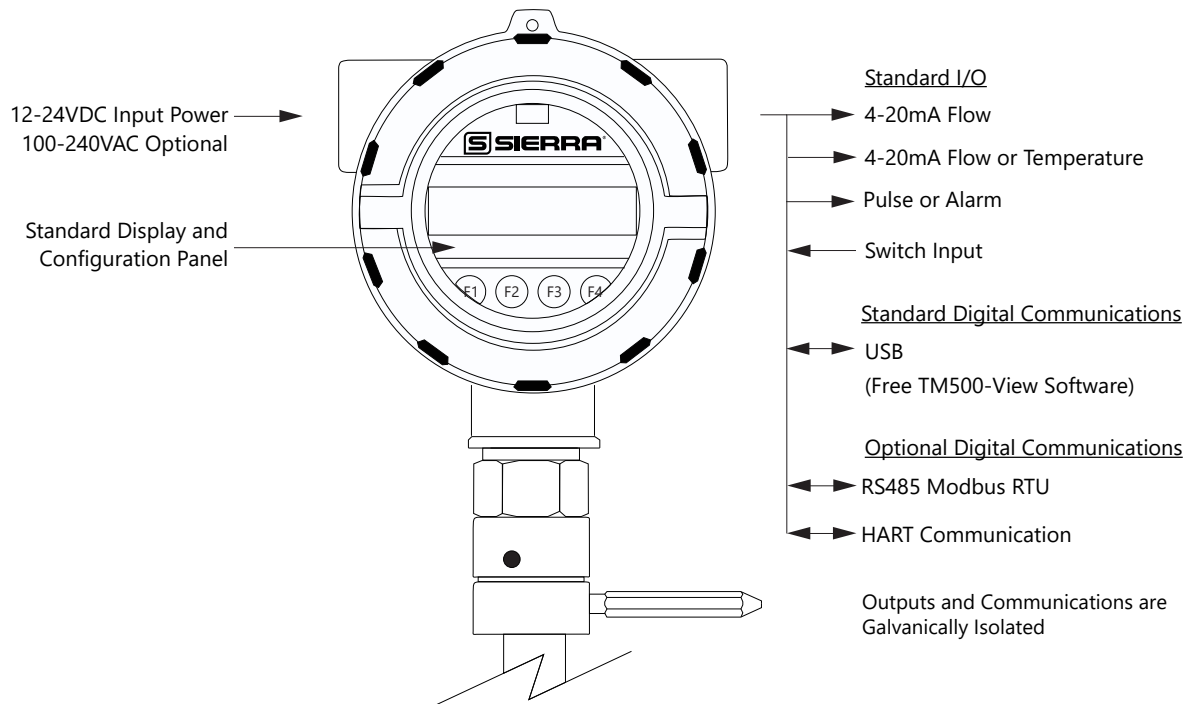
The TM500 features two galvanically isolated 4-20mA analog outputs, HART communication (optional), a pulse output, switch input and Modbus RTU (RS485) (optional). There is also a USB port for interfacing with a laptop or computer. The first 4-20mA output can be used for HART communication. The second 4-20mA output can be configured for flow rate or process gas temperature and can be scaled by the user. The pulse output can be used for pulse or alarm and is programmable to represent flow rate. The switch input can be configured to reset the flow totalizer and elapsed time.

TM500-View™ software interfaces to the USB port and is a free Sierra Instruments PC-based software program that displays flow meter readings and permits flow meter configuration. The software is available for download on the Sierra Instruments website.

TM500 Functional Diagram

An on-board 2 line x 16 character backlit LCD display shows flow rate, total flow, elapsed time, process gas temperature, and alarms. The display is also used in conjunction with the Configuration Panel for field configuration of flow meter settings such as gas selection, 4-20mA scaling, pulse output scaling, pipe area, flow cutoff, flow filtering, display configurations, diagnostics, communication parameters, and alarm limits.

Fig. 1.11: TM500 Function Diagram



Installation Scope

This section describes how to install the Sierra Instruments Model TM500 Flow Meter:

For TM500 Insertion Types:

1. Determine lateral position on the pipe
2. If moisture or condensation may be present in the gas, consider the radial orientation of the probe. See figure 2.2
3. Verify sensor installation depth
4. Determine sensor orientation in relation to sensor length and direction of flow
5. Determine if the display orientation must be changed
6. Ensure proper tightening of compression fitting for mounting meter

For TM500 Inline Types:

1. Determine lateral position on the pipe
2. Flow body orientation in relation to direction of flow in pipe
3. Changing the display orientation.
4. Proper tightening of compression fitting

Installation procedures must be performed using a combination of the end user's best engineering practices, in compliance with local codes, and with manufacturer's recommendations.



General Precautions

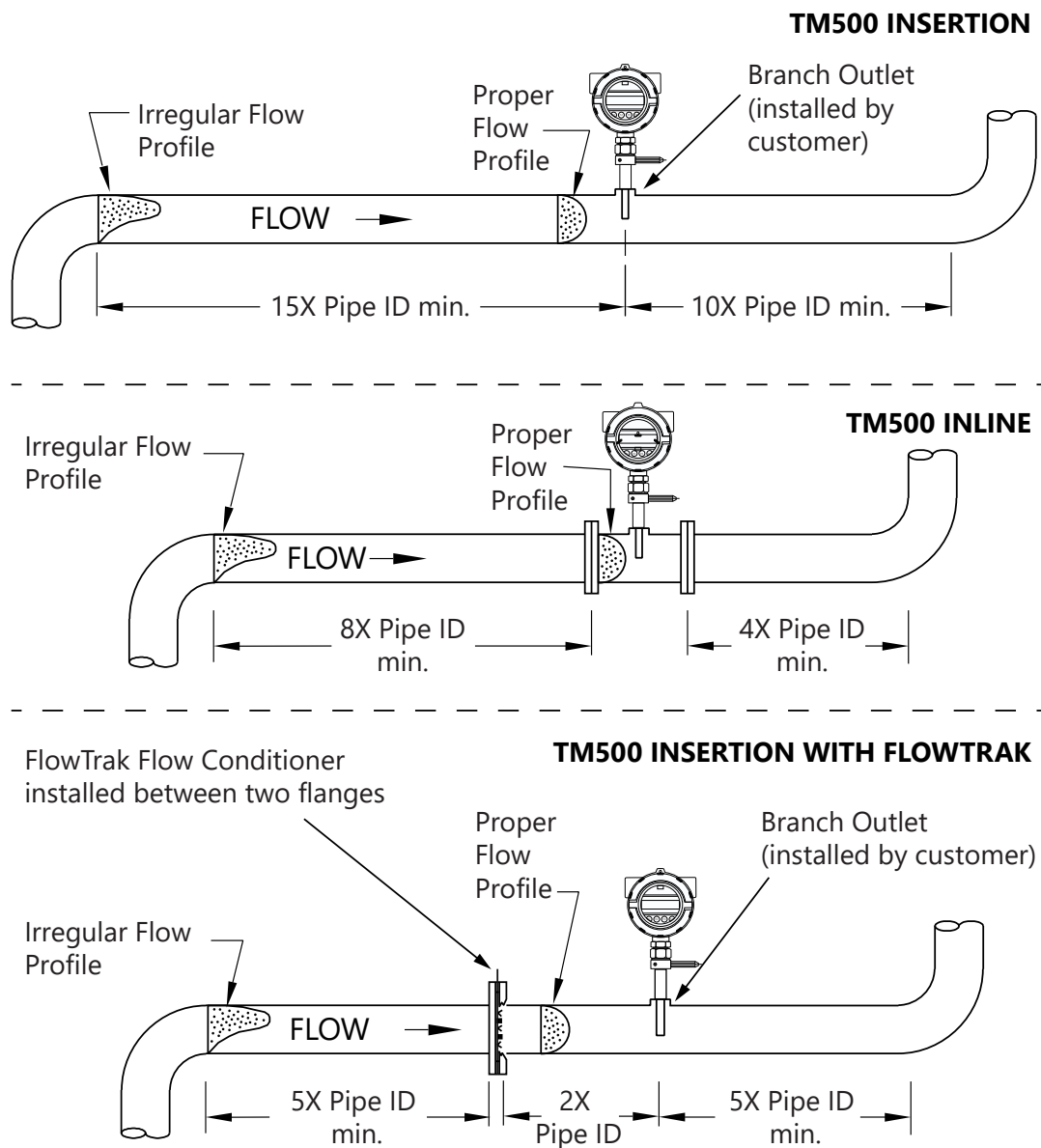
The following general precautions should be observed:

1. Exercise care when handling the flow meter to avoid damaging the probe, sensor or enclosure.
2. Close any unused conduit openings in the enclosure with plugs certified for your application.
3. The enclosure cover must be closed except during configuration or during installation.
4. Mounting TM500 in direct sunlight can cause the temperature inside the enclosure to increase beyond design limits, resulting in failure of LCD display and reduced component life. It is recommended that a sunshade be installed to avoid direct sunlight (see maximum enclosure operating temperature specification).
5. Ensure the flow direction indicator/pointer for the meter is in line with the direction of flow in the pipe.
6. Do not install the TM500 enclosure near an igniter, igniter-controller or switching equipment.
7. Do not install an external power supply in a cabinet containing an igniter controller or switching equipment.
8. For accurate flow measurement, review flow meter placement instructions before installation to ensure a proper flow profile in the pipe.
9. For safety reasons, Teflon ferrules are only appropriate for applications with pressures of 60 psig or less. At higher pressures, use of a Teflon ferrule risks unwanted probe movement or ejection of the probe from the pipe. For all applications above 60 psig, the standard stainless steel ferrule is required.

Instructions for Flow Meter Lateral Placement

Install the TM500 flow meter so that it is far enough away from bends in the pipe, obstructions, or changes in line sizes to ensure a consistent flow profile. See Fig. 2.1 below for your meter type.

Fig. 2.1: Upstream and Downstream Pipe IDs for Insertion and Inline Flow Meters



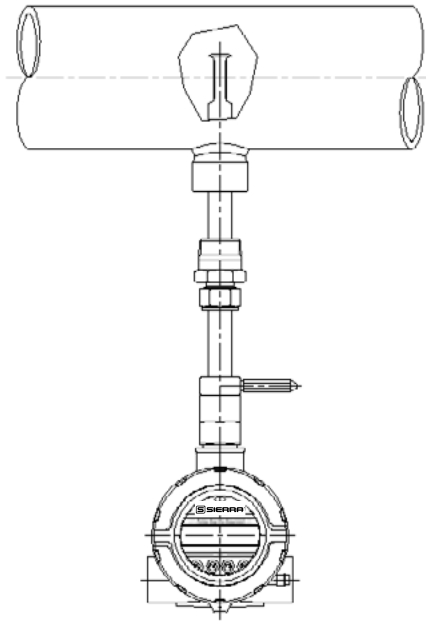
i NOTE!

- Pipe ID = Inside Diameter
- The probe diameter is $\frac{3}{4}$ "
- An irregular flow profile will affect sensor accuracy
- See FlowTrak installation instructions for more information

Radial Probe Position - Moisture in the Gas or Condensation

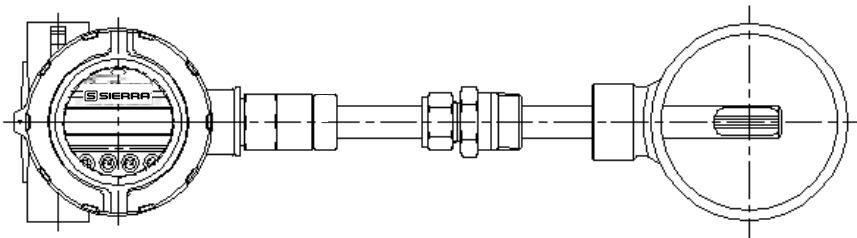
The radial position of the meter may help reduce collection of moisture on the sensor. Condensing liquids contacting the meter's sensing elements will disrupt accurate flow measurement. Sierra Instruments recommends the flow meter be used in dry gas conditions whenever possible for highest accuracy. Contact Sierra for further recommendations.

Fig. 2.2: Installation at 180°

**Alternate Installations - Vertical Pipes or Restricted Installation Spaces**

When restricted physical installation space exists, the TM500 can also be installed at other angles. Please note that the display and the enclosure orientation can be rotated in 90° increments.

Fig. 2.3: Alternate Installation at 90° (CCW)



Welding Branch Fitting to Pipe

The probe of the TM500 must be installed perpendicular to the pipe to measure flow accurately. Use the following steps to ensure that the branch fitting is correctly welded to the pipe.

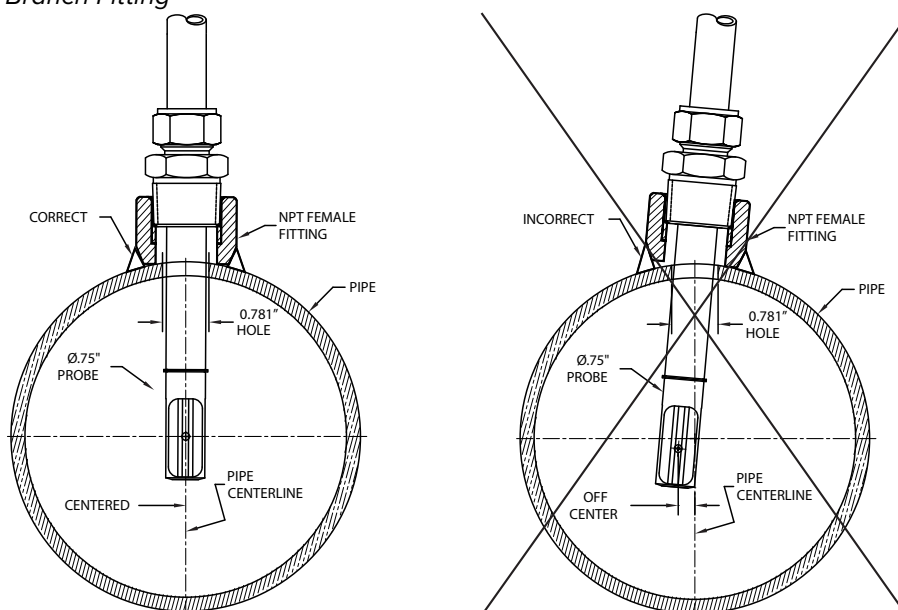
Directions:

1. Drill a 0.781" (25/32") hole through the wall of the pipe (1 wall only).
2. Assemble the hex nipple and branch fitting hand tight onto the probe of the TM500.
3. Insert the probe into the hole in the pipe and use the TM500 probe and compression fitting to align the branch fitting with the hole and the probe perpendicular to the pipe.
4. Tack-weld the branch fitting carefully onto the pipe.
 - Before welding the fitting completely, verify the probe is aligned to the center of the pipe and the hole is centered in the branch fitting (see Figure 2.4).
5. To verify that the correct hole position has been achieved, carefully slide the 0.75" sensor in and out of the branch fitting and 0.781" hole.

WARNING! Do not force the 0.75" sensor through the 0.781" hole. Forcing it through the 0.781" hole can damage the probe.

6. Verify that the temporary weld of the branch fitting positions the probe window on the pipe's centerline.
 - The picture on the right side of Figure 2.4 shows an incorrect welding of the branch fitting, causing the 0.75" sensor to be "off center".
7. Once the branch fitting is aligned properly, remove the 0.75" sensor from the branch fitting and finish welding. Then verify the probe is still aligned with the center of the pipe.
8. Set the depth of the flow meter (see "Fig. 2.5: Insertion Sensor Depth in Pipe" on page 26).
 - Do not tighten compression fitting until proper depth of flow meter is determined. See Fig. 2.5.

Fig. 2.4: Alignment of Branch Fitting

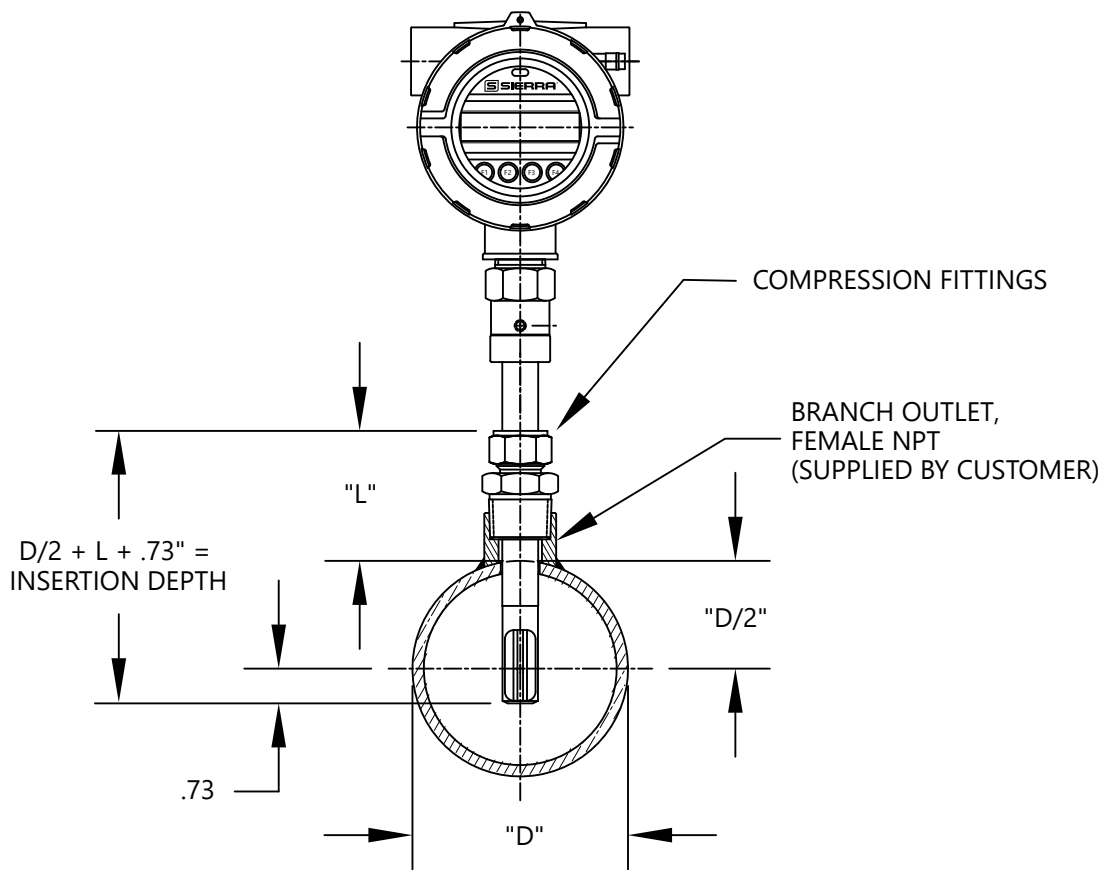


Installation Depth

The installation depth of the sensor in the pipe is dependent on the pipe size. To get the most accurate reading, proper placement of the sensor window within the pipe is necessary. As shown in Fig 2.5, the end of the sensor window should be 0.73" (18.5 mm) past the center line of the pipe. Review the dimensional drawing below with the following equation to calculate insertion depth: $L + D/2 + .73" = \text{insertion depth}$. Insertion depth is measured from the top of the compression fitting to the bottom end of the probe.

CAUTION! For a 1½" pipe, do not tighten compression fitting without 0.2" distance from wall or damage to probe will occur.

Fig. 2.5: Insertion Sensor Depth in Pipe

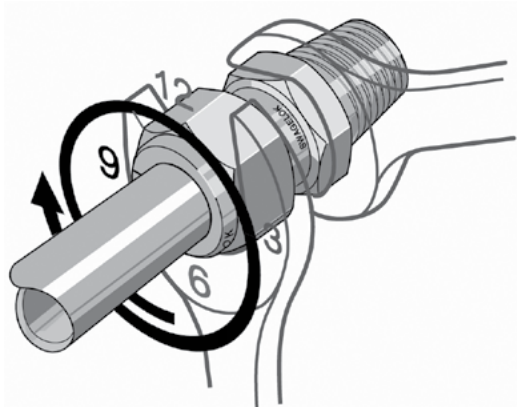


Mounting Instructions - Compression Fittings (TM500 Only)

The TM500 is mounted through a 0.781" hole and a female NPT branch outlet in the customer's pipe. Insertion style flow meters are not designed for use in pipes smaller than 1½".

- Install the compression fitting into the female NPT branch outlet.
- When installing in a 2" pipe or larger, install the end of the probe 0.73" (18.5 mm) past the center line of the pipe (refer to figure 2.5) .
- When installing into a 1½" pipe carefully install the probe into the pipe until it touches the opposite wall and pull back 0.2".
- Rotate the nut finger-tight.
- Further tighten the nut just enough until the tube will not turn by hand or move axially in the fitting.
- Mark the nut at the 6 o'clock position.
- While holding the fitting body steady, tighten the nut one and one-quarter (1 ¼) turns to the 9 o'clock position. See Figure 2.6.

Fig. 2.6: Proper Tightening of the Compression Fitting Nut



NOTE! Before removing a probe with compression fitting, mark the tube at the back of the nut, and mark a line along the nut and fitting body. Use these marks when reinstalling the probe. Reference the instructions on p. 28.

NOTE! When installing a probe with compression fitting that has been tightened previously, use the instructions on p. 28.

CAUTION! For a 1½" pipe, do not tighten compression fitting without 0.2" distance from wall or damage to probe will occur.

CAUTION! Once the stainless steel compression fitting ferrule is locked onto the probe, the probe can be removed or rotated, but the insertion depth is locked in place.

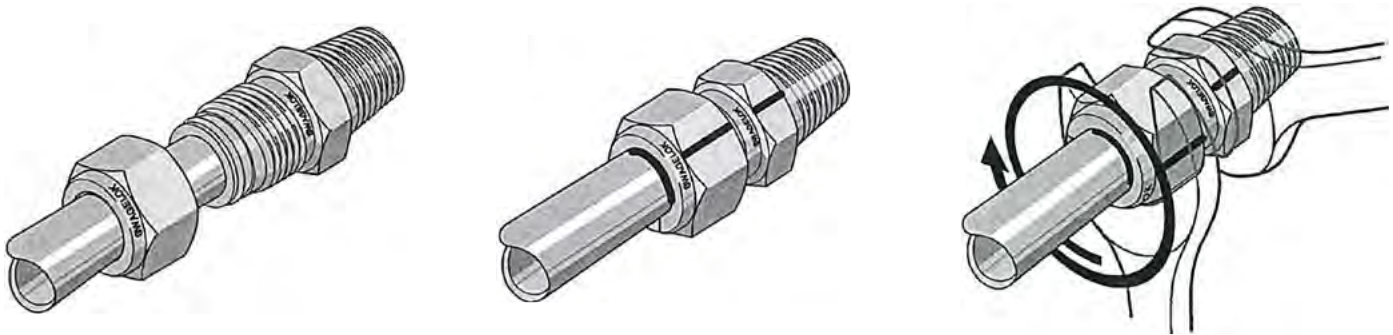
CAUTION! If the compression fitting is not properly tightened or the recommended pressure is exceeded, the fitting can slip on the probe and cause damage to the meter or bodily harm.

Mounting Instructions - Compression Fittings (Inline and Insertion Meters Previously Installed)

In cases where a compression fitting has already been swaged in an inline flow body or an insertion meter, use the following procedure.

- Carefully insert the probe with swaged ferrules into the fitting until the front ferrule seats against the fitting (see Figure 2.7).
- Verify that the probe is installed the correct depth in the pipe (refer to Figure 2.5 on p. 26).
- Rotate the nut with a wrench until the probe and nut are in their previously marked positions, or you feel a significant increase in resistance (see Figure 2.7).
- Tighten the nut slightly (approximately 1/8 turn).

Fig. 2.7: Proper Re-Tightening of the Compression Fitting Nut



CAUTION! Do not use a gap inspection gauge with reassembled fittings.

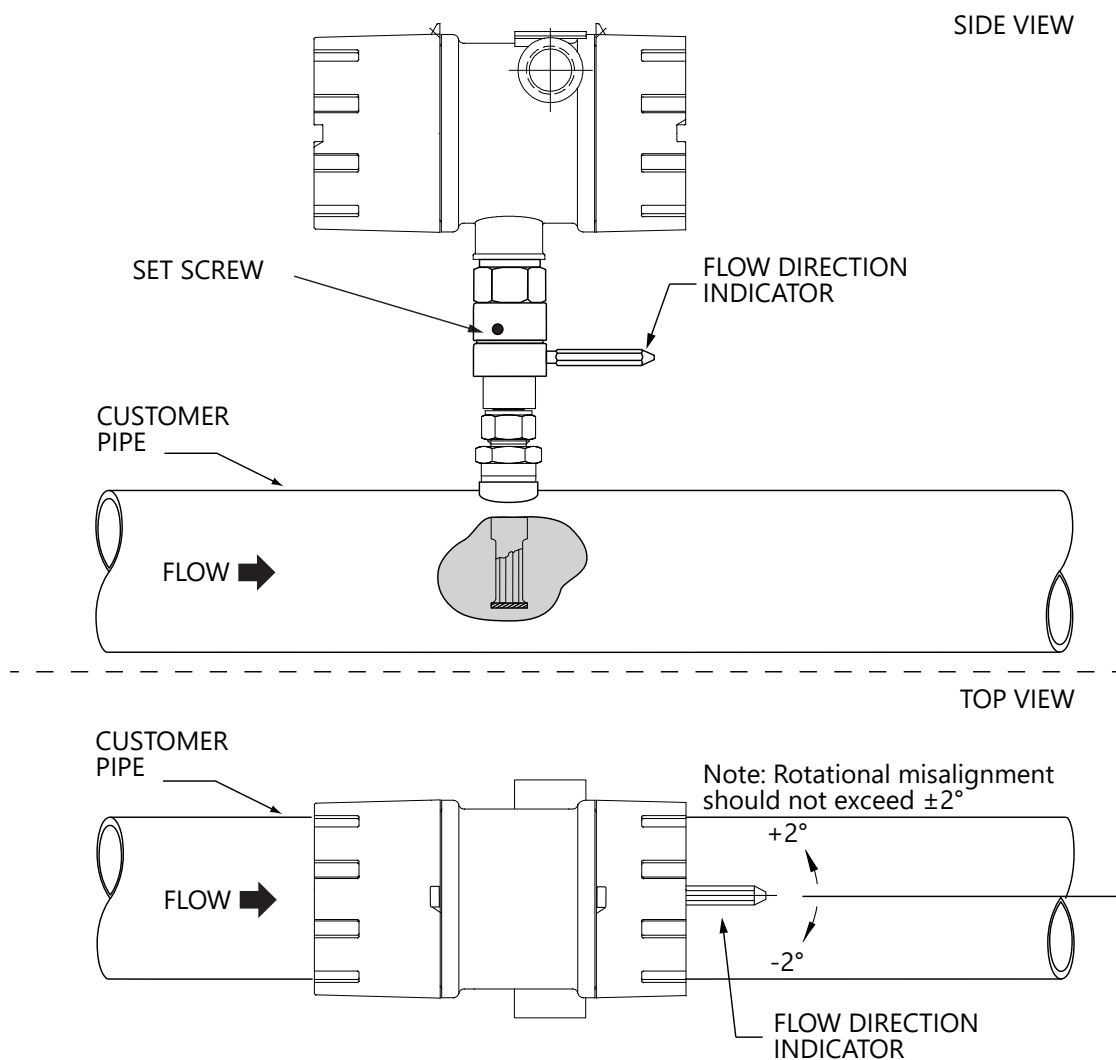
Rotating the Enclosure

The TM500 enclosure has been designed to allow the enclosure to rotate for optimal viewing of the display. To rotate the enclosure, first loosen the two set screws near the Flow Direction Indicator. Then rotate the enclosure into the desired position and tighten the set screws. Do not rotate the enclosure more than 360 degrees.

Direction of Flow and Orientation of the Probe

Install the meter with the flow direction indicator pointing in the direction of flow and centered on the middle of the pipe. The rotational misalignment of the flow direction indicator must be less than 2 degrees.

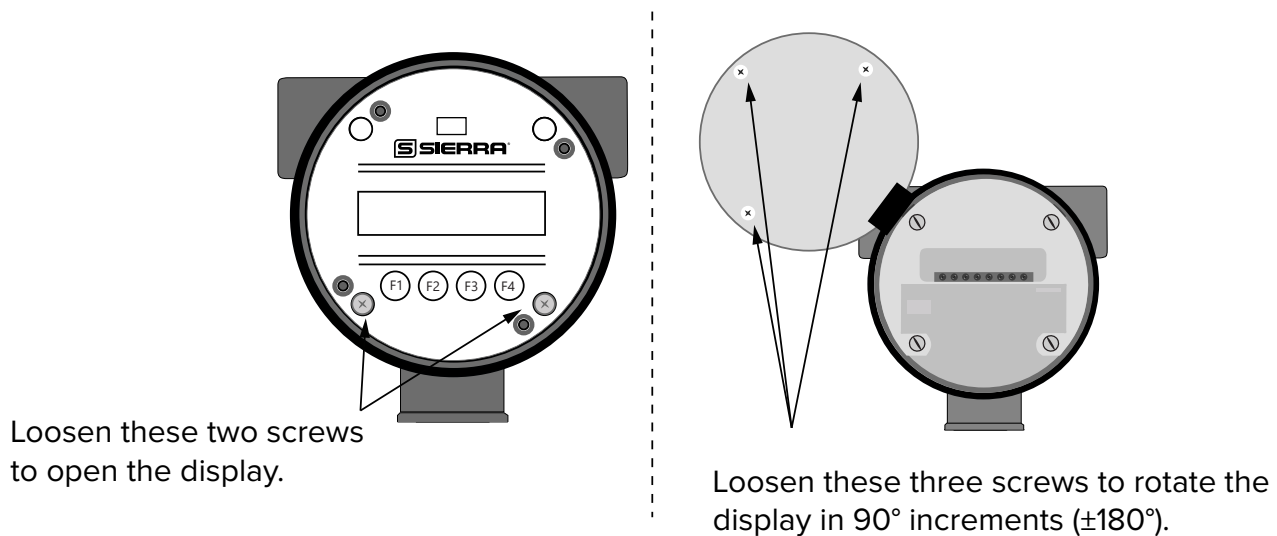
Fig. 2.8: Orientation of Flow Meter



Changing the Orientation of the TM500 Display

The display can be rotated in 90° increments for optimum viewing of the screen. First, open the enclosure by unscrewing the enclosure cap and loosen the two captive screws to open the display assembly. Detach the display board from the metal shield by loosening the three screws on the back of the round shield. Rotate the display board to the desired orientation. Ensure that the display cable is routed flat and straight through the display hinge to prevent binding. Reattach the display board to the metal shield by tightening the three screws. Close the display assembly and secure it to the enclosure with the two captive screws. Finally, install the enclosure cover back on the front of the enclosure.

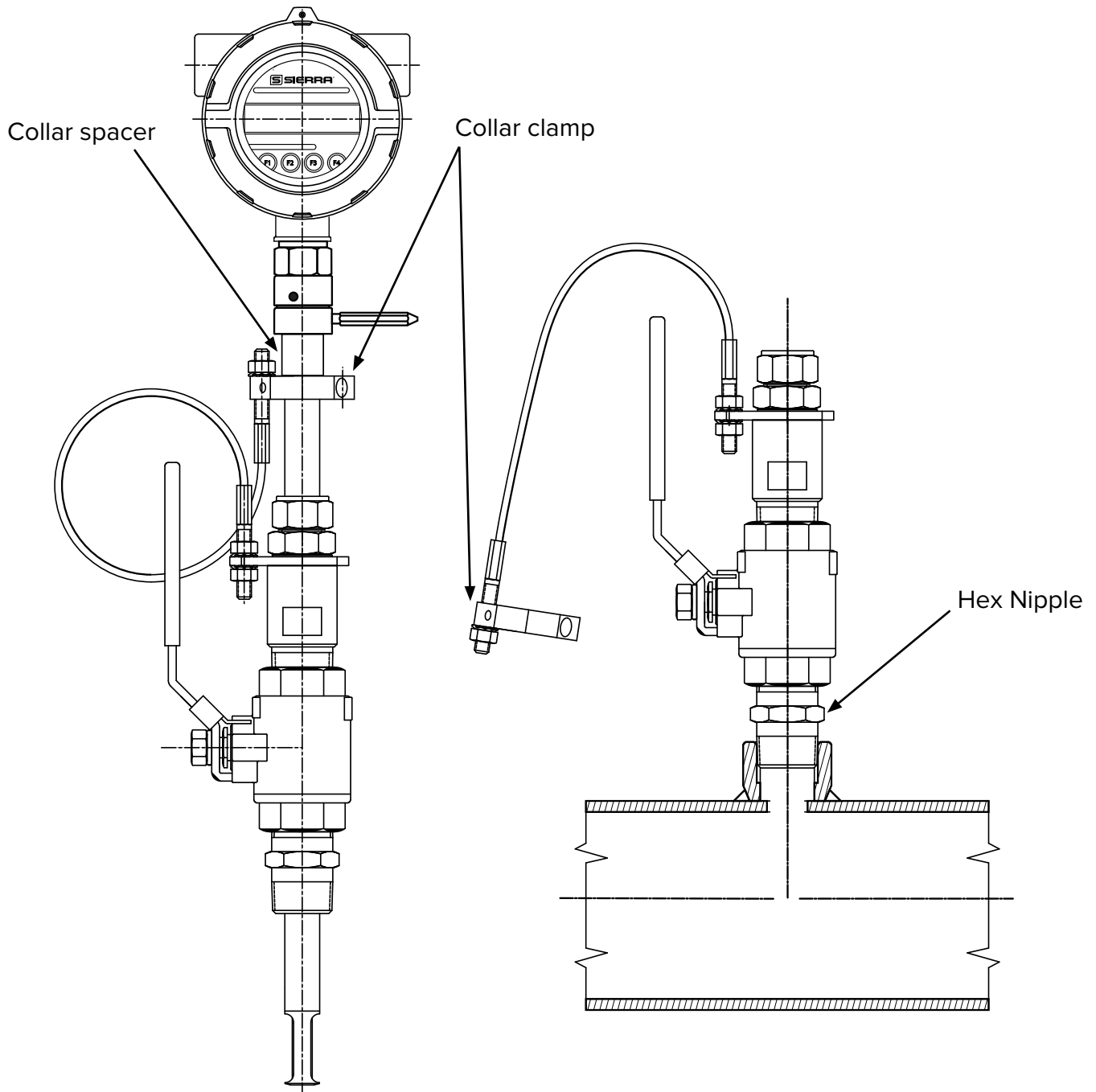
Fig. 2.9: Rotating the Display Orientation



Installation of a New Retractor Assembly

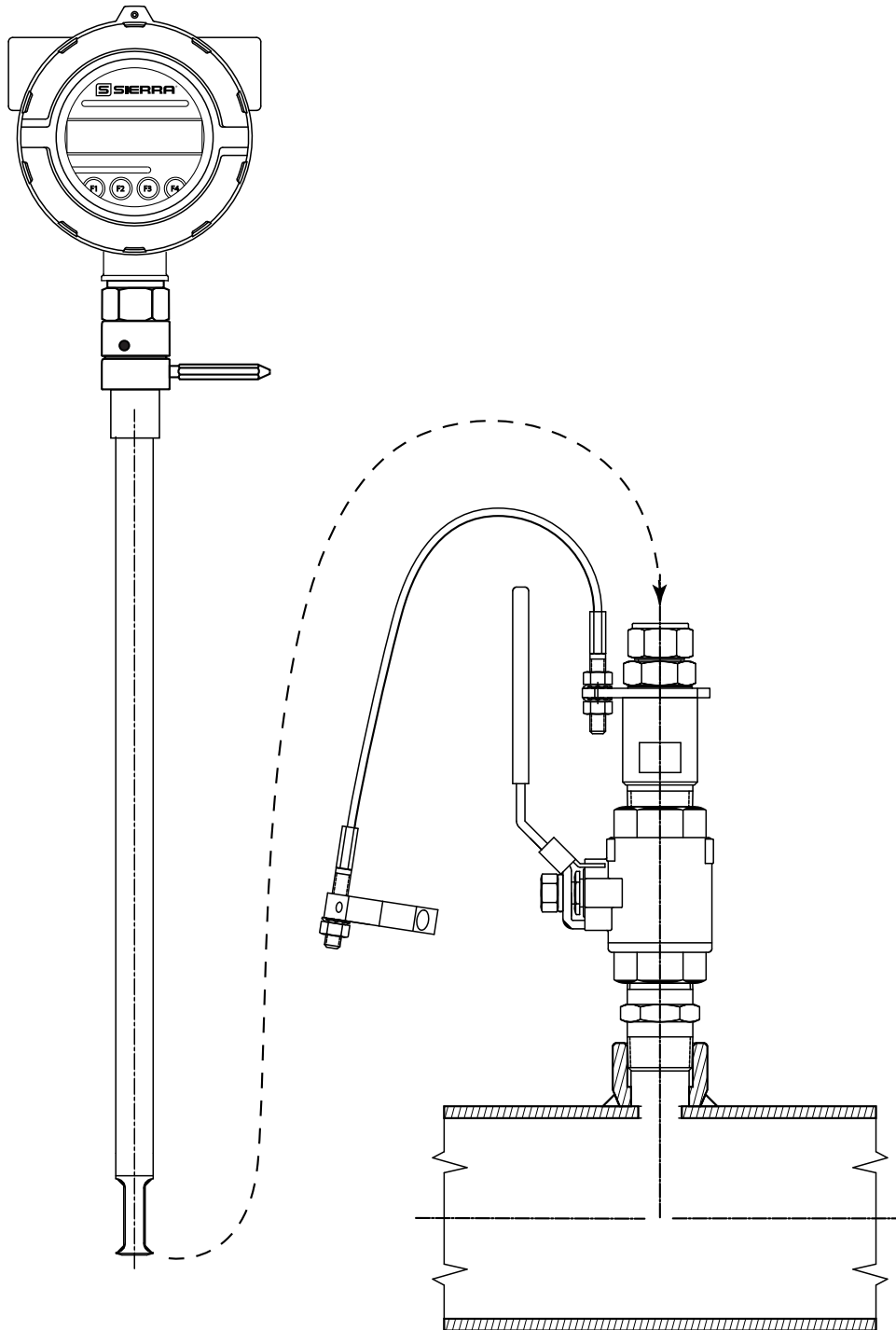
1. Remove collar clamp from probe using a 3/16" Hex Key.
2. Remove meter probe from retractor assembly and leave the ball valve open. Keep the collar spacer on the probe so it is not misplaced.
3. Install the valve assembly on the pipe, by tightening the Hex Nipple with a 1 3/8" wrench.

Fig. 2.10: Retractor Assembly With and Without Probe Installed



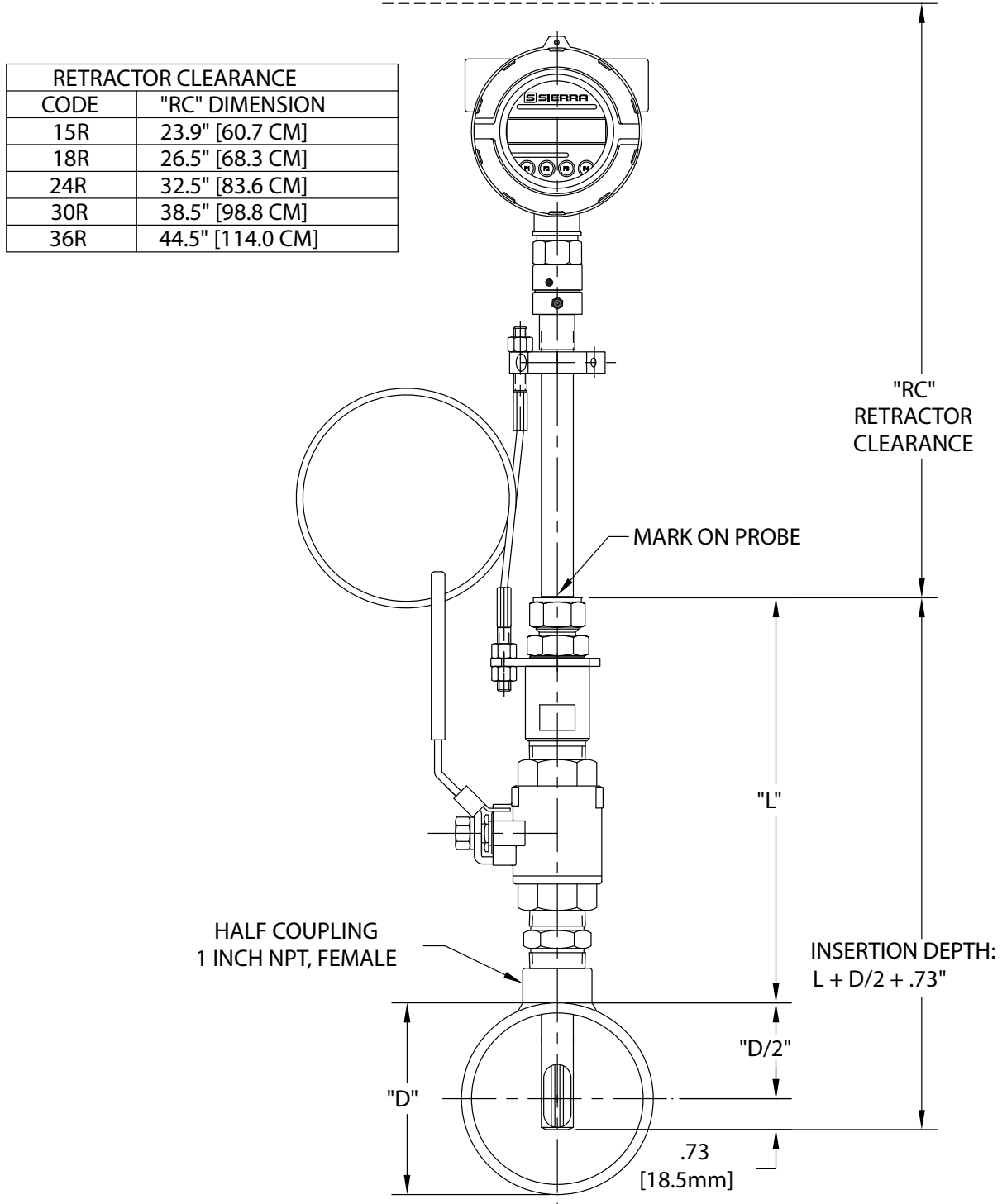
4. Carefully slide the probe through the retractor assembly and through the hole to see if there is interference by touching the pipe wall with the end of the probe on the far side or until the probe cannot go deeper. Remove the probe. Remove the retractor and rework the hole, if required.

Fig. 2.11: Verify Probe Insertion



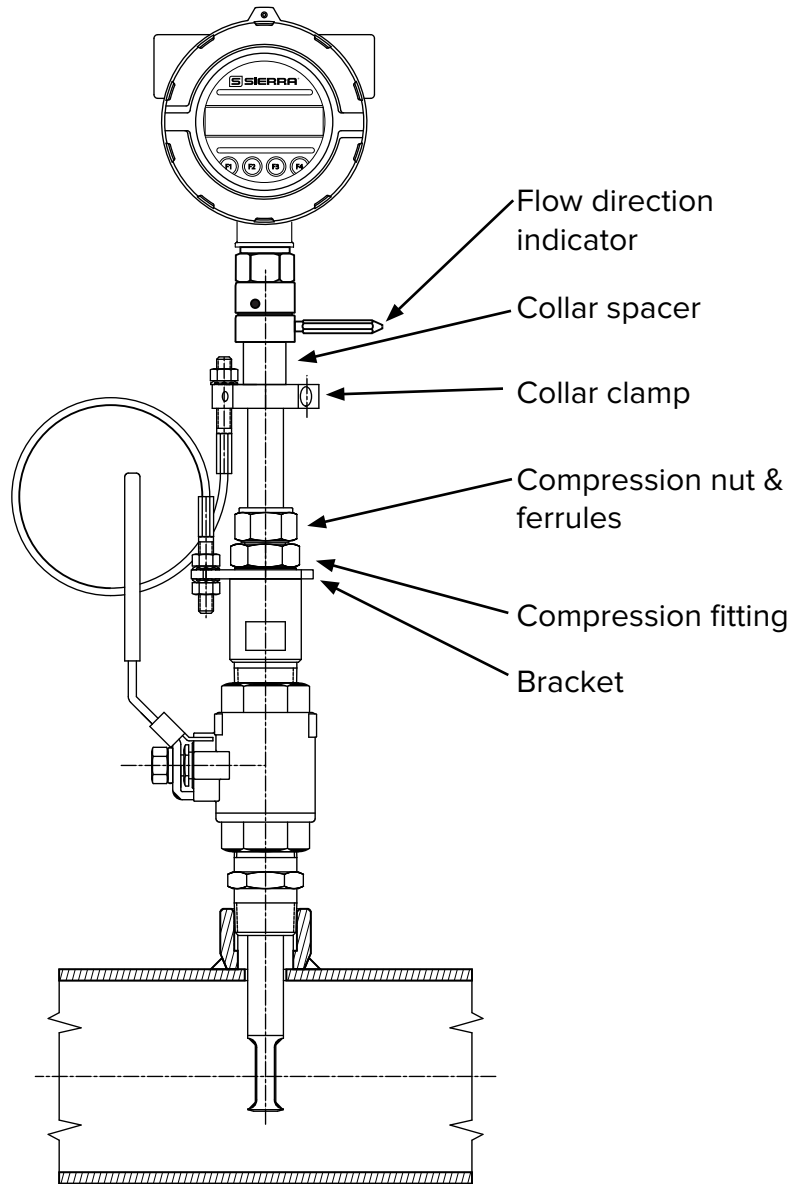
5. Using the equation $(L + D/2 + 0.73")$ from Figure 2.12, calculate the insertion depth and mark on the probe while measuring from the end of the probe.
6. The Retractor Clearance table of Figure 2.12 lists the space required to remove the meter from the retractor. Use the model code of your meter to determine the dimension.

Fig. 2.12: Determining and Marking Insertion Depth



7. Insert probe back into the retractor to the depth mark and hand-tighten the compression fitting. Make sure collar spacer is in place on the probe.
8. Verify that flow direction indicator is in line with pipe and in the direction of flow.

Fig. 2.13: Installed Retractor



9. Fully tighten compression fitting (refer to the instructions on p. 27).
10. Install collar clamp back on probe just below the collar spacer. Install collar so that the cable mounting hole is in line with the mounting hole on the bracket.



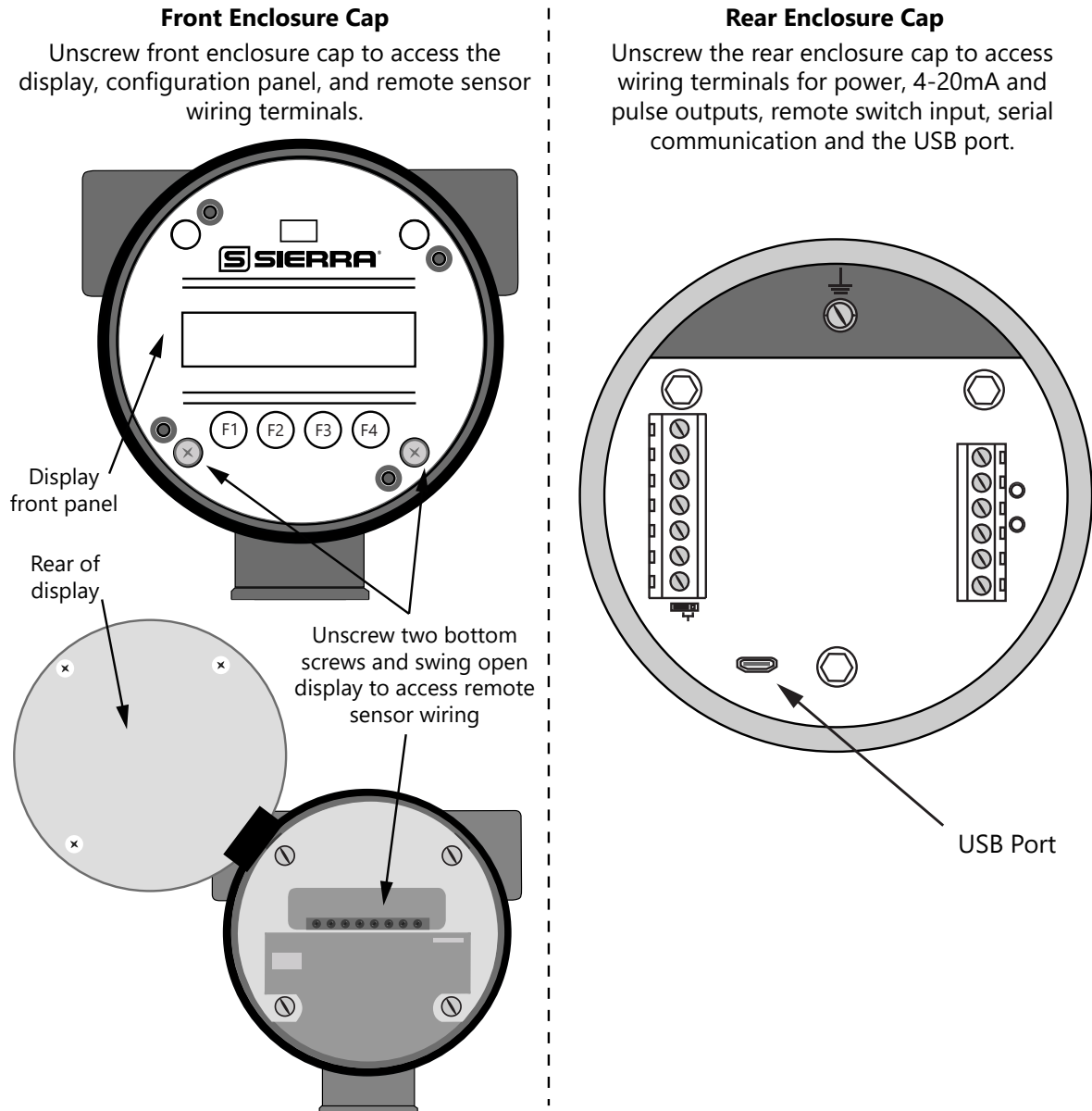
NOTE! For instructions on how to properly remove and replace the meter from a retractor, please refer to "Instructions for Removing and Inserting the Meter from a Pressurized Pipe using the Retractor" on page 90.

Wiring

Wiring Instructions

To wire the TM500 connect the power and signal wires to the terminal blocks according to the labeling and instructions on the following pages.

Fig. 3.1: TM500 Wiring Access



Cut all wires as short as allowable for a minimum service loop. Obtain the correct length for the TM500 wires using one of these methods:

- Conduit not connected to meter: 6" of wires exposed from end of conduit
- Conduit connected to meter: extend wire beyond enclosure face (w/o cover) +2.5"

**Wiring Precautions**

WARNING! DO NOT OPEN THE ENCLOSURE WHEN ENERGIZED OR AN EXPLOSIVE ATMOSPHERE IS PRESENT.

- Connect earth ground to a chassis ground screw on the inside of TM500 enclosure.
- All plumbing and electrical installations of flow meters must be in compliance with local codes, the end user's best engineering practices, and manufacturer's recommendations.
- Do not install the TM500 enclosure near an igniter, igniter-controller or switching equipment to eliminate the possibility of noise interference.
- Do not install an external power supply in a cabinet containing an igniter controller or switching equipment.
- This flow meter contains components that can be damaged by static electricity. You must discharge yourself by touching a grounded steel pipe or other grounded metal prior to working inside this flow meter.
- Close any unused conduit openings with suitable certified plugs

Power Wiring

For wiring the 12 to 24VDC or 100 to 240VAC power, use stranded copper wire. Twisted pair shielded cable is recommended for 12 to 24VDC power. Supply connection wiring must be rated for at least 90°C.

Grounding

The enclosure must be properly grounded with a quality earth ground. 16 gauge, stranded wire is recommended. For US and Canada installation, the internal ground terminal on the enclosure must be used. Use of the external ground terminal is optional.

Signal Wiring

For signal wiring, the recommended wire gauge is 18 to 22 AWG. Always use twisted pair shielded cable. Cable shields should be connected to a good earth ground at one end only.

Modbus Serial Communication Wiring

A shielded 22 to 18 gauge three conductor cable is recommended for Modbus communication wiring. Two of the wires in the cable should be twisted pair and used for the Modbus transmit and receive signals. The third wire is for the Modbus common signal. The shield drain wire of the cable should be connected to chassis or earth ground at the Modbus modem. Belden number 3106A or a similar type of cable is recommended, depending on the environment or temperature requirements of the application.

Remote Sensor Wiring

NOTE! Remote wiring is only required when the Remote Electronics option is provided.

NOTE! Serial Numbers: If you have more than one meter, you must ensure that the serial numbers of the probe/remote enclosure, electronics enclosure, and flow body match one another. These items have been manufactured and calibrated to operate as a unit and cannot be mismatched.

For remote sensor wiring use Belden number 5306FE or similar type of cable, depending on environment or temperature requirements of the application. Make sure that the cable length does not exceed 100 feet and the wire resistance does not exceed one ohm. Connect the cable shield at the remote enclosure end.

Power Input Requirements: 12 to 24VDC

External DC power supply must provide 12 to 24VDC (10 to 30VDC full input power range) at 6 Watts minimum.

With 12VDC power, the TM500 can use up to 500mA. With 24VDC power, the TM500 can use up to 250mA.

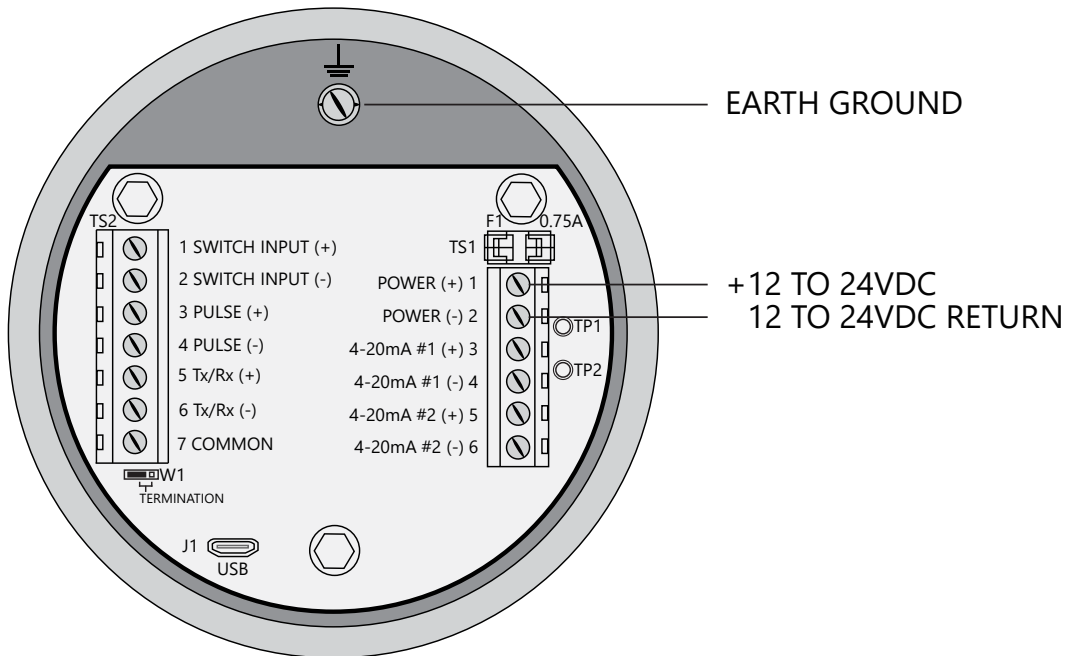
A 20 Watt or greater power supply is recommended to ensure it can provide enough current under all temperature, ventilation, and power on conditions.

The enclosure must be properly grounded with a quality earth ground. Sixteen (16) gauge, stranded wire, is recommended for earth ground.

For US and Canada Zones installations, the internal ground terminal on the enclosure must be used. Use of the external ground terminal is optional.

Connect the power wiring as shown in the diagram below.

Fig. 3.2: Connections for 12 to 24VDC Supply



CAUTION!

- Supply connection wiring must be rated for at least 90°C.

Power Input Requirements: 100 to 240VAC

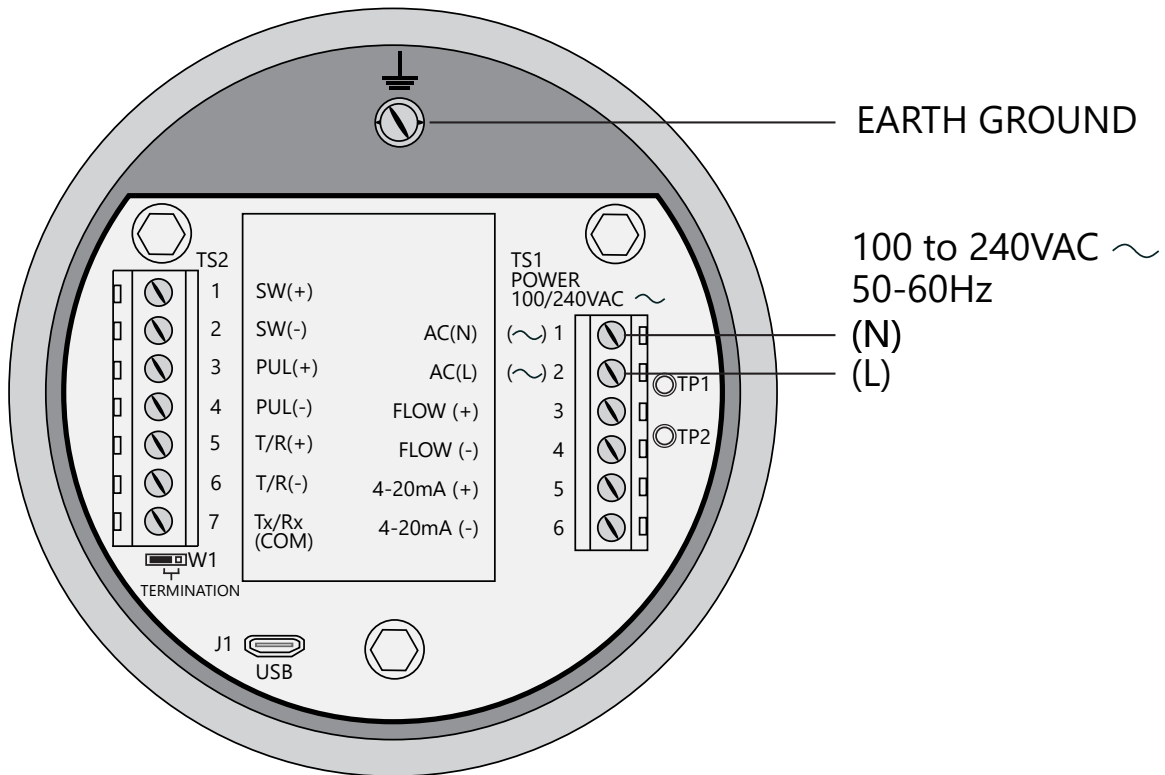
If the TM500 has the AC power supply option, the AC power must provide 100 to 240VAC at 7 Watts minimum.

Connect the power wiring to terminals TS1 pins 1 and 2 as shown in the diagram below.

The enclosure must be properly grounded with a quality earth ground. Sixteen (16) gauge, stranded wire, is recommended for earth ground.

For US and Canada installations, the internal ground terminal on the enclosure must be used. Use of the external ground terminal is optional.

Fig. 3.3: Connections for 100 to 240VAC Supply



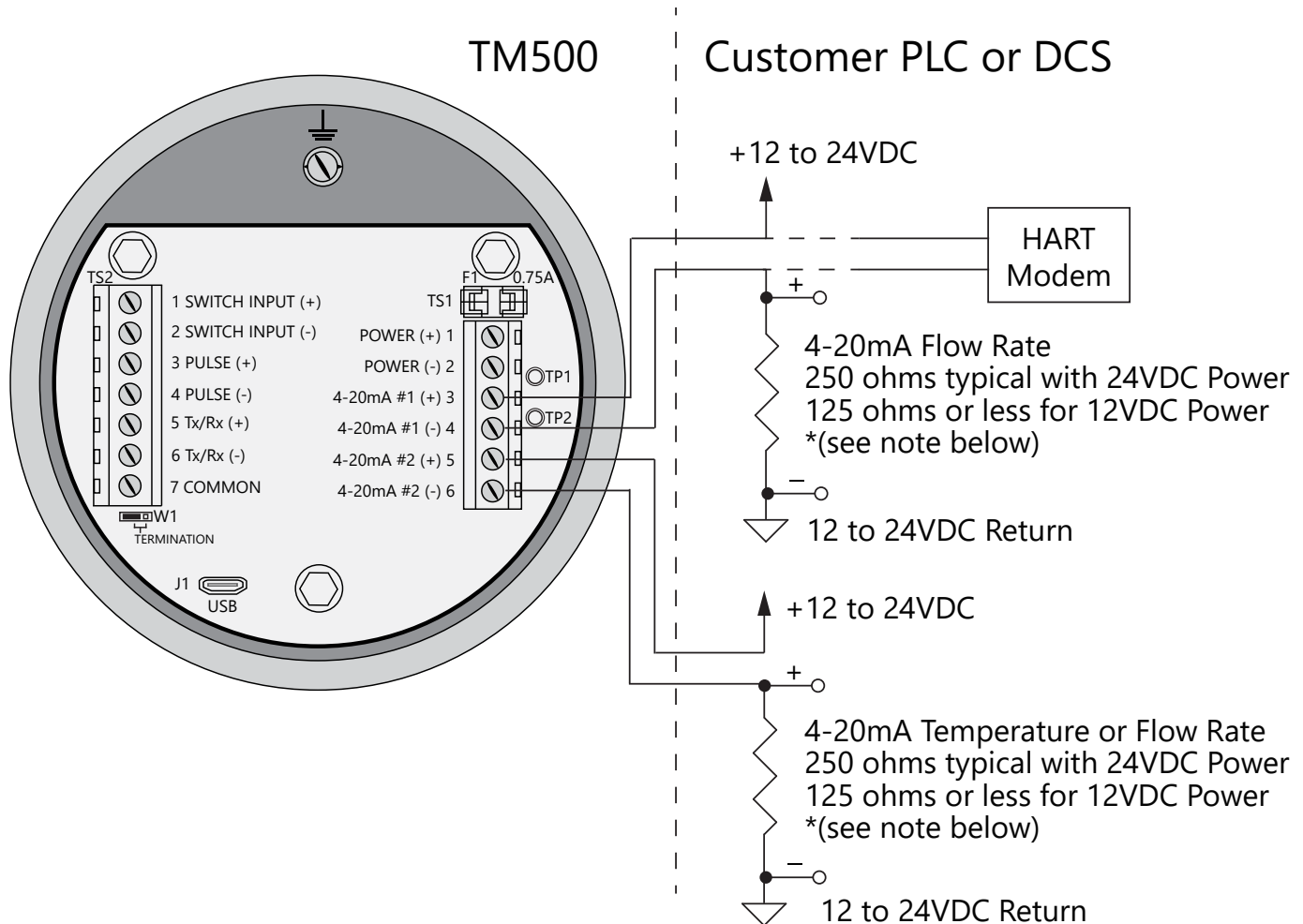
CAUTION!

- Supply connection wiring must be rated for at least 90°C.

4-20mA Output and HART Communication Wiring: Customer-Supplied Power Source (Recommended)

Bring the wiring in through either conduit hub. Connect the 4-20mA flow rate, 4-20mA temperature, and HART communication option wiring as shown in the diagram below.

Fig. 3.4: 4-20mA Output Wiring for Isolated Customer-Supplied Power Source



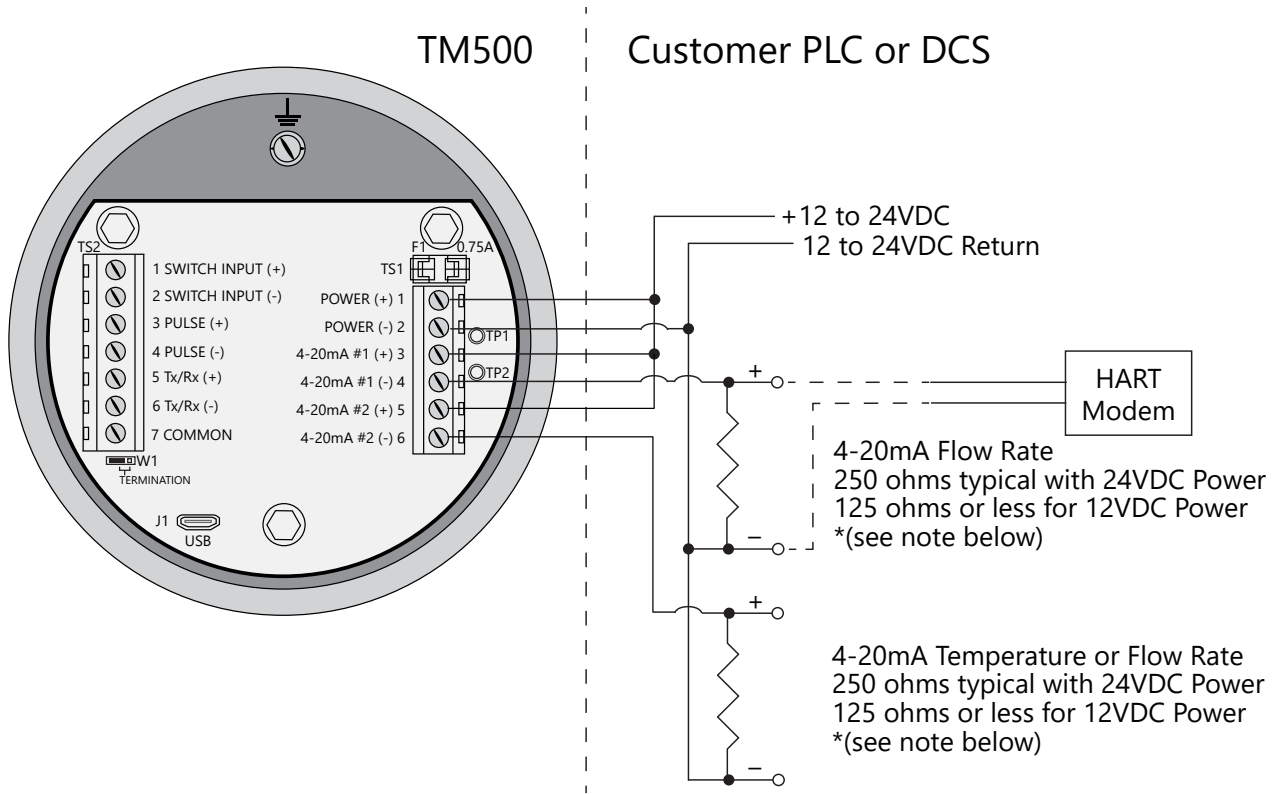
NOTE!

- When using a 12 volt power supply, the load resistor on the 4-20mA output must be 125 ohms or less to operate properly.
- When using 24 volt power, the load resistor is typically 250 ohms. A 250 ohm resistor in the 4-20mA circuit will result in a 1 to 5 volt signal to the PLC or DCS.
- When using a 24 volt power supply, the load resistor on the 4-20mA output must be 600 ohms or less.
- Some PLC and DCS equipment have built in load resistors, please refer to the technical manuals of such equipment.

**4-20mA Output and HART Communication Wiring: Loop Power Provided by TM500
(12 to 24VDC power option only)**

Bring the wiring in through either conduit hub. Connect the 4-20mA flow rate, 4-20mA temperature, and HART communication option wiring as shown in the diagram below.

Fig. 3.5: 4-20mA Output Wiring for Loop Power Provided by TM500



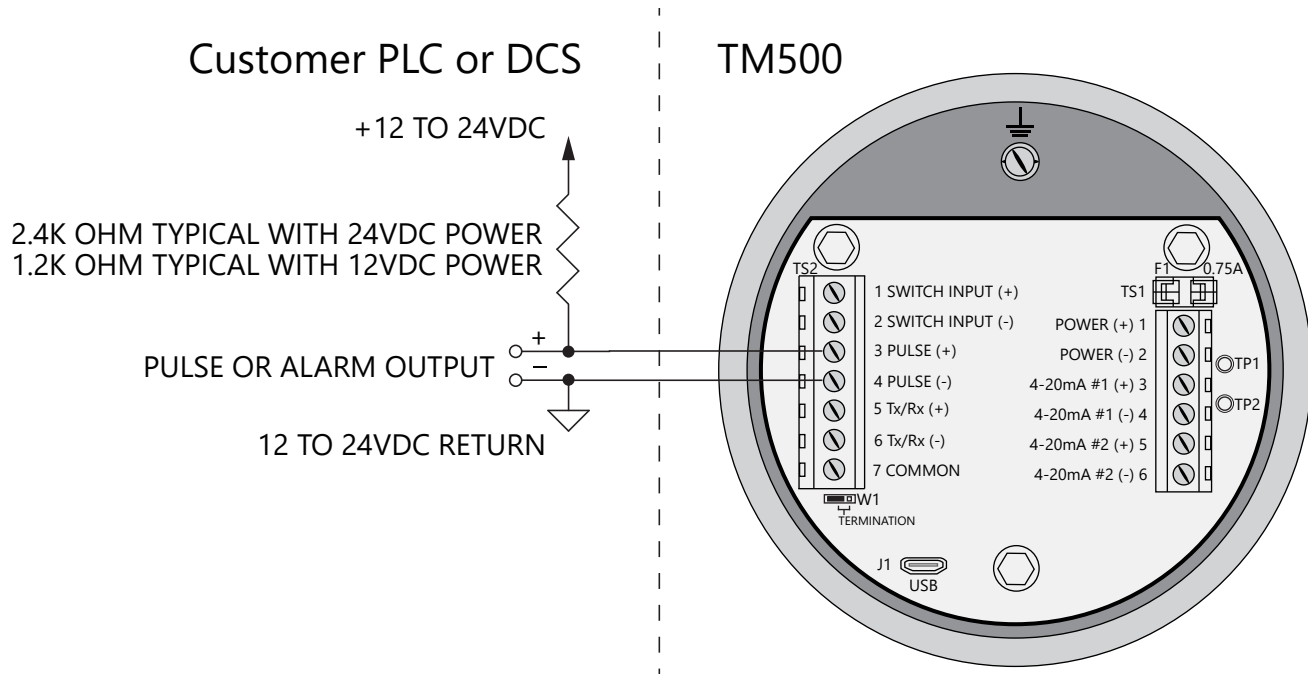
NOTE!

- When using a 12 volt power supply, the load resistor on the 4-20mA output must be 125 ohms or less to operate properly.
- When using 24 volt power, the load resistor is typically 250 ohms. A 250 ohm resistor in the 4-20mA circuit will result in a 1 to 5 volt signal to the PLC or DCS.
- When using a 24 volt power supply, the load resistor on the 4-20mA output must be 600 ohms or less.
- Some PLC and DCS equipment have built in load resistors, please refer to the technical manuals of such equipment.

Pulse/Alarm Output Wiring: Customer Supplied Power Source (Recommended)

Bring Pulse/Alarm wiring in through either conduit hub. Connect the pulse/alarm wiring as shown in the diagram below. The pulse/alarm output is an open collector circuit capable of sinking a maximum of 20mA of current. Pulse or alarm selection is programmed using the display or TM500-View Software™. Only one option, pulse or alarm, can be active at a time.

Fig. 3.6: Pulse/Alarm Output Isolated (Recommended)



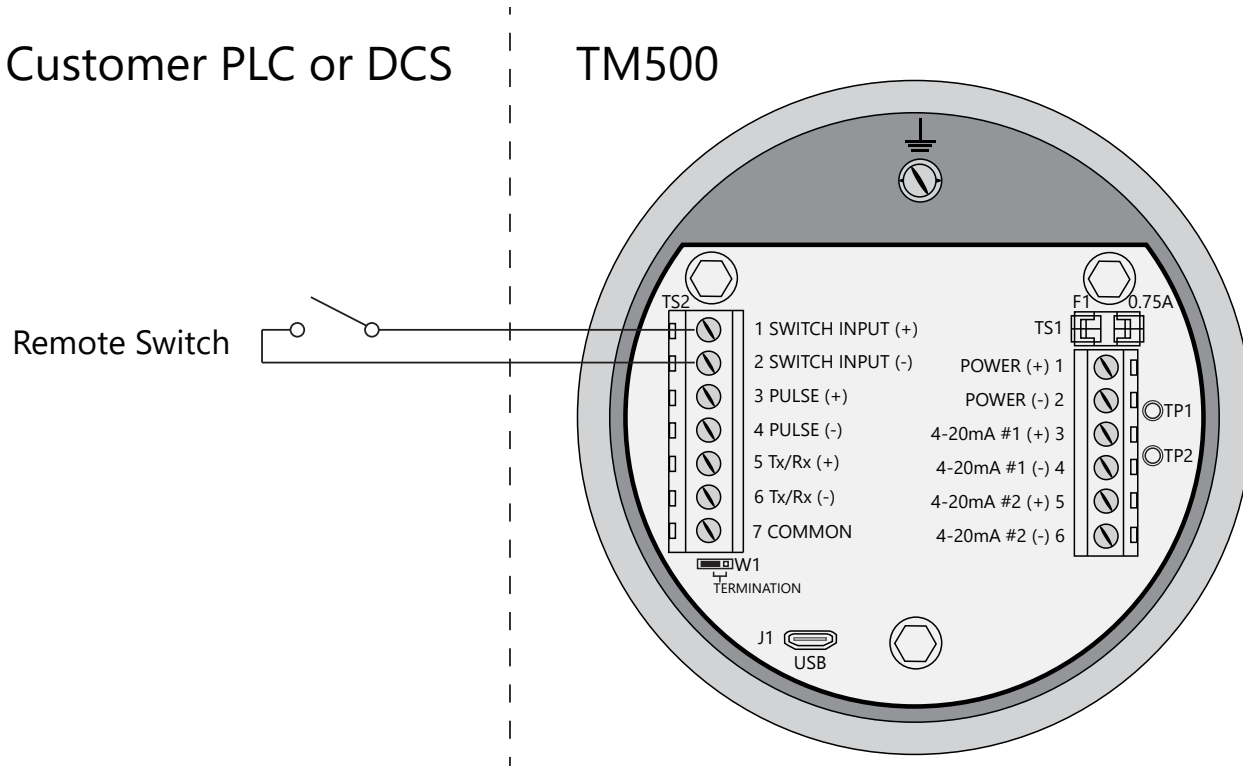
NOTE!

- The TM500 Pulse/Alarm output is typically used to drive digital circuitry or solid-state relays. The output of a solid state relay may, in turn, operate loads such as electromechanical relays or alarm indicators.
- The maximum load current of the Pulse/Alarm output is 20mA. Choose a load resistance that provides approximately 10mA with the power supply operating voltage.
- When the output is configured for Alarm and an alarm is not active, the output will be on (0 volts output). When an alarm is active, the output will be off (12 to 24 volts output).

Switch Input Wiring

A remote switch can be used to reset the Totalizer and elapsed time, if enabled in the programming settings. Connect the switch input wiring as shown in the diagram below.

Fig. 3.8: Switch Input Wiring



RS485 Wiring for Modbus RTU

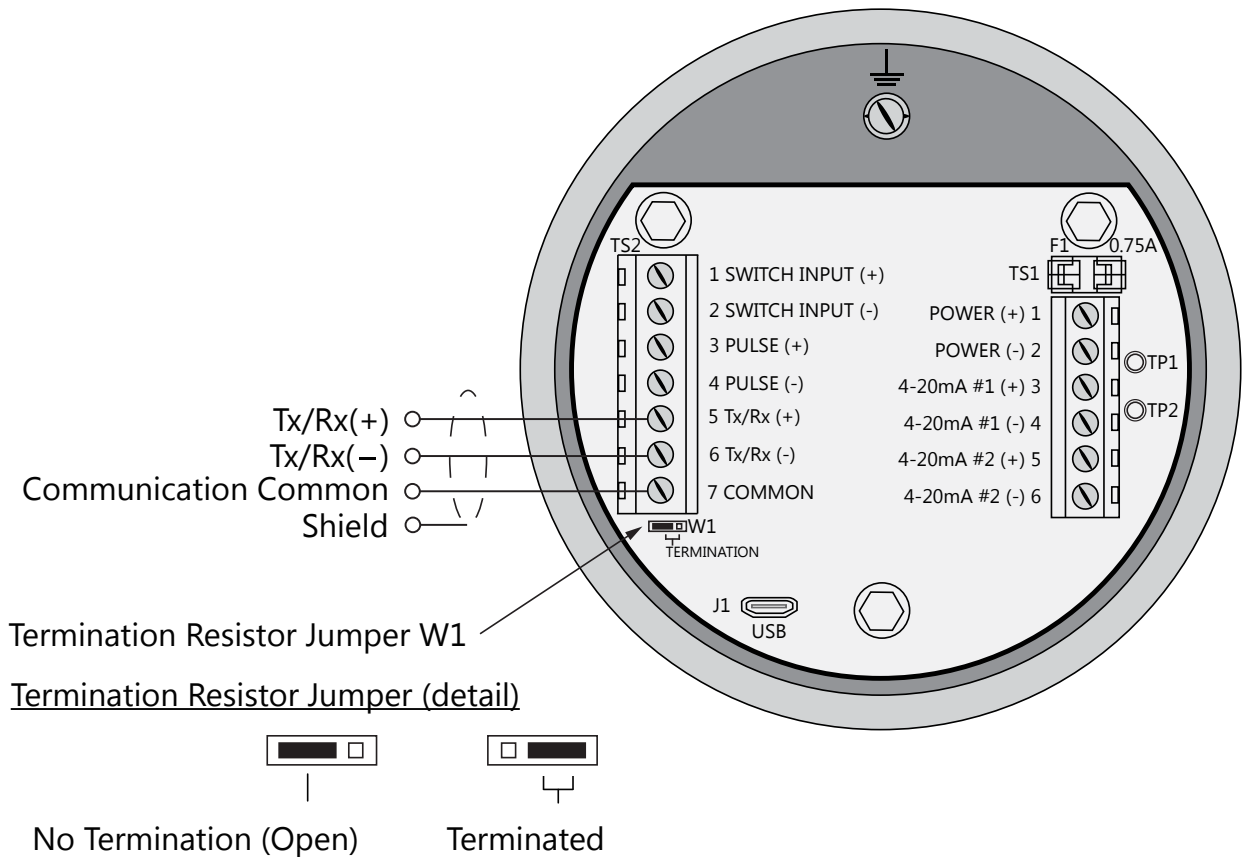
Wiring connections are made as shown in the diagram below for Modbus communication.

Termination Resistor

Connect a termination resistor across the receive/transmit signals of the last device on the communication line. To connect the 121 ohm termination resistor on the TM500, set jumper W1 to the TERM position.

Disconnect the termination resistor on all other external RS485 devices. The termination resistor of the TM500 is disconnected by setting jumper W1 to the "Open" position.

Fig. 3.9: RS485 Wiring



NOTE!

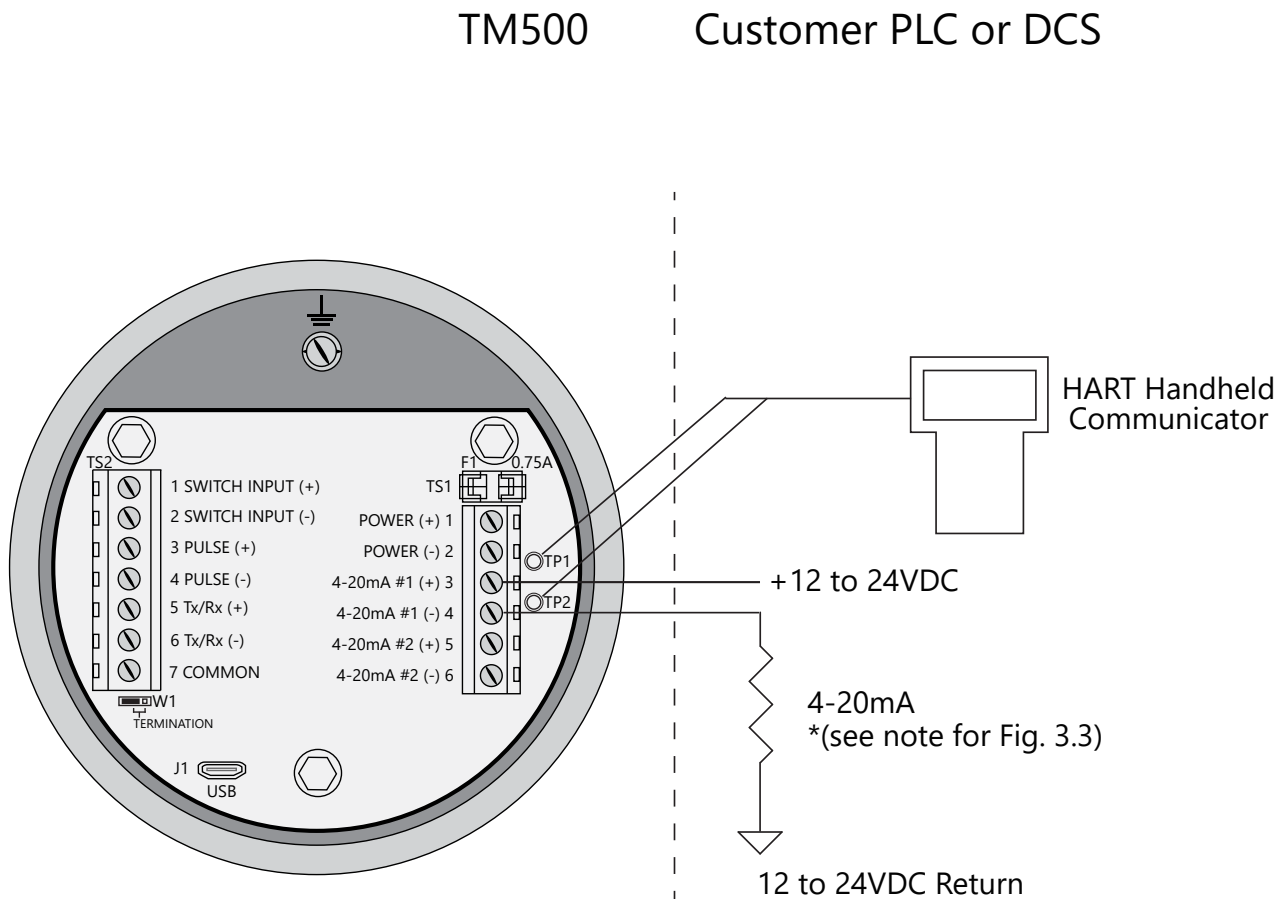
- W1 jumper will either be in the open or terminated position. It should be in the terminated position on the last meter in the series.

HART 4-20mA Output Wiring: Handheld Communicator

The 4-20mA current loop and HART modem connections are shown on p. 39 and p. 40.

A handheld HART communicator can be connected to test points TP1 (+) and TP2 (-) with clip leads or to the 4-20mA terminal block.

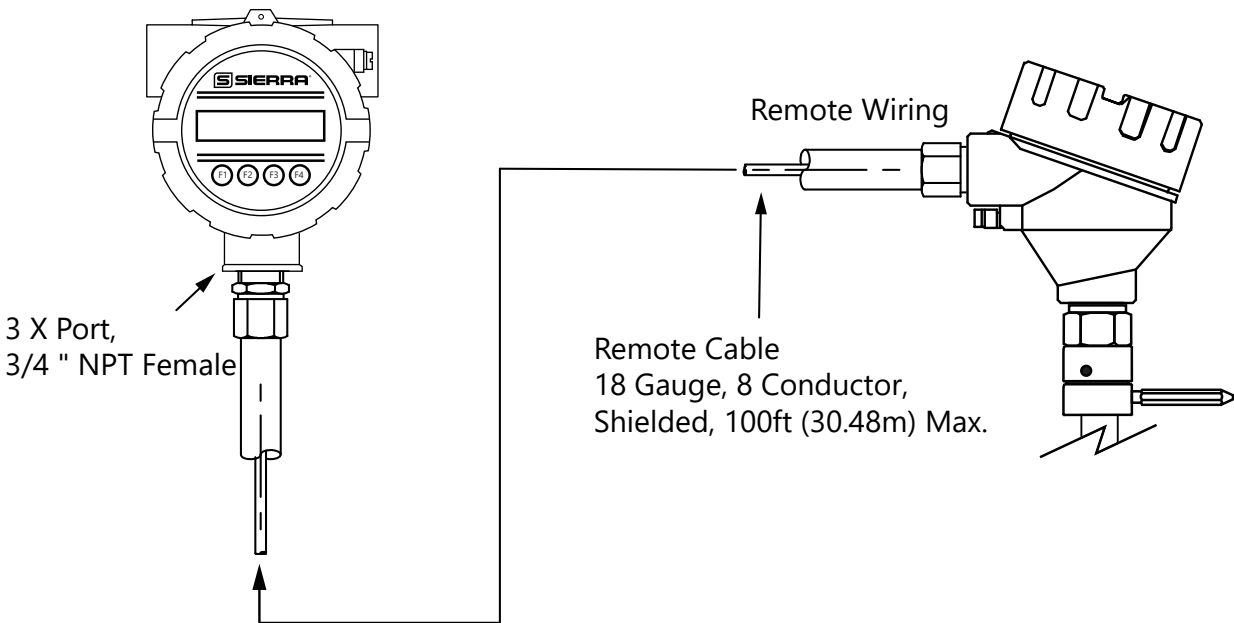
Fig. 3.10: HART 4-20mA Output Wiring, Handheld Communicator



Remote Wiring

Remote wiring is only necessary when the remote sensor option has been ordered.

Fig. 3.11: Remote Wiring



Use an extension cable to connect the TM500 remote sensor to the electronics enclosure.

Eight wire shielded cable required. The shielded cable should be run through a separate grounded steel conduit (no other cables or wires in the conduit). If you are using your own cable, make sure that the cable length does not exceed 100 feet and has a wire resistance that does not exceed one ohm (18 AWG recommended). The remote sensor wiring connections are shown on the following pages.

- NOTE!** Do not connect the cable shield at the electronics enclosure end. Connect the cable shield at the remote sensor terminal.
- NOTE!** The enclosures must be properly grounded with a quality earth ground. 16 gauge, stranded wire is recommended.
- NOTE!** Serial numbers: If you have more than one meter, you must ensure that the serial numbers of the probe/remote enclosure, electronics enclosure, and flow body match one another. These items have been manufactured and calibrated to operate as a unit and cannot be mismatched.

Fig. 3.12: Remote Sensor Wiring

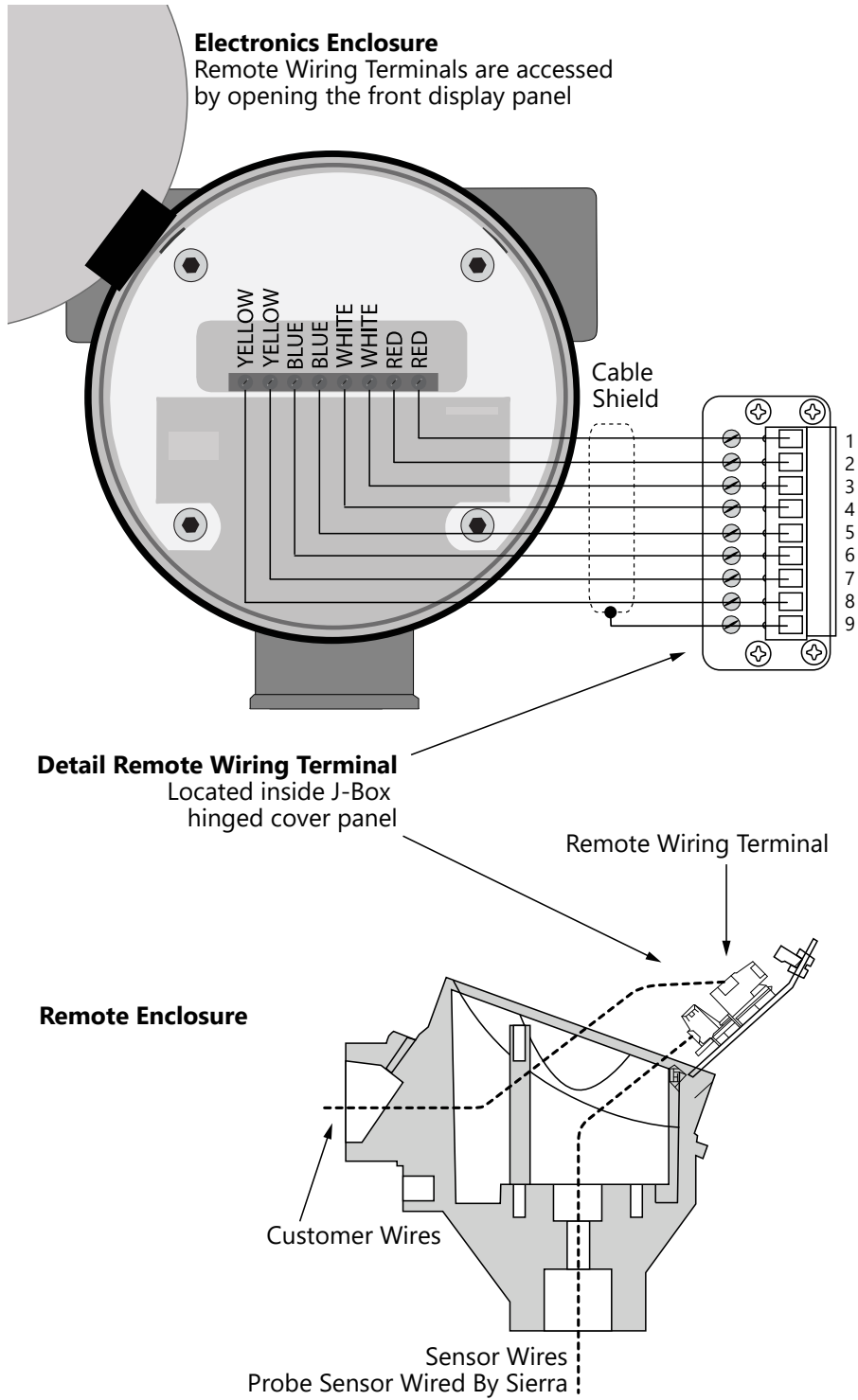


Table 3.1: Remote Sensor Cable Wiring

Electronics Enclosure Terminals	Extension Cable Wire Color	Remote Enclosure Terminal Numbers	Sensor Wire Color
Red	Red	1	Red
Red	Brown	2	Red
White	White	3	White
White	Black	4	White
Blue	Blue	5	Blue
Blue	Green	6	Blue
Yellow	Yellow	7	Yellow
Yellow	Orange	8	Yellow
No Connection	Shield	9	



NOTE! Wire colors listed here represent the wire colors of cables supplied by Sierra Instruments. Colors may vary if customer is supplying their own cable.

Start Up Sequence

The program automatically enters the "Run/Measure" mode after power up. The screen will show the software version of the TM500 during power up.

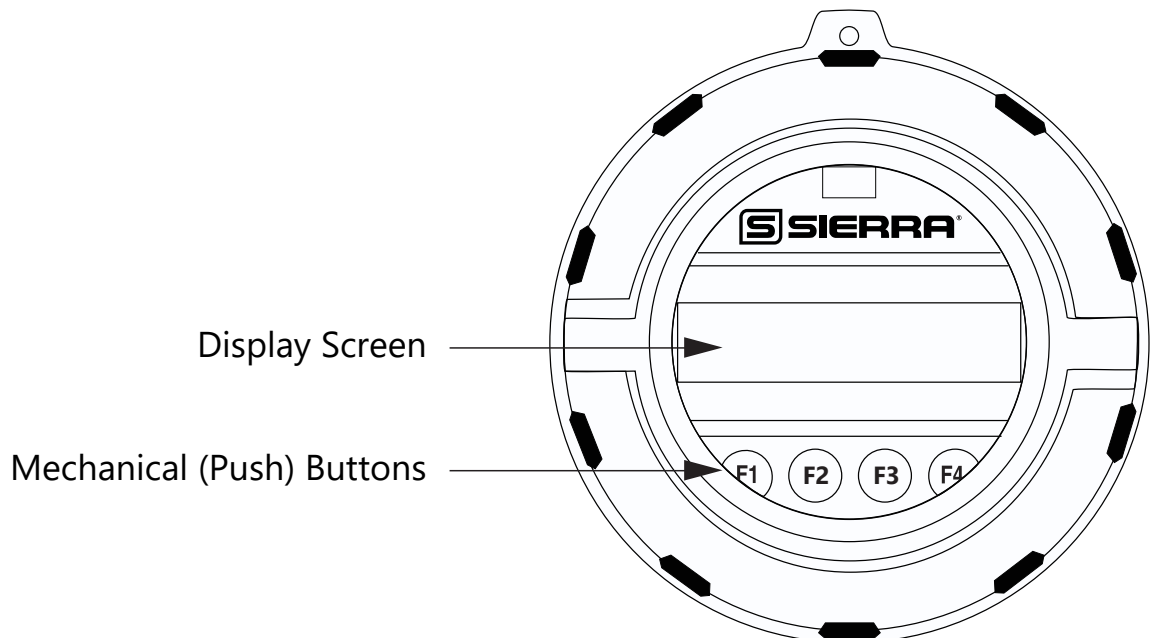
USB Interface

The USB interface is a standard feature which allows communication with a PC to monitor readings and configure settings. TM500-View™ software, is a free application program from Sierra Instruments that connects to the USB interface and allows data monitoring, configuration setting, and data logging to Excel.

TM500 Display and Configuration Panel

The TM500 has a 2 line x 16 character display with 4 mechanical buttons. The meter can be programmed by using the display and configuration panel. The configuration panel can be accessed by removing the TM500 cap. Be sure to replace the cap after you are done configuring the TM500.

Fig. 4.1: TM500 Display and Configuration Panel



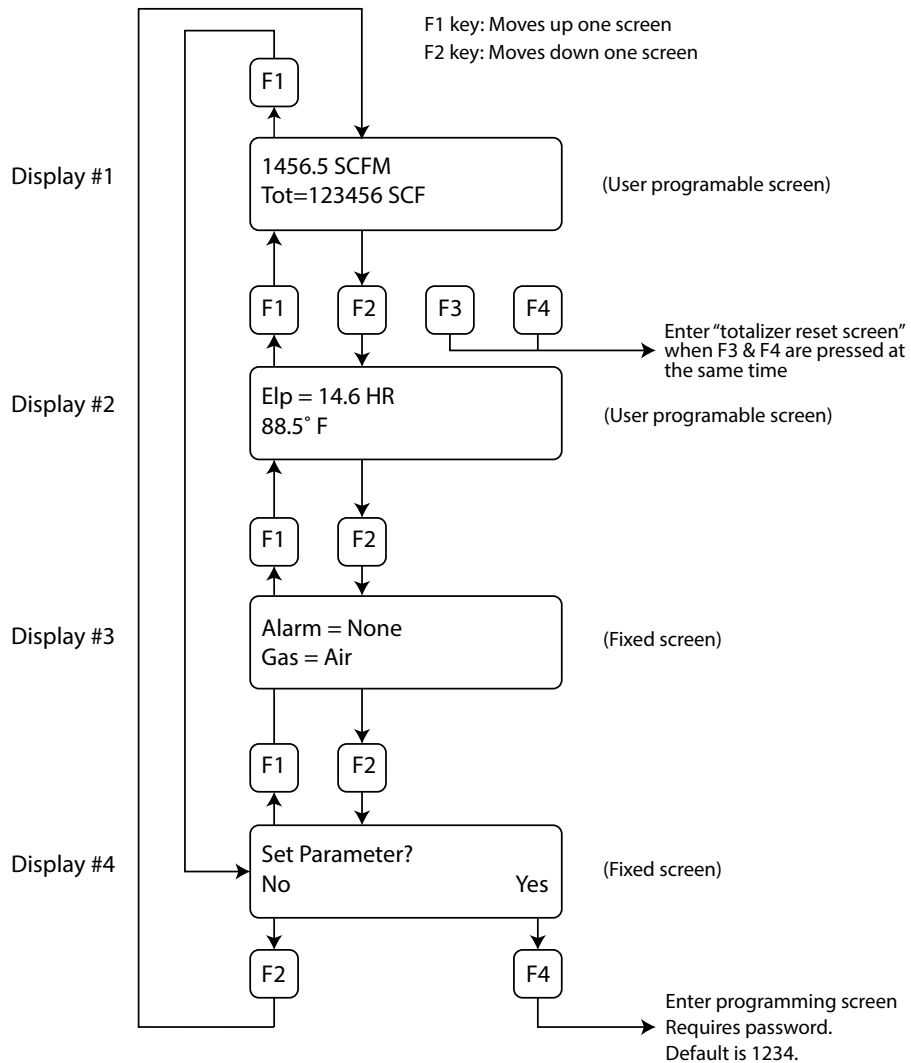
Measurement Mode Display Screens

In the measurement mode, there are four different display screens (Display 1, 2, 3 and a prompt screen to enter the programming mode). Two display screens are user programmable (refer to Display Setup p. 57). Scrolling through the display is accomplished by pressing the **F1** or **F2** key to view the next or previous screen.

Pressing the **F1** and **F2** keys at the same time enters the Engineering Screens (refer to p.18).

Pressing the **F3** and **F4** keys at the same time brings up the "Reset Total" screen prompt. (refer to p. 18).

Fig. 4.2: TM500 Measurement Mode Display Screen Navigation



Programming: Data Entry using the Display and Configuration Panel

There are two basic types of menu entries: one for changing value or string and one for selecting from a selection list.

To Change a Value or String:

VALUE = 0.91234		OK	
CHG			

F1 F2 F3 F4

Press **CHG (F1)** key to change the value, **OK (F4)** to accept the value.

VALUE = 0.91234			
UP	DN	NXT	OK

F1 F2 F3 F4

Press the **UP (F1)** or **DN (F2)** key to select a new digit or character, the cursor points to the selected digit. Press **NXT (F3)** to select the next digit and **OK (F4)** to accept the entry.

To Select from a List:

FLO UNT = SCFM		OK	
NXT			

F1 F2 F3 F4

Press **NXT (F1)** key repeatedly until the correct selection is made and **OK (F4)** key to accept the entry.

Entering the Programming Mode

To enter the programming mode and access the "Main Menu," press the **F1** or **F2** key in the normal running mode until the following screen is shown:

SET PARAMETERS ?			
No		Yes	

F1 F2 F3 F4

Press **YES (F4)** and the following screen will prompt user to enter password:

PASWD: _			
UP	DN	NXT	OK

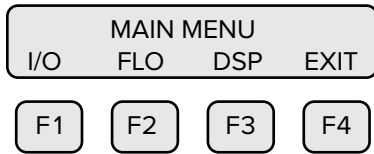
F1 F2 F3 F4

Enter the correct password, then follow the instructions for changing a value as specified on p. 51. The default Level 1 password is "1234".

If the wrong password is entered, the message "Wrong Password" will display and then return to the programming entry screen.

Main Menu

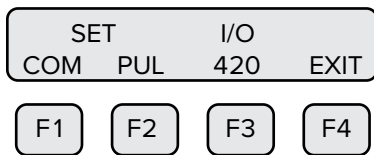
If the password is accepted, the "Main Menu" screen will be shown:



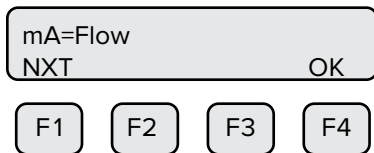
This is the "Main Menu" screen for the programming mode. To exit the programming mode, press **EXIT (F4)** repeatedly until "Normal Mode" is briefly displayed.

Analog 4-20mA Outputs

The following menu allows the scaling of the analog 4-20mA output. From the "Main Menu," press **I/O (F1)** to move to the 4-20mA output selection. In this screen press **420 (F3)** (screen appearance may vary according to options).



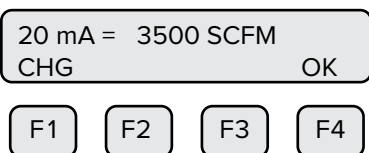
The 4-20mA output is programmable for "Flow" or "Temperature":



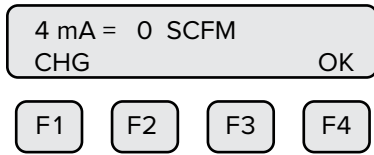
Selections for the 4-20mA output are:

- Flow
- Temp

Select **NXT (F1)** to select "Flow" or "Temperature" and then press **OK (F4)**.



Enter the value for the 20mA and press **OK (F4)** key to accept the setting. Then the following screen will display:

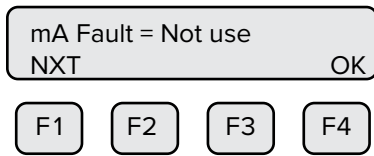


Enter the value for the 4mA and press **OK (F4)**.

NOTE! When the flow rate exceeds the programmed value for the 20mA set point, the analog output will stay at 20mA and an alarm code will be generated.

NOTE! 4mA is normally set to 0.

After setting the 4mA output value, choose the mA fault value:



This menu allows the user to select an alarm fault level on the 4-20mA output. The alarm is activated when a serious issue is detected preventing the calculation of the correct flow rate. The 3.6mA and 21mA alarm outputs are related to the NAMUR NE 43 alarm feature.

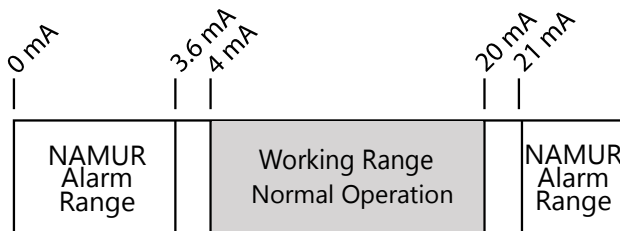
The options are:

- mA Fault=3.6 mA (Force the 4-20mA signal to 3.6mA on alarm)
- mA Fault=21 mA (Force the 4-20mA signal to 21mA on alarm)
- mA Fault=Not use (4-20mA signal alarm fault not used)

The following events will set the output to 3.6mA or 21mA if the alarm level is selected:

- Sensor resistance above high limit
- Bridge Shutdown

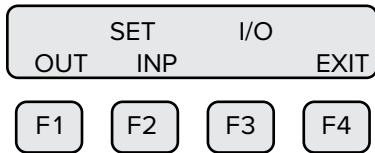
Fig. 4.3: Range of 4-20mA Output and NAMUR Alarm



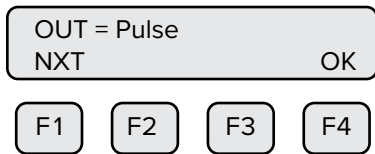
Press **(F4)** repeatedly until “Normal Mode” is seen briefly to exit the programming mode.

Pulse/Alarm Output

The Pulse/Alarm feature can be accessed from the "Main Menu," press I/O (**F1**).



Press **OUT (F1)** to select the pulse output. The following screen will show:

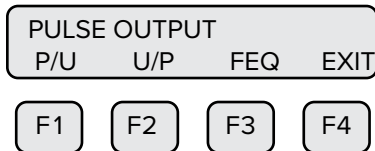


Press **NEXT (F1)** to cycle through output options until you have the selection for "OUT=Pulse" and press **OK (F4)**.

The pulse output can be configured in one of three ways:

1. Specifying how many pulses per unit, P/U (i.e., 10 pulses per SCF)
2. Specifying how many flow units total per pulse, U/P (i.e., 0.1 SCF per pulse)
3. Specifying a maximum frequency to a defined maximum value of flow rate

All of these approaches are equivalent.



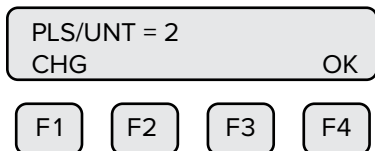
Use **P/U (F1)** to enter pulse per unit, **U/P (F2)** for unit per pulse or **FEQ (F3)** to enter the flow and maximum frequency to scale the pulse/alarm output.



NOTE! When data is entered with any of the three described methods, the other values will be re-calculated according to the settings.

Entering data in Pulse per Unit:

From the Pulse/Alarm Output Menu above, press **P/U (F1)** and the following screen will show:

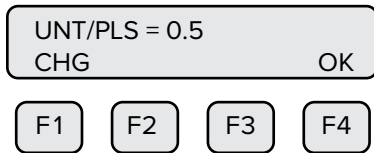


Press **CHG (F1)** to change the setting and then **OK (F4)** to accept entry.

The value entered is in pulse per selected flow unit total (i.e., 2 pulses per SCF).

Entering data in Unit per Pulse:

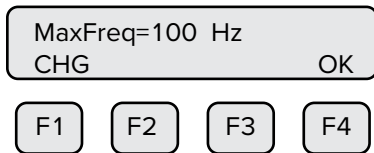
From the Pulse/alarm Output Menu, press **U/P (F2)** and the following screen will show:



Press **CHG (F1)** to change the setting and then **OK (F4)** to accept entry. The value entered is in unit per pulse (i.e. 0.5 flow unit total per pulse)

Entering data with flow and maximum frequency:

From the Pulse/alarm Output Menu, press **FEQ (F3)** and the following screen will show:

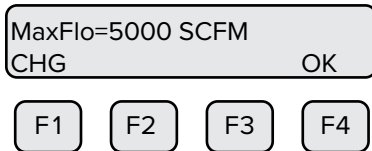


Enter the maximum pulse rate (frequency) and press **OK (F4)**.



CAUTION! Maximum pulse rate (frequency) cannot exceed 100 Hz.

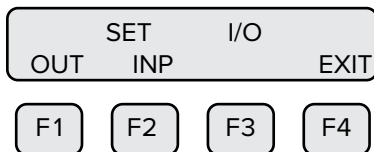
The next screen will show:



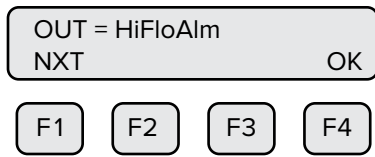
NOTE! If the flow rate exceeds the maximum pulse rate (frequency), the output will stay at 100 Hz and the TM500 will issue an alarm code.

Alarm Output

To access the Pulse/alarm feature, press **I/O (F1)** key from the "Main Menu" screen. The screen will show:



Then press **OUT (F1)** and the screen may show:

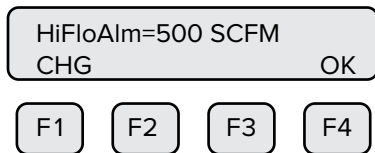


Then press **NXT (F1)** to select the correct alarm and press **OK (F4)**.

Selections are:

- Not used
- Pulse
- HiFloAlm = High Flow Alarm
- LoFloAlm = Low Flow Alarm
- HiTempAlm = High Temperature Alarm
- LoTempAlm = Low Temperature Alarm
- System Alarm

When the output is set to Alarm and there is no alarm condition, the output will be on (0 volts). When an alarm is active, the output is turned off (12 to 24 volts).



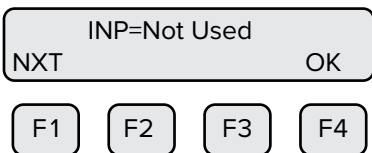
Enter the value for the limit by pressing **CHG (F1)** and then **OK (F4)**. A value of 0 disables the alarm.



NOTE! There is only one output to operate as a pulse output or an alarm output. Both cannot operate at the same time.

For Switch Input Settings:

From the "Main Menu", press **I/O (F1)** and then **I/O (F1)** and then **INP (F2)** key to select input. The following menu will display:



Press **NXT (F1)** until the correct selection is shown and then press **OK (F4)** to accept the setting.

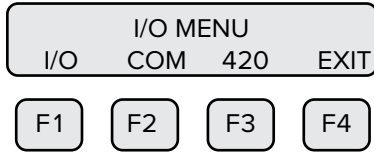
Selections are:

- Not used
- Tot Reset = Reset the totalizer

Press **EXIT (F4)** repeatedly until you exit programming mode.

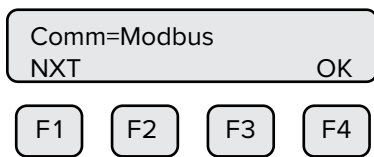
Serial Communication Settings

If a "Serial Communication" feature was purchased, the Serial communication settings can be programmed by pressing **I/O (F1)** key from the "Main Menu". The screen will show:



Press **COM (F2)** to select Serial communication.

The screen may show:



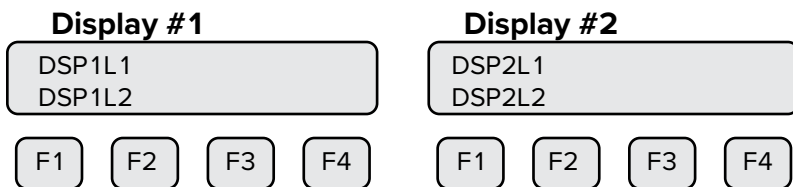
Options for serial communication are:

- None
- Modbus
- HART

NOTE! Any selection other than “None” requires the communication option for the selected communication type. If enabling a communication option, see the Communications Protocols section of this manual.

Display Setup

There are four display screens that you can cycle through in normal operating mode (see Figure 4.2 on p. 50). Two of the four display screens are fixed and cannot be changed (Display #3 and Display #4). The other two screens are programmable to show the information that you prefer and is discussed in this section.

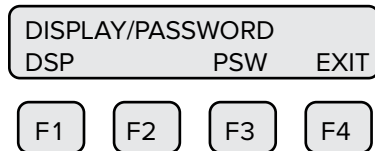


Selections are:

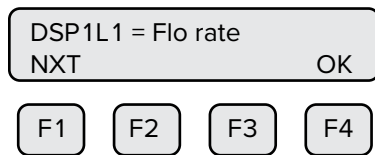
- DSP1L1 = Display 1, Line 1
- DSP1L2 = Display 1, Line 2
- DSP2L1 = Display 2, Line 1
- DSP2L2 = Display 2, Line 2

To Program Display Screens #1 & 2:

From the "Main Menu" press **DSP (F3)** to select the display menu:



Press **DSP (F1)** key. The display will show:

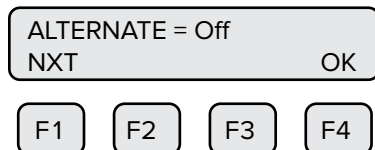


These are the selections for the Display #1 line #1.

Selections are:

- Flo rate = Flow rate
- Total = Total mass or volume
- Elps = Elapsed time
- Temp = Temperature
- Alarm = Error codes

When the selection is correct, press **OK (F4)** to accept. The display will then go through the same process for all four lines of the two programmable displays (DSP1L1, DSP1L2, DSP2L1 and DSP2L2). After the last line of Display 2 is accepted, the display will show the following menu:



This menu allows you to alternate between menu display 1 and 2 every few seconds.

Selections are: On or Off

Press **OK (F4)** to accept selection. Press **EXIT (F4)** repeatedly until "Normal Mode" is seen briefly to exit the programming mode.

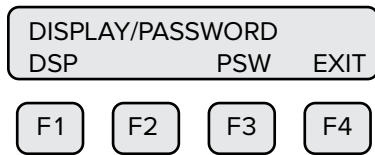
Password

There are two user level passwords, only **Level 1** is programmable and gives access to all the normal settings. The second password is used to allow access to calibration settings.

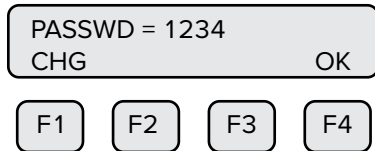
Default **Level 1** password is "1234", and **Level 2** password is "9111". The **Level 1** programmable password can be disabled by setting it to "0".

From the "Main Menu" press **DSP (F3)** to select the display menu.

To Program the Password:



Press **PSW (F3)** key to select password.



This screen displays the current **Level 1** password.

Press **CHG (F1)** key to change the password and enter new value.

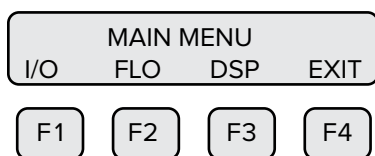
Press **OK (F4)** to accept new data and exit programming by pressing **EXIT (F4)** key repeatedly until out of the programming mode.

NOTE! Password can be number or letter characters up to four (4) digits.

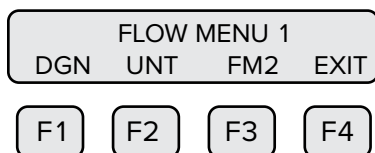
Units Settings Menu

This menu is used to set the units for flow, temperature, and pressure as well as the setting of reference temperature and reference pressure.

These values will be set at Sierra Instruments using information supplied by the customer. These values can be changed to match a new application. The units setting is accessed from the "Main Menu." To access the "Unit Settings Menu":

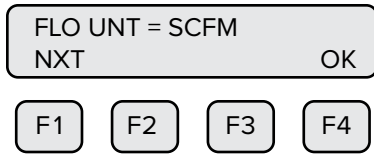


Press **FLO (F2)**:



Press **UNT (F2)** for "Unit" selection.

The screen will show:



Press **NXT (F1)** to change selection and **OK (F4)** to accept.

NOTE! The totalizer (total flow measured) will roll over when reaching a certain value. The maximum value is dependent on the flow units selected (see Totalizer Rollover p. 67).

Flow Units

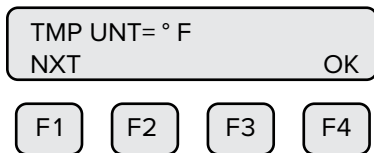
Selections for flow units are:

SCFM	KG/M	LBS/D	SM3/H	MSCFD (MCFD)
SCFH	KG/S	NLPH	SM3/D	MMSCFD (MMCFD)
NM3/H	LBS/H	NLPM	NM3/D	MCFD (MSCFD)
NM3/M	LBS/M	NLPS	SLPM	MMSCFM (MMCFM)
KG/H	LBS/S	SM3/M	SCFD	MT/H

WARNING! Changing the flow units will automatically recalculate the 4-20mA range values, the Pulse Output maximum flow, and the flow cutoff. The Pip ID will change between inches and millimeters to match Imperial vs Metric flow rates.

Temperature Units

After pressing **OK (F4)** to accept the Flow unit, the display will prompt for the temperature unit setting:



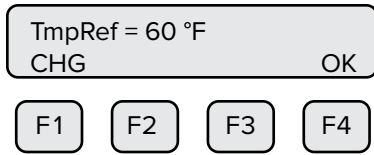
Press **NXT (F1)** to change selection and **OK (F4)** to accept.

Selections for Temperature units are: °C or °F

NOTE! To adjust the scaling of the 4-20mA temperature output after changing the temperature units, reference p. "Analog 4-20mA Outputs" on page 52.

Reference Temperature

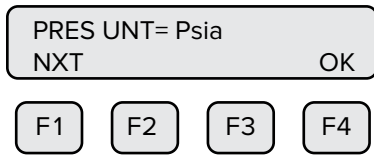
After pressing **OK (F4)** to accept the temperature unit setting, the display will prompt for temperature reference in selected unit.



Press **CHG (F1)** to change the reference and **OK (F4)** to accept.

Pressure Units

After pressing **OK (F4)** to accept the reference temperature, the display will prompt for the reference pressure unit selection:



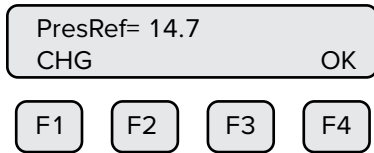
Press **NXT (F1)** to select next entry and **OK (F4)** to accept.

Selections are:

- mmHG = Millimeters of mercury (absolute)
- Psia = Pounds per square inch absolute
- bara = Bar absolute

Reference Pressure

After the pressure unit selection is made, the display will show a menu to enter the reference pressure:

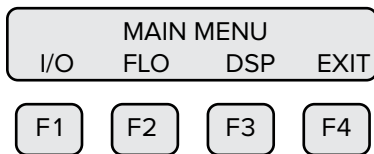


Press **CHG (F1)** to change it and **OK (F4)** to accept.

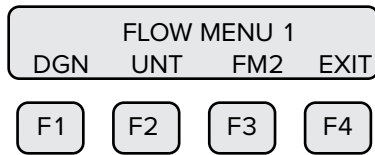
Accessing Flow Parameters and Alarm Settings

This is the menu used to set various flow parameter values. They are: Flow cutoff, pipe diameter, filter, high and low alarm for flow and temperature.

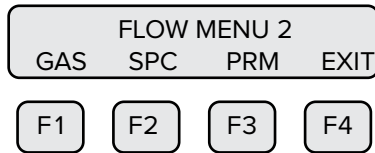
NOTE! The parameters in this menu are set to the customer specifications at the factory. They should only be changed when changing the application of the flow meter.



The menu is accessed from the "Main Menu" by pressing **FLO (F2)**:



Then press **FM2 (F3)**:



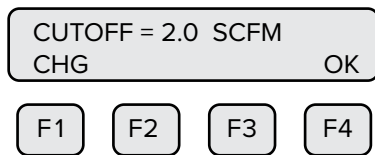
NOTE! The SPC function key will only appear and be accessible from a Level 2 password.

Then press **PRM (F3)**. This will move into settings for flow cutoff, pipe diameter, and filter value. These settings will be followed by the high and low alarm settings for flow rate and/or temperature.

Programming Flow Parameters

Flow Cutoff

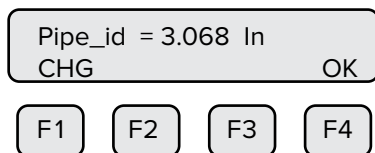
The first parameter is "Flow Cutoff":



Enter the value for the flow cutoff and then press **OK (F4)**. When the flow rate falls below the flow cutoff, the flow meter will display a flow value of zero.

Pipe Diameter

To set the pipe diameter: enter the pipe diameter in **inches** or **millimeters** and then press **OK (F4)**.

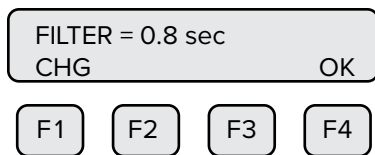


Use millimeters for metric flow unit selections and inches for English flow unit selections. This selection is dependent on the flow unit selected (English vs metric). If the pipe/duct is a square or rectangle, the hydraulic diameter (equivalent value for a round pipe) must be entered for the pipe ID.

Filter Value

The filter value is entered in seconds. The allowable time constant range is 0.8 to 10 seconds. The filter time interval is proportional to the dampening.

Enter the filter value and then press **OK (F4)**.



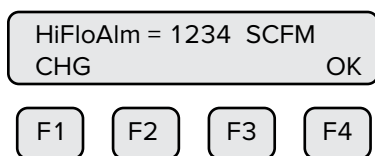
Programming High and Low Alarm Settings

Settings for the alarms directly follow the flow parameters for flow cutoff, pipe diameter, and filter value. These alarms can be used without the digital output assigned to the alarm. If that is the case, the alarm status will only be shown on the display, through serial communication, or TM500-View Software. If the digital output is assigned to an alarm, changing the value here will change that setting.

High Flow Rate Alarm

This is the upper flow limit alarm value that can be associated with the alarm output. An alarm code is generated when the flow value exceeds this limit. If no alarm is needed, set this value to zero.

To set the parameters for a high flow rate alarm, press **CHG (F1)**:

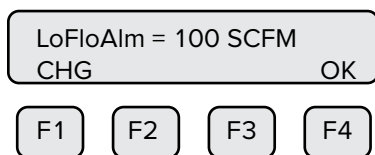


Press **OK (F4)** to accept the value.

Low Flow Rate Alarm

This is the lower flow limit alarm value that can be associated with the alarm output. An alarm code is generated when the flow value is below this limit. If no alarm is needed, set this value to zero.

To set the parameters for a low flow rate alarm, press **CHG (F1)**:



Press **OK (F4)** to accept the value.

High Temperature Alarm

This is the upper temperature limit alarm value that can be associated with the alarm output. An alarm code is generated when the temperature value exceeds this limit. If no alarm is needed, set this value to zero.

To set the parameters for a high temperature alarm, press **CHG (F1)**:

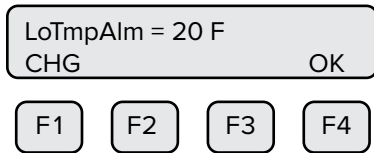


Press **OK (F4)** to accept the value.

Low Temperature Alarm

This is the lower temperature limit alarm value that can be associated with the alarm output. An alarm code is generated when the temperature value is below this limit. If no alarm is needed, set this value to zero.

To set the parameters for a high temperature alarm, press **CHG (F1)**:



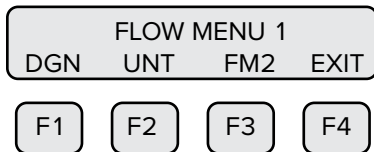
Press **OK (F4)** to accept the value.

Simulation

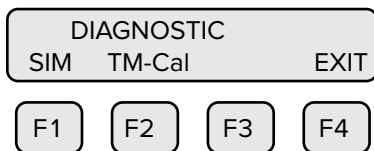
This menu allows for simulation of flow rate and temperature. It should only be used for testing and demonstration purposes. **Make sure to return all of these simulation values to zero, before returning to the normal mode of operation.**

CAUTION! If the 4-20mA and/or the pulse/alarm outputs are connected to controllers, set the controllers to “manual” to ensure that the simulated signals do not cause false controller action.

The menu is accessible from the "Main Menu" by pressing **FLO**:



Pressing **DGN (F1)** will show:



Pressing **SIM (F1)** will show:

Simulate Flow? YES	NO		
F1	F2	F3	F4

Press **YES (F1)** to continue.

FloSim = 0 SCFM CHG	OK		
F1	F2	F3	F4

Enter the value and then press **OK (F4)**.

i NOTE! Enter zero to disable this feature.

Simulate Temp? YES	NO		
F1	F2	F3	F4

Press **YES (F1)** to continue.

TmpSim = 0 C CHG	OK		
F1	F2	F3	F4

Enter the value and then press **OK (F4)**. Enter zero to disable this feature.

ENABLE SIM? YES	NO		
F1	F2	F3	F4

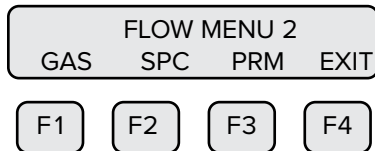
Press **YES (F1)** to start the simulation mode, otherwise press **NO (F4)**. Upon pressing either key, the program will return to the "Flow Menu 1" screen.

i NOTE! Simulation Mode will be cleared if the power is cycled.

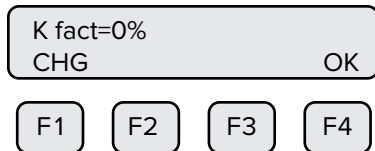
K Factor

The K Factor allows the user to adjust the meter's calibration. The Sierra Instruments flow meter increases the calculated flow rate by the K Factor. This results in a direct scaling of the meter's output across the entire full range.

The K Factor parameter is accessed from the “Flow Menu 2” menu by entering a **Level 2** password “9111” and pressing the **SPC** key (**F2**).



The following screen will be displayed:



Press **CHG (F1)**. Add the correction factor and press **OK (F4)**.

If you want the flow meter to read 5% higher, enter 5.0%.

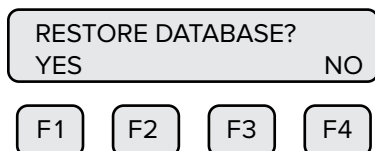
If you want the flow meter to read 5% lower, enter -5.0%.

If an existing K Factor is present, add the additional K Factor to the existing value.

Upon pressing **OK (F4)**, an option to restore the database will follow.

Restore Database

In case of user error, the ability to restore the meter to the original factory settings can be achieved in this menu. The display will show:



Press **YES (F1)** ONLY if you want to restore your database to the initial factory setting that the meter was shipped with. All current user-entered settings will be overwritten. The green LP3 LED will flash at a faster pace until the recall is performed. The "RESET CRC" screen will follow "RESTORE DATABASE". Upon pressing **OK (F4)**, an option to reset the NVRAM CRC will follow.

Reset CRC

If the NVRAM CRC check fails (Error Code 36), the programmed settings values will need to be verified and corrected before clearing the error. Call Sierra Instruments Customer Service if you need assistance.

RESET CRC?	
YES	NO

F1 F2 F3 F4

Press **YES (F1) ONLY** if you want to reset the CRC and generate a new CRC value.

Reset Total and Elapsed Time

Enter the "Flow Totalizer" and "Elapsed Time" screen by pressing the **F3** and **F4** keys at the same time in the normal running mode.

RESET TOTAL ?	
NO	YES

F1 F2 F3 F4

Press **YES (F4)** and enter password to reset total and elapsed time. Press **NO (F1)** to cancel.

i NOTE! This feature is not available on non-resettable units.

Totalizer Rollover: The TM500 has an automatic roll-over function. The total flow count of the TM500 will roll over after 99,999,999,999. Except for:

MSCFD:	999,999,999
MMSCFM:	9,999,999
MMSCFD:	999,999

Calibration of the Sierra Instruments Model TM500 Thermal Flow Meter

To ensure that all Sierra Instruments flow meters meet specified performance parameters and provide accurate, repeatable measurements in the field, all calibrations are performed with NIST-traceable flow standards. Each meter is shipped from the factory with a Sierra Instruments Calibration Certificate.

TM-Cal™ Calibration Validation Test

Sierra Instruments has developed the TM-Cal™ Calibration Validation test to help our customers avoid sending the meter back for annual or biennial recalibration.

TM-Cal™ ensures the repeatability, functionality of the sensor and its associated signal processing circuitry. By performing a simple test, the operator can verify that the meter is running accurately.

During the TM-Cal™ calibration validation test, the microprocessor adjusts current to the sensor elements and determines the resulting electrical characteristics. Data within established tolerances confirms the meter is accurate.

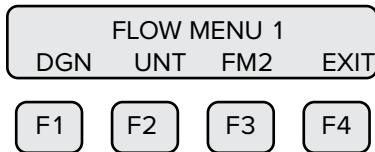
Recommended Conditions for Performing TM-Cal™ Test

Sierra Instruments recommends the TM-Cal™ test be run under flowing conditions, especially in smaller pipe sizes. If the TM-Cal™ test does not produce a "PASS" result, refer to "TM-Cal™ Test Results" on page 69.

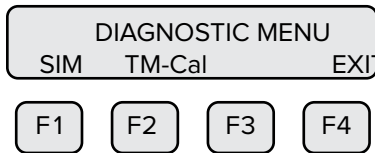
NOTE! If the TM-Cal™ test is performed using the Sierra Instruments TM500-View™ software, at the completion of the test, a TM-Cal™ Certificate may be printed for a record of the test. This certificate will display a pass/fail result.

Performing the TM-Cal™ Calibration Validation Test

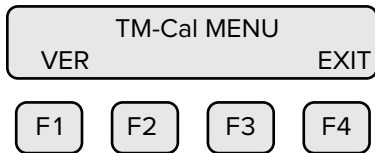
Press **FLO (F2)** from the "Main Menu." The display will show:



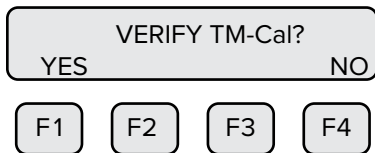
Press **DGN (F1)**. The display will show:



Press **TM-Cal (F2)**. The display will show:

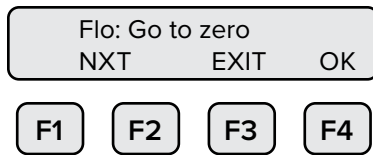


Press **VER (F1)** to perform the TM-Cal™ verification test.

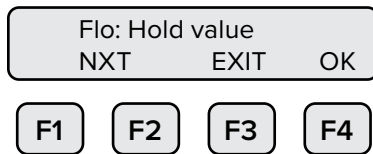


Press **YES (F1)** to continue.

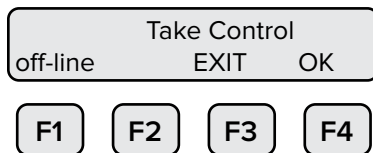
Press **NXT (F1)** to toggle between "Hold value" and "Go to zero". During the TM-Cal test, "Hold value" will keep the flow at the last value measured. "Go to zero" will set the flow output to zero.



Press **OK (F4)** to continue.

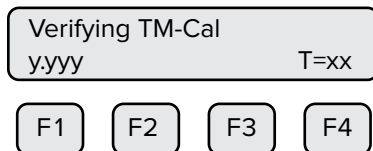


When ready to begin the test, press **OK (F4)**.



! WARNING! If you are using closed loop control, the system needs to be taken off-line during the test.

Press **OK (F4)** to start TM-Cal™. TM-Cal™ test screen:



This test takes about three minutes (200 seconds). During the test, the display will show the TM-Cal™ value changing as the power to the sensor is adjusted. "T=xx" is a TM-Cal™ timer indicating how much time is left to finish the test.

TM-Cal™ Test Results

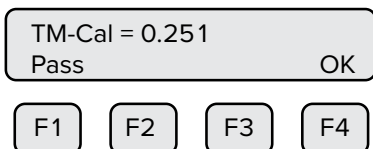
Upon test completion, the final TM-Cal™ value will be displayed along with a "Pass," "Fail," or "Warning" message:

- Pass: less than ± 0.80
- Warning: between ± 0.80 to ± 1.0
- Fail: greater than ± 1.0

Recommended next steps if a "Warning" or "Fail" result is displayed:

- Run the test again under a higher flow rate if possible.
- Remove the probe from the pipe, clean the sensor, and perform the test again under a normal or high flow rate.

If a "Warning" or "Fail" result is displayed after repeating the test, please call Sierra Instruments Customer Service at (831) 373-0200 for assistance.



Press **OK (F4)** to exit the menu when the test is complete.

NOTE! The TM500 will stop measuring flow when performing this test.

CAUTION!

- For applications with temperature exceeding 250°F (121°C), TM-Cal™ test results may vary.
- Periodic inspection for damage and cleaning of the sensor elements is required.

Gas-Mix[®] Available Gases and Gas Mix Menus

This menu allows the user to select a gas or gas mix from a pre-calibrated list of gases/gas mixtures available in the Sierra Instruments TM500 flow meter. When entering the TM500 gas menu the user will have two choices:

1. Pure Gas Menu
2. Gas Mix (MIX) - any combination in the Gas Mix (MIX) menu- total must equal 100%

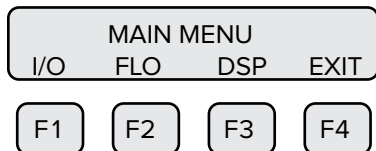
Pure Gas Menu / Gas Mix Menu	
Air	Oxygen
Argon	Helium
Butane	Hydrogen
Carbon Dioxide	Propane
Methane	Ethane
Natural Gas *	Ethylene
Nitrogen	Propylene

*Natural Gas is defined as the NAESB Natural Gas mix (94.9% Methane, 0.7% CO₂, 1.6% N₂, 0.3% Propane, and 2.5% Ethane).

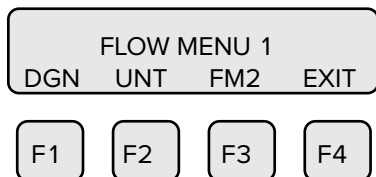
After installing your TM500 flow meter, power up the device. When the meter finishes initializing, it will begin to monitor flow in the assigned gas and flow units.

Accessing the Gas-Mix™ Gas Selection Menu Feature

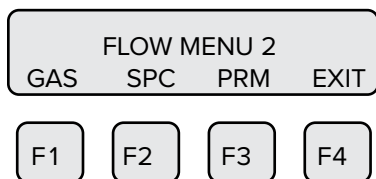
Enter the programming mode on the meter (refer to p. 51) and then follow these instructions to access the Gas-Mix™ feature:



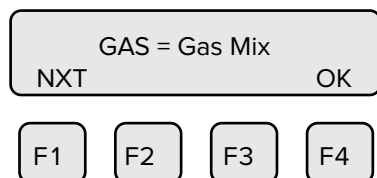
Press **FLO (F2)** from the "Main Menu" to enter Flow Menu 1.



Press **FM2 (F3)** to get to Flow Menu 2.



Press **GAS (F1)** to access the Gas-Mix™ feature. The display will show:




Press **NXT (F1)** to choose from a list of gases.

Choices are:

- Pure Gas
- Gas Mix

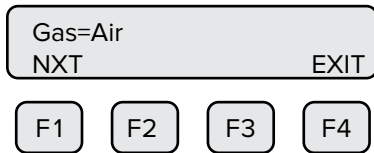
In the Pure Gas menu, the user can choose from a list of pure gases. The Gas Mix menu is used for programming a specific mixture of gases.

 **NOTE!** Switching between Pure Gas and Mix, settings will clear the previous gas settings.

See previous pages for gases available in each menu.

Gas Mix™ Single Gas Menu

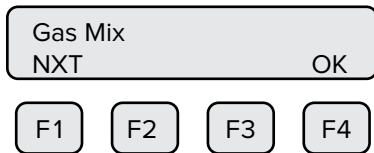
To select a pure gas, choose "Pure Gas" (F1) and then press "OK" (F4) to accept the setting:



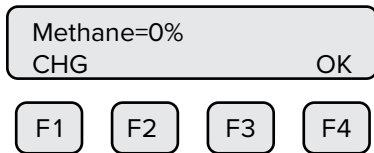
To choose any pure gas, press NXT (F1) to cycle through until the correct gas is displayed and press OK (F4) to select the gas. "Gas Mix™ Available Gases and Gas Mix Menus" on page 70.

Choosing a Gas: Gas Mix Menu

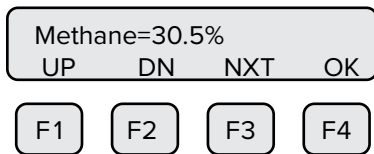
To create a "Gas Mix," choose **Gas Mix** from the list and press **OK (F4)**.



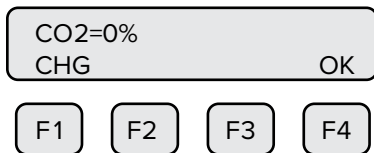
The screen will show the first gas available in the menu:



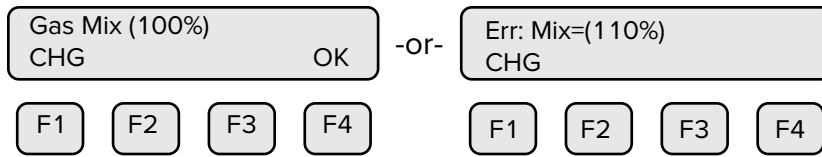
This screen shows the percentage of the gas mixture allocated to "Methane." In this case, it shows 0%. To program the specific mixture of "Methane", press **CHG (F1)**.



To set the percentage of "Methane" in the gas mix, press **UP (F1)** or **DN (F2)** to choose the first digit of the percentage. Press **NXT (F3)** to move to the next digit in the percentage and then use **UP (F1)** or **DN (F2)** again to choose the next digit of the percentage. Once the desired "Methane" percentage is displayed, press **OK (F4)**. the display will move to view the concentration of other gases.



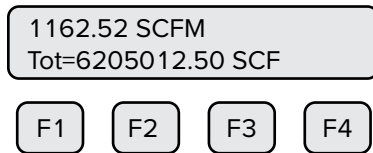
Once the desired gas percentages are programmed, press **OK (F4)**. One of the following messages will appear:



If the gas mix does not equal 100%, press **CHG (F1)** to return to the gas entry menu.

Once the "Gas Mix (100%)" message appears, you have successfully programmed the gas mix in Gas-Mix™ and can exit. Press **OK (F4)** to set the mixture.

After the gases are programmed, the TM500 will begin to monitor flow based on the pre-calibrated algorithm for the gas/gas mix selected in the Gas-Mix™ feature. The screen will show the flow in units and the total flow similar to the example below:



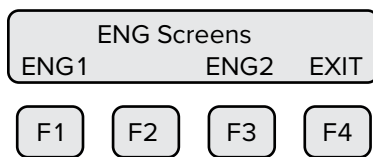
In normal operating mode, the gas selection can be seen on display 3 (see p. 50).

i NOTE!

- Gas mix must equal 100%
- Any gases not included in the gas mix should have percentages set to 0%.

Viewing the Engineering Screen

From the normal operating mode, press **F1** and **F2** keys at the same time:



ENG1 (F1) will enter Engineering Screen 1:

- The Gas or Gas Mix can be viewed here
- The meters configuration settings can be viewed here
- The most recent TM-Cal™ Calibration Validation, record can be viewed here

ENG2 (F3) will enter Engineering Screen 2:

- Displays information about alarm settings, serial numbers, firmware versions, CSV, and output information

Reference the Engineering Screens, flow chart on pg 18.

Communication

Scope - Modbus Communication

This portion of the manual describes the Modbus implementation using RS485 serial communication physical layer for the Sierra Instruments TM500 Mass flow meter based on the Modicon Modbus Protocol (PI-MBUS-300 Rev. J).

Modbus Protocol

Modbus Protocol is an application layer messaging protocol that provides client/server communications between devices. Modbus is a request/reply protocol and offers services specified by function codes.

The size of the Modbus Protocol Data Unit is limited by the size constraint inherited from the first Modbus implementation on Serial Line network (max. RS485 Application Data Unit = 256 bytes). Therefore, Modbus PDU for serial line communication = 256 – Server address (1 byte) – CRC (2 bytes) = 253 bytes.

RS485 ADU = 253 + Server address (1 byte) + CRC (2 bytes) = 256 bytes.

For more information on Modbus go to the web site <http://www.modbus.org/>.

Command Request:

<Meter Address> <Function code> <Register start address high> <Register start address low>
<Register count high> <Register count low> <CRC high> <CRC low>

Command Response:

<Meter Address> <Function code> <Data byte count> <Data register high>
<Data register low> ... <Data register high> <Data register low> <CRC high> <CRC low>

 **NOTE!** The data shown in brackets < > represents one byte of data.

Modbus Indicators

Green LED indicator LP3 cycles on and off to indicate that the TM500 is operating. Orange LED indicator LP2 blinks when Modbus signals are received and Yellow LP1 blinks when Modbus signals are transmitted. The LEDs are located behind the display panel.

Modbus Function Codes Supported by the TM500

The TM500 supports the following commands:

- 1) Command 03: Read multiple registers
- 2) Command 04: Read single register
- 3) Command 06: Write single register
- 4) Command 16: Write multiple registers (limited to gas percentage register pairs)

Read Multiple Registers (command 03)

This command reads one or more 16-bit registers from the TM500 and has the following format:

Request:

<Meter Address> <Command code=03> <Register start address high> <Register start address low> <Register count high> <Register count low> <CRC high> <CRC low>

Response:

<Meter Address> <Command code=03> <Byte count> <Data high> <Data low> ...
<Data high> <Data low> <CRC high> <CRC low>

Example: Request data register at starting address 0x0000 and specifying 2 registers

<0x01> <0x03> <0x00> <0x00> <0x00> <0x02> <0xC4> <0x0B>

Response:

<0x01> <0x03> <0x04> <xx> <xx> <xx> <xx> <CRC high> <CRC low>

Where xx xx is the data register value.

Table 5.1: TM500 Modbus Registers

Modbus Register	Data Type	Description	Units
40001	32-bit int LSW	Flow	User selected
40002	32-bit int MSW		
40003	32-bit int LSW	Flow Total	User selected
40004	32-bit int MSW		
40005	32-bit int LSW	Temperature x10	Tenths of user selected
40006	32-bit int MSW		
40007	32-bit int LSW	Elapsed time x10	Tenths of user selected
40008	32-bit int MSW		
40009	16-bit int	Firmware version x10 (scaled up for 16-bit format)	
40010		Reserved	
40011	16-bit int	Flow x 10 (flow scaled for 16 bits)	Tenths of user selected
40012	16-bit int	Flow x 100 (flow scaled for 16 bits)	Hundredths of user selected
40013	16-bit int	Total x 100 (flow total scaled for 16 bits)	Hundredths of user selected
40014	32-bit float LSW	Gross Heating Value (GHV)	BTU/Ft3
40015	32-bit float MSW		
40016	16-bit int	Status	
40017	16-bit int	Status 2	

Table 5.1: TM500 Modbus Registers (cont'd)

Modbus Register	Data Type	Description	Units
40018	16-bit int	Control Register (Write Only): Reset Total = 2 Perform TM-Cal = 173 Abort TM-Cal = 174	
40019	16-bit int	Model Status (Read only) M500 = 0x1000	
40020	32-bit float LSW	Flow	User selected
40021	32-bit float MSW		
40022	32-bit float LSW	Total	User selected
40023	32-bit float MSW		
40024	32-bit float LSW	Reference pressure	User selected
40025	32-bit float MSW		
40026	32-bit float LSW	Temperature	User selected
40027	32-bit float MSW		
40028	32-bit float LSW	Elapsed time	Hour
40029	32-bit float MSW		
40030	32-bit float LSW	TM-Cal calibration validation result	
40031	32-bit float MSW		
40032 - 40037		Reserved	
40038	16-bit int	Flow Unit Code (SCFM = 0, SCFH = 1, NM3_H = 2, NM3_M = 3, KG_H = 4, KG_M = 5, KG_S = 6, LBS_H = 7, LBS_M = 8, LBS_S = 9, NLPH = 10, NLPM = 11, MMSCFD = 15, LBS_D = 16, SLPM = 17, NLPS = 18, MSCFD = 19, SM3_H = 20, MT_H = 21, NM3_D = 22, MMSCFM = 23, SCFD = 24, MCFD = 25, SM3M = 26, SM3D = 27)	User selected
40039	16-bit int	Temp Unit Code (Degree F = 0, Degree C = 1)	User selected
40040	16-bit int	Pressure Unit Code (MMHG = 0, PSIA = 1, BARA = 2)	User selected
40041 - 40055		Reserved	
40197	32-bit float LSW	Gas Density	STP KG/M3
40198	32-bit float MSW		
40199	32-bit int LSW	Meter Serial Number	
40200	32-bit int MSW		
40201	16-bit int	ADC Status	
40202	32-bit float LSW	Electronics Temperature	Degrees Celsius
40203	32-bit float MSW		
40204	16-bit int	Last TM-Cal Year	Years
40205	16-bit int	Last TM-Cal Month	Month
40206	16-bit int	Last TM-Cal Day	Days
40207	16-bit int	Last TM-Cal Hour	Hours
40208	16-bit int	Last TM-Cal Min	Minutes
40209	16-bit int	Last TM-Cal Sec	Seconds
40210	32-bit float LSW	Last TM-Cal Value	
40211	32-bit float MSW	Last TM-Cal Value	

**These time registers can only be set with valid values when a TM-Cal test is performed through the TM500-View Software

NOTES!

- In Least Significant Word (LSW) and Most Significant Word (MSW), “word” is one 16-bit Modbus register. A 32-bit float or 32-bit integer is stored in a pair of Modbus registers. When a register is designated as “32-bit int LSW”, it means that bits 0-15 of the variable are in that register. A register designated as MSW has bits 16-31 of the variable. For instance, the flow total can be read as a 32-bit integer from registers 40003 (LSW) and 40004 (MSW). If the flow total is 0x12345678, then register 40003 will hold 0x5678, and register 40004 will hold 0x1234. See the layout of a 32-bit floating point value on p. 78.
- 32-bit floating point values are defined by the IEEE 754 standard: <https://ieeexplore.ieee.org/document/8766229>
- Refer also to Wikipedia: https://en.wikipedia.org/wiki/Single-precision_floating-point_format

Read Single Register (Command 04)

This command is used to read a single 16-bit register and has the following format:

Request:

<Meter Address> <Command code=04> <Register address =0> <Register address =0>
<Register count =0> <Register count =1> <CRC high> <CRC low>

Response:

<Meter Address> <Command code=04> <Byte count =2> <Status High> <Status Low>
<CRC high> <CRC low>

Table 5.2: Status Bits Definitions for Modbus Address 40016

Bit	Definition	Comment
0	Power up indication	Cleared when out of the power up sequence
1	Flow rate reached high limit threshold	Set limit to zero to disable
2	Flow rate reached low limit threshold	Set limit to zero to disable
3	Temperature reached high limit threshold	Set limit to zero to disable
4	Temperature reached low limit threshold	Set limit to zero to disable
5	Sensor reading is out of range	Check sensor wiring
6	Gas mix error	Gas mix must total 100%
7	Incorrect Settings	Check settings
8	In simulation mode	Set simulation value to 0 to disable
9	Pulse/alarm output is out of range	Check pulse/alarm output settings
10	Analog CH1 4-20mA is out of range	Check analog output settings
11	Analog CH2 4-20mA is out of range	Check analog output settings
12	Not used	Not used
13	Not used	Not used
14	CRC error	Check parameters and reset CRC
15	Error in Total	Reset total to clear alarm

Table 5.3: Status 2 Bits Definitions for Modbus Address 40017

Bit	Definition	Comment
0	Pulse hardware	
1	Busy	
2	HART hardware	
3	TM500	
4	TM-Cal in process	
5	TM-Cal fail	
6	TM-Cal aborted	
7	TM-Cal warning	

Write Single Register (Command 06)

This command is used to perform miscellaneous functions such as clearing the totalizer and elapsed time. The register address is Modbus=40018 and the data to write is described in table 5.1.

Request:

<Meter Address> <Command code=06> <Register address high=0x00> <Register address low=0x11> <Register data high=0x00> <Register data low =0x02> <CRC high> <CRC low>

Response:

<Meter Address> <Command code=06> <Register address =0x00> <Register address =0x11> <Register data=0x00> <Register data =0x02> <CRC high> <CRC low>

Write Multiple Registers (Command 16)

This command is restricted to writing to the gas mix percentage settings in registers 40058 - 40061. The preset single register command is not allowed to write to these registers. The percentage settings are 32-bit floating point numbers in units of percent. A setting of 12.7 means 12.7%.

Request message:

<Meter Address> <Command code=16 (0x10)> <Starting register address MSB> <Starting register address LSB> <Number of registers MSB> <Number of registers LSB> <Byte count> <Register data MSB> <Register data LSB> ... <Register data MSB> <Register data LSB> <CRC LSB> <CRC MSB>

Response message:

<Meter Address> <Command code=16 (0x10)> <Starting register address MSB> <Starting register address LSB> <Number of registers high> <Number of registers low> <CRC LSB> <CRC MSB>

Floating point data layout

Each 32-bit floating point value uses two consecutive Modbus registers. The most significant byte of the lower numbered register holds the least significant byte of the significand. The least significant byte of the lower numbered register holds the next most significant byte of the significand. The most significant byte of the higher numbered register holds the sign bit and most significant 7 bits of the exponent. The least significant byte of the higher numbered register holds the least significant bit of the exponent and the most significant 7 bits of the significand.

In the following tables:

S0 – S23 are the significant bits from least to most significant.

E0 – E7 are the exponent bits from least to most significant.

Sign is 1 if the number is negative, and 0 if the number is positive.

Lower numbered register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
S15	S14	S13	S12	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1	S0

Higher numbered register															
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Sign	E7	E6	E5	E4	E3	E2	E1	E0	S22	S21	S20	S19	S18	S17	S16

Since the Modbus register data is sent most significant byte first and the registers are sent lowest numbered first, a floating point value will look like this in the data stream:

First byte (MSB of lower register)								
Data bit	7	6	5	4	3	2	1	0
Value bit	S15	S14	S13	S12	S11	S10	S9	S8

Second byte (LSB of lower register)								
Data bit	7	6	5	4	3	2	1	0
Value bit	S7	S6	S5	S4	S3	S2	S1	S0

Third byte (MSB of higher register)								
Data bit	7	6	5	4	3	2	1	0
Value bit	Sign	E7	E6	E5	E4	E3	E2	E1

Fourth byte (LSB of higher register)								
Data bit	7	6	5	4	3	2	1	0
Value bit	E0	S22	S21	S20	S19	S18	S17	S16

Example: Set the gas mix as 60% Methane and 40% Carbon Dioxide.

First you must set the Gas selection Code to 250 for Digester Mix, using a preset single register command to 40057. Then you will be able to set the gas percentages. This requires setting the four registers 40058 through 40061. Register pair 40058-40059 will be set to 60.0, register pair 40060-40061 will be set to 40.0.

The message byte stream will be (bytes on the same line are sent leftmost first):

<0x01>

Address = 1

<0x10>

function = write multiple registers

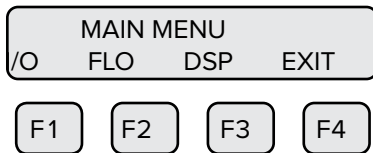
<0x00> <0x39>	start index = fifty seven, meaning register 40058
<0x00> <0x04	register count = 4 (holding 2 32-bit floating point values)
<0x08>	number of data bytes = 8
<0x00> <0x00> <0x42> <0x70>	value = 60.0%
<0x00> <0x00> <0x42> <0x20>	value = 40.0%
<0xCA> <0x24>	CRC

Response message:

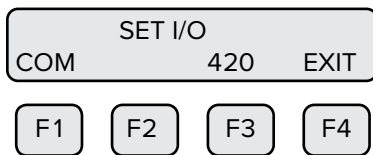
<0x01>	Address = 1
<0x10>	function = write multiple registers
<0x00> <0x39>	start index = fifty-seven = register 40058
<0x00> <0x08>	Number of data bytes written = 8
<0x10> <0x37>	CRC

Communication Protocol and Parameters

To program the communication parameters, start at the "Main Menu":

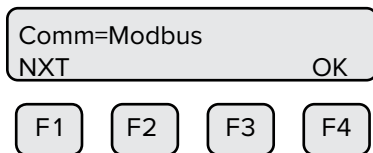


Then press **I/O (F1)** to set "Inputs/Outputs":



Then press **COM (F1)** to select communication parameters.

Set Bus protocol for Modbus:



Press **NXT (F1)** repeatedly until Modbus is selected as shown and then press **OK (F4)** to accept the setting.

The following communication settings apply only to Modbus:

Baud=9600			
NXT			OK

F1 F2 F3 F4

Press **NXT (F1)** repeatedly until the correct selection is shown then press **OK (F4)** to accept the setting.

Selections are:	115200	38400	4800
	76800	19200	2400
	57600	9600	1200

Parity=EVEN			
NXT			OK

F1 F2 F3 F4

Press **NXT (F1)** repeatedly until the correct selection is shown and then press **OK (F4)** to accept the setting.

Selections are: NONE
 ODD
 EVEN

Address=02			
CHG			OK

F1 F2 F3 F4

Press **CHG (F1)** to change the address and then press **OK (F4)** to accept the setting.

Selections are between 01 and 247.

 **NOTE!** Power cycle is required for the new settings to take effect.

Using Modbus to Program Gas-Mix™

Modbus can be used to access and program gases/gas mixes in the Gas-Mix™ feature available on the Model TM500.

Selecting TM500 Gases and Gas Mixes

Modbus register 40057 is used to set the gas type, which may be a pure gas or gas mix. Register 40057 will read zero, and register 40056 will read the gas selection that was chosen. Writing to register 40056 will produce an error response. See the Gas Selection Codes table for the values to write.

Table 5.4: Gas Selection Codes

Selection Code	Gas
0	Methane
1	CO2 (Carbon Dioxide)
2	Nitrogen
3	Air
4	Natural Gas
5	Argon
6	Propane
7	Helium
8	Oxygen

Selection Code	Gas
8	Oxygen
9	Reserved
10	Butane
11	Hydrogen
12	Ethane
13	Ethylene
14	Propylene
250	Mixed gas (must set percentages)

NOTE! Natural gas is defined as NAESB typical mixture of 94.9% Methane, 2.5% Ethane, 1.6% Nitrogen, 0.7% CO2, 0.3% Propane.

Setting Mix Percentages

First set the gas select code to Gas-Mix (250). Next, go through each gas relevant to the mix type and set their percentage to the desired 32 bit floating point value - this value is split in two 16 bit registers. Ensure that all gases total up to 100%. Do not write a custom gas percent when the gas select code is set to a pure gas..

Table 5.5: FT4X Modbus Holding Registers for Gas-SelectX®

40056	16-bit int	Gas type selection	See table of gas selection codes for Modbus
40057	16-bit int	Gas type selection	
40058	32-bit float LSW	Methane (C1) percentage	Percent (31.4 = 31.4%)
40059	32-bit float MSW		
40060	32-bit float LSW	Carbon Dioxide percentage	Percent (31.4 = 31.4%)
40061	32-bit float MSW		
40062	32-bit float LSW	Nitrogen percentage	Percent (31.4 = 31.4%)
40063	32-bit float MSW		
40064	32-bit float LSW	Air percentage	Percent (31.4 = 31.4%)
40065	32-bit float MSW		
40066	32-bit float LSW	Argon percentage	Percent (31.4 = 31.4%)
40067	32-bit float MSW		
40068	32-bit float LSW	Propane percentage	Percent (31.4 = 31.4%)
40069	32-bit float MSW		
40070	32-bit float LSW	Helium percentage	Percent (31.4 = 31.4%)
40071	32-bit float MSW		
40072	32-bit float LSW	Oxygen percentage	Percent (31.4 = 31.4%)
40073	32-bit float MSW		
40074	32-bit float LSW	Butane percentage	Percent (31.4 = 31.4%)
40075	32-bit float MSW		

40076	32-bit float LSW	Hydrogen percentage	Percent (31.4 = 31.4%)
40077	32-bit float MSW		
40078	32-bit float LSW	Reserved	
40079	32-bit float MSW		
40080	32-bit float LSW	Ethane percentage	Percent (31.4 = 31.4%)
40081	32-bit float MSW		
40082 - 40091		Reserved	
40092	32-bit float LSW	Ethylene percentage	Percent (31.4 = 31.4%)
40093	32-bit float MSW		
40094	32-bit float LSW	Propylene percentage	Percent (31.4 = 31.4%)
40095	32-bit float MSW		
40096 - 40195		Reserved	



NOTES!

- In Least Significant Word (LSW) and Most Significant Word (MSW), “word” is one 16-bit Modbus register. A 32-bit float or 32-bit integer is stored in a pair of Modbus registers. When a register is designated as “32-bit int LSW”, it means that bits 0-15 of the variable are in that register. A register designated as MSW has bits 16-31 of the variable. For instance, the flow total can be read as a 32-bit integer from registers 40003 (LSW) and 40004 (MSW). If the flow total is 0x12345678, then register 40003 will hold 0x5678, and register 40004 will hold 0x1234. See the layout of a 32-bit floating point value on p. 78.
- 32-bit floating point values are defined by the IEEE 754 standard: <https://ieeexplore.ieee.org/document/8766229>
- Refer also to Wikipedia: https://en.wikipedia.org/wiki/Single-precision_floating-point_format

Scope - HART Communication

The Sierra Instruments Model TM500 transmitter complies with HART Protocol Revision 7.1. This section of the manual specifies all the device-specific features and documents HART Protocol implementation details (e.g., the Engineering Unit Codes supported). The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART-capable Host Applications.

Purpose

This specification provides a complete description of this Field Device from a HART Communication perspective. The specification is designed to be a technical reference for HART capable Host Application Developers, System Integrators and knowledgeable End Users. It also provides functional specifications (e.g., commands and performance requirements) used during development, maintenance and testing. This document assumes the reader is familiar with HART Protocol requirements and terminology.

References

HART Communication Protocol Specification. HCF_SPEC-12.

Device Identification

Manufacturer Name:	Sierra Instruments	Model Name:	TM500
Manufacture ID Code:	165	Device Type Code:	63784 (F982 Hex)
HART Protocol Revision:	7.1	Device Revision:	1
No. of Device Variables:	None		
Physical Layers Supported:	FSK		
Physical Device Category:	Transmitter, DC-isolated Bus Device		

Product Overview

The TM500 HART communication option can be monitored and configured using a HART master device or a hand-held communicator.

Process Flow Rate 4-20mA Analog Output

The 4-20mA output of the TM500 HART represents the process flow rate measurement, linearized and scaled according to the configured range of the instrument. This output corresponds to the Primary Variable. HART Communication is supported on this loop.

The 4-20mA output of the TM500 should be configured for flow rate when using HART. If the 4-20mA output is set to report temperature, HART communication will report the 4-20mA value for temperature rather than flow.

HART Indicators

Green LED indicator LP3 cycles on and off to indicate that the TM500 is operating. Orange LED indicator LP2 blinks when HART signals are received and Yellow LP1 blinks when HART signals are transmitted. The LEDs are located behind the display panel.

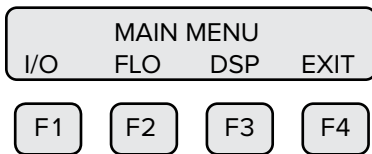
The orange LED indicator LP2 will be on continuously when HART communication is enabled and the 4-20mA wiring is not connected.

TM500 HART Communication Setup

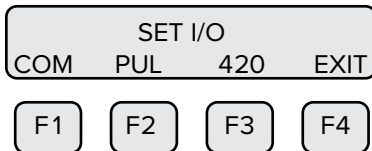
HART communication must be selected in the TM500 Serial Communication menu for HART communication to operate. When this communication parameter is changed, power to the TM500 must be cycled for it to take effect.

Communication Protocol and Parameters

To program the communication parameters, press **I/O (F1)** key from the "Main Menu".

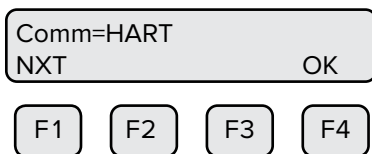


This is the "Main Menu" for the programming mode. To exit the programming mode, press EXIT (F4) repeatedly until "Normal Mode" is seen briefly. Choose I/O (F1) to access the communication output.



Then press **COM (F1)** to select communication parameters.

Set Bus protocol for HART:



Press **NXT (F1)** until HART is selected as shown and then press **OK (F4)** to accept the setting.

NOTE! Power cycle is required for the new settings to take effect.

Dynamic Variables

Four Dynamic Variables are implemented.

Variable	Meaning	Units
PV	Flow Rate	In Selected Units
SV	Total	In Selected Units
TV	Temperature	In Selected Units
QV	Elapsed Time	In Hours

Status Information

Device Status

Bit 4 ("More Status Available") is set when any failure is detected.

Command #48 provides additional detail.

Extended Device Status

This bit is set if a sensor error is detected. "Device Variable Alert" is set if the Primary Variable (PV) is out of limit.

Additional Device Status (Command 48)

Command #48 returns 2 Device-Specific Status bytes of data, with the following status information:

These bits are set when an alarm or error condition is present. The bit automatically clears when the condition returns to its normal state.

Byte	Bit	Meaning	Class
0	0	Power Up Indication	Status
	1	High Flow Limit Alarm	Alarm
	2	Low Flow Limit Alarm	Alarm
	3	High Temperature Limit Alarm	Alarm
	4	Low Temperature Limit Alarm	Alarm
	5	Sensor out of range	Error
	6	Velocity out of range	Error
	7	Check Parameter Settings	Error
1	0	In Simulation Mode	Alarm
	1	Frequency output out of range	Alarm
	2	CH 1 4-20mA out of range	Alarm
	3	CH 2 4-20mA out of range	Alarm
	4	Busy	Alarm
	5	Bridge shutdown	Error
	6	CRC database error	Error
	7	Error with Total	Error

Common-Practice Commands, Supported Commands

The following common-practice commands are implemented:

- 34 Write Primary Variable (PV) Damping Value
- 35 Write PV Range Value
- 36 Set PV Upper Range Value
- 37 Set PV Lower Range Value
- 38 Reset "Configuration Changed" Flag
- 40 Enter/Exit Fixed Current Mode
- 44 Write PV Units
- 45 Trim Loop Minimum
- 46 Trim Loop Maximum
- 48 Read Additional Device Status (Command #48 returns 2 bytes of data)
- 59 Write Number of Response Preambles

Common-Practice Commands, Unsupported Commands

Burst Mode - This device does not support Burst Mode.

Catch Device Variable - This device does not support Catch Device Variable.

Device-Specific Commands - No Device-Specific commands are implemented.

Modes

Fixed current mode is implemented, using Command 40. This mode is cleared by power loss or reset.


Damping

Damping is standard, affecting only the PV and the loop current signal.

Capability Checklist

Manufacturer, model	Sierra Instruments Instruments, TM500
Device Type	Transmitter
HART revision	7.1
Device Description available	No
Number and type of sensors	1
Number and type of actuators	0
Number and type of host side signals	1 : 4-20mA analog
Number of Device Variables	0
Number of Dynamic Variables	4
Mappable Dynamic Variables	No
Number of common-practice commands	17
Number of device-specific commands	0
Bits of additional device status	8
Alternative operating modes	No
Burst mode	No
Write-protection	Yes

PRECAUTIONS


 **WARNING!** BEFORE ATTEMPTING ANY MAINTENANCE, TAKE THE NECESSARY SAFETY PRECAUTIONS BEFORE REMOVING THE PROBE FROM THE DUCT (EXAMPLE: PURGE LINES OF TOXIC AND/OR EXPLOSIVE GAS, DEPRESSURIZE, ETC...).

WARNING! EXPLOSION HAZARD. DO NOT REMOVE OR REPLACE COMPONENTS OR FUSES UNLESS POWER HAS BEEN SWITCHED OFF WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

WARNING! EXPLOSION HAZARD. DO NOT DISCONNECT EQUIPMENT WHEN A FLAMMABLE OR COMBUSTIBLE ATMOSPHERE IS PRESENT.

Access to Electronics

Accessing electronics is not normally required for maintenance purposes. If a loose connection is suspected, unscrew the rear cap of the meter to access the wiring terminations.

 **CAUTION!** BE SURE POWER TO METER IS SWITCHED OFF BEFORE ATTEMPTING TO ACCESS ELECTRONICS. If there is a problem and a loose connection is not found, please contact Sierra Instruments Customer Service for technical assistance at (831) 373-0200.


Broken or Damaged Probe

If the sensor is broken or damaged, the probe and electronics must be returned to the factory. A new sensor will be installed and calibrated. Refer to "Returning Your Meter" on p. 112.

Flow Calibration and Calibration Validation

To ensure high accuracy of your Model TM500 Flow Meter, Sierra Instruments provides a full NIST traceable calibration. It is recommended that the meter's accuracy be checked annually by performing the TM-Cal™ Calibration Validation test.

FUSE REPLACEMENT

 **WARNING!** Turn input power OFF before removing or installing a fuse. Use only recommended fuse replacements.

Verify the fuse is defective by measuring it with an Ohm meter (two replacement fuses are provided with each unit). Replacement fuse is Littelfuse part number 0454.750MR

The 100 to 240VAC power option TM500 does not have a replaceable fuse.

To replace the fuse:

The fuse F1 is located near the power terminal block and can be removed by using tweezers or needle-nose pliers.

Sensor Cleaning

The sensor is insensitive to small amounts of residue, but continued use in dirty environments will require periodic cleaning. To inspect the sensor, remove power from electronics and remove the unit from the pipe or duct, exposing the sensor elements. If they are visibly dirty, clean them with water or alcohol (ethanol) using an appropriate brush until they appear clean again. Even though the sensor elements are rugged, avoid touching them with any solid object and use a light touch while cleaning them.

Instructions for Removing and Inserting the Meter from a Pressurized Pipe using the Retractor

- ! WARNING!** Possible injury or damage to equipment may occur if the retractor is not used correctly. Please read the following instructions carefully prior to using the retractor.
- ! CAUTION!** Never remove the restraint cable without first closing the Ball Valve and bleeding off pressure.
- ! WARNING!** When working with the retractor, do not stand or position any part of your body in the path of the flow meter. An injury may occur if the probe is forced outward by system pressure.

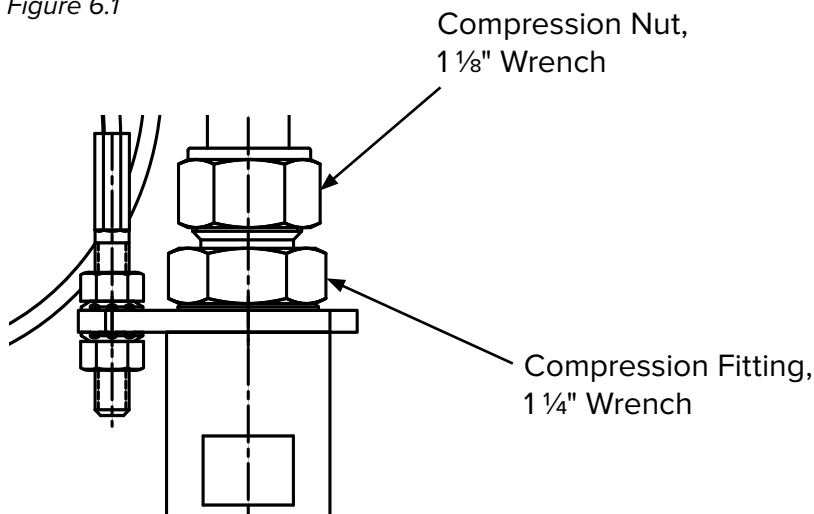
How to Remove the Meter from the Retractor (System Pressurized)

Step 1 - Remove the Probe from the Flow Stream

1. Disconnect power from the meter.
 - i NOTE!** At 150 psig of max system pressure, the probe will have approximately 66 lbs. of force pushing it out.
2. System pressure may force the probe out of the retractor when the compression nut is loosened. Hold the flow meter to counteract the force of the system pressure, and carefully loosen and unscrew the compression nut.
3. While supporting the meter, slowly slide the probe out of the retractor until the restraint cable is taut.
4. Close the ball valve all the way.

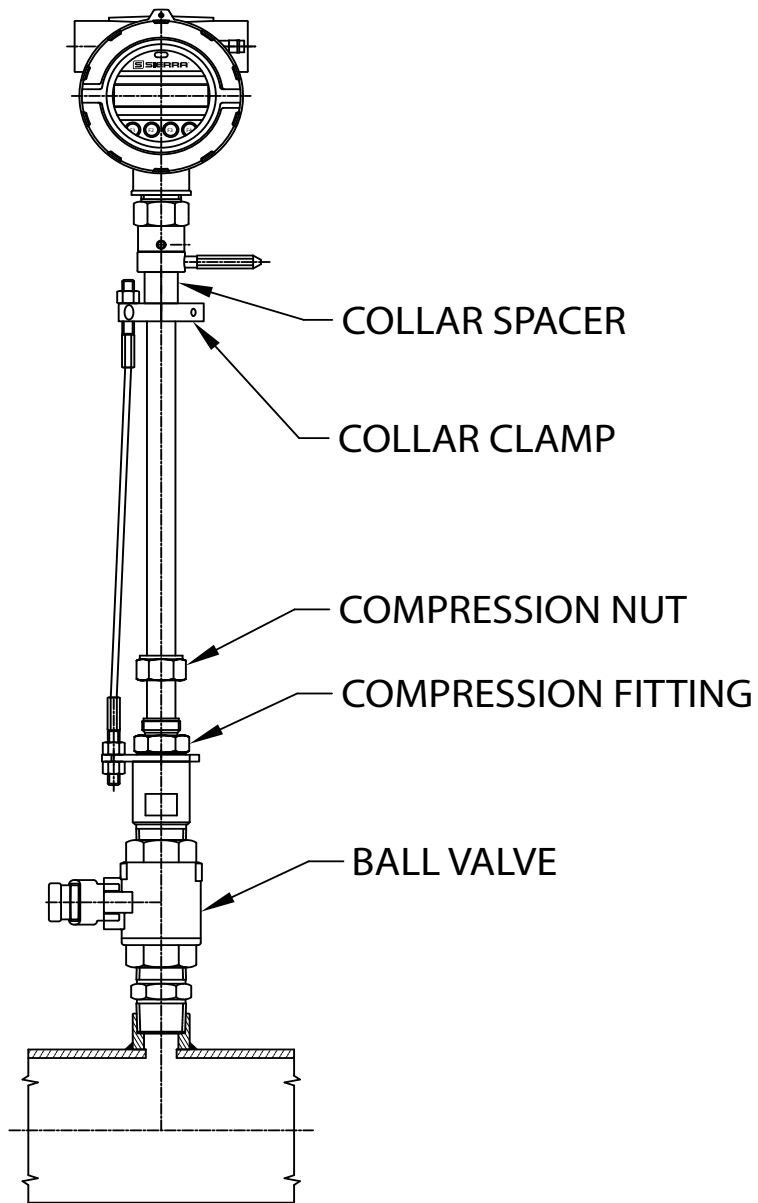
- ! CAUTION!** At this point there is still pressure inside of the retractor.

Figure 6.1



Step 2 - Remove the Probe from the Retractor Body

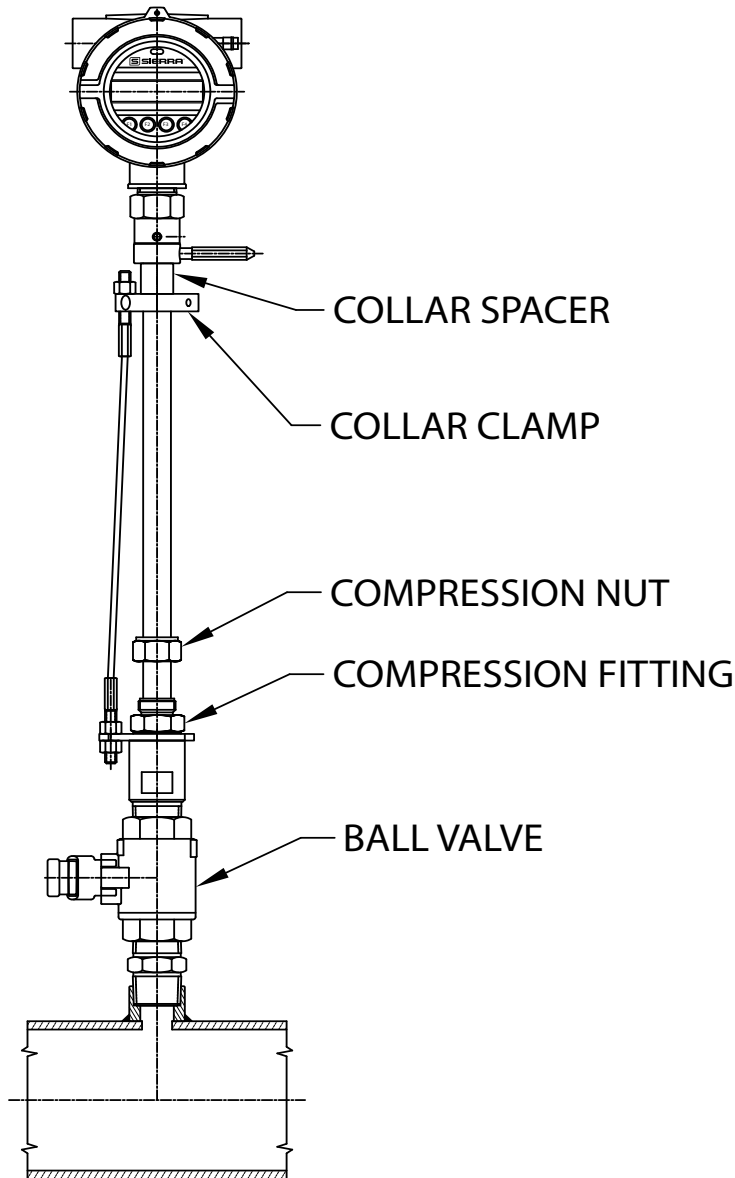
5. After removing the probe from the flow stream (#1-4 on previous page), slowly loosen the compression fitting (see figure 6.2), until the pressure in the retractor is relieved.
6. Retighten the compression fitting.
7. Remove the Collar Clamp by using a 3/16" Hex Key.
8. Carefully slide the probe out of the retractor while supporting the meter.

Figure 6.2

How to Insert the Probe into the Flow Stream (Valve closed, System Pressurized)

1. Carefully, slide the probe into the retractor.
2. Install the collar clamp just below the collar spacer, and tighten it in place on the probe. Slide the probe back out of the retractor until the cable is straight and taut.

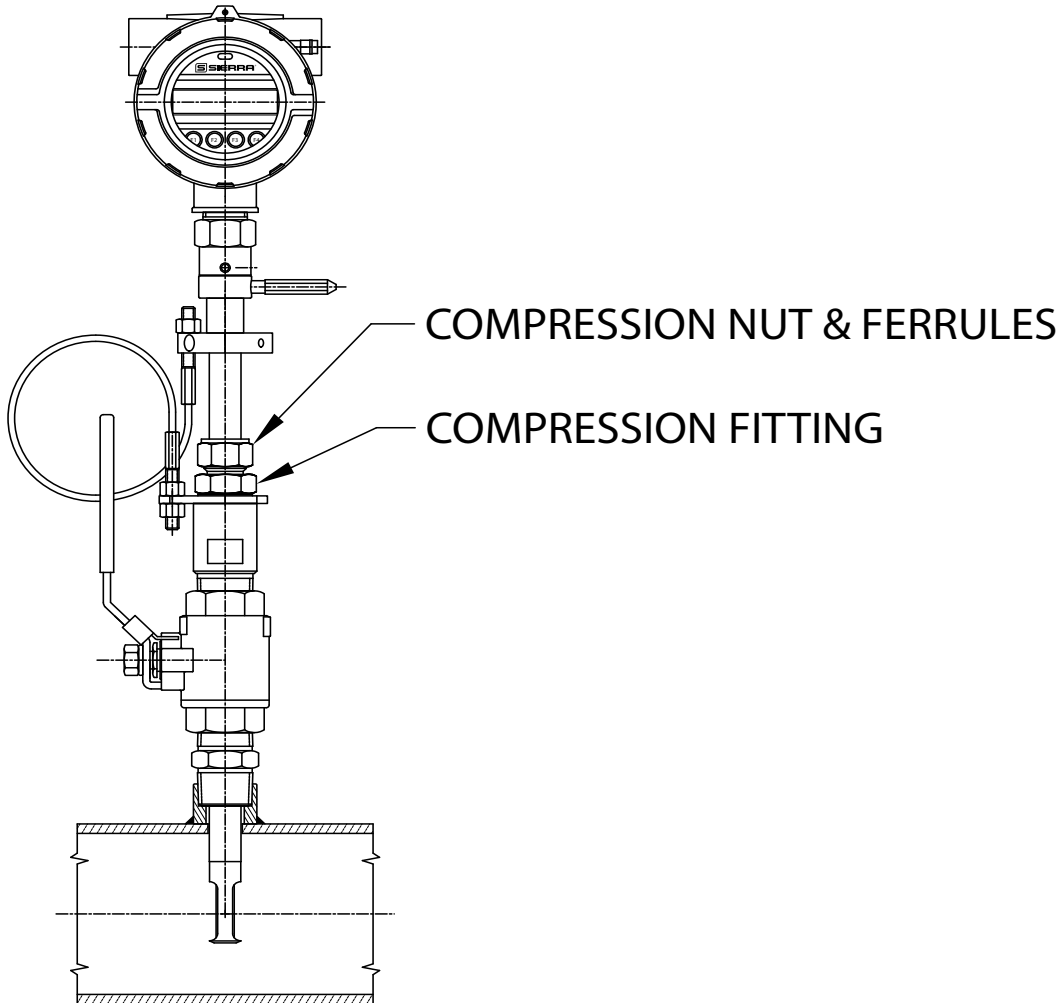
Figure 6.3



- NOTE!** At a maximum system pressure of 150 psig, the force required to push the probe in place to tighten the compression Nut will be approximately 66 lbs.
3. Slowly open the ball valve to the full open position. Push the meter and probe into the pipe, then hand tighten the compression nut onto the compression fitting.
 4. Verify that the probe is aligned with the center line of the pipe, and pointed in the direction of flow.

5. Secure the probe in place by tightening the compression nut with a 1 1/8" wrench and a 1 1/4" wrench on the compression fitting. See p. 27 of the manual for detailed instructions to tighten the compression nut.
6. Power may now be applied to the meter.

Figure 6.4



Troubleshooting

 **CAUTION!** The electronics and sensor supplied by Sierra Instruments are calibrated as a single precision mass flow meter. Interchanging sensors will decrease the accuracy of the flow meter. If you experience any problem with your Model TM500 Flow meter, call Sierra Instruments Customer Service Department, Technical Assistance at (831) 373-0200.

Problem	Possible Cause	Action
Meter does not initialize	<ol style="list-style-type: none"> 1. Malfunction in flow meter 2. Electromagnetic interference (EMI) 	<ol style="list-style-type: none"> 1. Return flow meter to Sierra Instruments for repair (Refer to p. 112 for shipping instructions) 2. Check meter power cycles. 3. Press and release F1 and F2 at the same time; the display will enter Engineering screens. 4. Press F1 to get to screen #23; record power cycle value. 5. Press F4 to return to normal operation; monitor meter until problem returns. 6. Return to screen #23 to see if power cycles have increased; microprocessor is resetting due to EMI electrical noise entering the meter. 7. Check Power input and output cables grounding and routing.
Flow measurement is erratic or fluctuating	<ol style="list-style-type: none"> 1. Very turbulent flow 2. Sensor dirty 3. Sensor broken 4. Probe not mounted securely 5. Malfunction in flow meter 6. Meter installed incorrectly 	<ol style="list-style-type: none"> 1. Increase dampening (see filter settings in "Flow Parameters" on p. 62) 2. Clean sensor (Refer to Maintenance section, p. 89) 3. Return flow meter to Sierra Instruments for repair (Refer to p. 112 for shipping instructions) 4. Remount probe (see Installation section, p. 22); must be mounted securely without vibration. If vibration persists, choose a new mounting location without vibration. 5. Return flow meter to Sierra Instruments for repair (Refer to p. 112 for shipping instructions) 6. Re-install meter according to instructions (Refer to installation section, p. 22)

Problem	Possible Cause(s)	Action(s)
Display Error	<ol style="list-style-type: none"> 1. Loose or damaged ribbon cable 2. Damaged electronics 3. Ambient temperature 	<ol style="list-style-type: none"> 1. Visual inspection. 2. Return the meter or display for repair. 3. Operate meter between -20 to 70°C
Flow measurement seems low	<ol style="list-style-type: none"> 1. Probe not oriented properly 2. Sensor dirty 	<ol style="list-style-type: none"> 1. Orient probe per installation sections: Insertion (p. 29) 2. Clean sensor (p. 89)
Unit will not power-up	<ol style="list-style-type: none"> 1. No power input 2. Bad fuse 3. Bad Power supply 	<ol style="list-style-type: none"> 1. Check fuse (F1) located next to TS1 on main board. 2. Check for correct power supply voltage at TS1 on main board. <p style="margin-left: 40px;">If fuse is OK and unit still won't power up, call Sierra Instruments for additional assistance.</p> <p style="margin-left: 40px;">The 100 to 240VAC power option TM500 does not have a replaceable fuse.</p>

Troubleshooting TM-Cal™

If the TM500 Meter fails a TM-Cal™ Calibration Validation test, there are a few reasons that could be the cause:

1. Flow rate in the pipe:
 - Run the test again under a higher flow rate if possible.
2. The sensor may be dirty or damaged:
 - Visually inspect the meter for damage. If damage is found, meter may need to be serviced. Contact Sierra Instruments Technical Assistance at 831-373-0200 for more information.
 - Try cleaning the sensor and try the test again under flow conditions.
3. If the meter fails again, contact Sierra Instruments Technical Assistance at 831-373-0200 for more information.

Installation Problems

The following is a summary listing of problems that may be encountered with the installation of the TM500 Thermal Mass Flow Meter.

1. Improper wiring connections.
2. Refer to Figures 3.1 to 3.11 and "Wiring Precautions" in Wiring section (p. 35) for further guidance.
3. Inadequate DC power source.
4. The TM500 requires 12 to 24VDC at to 6 Watts minimum to operate. A 20 Watt power supply is recommended for powering the TM500 to ensure it operates properly under all temperature ventilation, and power on conditions. If the voltage supplied at the input terminals of the TM500 is not within the range of 10VDC to 30VDC, a variety of problems can occur including a dim display, inaccurate flow readings or faulty 4-20mA, pulse and communication interface. The 100 to 240VAC power option requires 85 to 264VAC to operate.
5. Flow measurement seems inaccurate.
 - Check to ensure that the flow meter is installed so that the Flow Direction Indicator is pointing in the direction of flow. Refer to Figure 2.8 (p. 29). If not, change orientation of meter.
 - Check that the insertion depth of the sensor/probe is correct. The end of the probe should be adjusted as per Figure 2.8 (p. 29).
 - Ensure that there are a minimum of fifteen diameters of straight pipe upstream of the sensor and ten diameters downstream. If complex flow disturbances are upstream of the sensor, extension of the straight pipe may be required to ensure accurate flow measurement. Contact Sierra Instruments for assistance.
 - Ensure that pipe inside diameter in the meter matches data on the Sierra Instruments Calibration Certificate. The pipe inside diameter is programmed into the flow meter through the front panel (see Flow Parameters, p. 61).
6. *Erratic flow reading (especially a flow reading spiking high).*
7. This may be a symptom of moisture in the flow stream. Sierra Instruments flow meters are designed to work in relatively dry gas applications only. Contact Sierra Instruments to discuss resolutions to this problem.
8. *Flow meter is not responding to flow.*
 - Check to ensure adequate power is supplied to the flow meter. If things appear to be correct, perform this functional test before calling Sierra Instruments. Carefully remove the probe and sensor from the pipe. For those flow meters with a display - and if the display is reading zero - blow on the sensor to see if a response occurs. If nothing happens, take a damp rag or sponge and place it in contact with the sensor. A reading should occur. Contact Sierra Instruments Customer Service with this information.
9. Display and/or 4-20mA signal reading above zero flow when no flow is occurring in the pipe.
10. If the reading is less than 5% of full scale, it is likely this is a normal condition caused by convection flow created by the heated sensor. It does not mean that the zero of the instrument is improperly set. The sensor is extremely sensitive to gas flow and can even read the small flow caused by convection. If this is an unacceptable condition, please contact Sierra Instruments Customer Service for alternatives.

Alarm Codes

Alarm Code	Reason	Action
13	Flow rate above high limits	Refer to the FLOW MENU 2 section on p. 61 of this Manual to verify limit is within range. Check ALM = HiFloAlm under PRM.
14	Flow rate below low limits	Refer to the FLOW MENU 2 section on p. 61 of this Manual to verify limit is within range. Check ALM = LoFloAlm under PRM.
15	Temperature above high limits	Refer to the FLOW MENU 2 section on p. 61 of this Manual to verify limit is within range. Check ALM=HiTempAlm under PRM.
16	Temperature below low limits	Refer to the FLOW MENU 2 section on p. 61 of this Manual to verify limit is within range. Check ALM = LoTempAlm
22	Sensor out of range	<p>Check the CSV voltage in ENG menu in ENG Screens, refer to page 18. It should be approximately 0.04 volts when TM500 is measuring no flow and up to 0.25 volts at high flow.</p> <p>Measure resistance of the sensor wires, the wires must be removed from TM500 terminal block, refer to page 35. Resistance from red to White wires, approximately 9 ohms. Resistance from blue to Yellow waves, approximately 109 ohms.</p> <p>If TM500 has remote sensor option, verify, this wiring is correct, refer to page 47.</p> <p>Verify that parameters in TM500 are set correctly. If TM500-View Software is available, check parameter settings in Configuration page. If using TM500 front panel, checked parameters in UNIT menu of FLOW MENU 1 and PRM menu of FLOW MENU 2, refer to pages 13-14.</p>
23	Gas mix error	Gas mix must equal 100%.
24	Check settings	One or more internal settings are corrupted or out of spec. Contact Sierra Instruments Service for instructions to verify settings.
25	Simulation mode	Meter is in Simulation Mode. Refer to the FLOW MENU 1 section on p. 64 of this Manual. Use the SIM Section under Diagnostics to return to normal operation.
26	Pulse/alarm output over range	Refer to the DIGITAL OUTPUT MENU on p. 12 of this Manual. Verify the Pulse/ alarm Output settings are within limits.
32	4-20mA is out of range	Refer to the MAIN MENU on p. 11 of this Manual. Use the Set I/O section to verify range limits.
33	Temperature 4-20mA out of range	Refer to the MAIN MENU on p. 11 of this Manual. Use the Set I/O section to verify range limits.
34	Busy	Meter is recalculating new parameters.
36	Database CRC Error	Refer to the Reset CRC section on p. 66 of this manual. Verify the programmed values are verified and corrected before clearing the error. Contact Sierra Instruments Service Department for possible causes.

Alarm Codes continued

38	CSV Volt Error	The CSV Voltage is out of the acceptable range. This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22.
39	VFLO Volt Error	The VFLO Voltage is out of the acceptable range. This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22.
40	TSV Volt Error	The TSV Voltage is out of the acceptable range. This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22.
41	VTEMP Volt Error	The VTEMP Voltage is out of the acceptable range. This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22.
42	Delta T Error	The Delta T error between the sensor elements is too large. This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22.
43	Invalid Board Calibration Values	The board calibration values do not match the values saved in the backup. This is the result of data corruption. The best course of action is to perform a "Restore Database" within the meter menus - this will restore the meter to its factory settings and calibrations.
46	TEMP Input Error	This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22. Focus on Yellow and Blue wires.
47	TSV Input Error	This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22. Focus on Yellow and Blue wires.
48	CSV Input Error	This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22. Focus on Red and White wires.
49	FLO Input Error	This may be a result of failed electronics, parameters, or sensor connections. Refer to action of Alarm Code 22. Focus on Red and White wires.
53	ADC Temp Below Spec	This is the result of low temperatures inside the meter enclosure. Be sure to keep the meter within the specification.
54	ADC Temp Above Spec	This is the result of high temperatures inside the meter enclosure. Be sure to keep the meter within the specification.
55	ADC NOREF	This is a result of failed electronics. Contact support for further assistance.

Specifications

Performance Specs

Flow Accuracy:

- Air and Nitrogen (N₂): $\pm 1\%$ of reading $\pm 0.2\%$ of full scale
- Other gases: $\pm 1.5\%$ of reading $\pm 0.5\%$ of full scale
- Accuracy specification applies to customer's selected flow range
- Maximum range: 15 to 45,000 SFPM (0.07 to 212 NMPS)
- Minimum range: 15 to 500 SFPM (0.07 to 2.4 NMPS)
- Straight, unobstructed pipe requirement
 - Insertion Meters: 15 diameters upstream; 10 downstream
 - Inline Meters: 8 diameters upstream; 4 downstream
 - Insertion Meters with FlowTrak: 7 diameters upstream; 5 downstream

Flow Repeatability: $\pm 0.2\%$ of full scale

Flow Response Time: 0.8 seconds (one time constant)

Temperature Accuracy: $\pm 1^\circ\text{F}$ ($\pm 0.6^\circ\text{C}$)

Calibration:

- Factory Calibration to NIST traceable standards
- TM-Cal™: In situ, operator-initiated calibration validation

Operating Specs

Gas-Mix™ Selections:

Pure Gas Menu, Gas Mix Menu. Visit www.sierrainstruments.com/TM500 for more information on availability of current gases.

Units of Measurement (field selectable):


SCFM, SCFH, NM³/M, NM³/H, NM³/D, NLPS, NLPM, NLPH, MCFD, MSCFD, SCFD, MMSCFD, MMSCFM, SM³/D, SM³/H, SM³/M, LB/S, LB/M, LB/H, LB/D, KG/S, KG/M, KG/H, SLPM, MT/H


Gas Pressure (maximum at 100° F):

- Insertion meter: 740 psig (51.02 barg)
- 316 SS inline meter with NPT ends: 500 psig (34.47 barg)
- 316 SS inline meter with 150 lb. flanges: 230 psig (15.86 barg)
- 316 SS inline meter with 300 lb. flanges: 600 psig (41 barg)
- Carbon steel inline meter with NPT ends: 500 psig (34.47 barg)
- Carbon steel inline meter with 150 lb. flanges: 285 psig (19.65 barg)
- Carbon steel inline meter with 300 lb. flanges: 740 psig (51 barg)

Retractor Assembly: 150 psig (10.34 barg)

 **NOTE!** Check with factory for higher pressure options.

 **NOTE!** When teflon ferrule option ordered, gas pressure is 60psig (4.1 barg) maximum.

 **NOTE!** The EU Pressure Equipment Directive (PED) requires that the minimum ambient and fluid temperature rating for carbon steel flow bodies not be below -29°C .

Operating Specs (cont'd)

Temperature:

DigiSense™ Sensor: -40°F to 250°F (-40°C to 121°C)

Enclosure: -40°F to 158°F (-40°C to 70°C)*

Remote Sensor Enclosure: -40°F to 158°F (-40°C to 70°C)

i NOTE! Display dims below -4°F (-20°C), function returns once temperature rises again.

Relative Humidity: 90% RH maximum; non-condensing

i NOTE! Condensing liquids contacting the sensor can cause erratic flow indication.

Flow Velocity Range:

15 to 45,000 SFPM (0.07 to 212 NMPS)

Turndown: up to 1000:1; 100:1 typical

Maximum Flow Ranges for 645S Insertion Flow Meters			
Pipe Diameter	SCFM	MSCFD	NM ³ /hr
1.5" (40mm)	0-630	0-910	0-1,000
2" (50mm)	0-1,040	0-1,490	0-1,640
2.5" (63mm)	0-1,490	0-2,140	0-2,350
3" (80mm)	0-2,300	0-3,320	0-3,630
4" (100mm)	0-3,970	0-5,720	0-6,270
6" (150mm)	0-9,020	0-12,990	0-14,230
8" (200mm)	0-15,630	0-22,500	0-24,650
10" (250mm)	0-24,630	0-35,080	0-38,430
12" (300mm)	0-34,980	0-50,370	0-55,180

i NOTE! To determine if the TM500 will operate accurately in other pipe sizes, divide the maximum flow rate by the pipe area. The application is acceptable if the resulting velocity is within the velocity range above.

Maximum Flow Ranges for 745S Inline Flow Meters			
Size	SCFM	MSCFD	NM ³ /hr
0.75"	0-160	0-230	0-260
1"	0-270	0-380	0-420
1.25"	0-460	0-670	0-730
1.5"	0-630	0-910	0-1,000
2"	0-1,040	0-1,490	0-1,640
2.5"	0-1,490	0-2,140	0-2,350
3"	0-2,300	0-3,320	0-3,630
4"	0-3,970	0-5,720	0-6,270
6"	0-9,020	0-12,990	0-14,230

i NOTE! Standard conditions of air at 70°F and one atmosphere. Consult factory for other gases and for flow ranges above those listed. Inline Meters above 2,500 SCFM (3,950 NM³/H) may require third-party calibration. Contact Sierra Instruments.

Operating Specs (cont'd)**Input Power:**

12 to 24VDC $\overline{\text{---}}$, 6 Watts. Full Input Power Range: 10 to 30VDC (standard DC power).

- A 20 Watt or greater DC power supply is recommended to power the TM500.

100 to 240VAC \sim , 7 Watts, 50/60Hz (AC power option)

- Full Input Power Range: 85 to 264VAC

Class I Equipment (Electrical Grounding Required for Safety).

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

Inputs/Outputs:**4-20mA Channel 1:**

- Standard isolated 4-20mA output configured to indicate flow; fault indication per NAMUR NE43. HART serial communication option.

The 4-20mA load resistance must be 125 ohms or less when operating on 12 volt power and 600 ohms or less on 24 volt power.

4-20mA Channel 2:

- Standard isolated 4-20mA output configured to indicate either flow or temperature

Pulse/Alarm:

- Isolated open collector output rated for 5 to 24VDC, 20mA maximum load, 0 to 100Hz (the pulse output can be configured to either transmit a 0 to 100Hz signal proportional to flow rate or an on/off alarm).

Remote Switch Input:

- Can be configured to reset the flow totalizer and elapsed time.

Serial Communication

- Isolated Modbus RTU (RS485) option
- Isolated HART communication option

USB Communication:

- Isolated USB 2.0 for interfacing with a laptop or computer is standard.
- TM500-View Software™: A free PC-based software tool that provides complete configuration, remote process monitoring, and data logging functions through USB communication.

4-20mA and Loop Verification:

Simulation mode used to align 4-20mA output with the input to customer's PLC/DCS.

Physical Specs**Sensor material:**

316 stainless steel

Enclosure:

NEMA 4X (IP67), aluminum, dual ¾" FNPT conduit entries. Cabling to remote enclosure: 8-conductor, 18 AWG, twisted, shielded, 100 feet maximum.

Flow Meter Installation:

A ¾" MNPT compression fitting is provided with the TM500 to connect with a customer supplied ¾" female branch outlet welded to the pipe. Extra ¾" and 1" MNPT compression fittings are an ordering option from Sierra Instruments.

Agency Approvals

CE: Approved

EMC Directive; 2014/30/EU

Electrical Equipment for Measurement, Control and Lab Use: EN61326-1:2013

Low Voltage Directive (LVD): 2014/35/EU

Product Safety Testing: EN 61010-1: 2010

Pressure Equipment Directive: 2014/68/EU

Weld Testing: EN ISO 15614-1 and EN ISO 9606-1, ASME B31.3

FM (FM21US0124X) and FMc (FM21CA0090X): Approved

Class I, Division 1, Groups B,C,D;

Class II, Division 1, Groups E,F,G;

Class III, Division 1; T6 or T4, Ta = - 40°C to +70°C;

Class 1, Zone 1, AEx/Ex db IIB + H2 T6 or T4 Gb; Ta= -20°C to +70°C; Type 4X, IP67

ATEX (FM23ATEX0042X): Approved

II 2 G Ex db IIB + H2 T6 or T4 Gb Ta = - 20°C to +70°C; IP67

II 2 D Ex tb IIIC T85°C or T135°C Db Ta = - 20°C to +70°C; IP67

IECEX (IECEX FMG 23.0020X): Approved

Ex db IIB + H2 T6 or T4 Gb Ta = - 20°C to +70°C; IP67

Ex tb IIIC T85°C or T135°C Db Ta = - 20°C to +70°C; IP67

UKEX (FM23UKEX0041X): Approved

II 2 G Ex db IIB + H2 T6 or T4 Gb Ta = - 20°C to +70°C; IP67

II 2 D Ex tb IIIC T85°C or T135°C Db Ta = - 20°C to +70°C; IP67

ATEX and IECEX Standards:

EN IEC 60079-0

EN 60079-31

IEC 60079-0

IEC 60079-31

EN 60079-1

EN 60529 +A1 +A2

IEC 60079-1

IEC 60529

Specific Conditions of Use:

1. The flameproof joints of the equipment are not intended to be repaired. Consult the manufacturer if dimensional information on the flameproof joints is necessary.
2. Refer to the manufacturer's instructions to reduce the potential of an electrostatic charging hazard on the equipment or enclosure.
3. The equipment temperature code ratings are dependent on the enclosure configuration model code (local or remote). Refer to the following table for specific temperature code markings.

Enclosure Model Code	Temperature Code Marking - Divisions (All)		Temperature Code Marking - Zones (Gas)		Temperature Code Marking - Zones (Dust)	
	Main Enclosure	Remote Enclosure	Main Enclosure	Remote Enclosure	Main Enclosure	Remote Enclosure
E1	T4	N/A	T4	N/A	T135°C	N/A
E2	T4	N/A	T4	N/A	T135°C	N/A
E3	T6	T4	T6	T4	T85°C	T135°C
E4	T6	T4	T6	T4	T85°C	T135°C

Fig. 7.1: TM500 Insertion Meter with Retractor Dimensions

NOTE: Dimensions shown in inches (millimeters) Fig. 7.1 - 7.11.

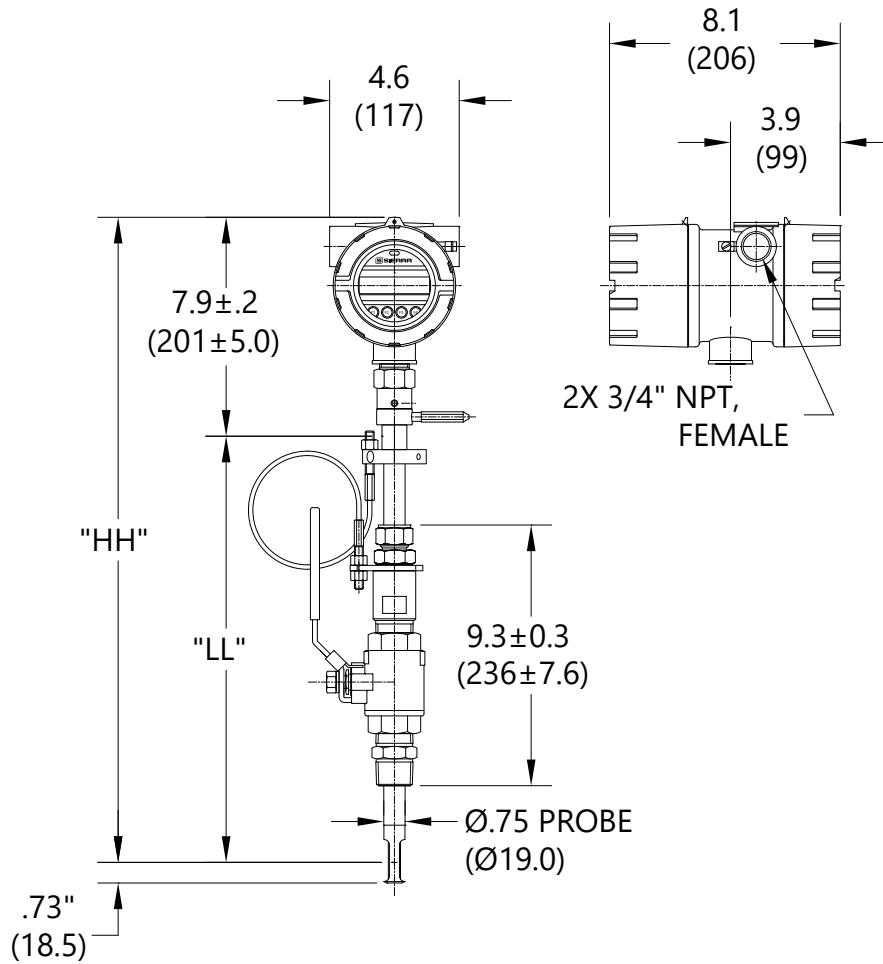


Table 7.1: TM500 Insertion Meter with 316 stainless steel probe

Probe Size	Probe Size	Dimension "LL" ± .10	Dimension "HH" ±.30
[model code]	[inches]	[inches / millimeters]	[inches / millimeters]
15R	15"	15.0" (381mm)	22.9" (582mm)
18R	18"	18.0" (457mm)	25.9" (658mm)
24R	24"	24.0" (610mm)	31.9" (810mm)
30R	30"	30.0" (762mm)	37.9" (963mm)
36R	36"	36.0" (914mm)	43.9" (1115mm)

Fig. 7.2: Remote TM500 Insertion Meter with Retractor Dimensions

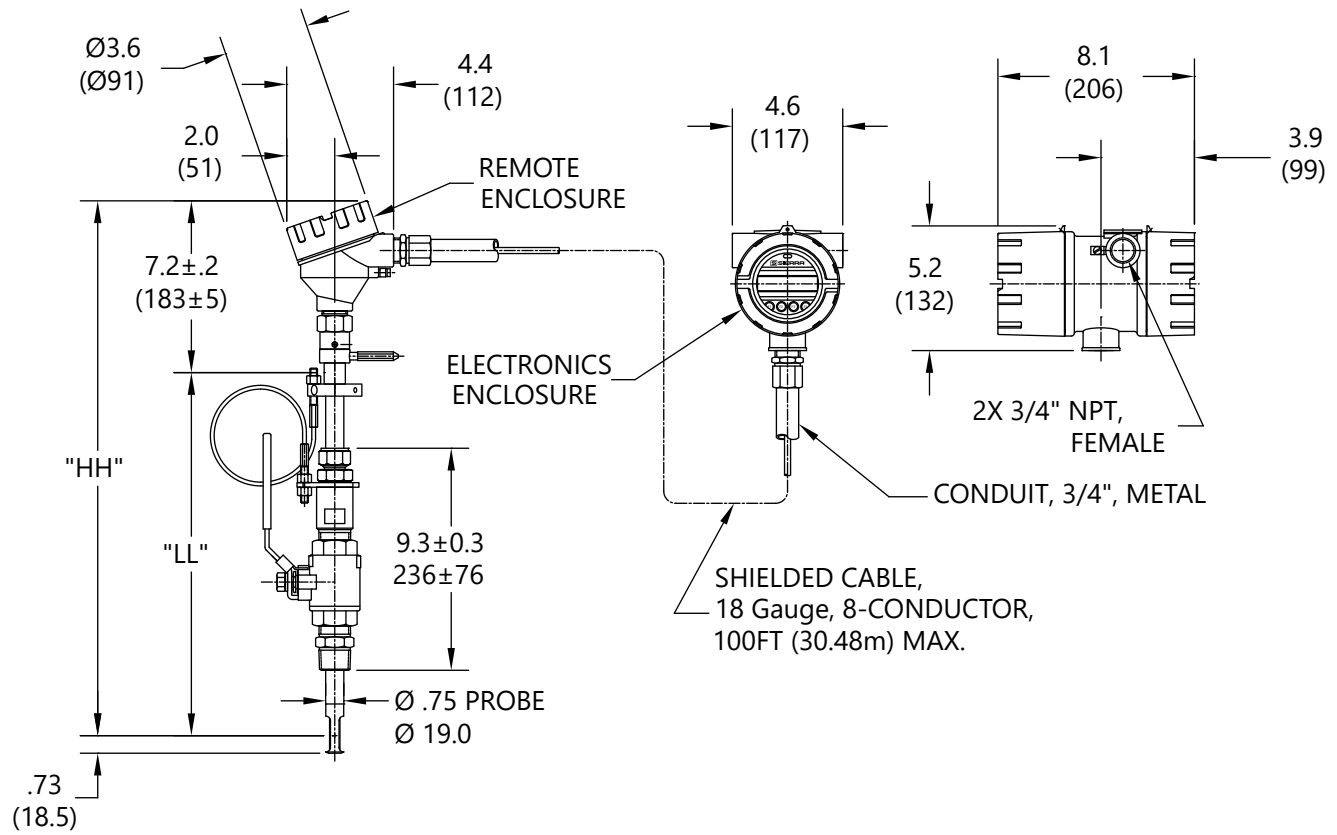


Table 7.2: Remote TM500 Insertion Meter with Retractor

Probe Size	Probe Size	Dimension "LL" ± .10	Dimension "HH" ±.30
[model code]	[inches]	[inches / millimeters]	[inches / millimeters]
15R	15"	15.0" (381mm)	22.2" (564mm)
18R	18"	18.0" (457mm)	25.2" (640mm)
24R	24"	24.0" (610mm)	31.2" (792mm)
30R	30"	30.0" (762mm)	37.2" (945mm)
36R	36"	36.0" (914mm)	43.2" (1097mm)

Fig. 7.3: Remote Mounting Kit Dimensions

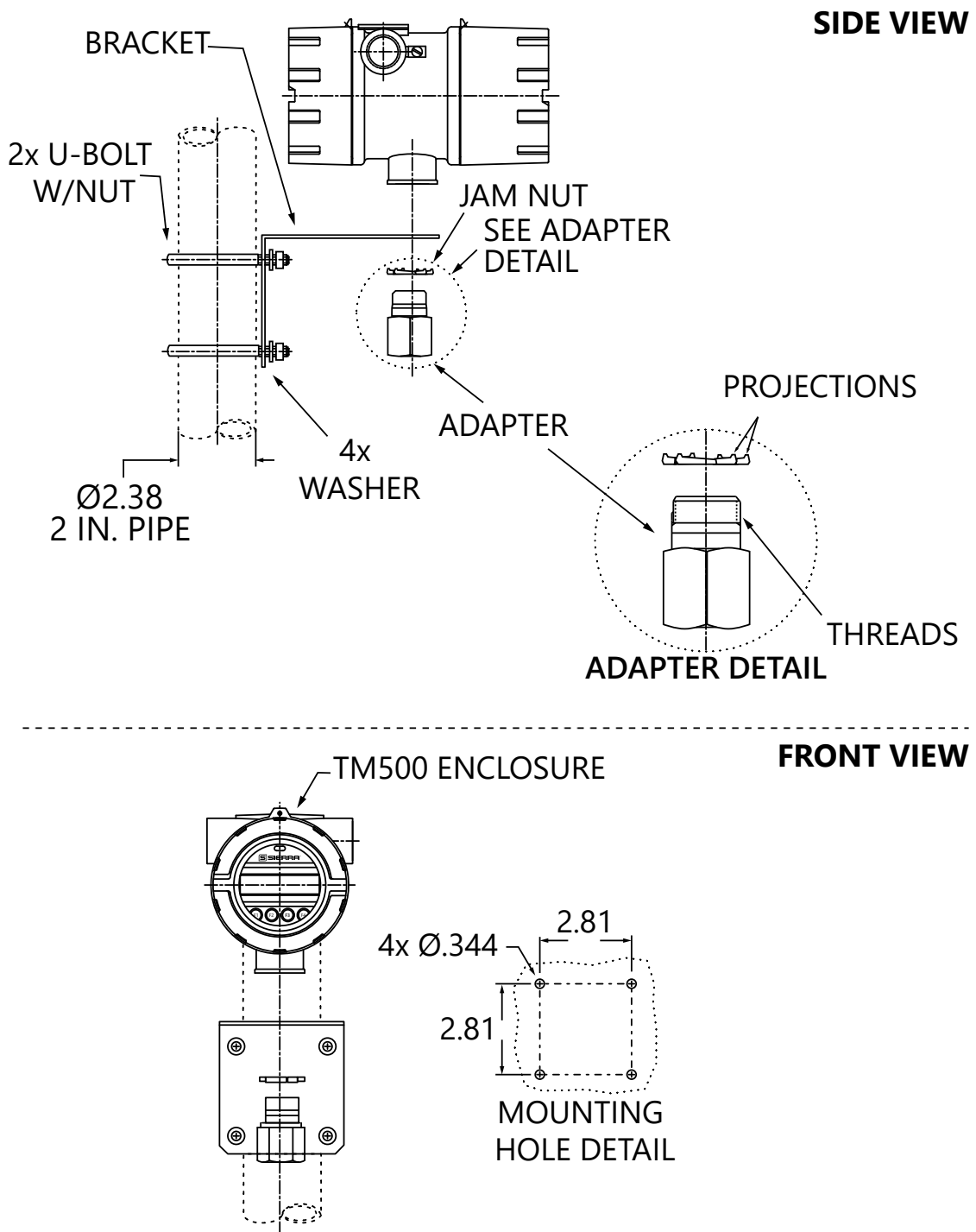


Fig. 7.4: TM500 Insertion Meter Dimensions

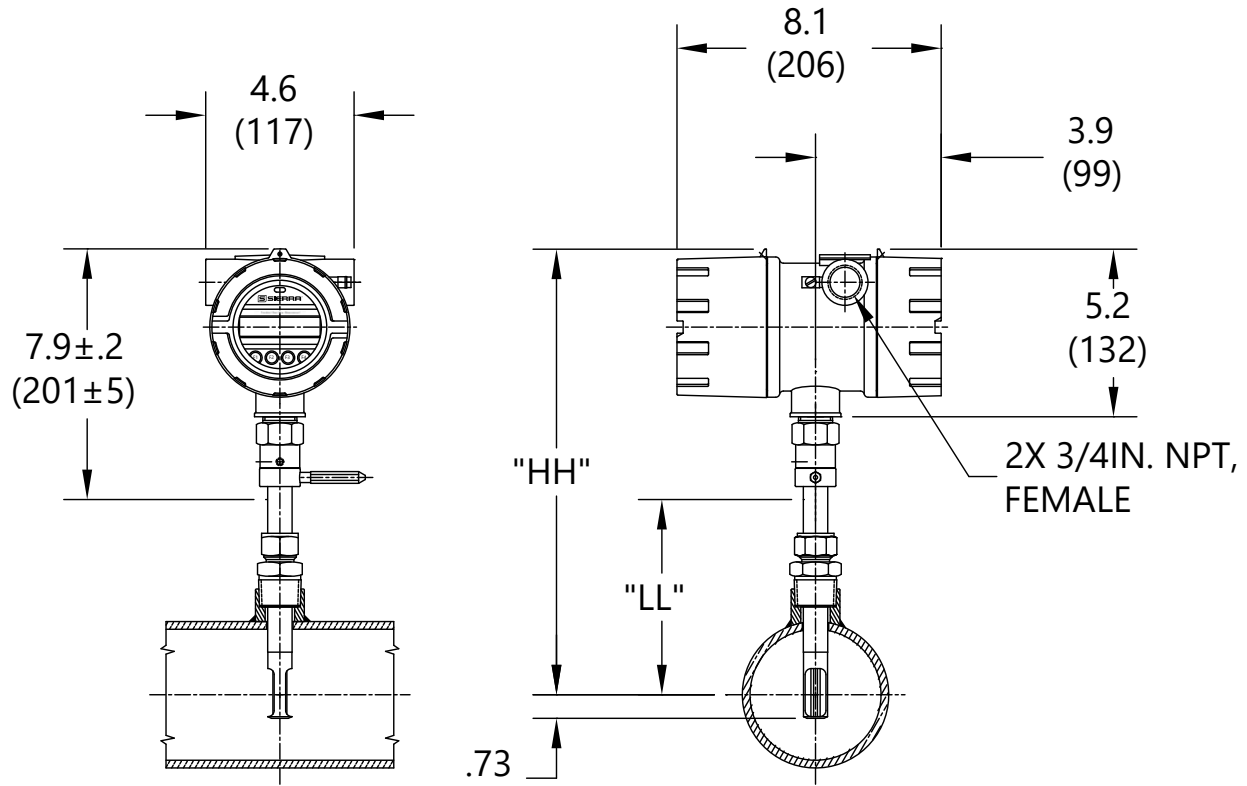


Table 7.4: TM500 Insertion Meter with 316 stainless steel probe

Probe Size [model code]	Probe Size [inches]	Dimension "LL" ± .10 [inches / millimeters]	Dimension "HH" ± .30 [inches / millimeters]
06I	6"	6.0" (152mm)	13.9" (353mm)
09I	9"	9.0" (229mm)	16.9" (429mm)
12I	12"	12.0" (305mm)	19.9" (505mm)
15I	15"	15.0" (381mm)	22.9" (582mm)
18I	18"	18.0" (457mm)	25.9" (658mm)
24I	24"	24.0" (610mm)	31.9" (810mm)
30I	30"	30.0" (762mm)	37.9" (963mm)
36I	36"	36.0" (914mm)	43.9" (1115mm)

Fig 7.5: TM500 Insertion Remote Meter Dimensions

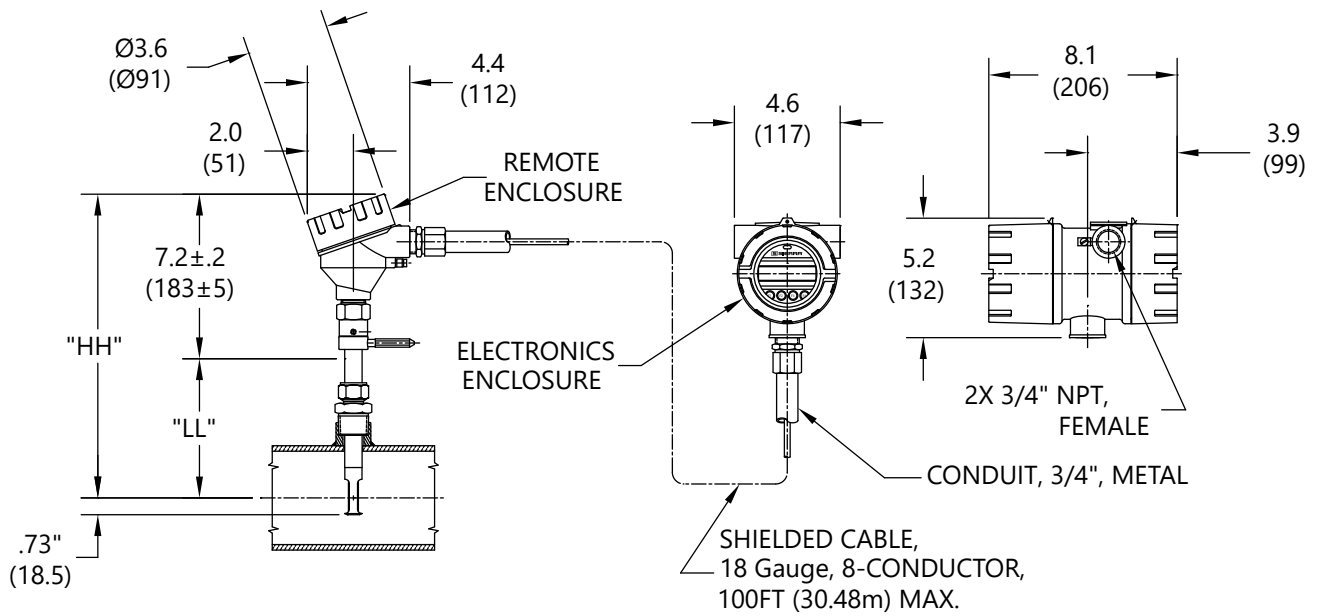


Table 7.5: TM500 Insertion Remote Meter with 316 stainless steel probe

Probe Size [model code]	Probe Size [inches]	Dimension "LL" ± .10 [inches / millimeters]	Dimension "HH" ± .30 [inches / millimeters]
06I	6"	6.0" (152mm)	13.2" (335mm)
09I	9"	9.0" (229mm)	16.2" (411mm)
12I	12"	12.0" (305mm)	19.2" (488mm)
15I	15"	15.0" (381mm)	22.2" (564mm)
18I	18"	18.0" (457mm)	25.2" (640mm)
24I	24"	24.0" (610mm)	31.2" (792mm)
30I	30"	30.0" (762mm)	37.2" (945mm)
36I	36"	36.0" (914mm)	43.2" (1097mm)

Fig. 7.6: TM500 Inline Meter with 316 Stainless Steel Flow Body and NPT End Connections Dimensions

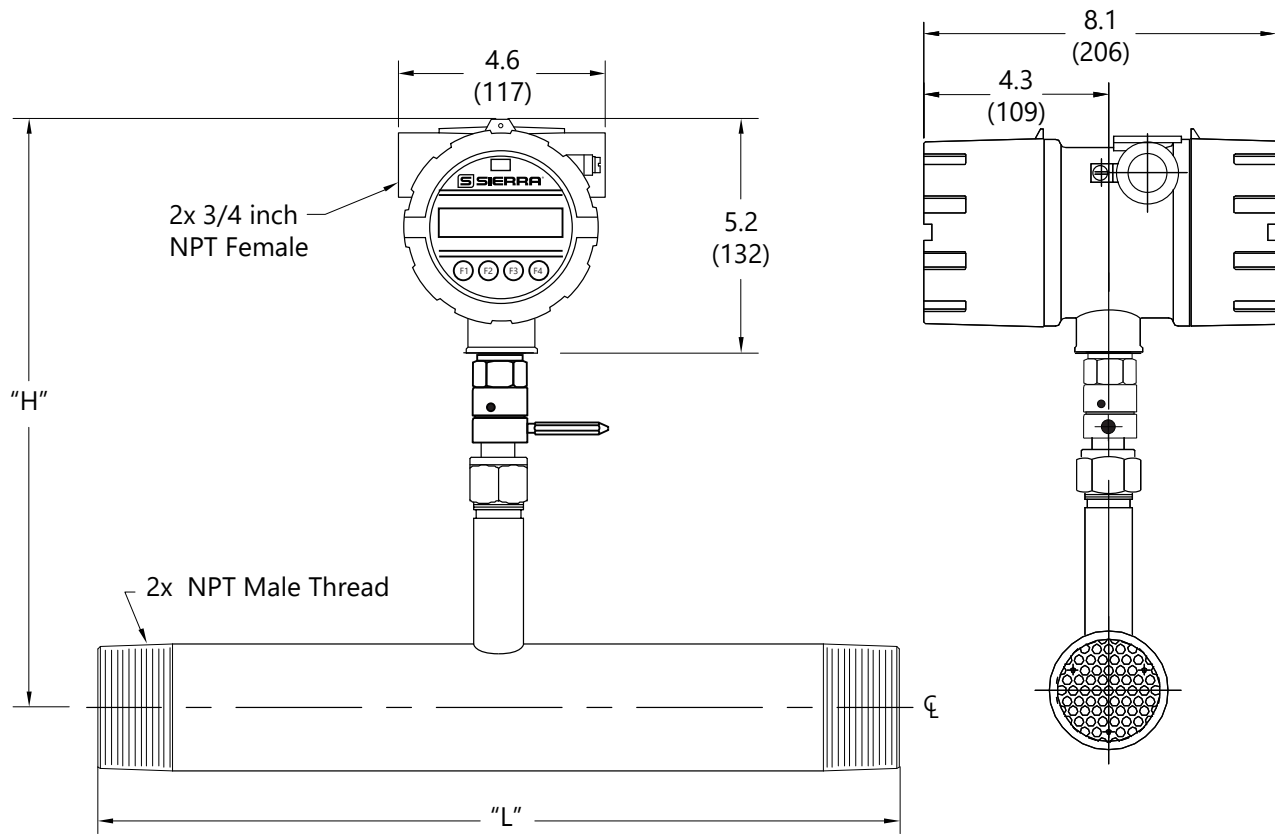


Table 7.6: TM500 Inline Meter with 316 Stainless Steel Flow Body and NPT End Connections

Body Size	Body Size	Dimension "L" ± .10	Dimension "H" ± .30
[model code]	[inches]	[inches]	[inches / millimeters]
075P	0.75"	12"	11.9" (302mm)
10P	1.00"	12"	11.9" (302mm)
125P	1.25"	12"	11.9" (302mm)
15P	1.50"	12"	13.9" (353mm)
20P *	2.00"	12"	13.9" (353mm)
25P *	2.25"	18"	13.9" (353mm)
30P *	3.00"	18"	13.9" (353mm)

*Also available in A106 Grade B Carbon steel pipe.

Fig 7.7: TM500 Inline Remote Meter with 316 Stainless Steel Flow Body and NPT End Connections Dimensions

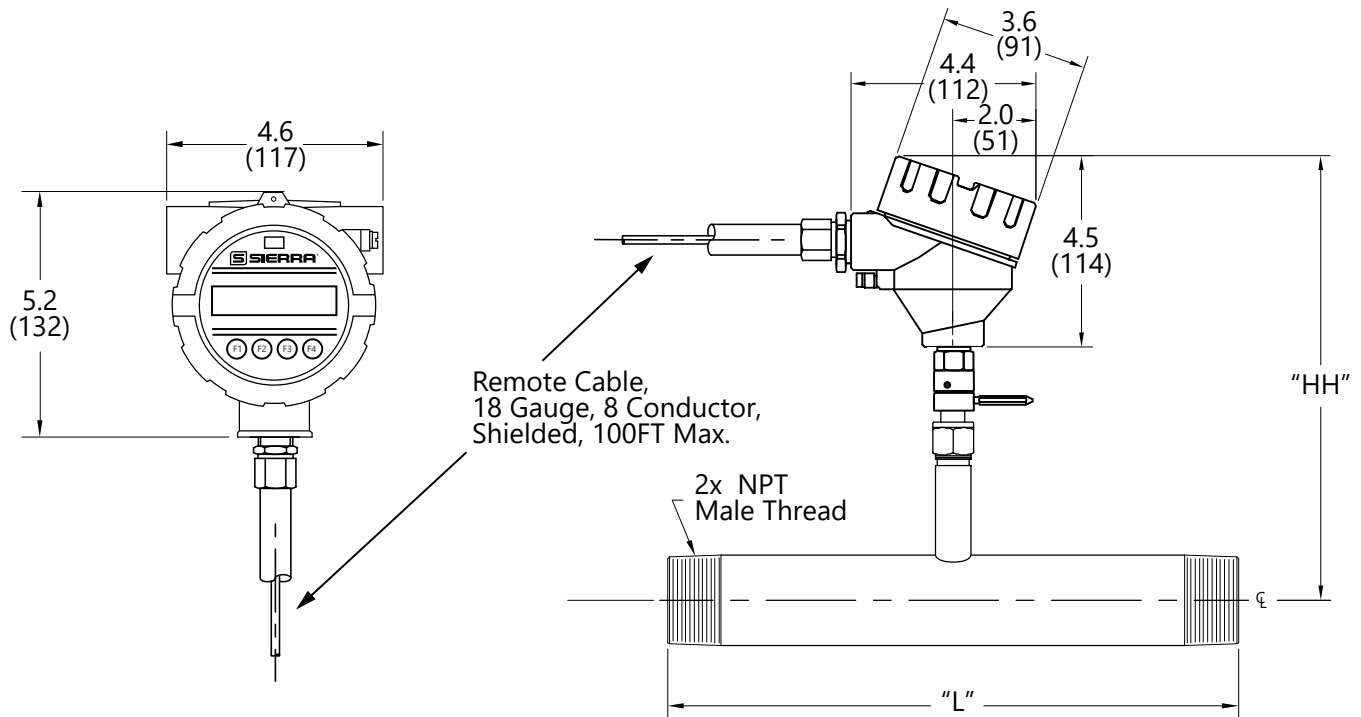


Table 7.7: TM500 Inline Remote Meter with 316 Stainless Steel Flow Body and NPT End Connections

Body Size	Body Size	Dimension "L" ± .10	Dimension "HH" ± .30
[model code]	[inches]	[inches]	[inches / millimeters]
075P	0.75"	12"	11.2" (284mm)
10P	1.00"	12"	11.2" (284mm)
125P	1.25"	12"	11.2" (284mm)
15P	1.50"	12"	13.2" (355mm)
20P *	2.00"	12"	13.2" (355mm)
25P *	2.50"	18"	13.2" (355mm)
30P *	3.00"	18"	13.2" (355mm)

*Also available in A106 Grade B Carbon steel pipe.

Fig. 7.8: TM500 Inline Meter with 316 Stainless Steel Flow Body and 150 lb RF Flange End Connections Dimensions

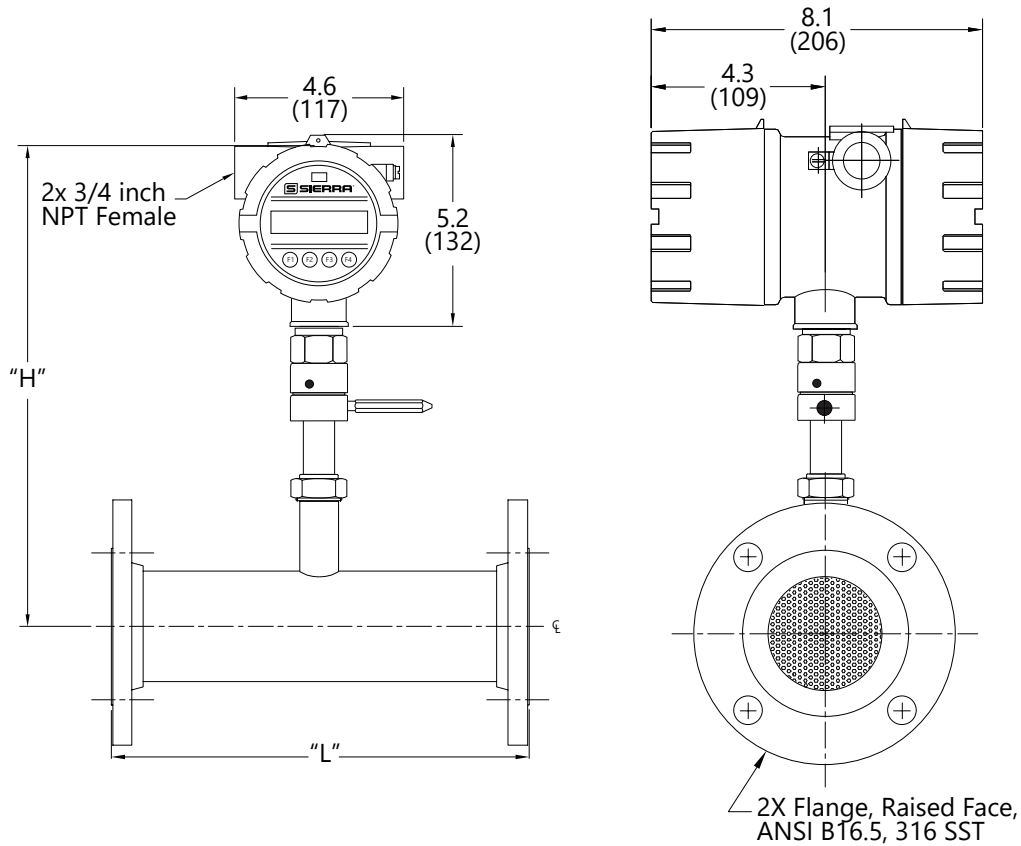


Table 7.8: TM500 Inline Meter with 316 Stainless Steel Flow Body and 150 lb RF Flange End Connections Dimensions

Body Size	Body Size	Dimension "L" ± .10	Dimension "H" ± .30
[model code]	[inches]	[inches]	[inches / millimeters]
075F	0.75"	12"	11.9" (302mm)
10F	1.00"	12"	11.9" (302mm)
125F	1.25"	12"	11.9" (302mm)
15F	1.50"	12"	13.9" (353mm)
20F *	2.00"	12"	13.9" (353mm)
25F *	2.50"	18"	13.9" (353mm)
30F *	3.00"	18"	13.9" (353mm)
40F *	4.00"	18"	13.9" (353mm)
60F *	6.00"	24"	13.9" (353mm)

*Also available in A106 Grade B carbon steel pipe plus A105 flanges.

Fig 7.9: TM500 Inline Remote Meter with 316 Stainless Steel Flow Body and 150 lb RF Flange End Connections
Dimensions

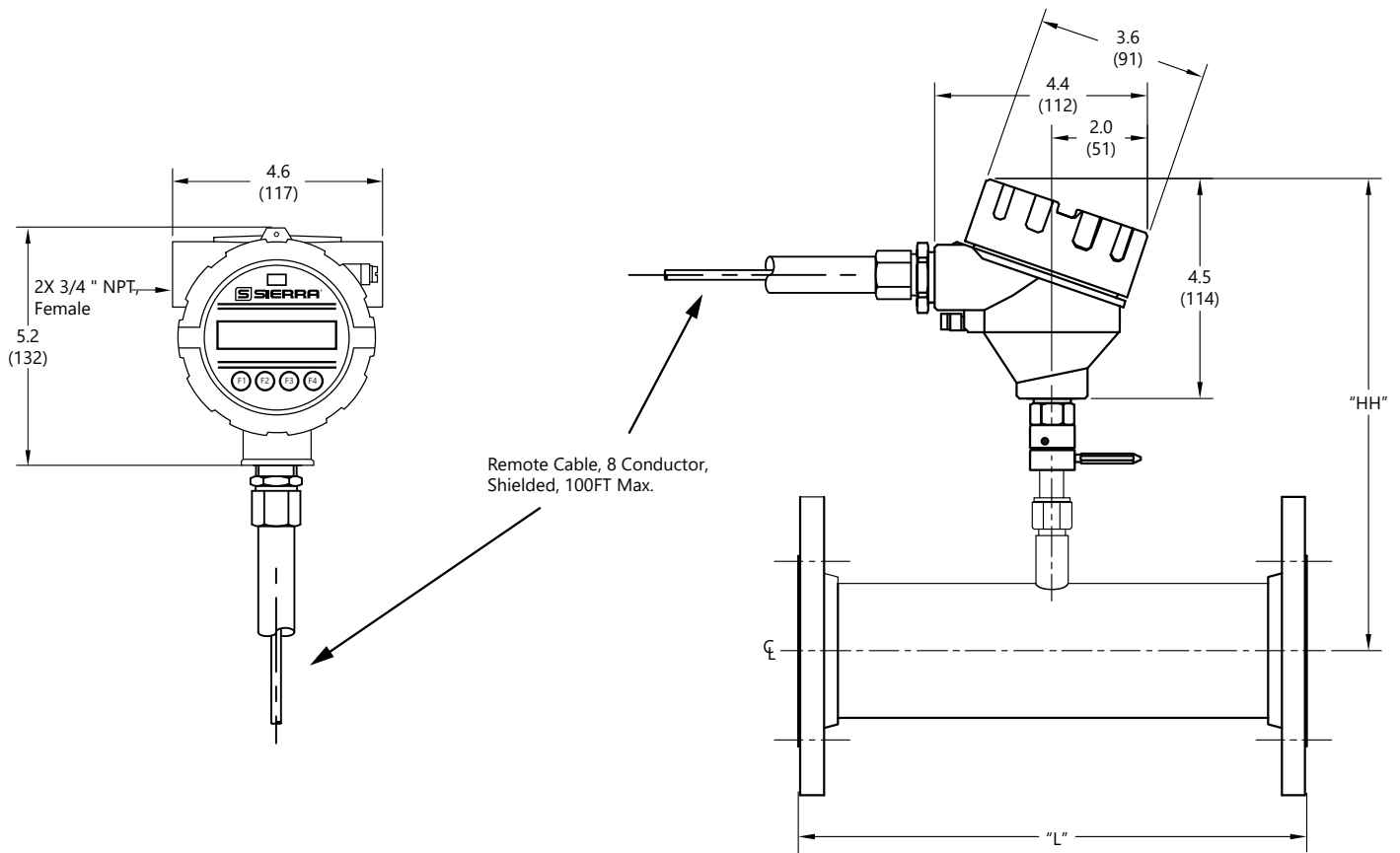


Table 7.9: TM500 Inline Remote Meter with 316 Stainless Steel Flow Body and 150 lb RF Flange End Connections
Dimensions

Body Size	Body Size	Dimension "L" ± .10	Dimension "HH" ± .30
[model code]	[inches]	[inches]	[inches / millimeters]
075F	0.75"	12"	11.2" (284mm)
10F	1.00"	12"	11.2" (284mm)
125F	1.25"	12"	11.2" (284mm)
15F	1.50"	12"	13.2" (335mm)
20F *	2.00"	12"	13.2" (335mm)
25F *	2.50"	18"	13.2" (335mm)
30F *	3.00"	18"	13.2" (335mm)
40F *	4.00"	18"	13.2" (335mm)
60F *	6.00"	24"	13.2" (335mm)

*Also available in A106 Grade B Carbon steel pipe + A105 Flanges

Fig. 7.10: TM500 Inline Meter with 316 Stainless Steel Flow Body and 300 lb RF Flange End Connections Dimensions

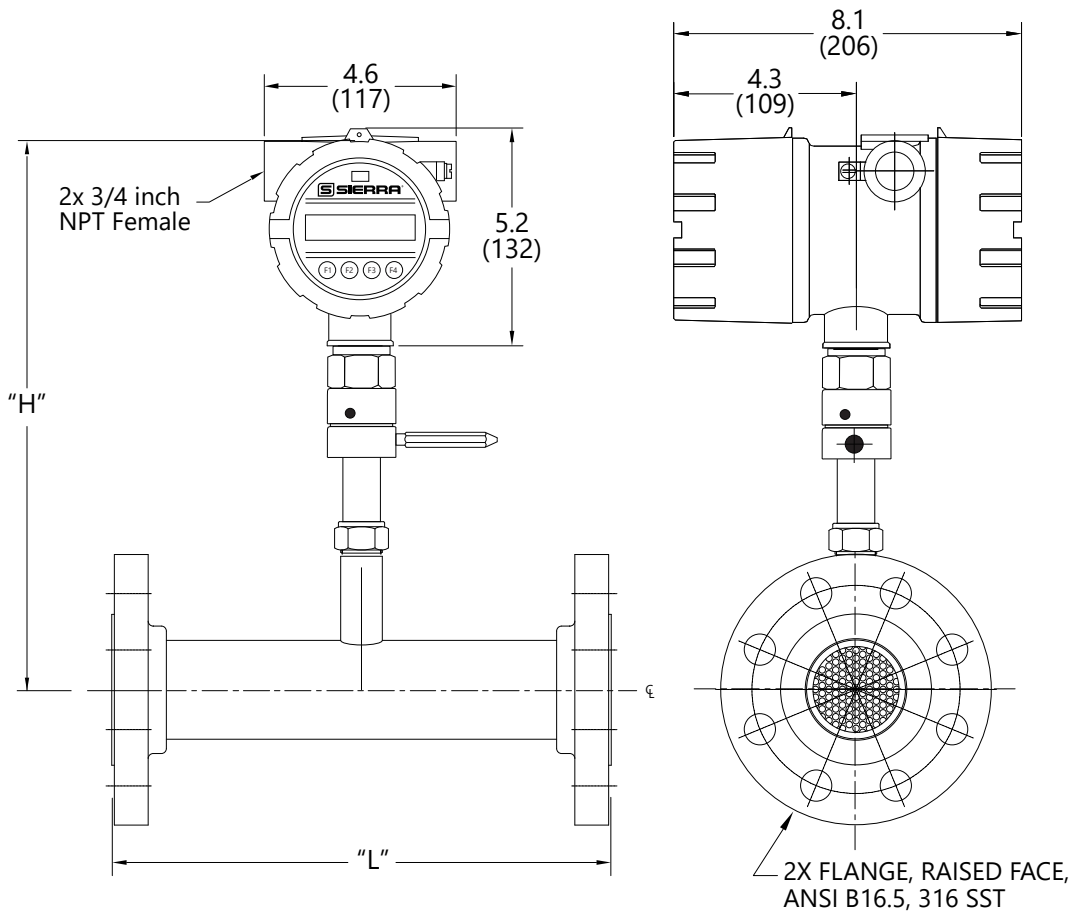


Table 7.10: TM500 Inline Meter with 316 Stainless Steel Flow Body and 300 lb RF Flange End Connections Dimensions

Body Size	Body Size	Dimension "L" ± .10	Dimension "H" ± .30
[model code]	[inches]	[inches]	[inches / millimeters]
15G	1.50"	12"	13.9" (353mm)
20G *	2.00"	12"	13.9" (353mm)
25G *	2.50"	18"	13.9" (353mm)
30G *	3.00"	18"	13.9" (353mm)
40G *	4.00"	18"	13.9" (353mm)
60G *	6.00"	24"	13.9" (353mm)

*Also available in A106 Grade B Carbon steel pipe + A105 Flanges

Fig 7.11: TM500 Inline Remote Meter with 316 Stainless Steel Flow Body and 300 lb RF Flange End Connections Dimensions

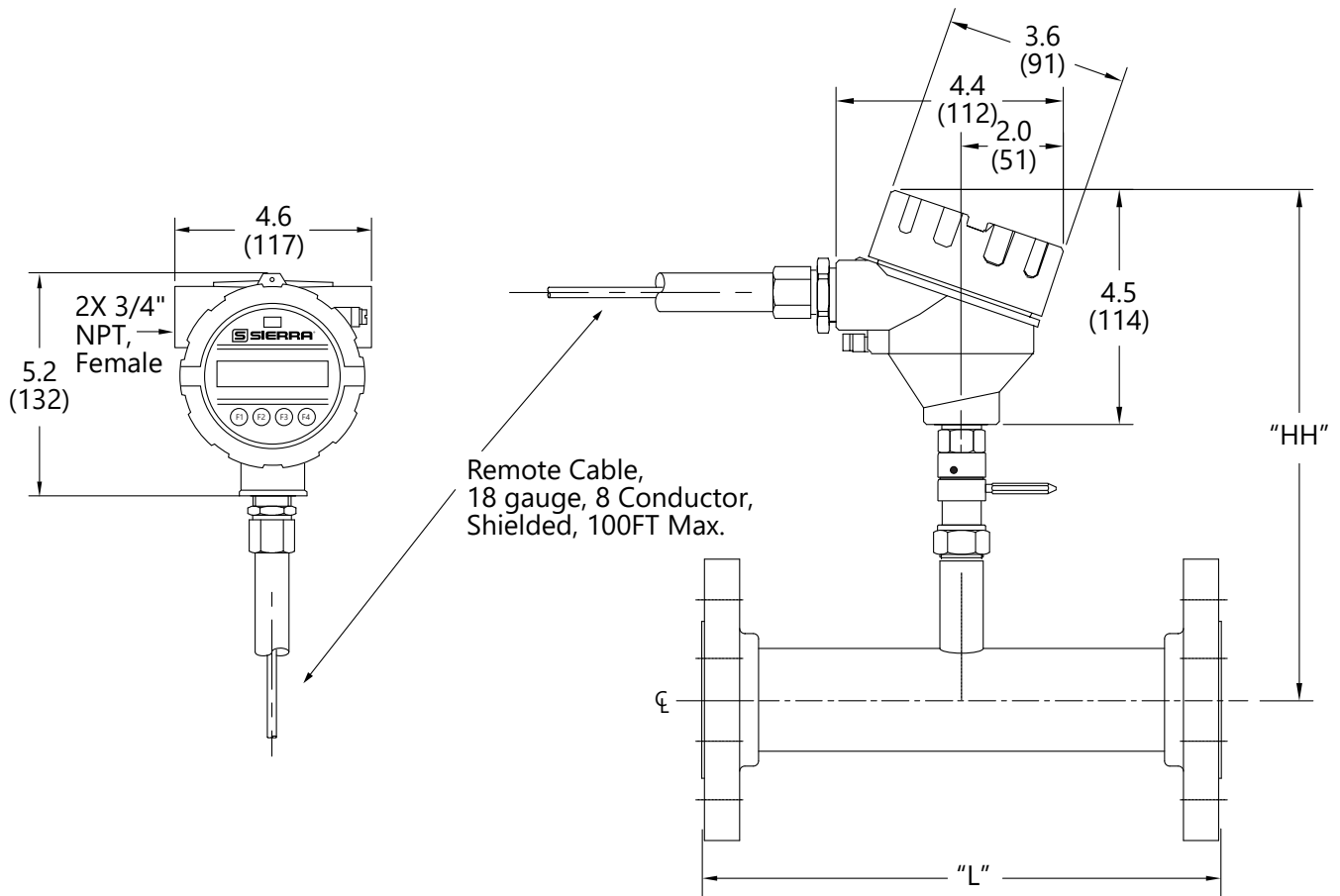


Table 7.11: TM500 Inline Remote Meter with 316 Stainless Steel Flow Body and 300 lb RF Flange End Connections Dimensions

Body Size	Body Size	Dimension "L" ± .10	Dimension "HH" ± .30
[model code]	[inches]	[inches]	[inches / millimeters]
15G	1.50"	12"	13.2" (335mm)
20G *	2.00"	12"	13.2" (335mm)
25G *	2.50"	18"	13.2" (335mm)
30G *	3.00"	18"	13.2" (335mm)
40G *	4.00"	18"	13.2" (335mm)
60G *	6.00"	24"	13.2" (335mm)

*Also available in A106 Grade B Carbon steel pipe + A105 Flanges

Warranty Policy

Limited Warranty Policy- Register Online

All Sierra products are warranted to be free from defects in material and workmanship and will be repaired or replaced at no charge to Buyer, provided return or rejection of product is made within a reasonable period but no longer than one (1) year for calibration and non-calibration defects, from date of delivery. To assure warranty service, customers must register their products online on Sierra's website. Online registration of all of your Sierra products is required for our warranty process. Register now at www.sierrainstruments.com/register.

Returning Equipment to Factory

Factory Calibration—All Models

Sierra Instruments maintains a fully-equipped calibration laboratory. All measuring and test equipment used in the calibration of Sierra transducers are traceable to NIST Standards. Sierra is ISO-9001 registered and conforms to the requirements of ANSI/NCSL-Z540 and ISO/IEC Guide 25.

Instructions for Returning Your Instrument for Service

The following information will help you return your instrument to Sierra Instruments' Factory Service Center and will ensure that your order is processed promptly. Prices may vary depending on the flow range, type of gas and operating pressure of your unit. To request detailed pricing, contact your local Sierra Instruments distributor or contact one of our offices directly.

Please follow these easy steps to return your instrument for factory service:

1. To obtain a Return Materials Authorization (RMA) number from the Sierra Instruments to <http://www.sierrainstruments.com/rma/new.php> to create a Sierra Account.
2. Once you have created an account, click on the Submit New RMA tab and fill in the RMA form and follow the instructions. You will receive an email confirmation once you have submitted your RMA.
3. Print a copy of the RMA (that now includes RMA #) and send a copy of the RMA form along with your meter back to the factory.

If you require service beyond calibration, but do not know which service(s) will be required, describe the symptoms as accurately as possible on the RMA form.

Pack your instrument carefully. Use the original packaging and foam or bubble wrap (packing peanuts NOT recommended) and include a copy of the RMA form (complete with Sierra supplied RMA number) with the unit(s).

Ship the unit(s) to the following address:

Sierra Instruments, Inc.
Attention: Factory Service Center
5 Harris Court, Building L
Monterey, CA 93940 USA
RE: RMA# (your number)

Glossary of Terms and Definitions

AWG	American Wire Gauge	NL	Normal Liter
Bara	Bar absolute	NLPH	Normal Liter per Hour
CTC	Contact	NLPM	Normal Liter per Minute
CAL	Calibration	NM3	Normal cubic Meter
CHG	Change	NM3/H	Normal cubic Meter per Hour
COM	Communication	NM3/M	Normal cubic Meter per Minute
CSV	Current Sense Voltage	NPT	National Pipe Thread
DC	Direct Current	PDA	Personal hand held computer
DCS	Distributed Control System	PC	Personal Computer
DN	Down	P/U	Pulse per Unit
DSP	Display	PIP A ²	Pipe Area
ELP	Elapsed time	PLC	Programmable Logic Controller
Feq	Frequency	PRM	Parameters
Ft ²	Square Feet	PRS	Pressure
I/O	Input/Output	PSIA	Pounds per Square Inch Absolute
INP	Input	Pt	Point
LB	Pound	PSW	Password
LB/D	Pound per Day	SIM	Simulation
LB/H	Pound per Hour	SCF	Standard Cubic Feet
LB/M	Pound per Minute	SCFM	Standard Cubic Feet per Minute
LB/S	Pound per Second	SCFH	Standard Cubic Feet per Hour
LCD	Liquid Crystal Display	SCFD	Standard Cubic Feet per Day
KG	Kilogram	SPC	Special Control
KG/H	Kilogram per Hour	STP	Standard Temperature and Pressure
KG/M	Kilogram per Minute	TMP	Temperature
KG/S	Kilogram per Second	TSI	Internal Variable
M ²	Square Meter	TSV	Internal Variable
mmHG	Pressure in millimeters of mercury	UNT	Unit
MMSCFD	Million Standard Cubic Feet per Day	U/P	Unit per Pulse
MS/TP	Master-Slave/Token Passing	420	4-20mA output
MXFLO	Maximum Flow		
NAESB	North American Energy Standards Board		
NEMA	National Electrical Manufactures Association		
NIST	National Institute of Standards and Technology		

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Wiring



Definition of Terms



Troubleshooting Tips



NOTE! is used for Notes and Information



WARNING! is used to indicate a hazardous situation which, if not avoided, could result in death or serious injury.



CAUTION! is used to indicate a hazardous situation which, if not avoided, could result in minor or moderate injury.



Indicates compliance with the WEEE Directive. Please dispose of the product in accordance with local regulations and conventions.



Indicates compliance with the applicable European Union Directives for Safety and EMC (Electromagnetic Compatibility Directive 2014/30/EU).



Indicates compliance with the UKCA (UK Conformity Assessed) regulations for Great Britain.

IP67

Enclosure Protection Classification per IEC 60529: Protected against the ingress of dust and Immersion.