MODEL

# FT3

## Fox Thermal Gas Mass Flow Meter

**Instruction Manual**

Document #104488

Rev K

831.384.4300 | 399 Reservation Rd, Marina, CA 93933 | foxthermal.com

*This publication must be read in its entirety before performing any operation. Failure to understand and follow these instructions could result in serious personal injury and/or damage to the equipment. Should this equipment require repair or adjustment beyond the procedures given herein, contact the factory at:*

**FOX THERMAL INSTRUMENTS, INC.**
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**Download Technical Data Sheets from our website:**
**www.foxthermal.com**

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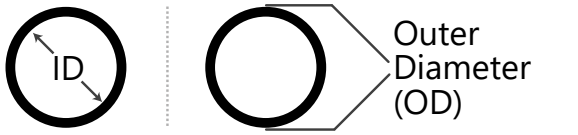
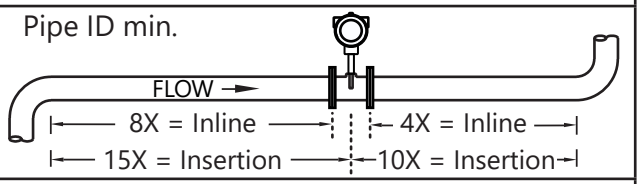
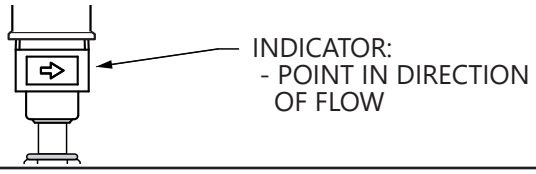
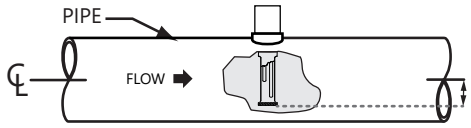
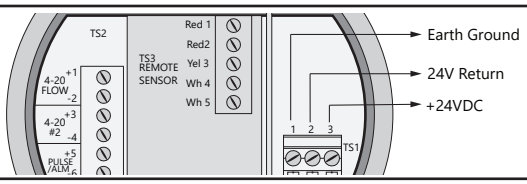
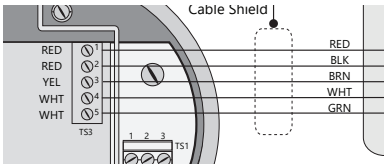
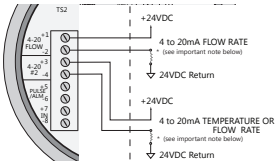
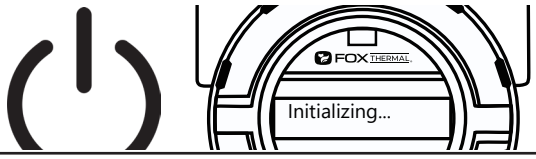
**Fox Thermal FT3 Manuals:**
- **Fox Thermal FT3 View™ Manual**

*All Fox Thermal Manuals and software available in English only.*

## Table of Contents

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.

| | | |
|---|---|---|
| 1. | 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 Area" on page 68. |  |
| 2. | Record up/downstream straight-pipe requirements based on Pipe ID and meter style (insertion or inline). [refer to p. 21] |  |
| 3. | The Flow Direction Indicator must point in the direction of flow. |  |
| 4. | Ensure correct probe depth setting. If using 1 ½" size pipe, please see note on p. 24. |  |
| 5. | Ensure power wiring [p. 36] properly connected. [refer to Wiring section p. 33 for more information] |  |
| 6. | Ensure remote wiring is correct if remote option ordered. [refer to p. 48 for more information] |  |
| 7. | Verify you have the proper output signal wiring [refer to p. 38 - p. 45 for more information] |  |
| 8. | Power on the flow meter. |  |
| 9. | Check the remaining flow meter settings by accessing the meter settings either through the front panel of the display or by using the FT3 View™ software tool. Record the settings in the spaces given for items A - E on the following page. | |

Before powering on 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 =<br>DN = | UP =<br>DN = | UP =<br>DN = | UP =<br>DN = |
| 3. | Is the flow indicator pointed in direction of flow? | Y / N | Y / N | Y / N | Y / N |
| 4. | Is the probe depth setting correct? | Y / N | Y / N | Y / N | Y / N |
| 5. | Verify proper power wiring | | | | |
| 6. | Verify proper remote wiring (if ordered) | | | | |
| 7. | Verify proper input/output wiring | | | | |

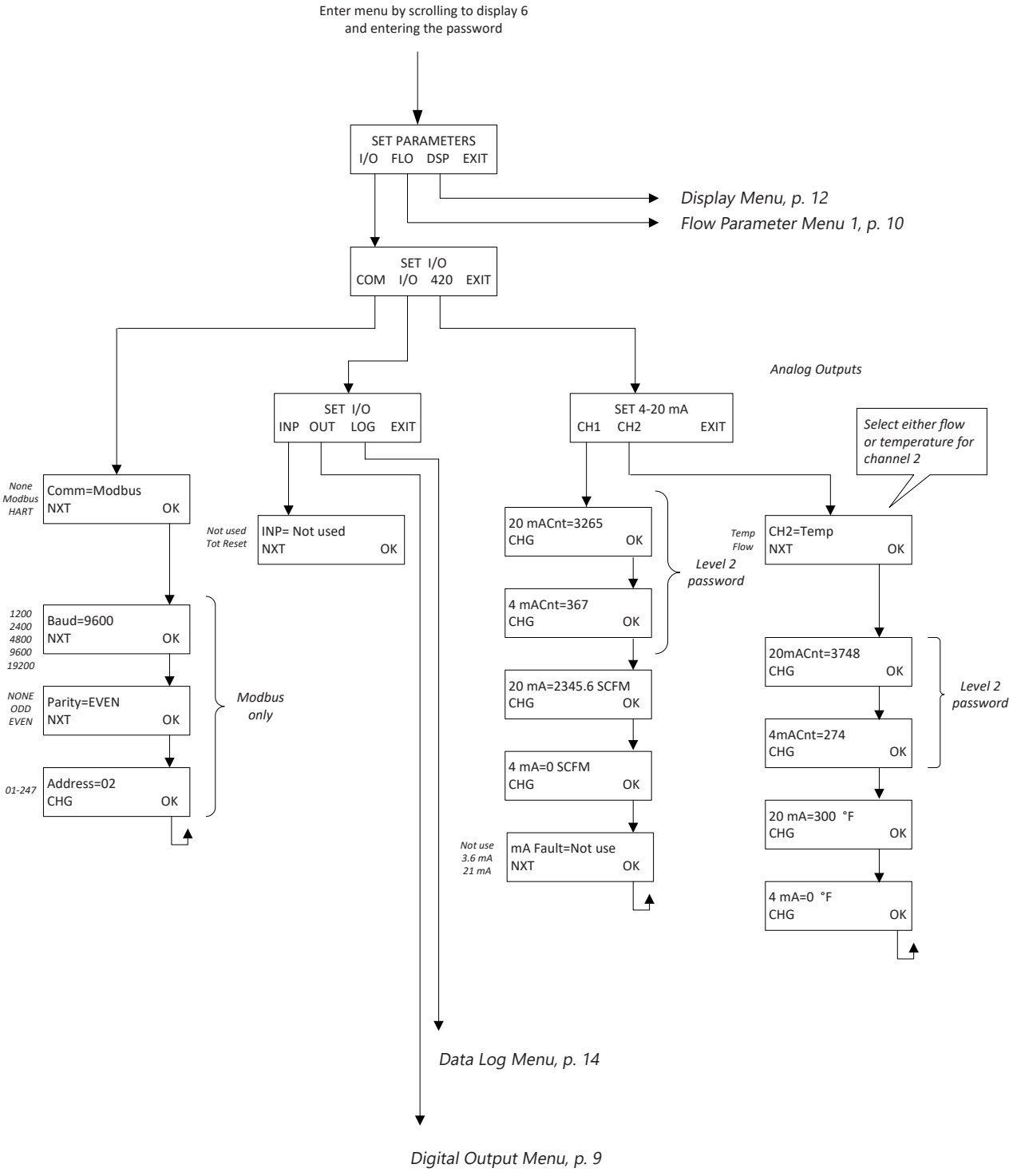
After powering on your meter, check items A - E below by accessing the meter settings either through the front panel of the meter's display or by using the FT3 View™ software tool.

| | | | | | |
|---|---|---|---|---|---|
| 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 =<br>20mA = | 4mA =<br>20mA = | 4mA =<br>20mA = | 4mA =<br>20mA = |
| E. | Verify the 2nd 4mA and 20mA meter settings | 4mA =<br>20mA = | 4mA =<br>20mA = | 4mA =<br>20mA = | 4mA =<br>20mA = |

Your Notes:

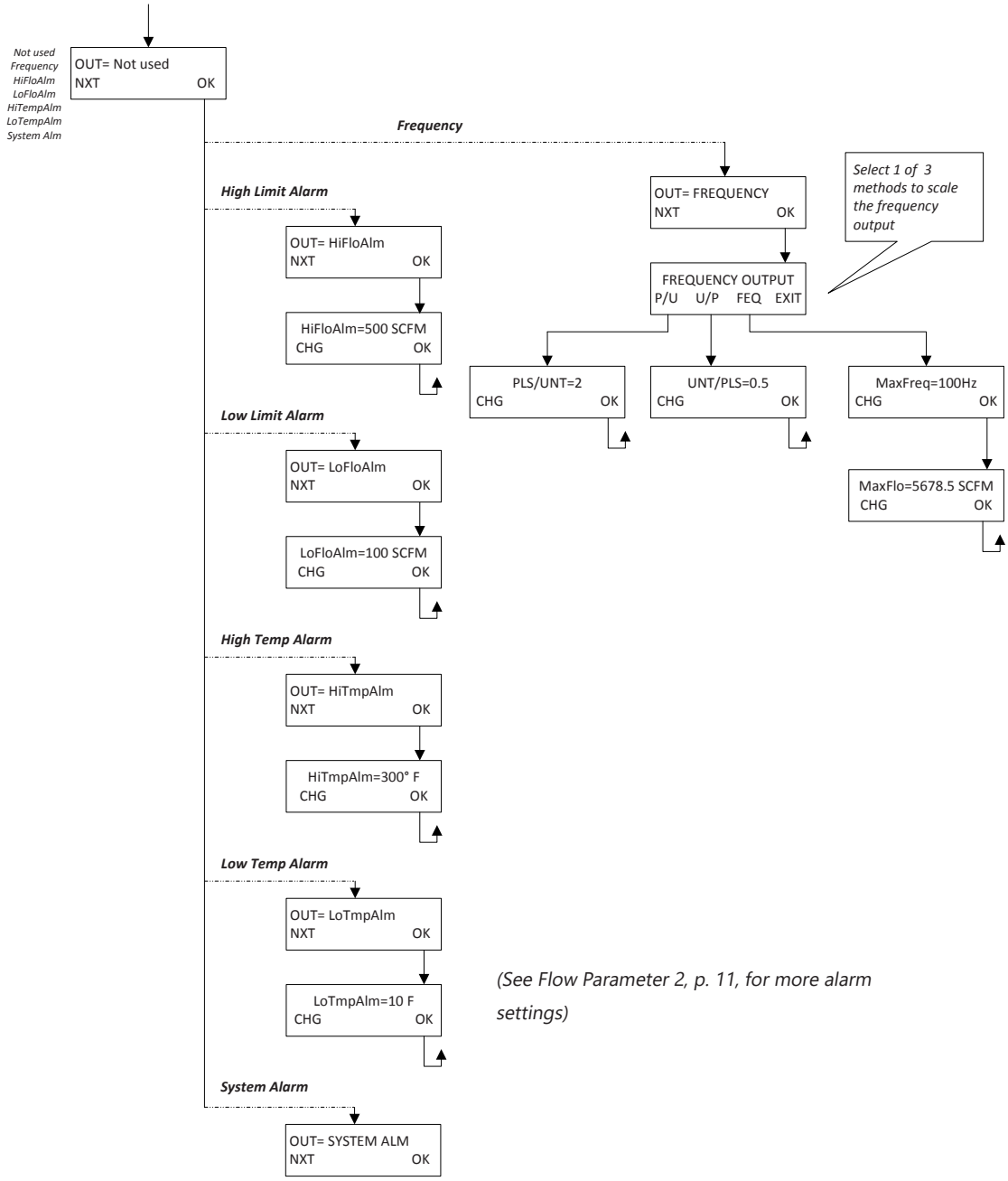
If you are experiencing any problems after completing this procedure, please call the Fox Thermal Service Department at 831-384-4300 to review this information.

*Fig. 1.1: FT3 Menu Tree - Main Menu*




**NOTE!** Some menus will only be available with a level 2 password.
**NOTE!** Menu tree boxes are populated with example values.

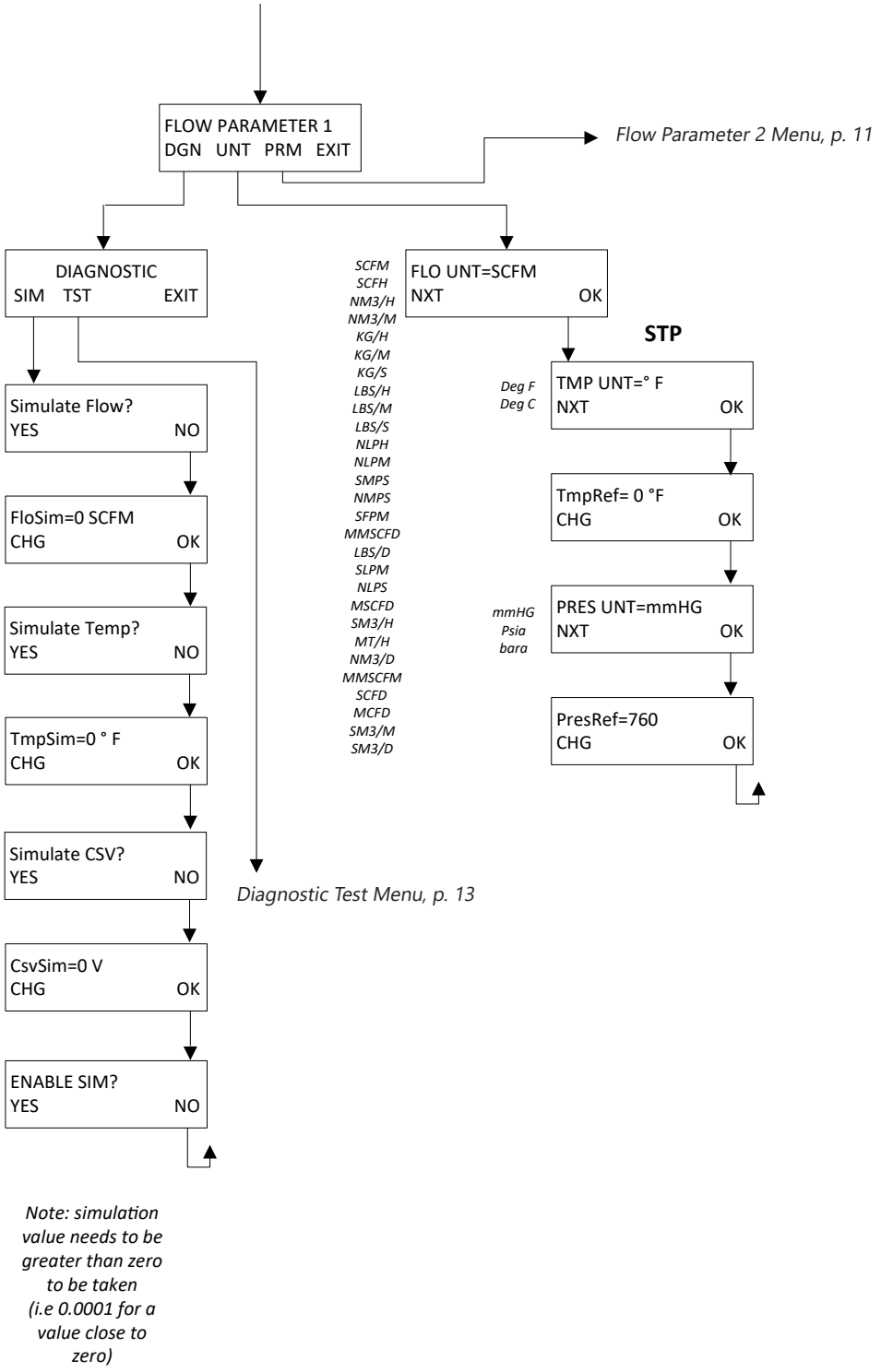
*Fig. 1.2: FT3 Menu Tree - Digital Outputs and Input*




*(See Flow Parameter 2, p. 11, for more alarm settings)*

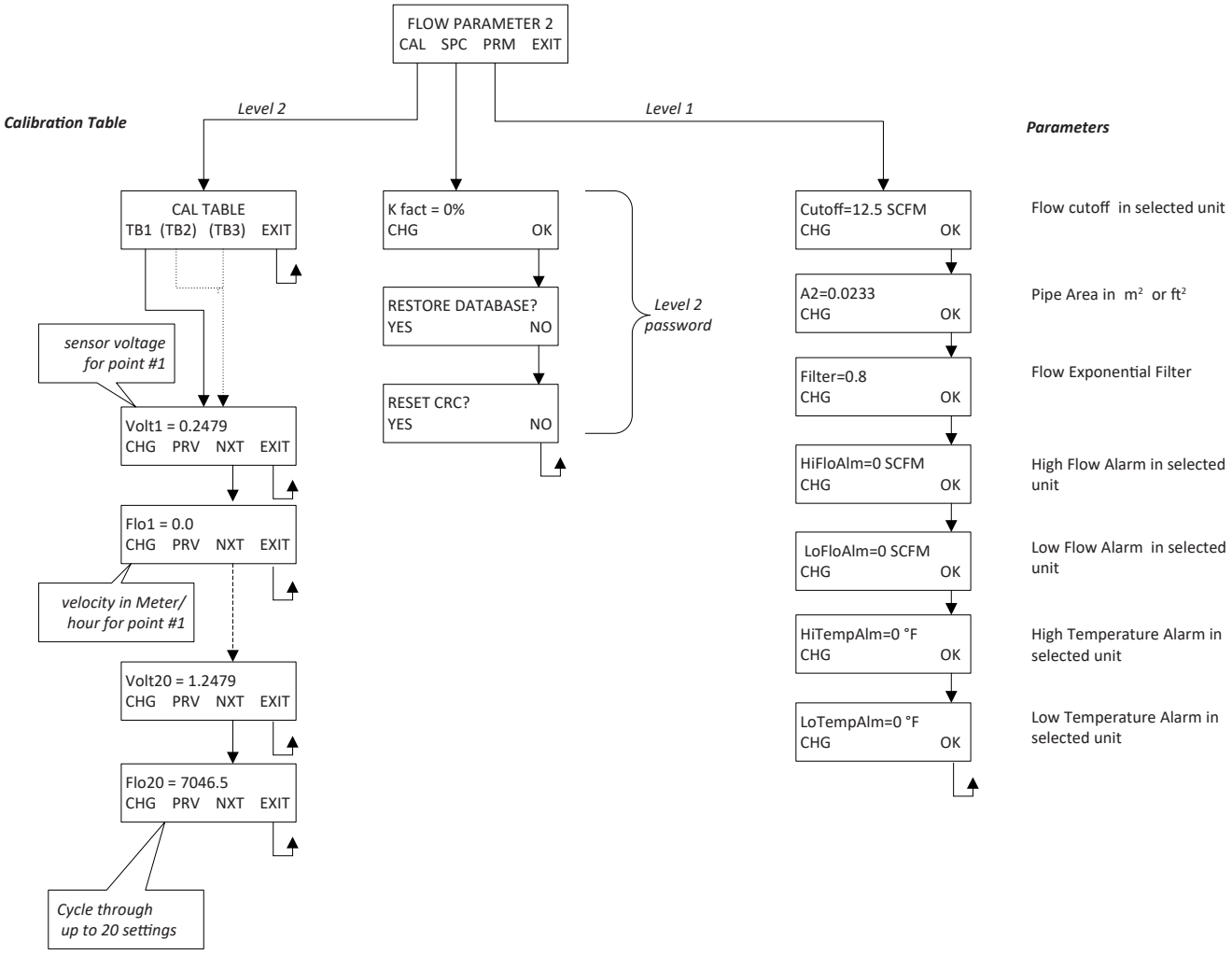
**NOTE!** A value of 0 disables the alarms

*Fig. 1.3: FT3 Menu Tree - Flow Parameter 1*



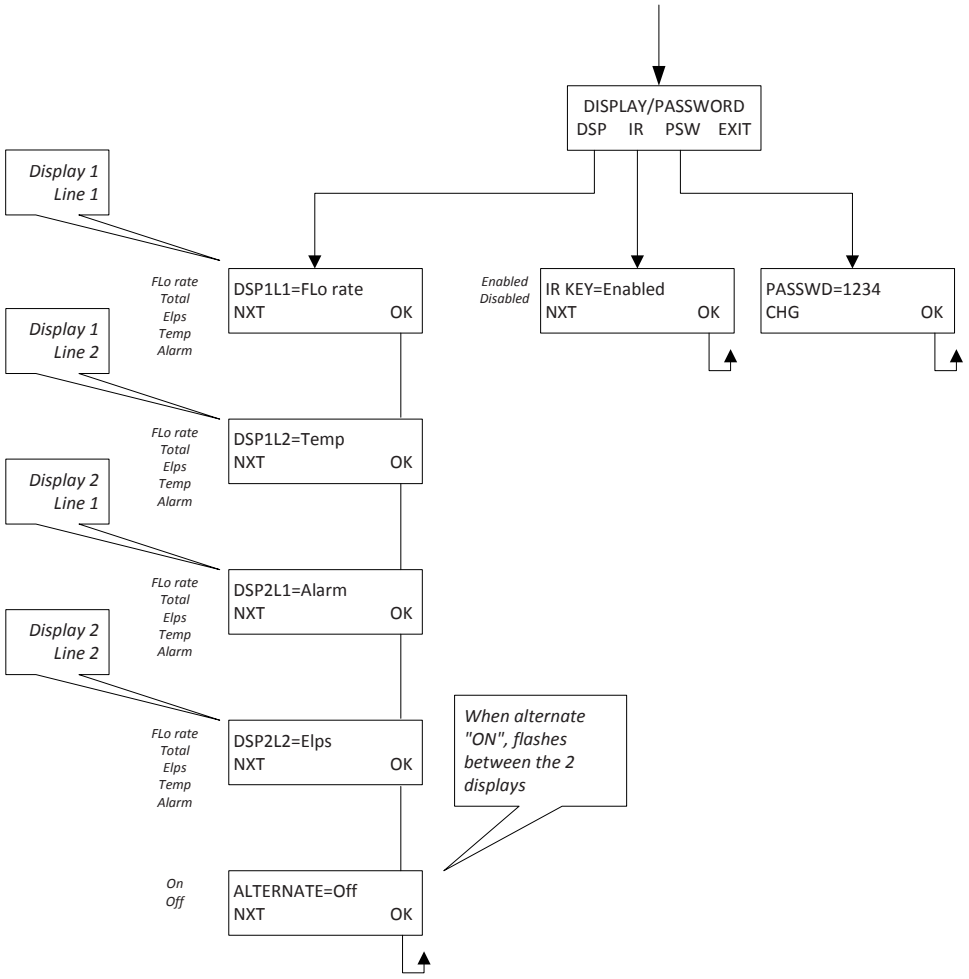

*Note: simulation value needs to be greater than zero to be taken (i.e 0.0001 for a value close to zero)*

*Fig. 1.4: FT3 Menu Tree - Flow Parameter 2*




**NOTE!** Some menus will only be available with a level 2 password.

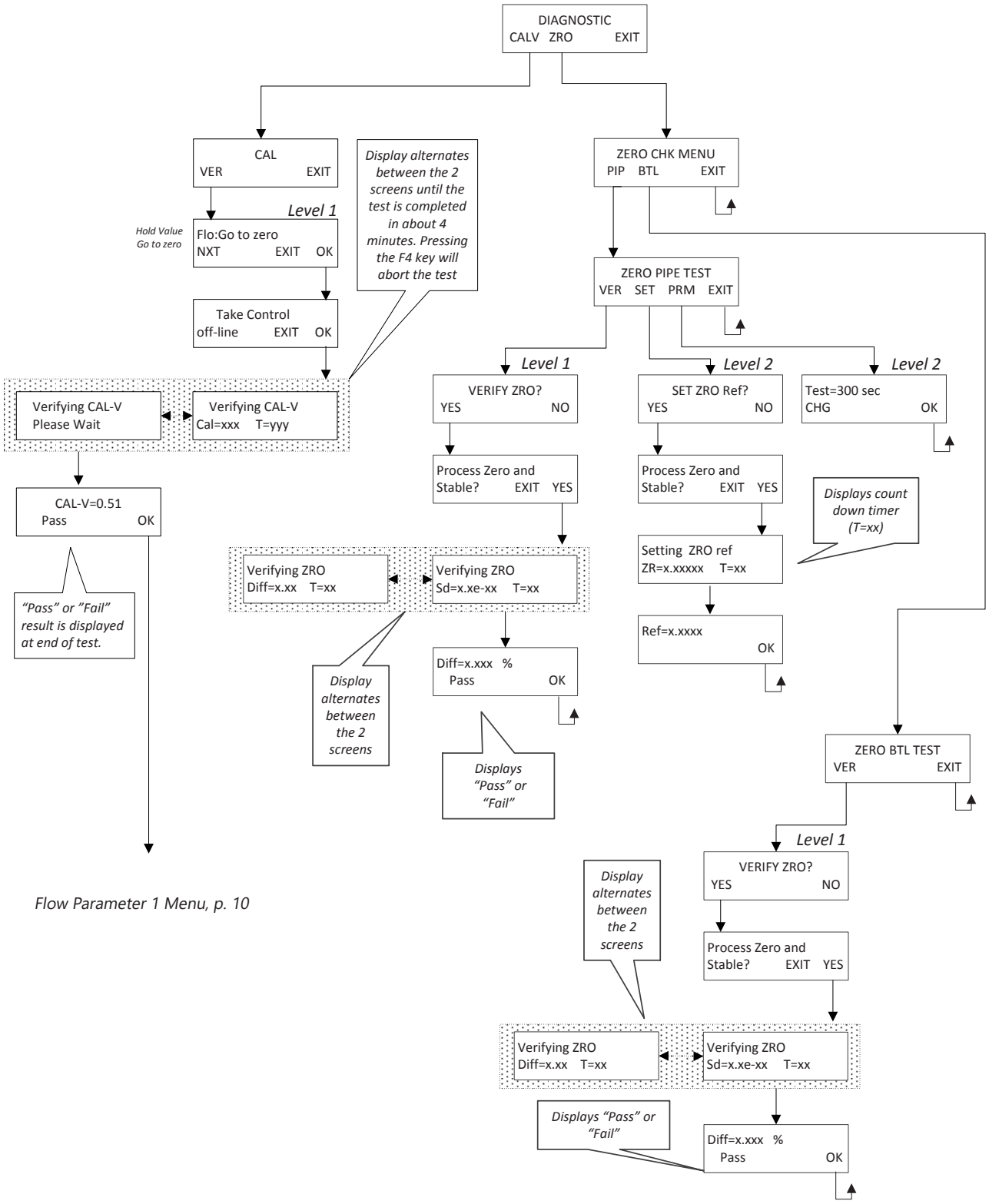
*Fig. 1.5: FT3 Menu Tree - Display Menu*




**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: FT3 Menu Tree - Diagnostic Tests Menu*




*Flow Parameter 1 Menu, p. 10*

**NOTE!** Some menus will only be available with a level 2 password.

*Fig. 1.7: FT3 Menu Tree - Accessing Data Logger Functions from the Front Panel*

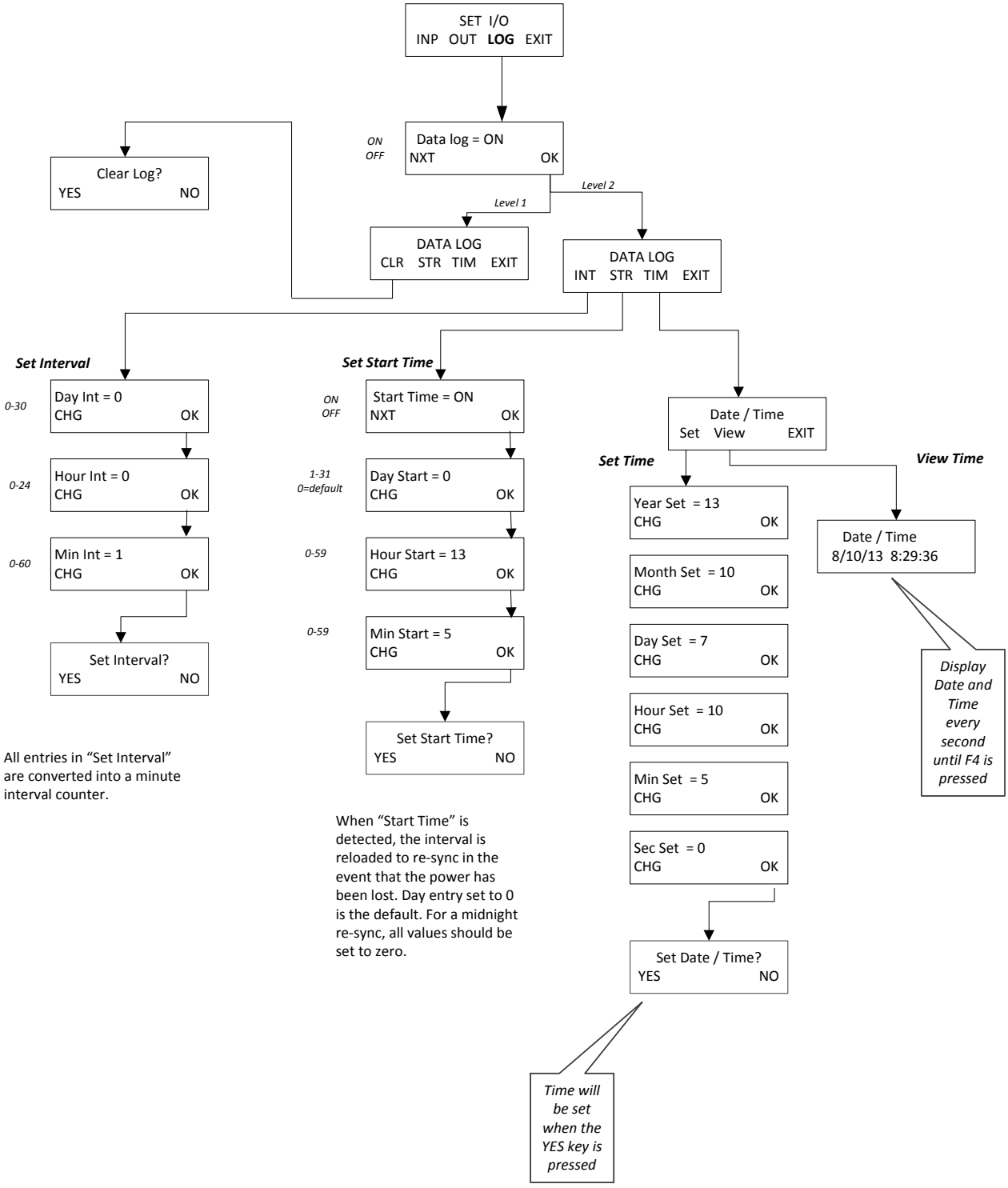


*Fig. 1.8: Viewing Data Logger Records from the Front Panel*

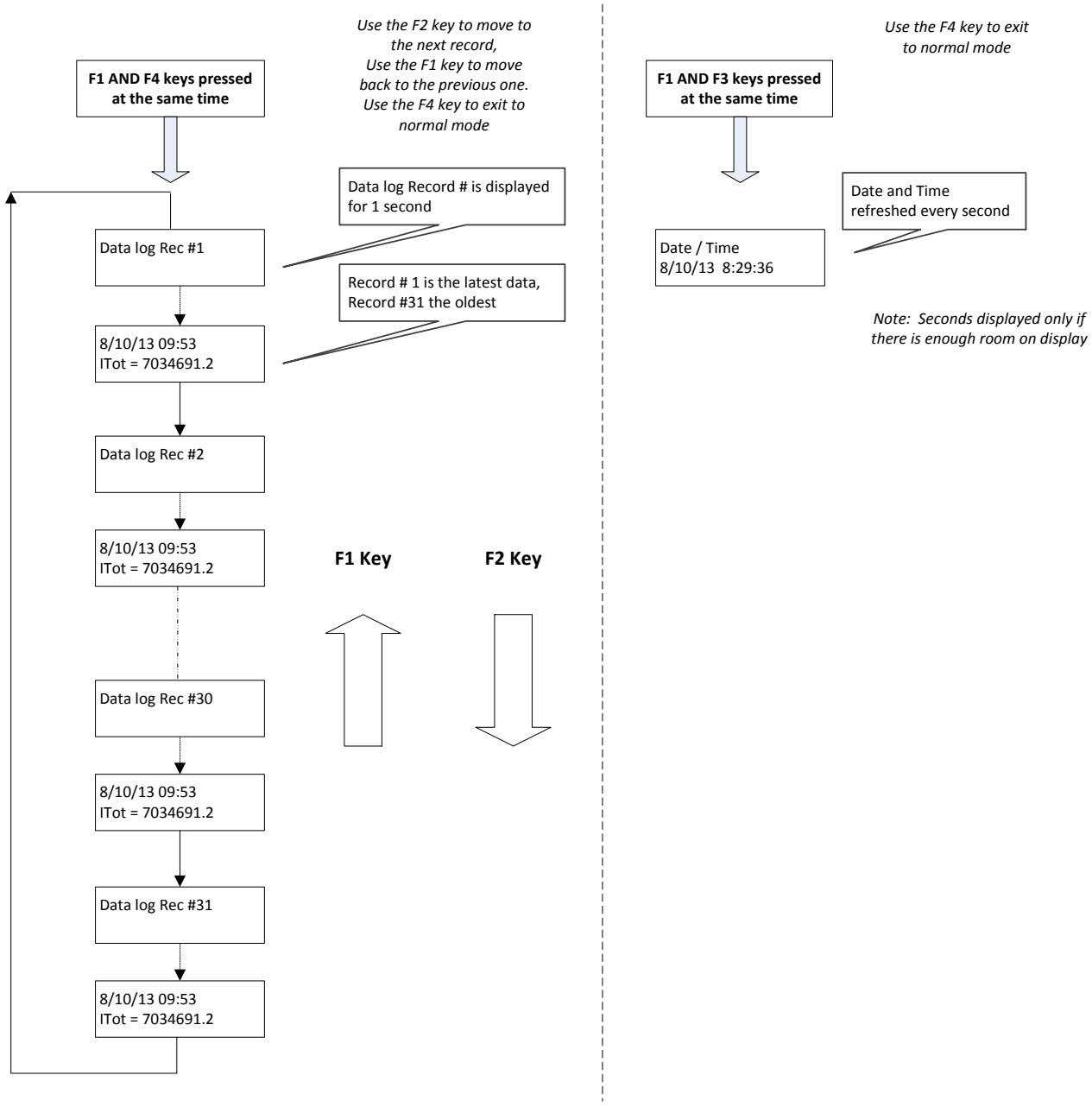
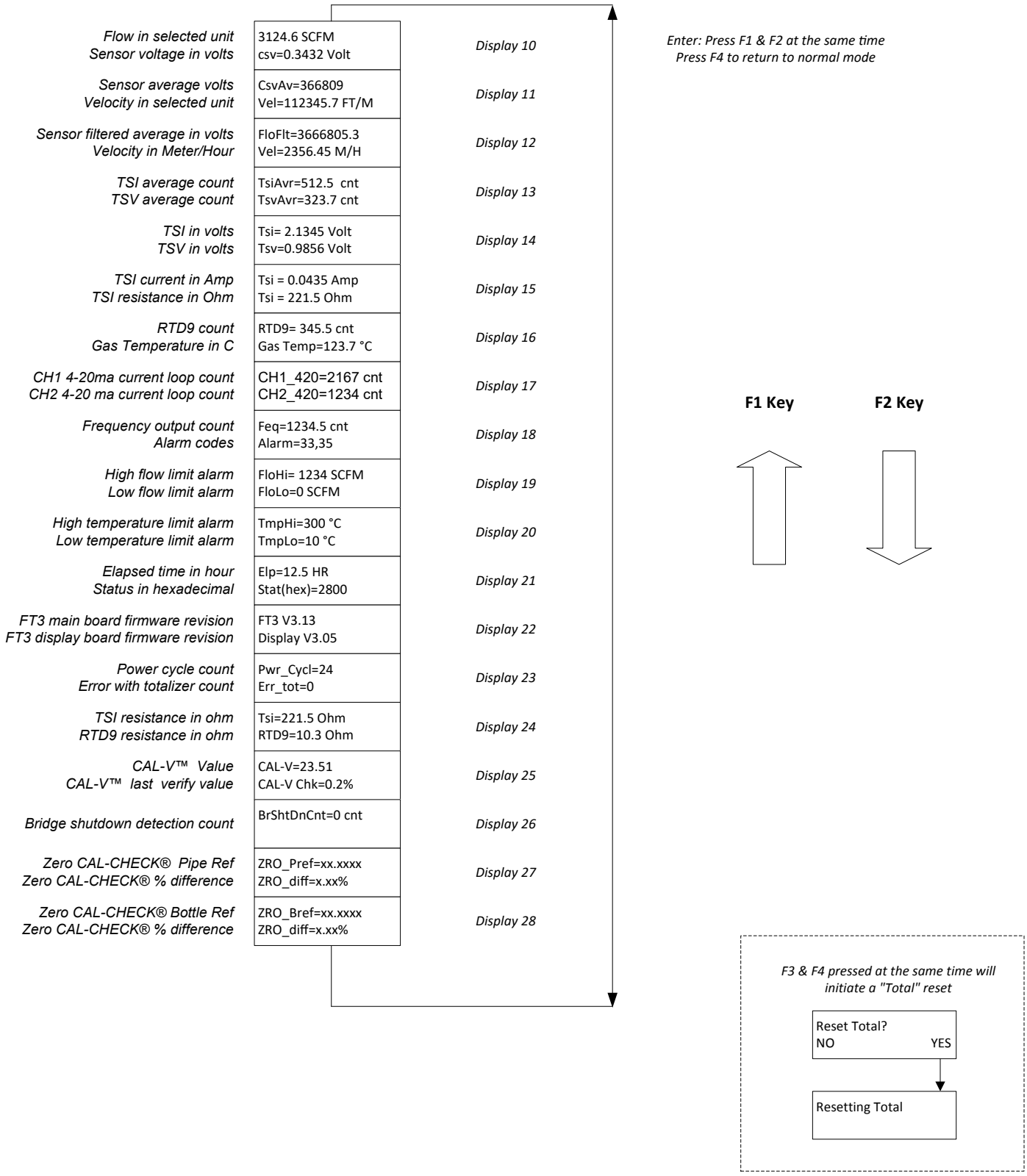


*Fig. 1.9: FT3 Menu Tree - Engineering Displays*



**Welcome**
Thank you for purchasing the model FT3 thermal gas mass flow meter from Fox Thermal. The FT3 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, Data Logger, Maintenance, Appendix, Definitions, and Index.

**Theory of Operation**
The model FT3 is an innovative thermal mass gas flow meter and temperature transmitter. It is microprocessor-based and field programmable. The FT3 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 FT3 flow meter maintains accurate flow measurement over a large temperature and pressure range.

**Mass Flow**
The model FT3 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 model FT3 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**
Fox Thermal has developed a method to validate the calibration of the flow meter in the field. This method is called Calibration Validation and it is made up of two distinct tests: CAL-V™ and Zero CAL-CHECK™. 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 CAL-V™ 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 and in normal processing conditions. The second test, Zero CAL-CHECK™, ensures the effectiveness and sensibility of the sensor at a "no flow" condition.

**Flow Calibration**
Every Fox Thermal 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,

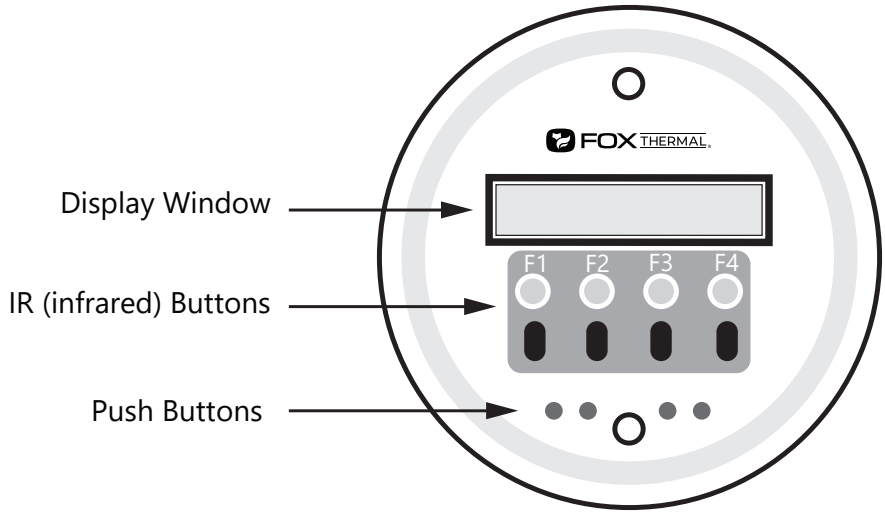
the meter is ready to use. The Fox Thermal Calibration Lab maintains instrument calibration data on every flow meter. Calibration files include details on process conditions, customer gas, line size and other information. All NIST-traceable equipment utilized for the calibration procedure is identified on the Calibration Certificate, which is sent with every flow meter.

**I/O Description**
The FT3 features two galvanically isolated 4-20mA analog outputs, one isolated digital output that can be used for pulse output or alarm, one programmable contact input, and a USB connection for communication with a computer.

The first 4-20mA output is for flow rate. The second 4-20mA output can be configured either for flow rate or process gas temperature. Both 4-20mA outputs can be scaled by the user. The pulse output is programmable to represent flow rate and can be scaled for maximum flow/maximum frequency, units-per-pulse or pulse-per-units. The maximum frequency is 100 Hz. An isolated 24VDC output power option is provided for use with these outputs. It can supply a 42mA maximum total load (do not use for other external devices). FT3 View™ interfaces to the USB port and is a free Fox Thermal PC-based software program available for download on the Fox Thermal website. FT3 View™ displays flow meter readings and permits flow meter configuration. Industry standard communication options are available including HART or Modbus RTU (RS485). Only one of these options can be provided in a single FT3 flow meter.

**FT3 Optional Display and Configuration Panel**
The configuration panel allows the user to change a variety of settings in the FT3. The display is 2 lines x 16 characters with 4 mechanical and 4 IR (infrared) keys. The IR and mechanical (push) buttons perform the same function but the IR keys can be used without opening the cover. The IR keys can be calibrated for better operation in the field or disabled when the meter is used in snow or ice in order to avoid false key detection (see p. 89).

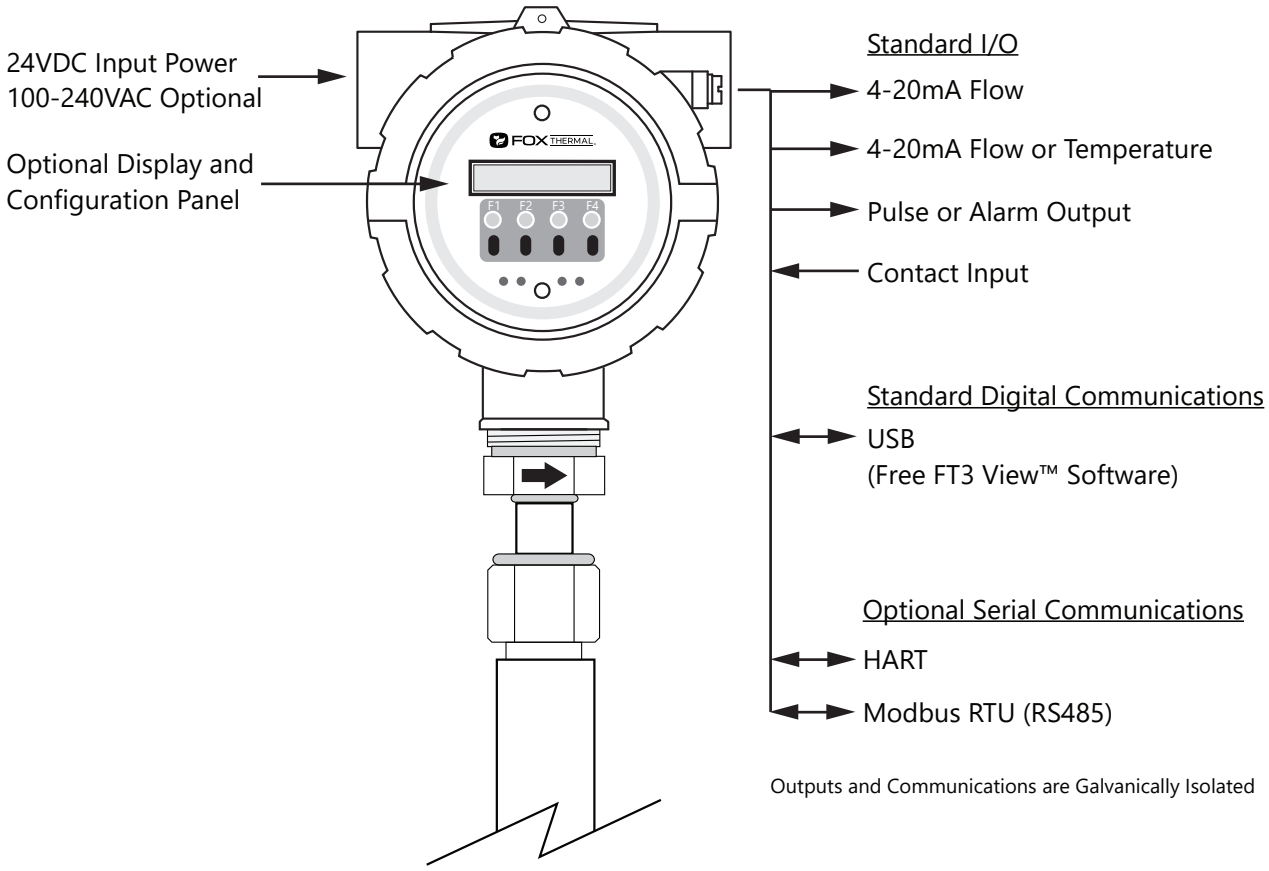
*Fig. 1.11: FT3 Optional Display and Configuration Panel*



**FT3 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 4-20mA scaling, pulse output scaling, pipe area, zero flow cutoff, flow filtering or damping, display configurations, diagnostics, and alarm limits.

*Fig. 1.11: FT3 Function Diagram*



**Installation Scope**
This section describes how to install the Fox Thermal model FT3 Flow Meter and how to get started. Installation methods will vary according to the flow meter type (insertion or inline).

For Insertion Types:
1. Determine lateral position on the pipe.
2. Determine radial position of probe if moisture or condensation present in the gas.
3. Sensor installation depth.
4. Sensor orientation in relation to sensor length and direction of flow.
5. Proper tightening of compression fitting for mounting meter.

For Inline Types:
1. Determine lateral position on the pipe.
2. Flow body orientation in relation to direction of flow in pipe.
3. 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.

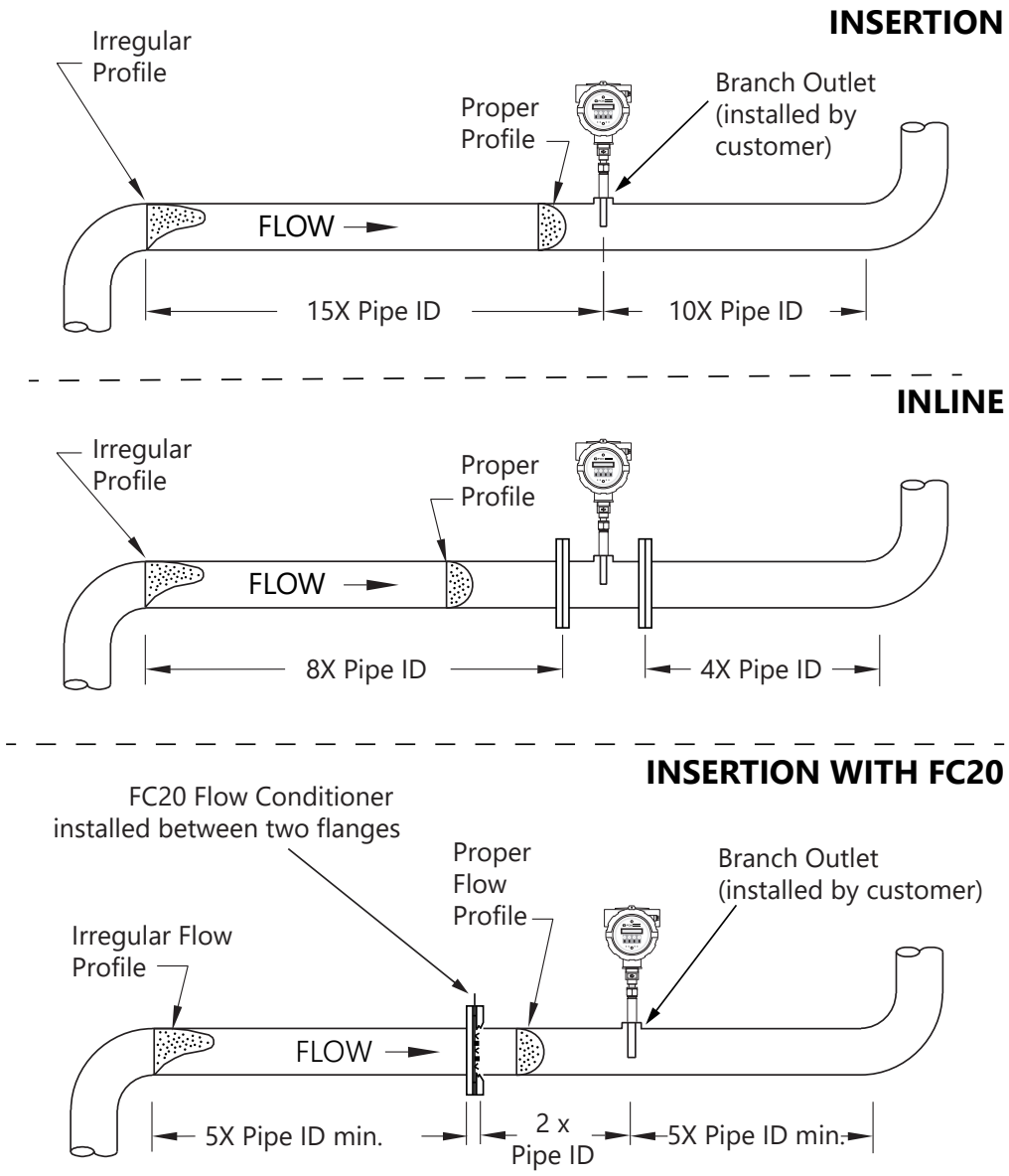
**General Precautions**
The following general precautions should be observed:

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 FT3 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 points in the direction of flow.
6. Do not install the FT3 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 model FT3 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*

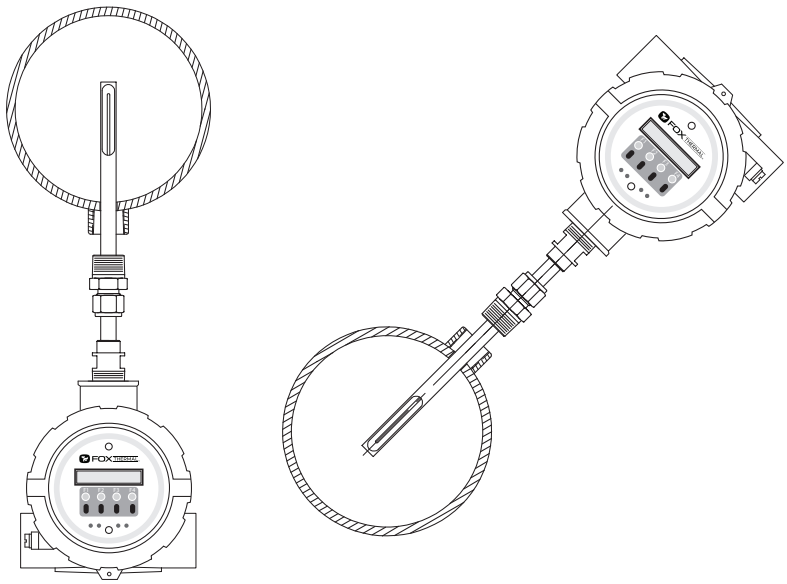



**NOTE!**

- Pipe ID = Inside Diameter
- The probe diameter is ½"
- An irregular flow profile will affect sensor accuracy
- See FC20 Installation Instructions (PN 109193) for more information

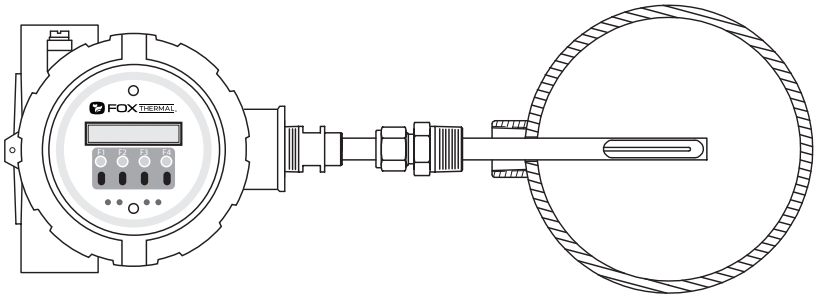
**Radial Probe Position - Moisture in the Gas or Condensation**
The radial position of the meter may help reduce collection of moisture on the sensor. Condensing liquids contacting the meter's sensing elements will disrupt accurate flow measurement. Fox Thermal recommends the flow meter be used in dry gas conditions whenever possible for highest accuracy. Contact Fox for further recommendations.

*Fig. 2.2: Installation at 180° and 45°*



**Alternate Installations - Vertical Pipes or Restricted Installation Spaces**
When restricted physical installation space exists, the FT3 can also be installed at other angles. Please note that the display and the enclosure orientation can be rotated in 90º increments.

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



*"D5/D6" Display Configuration Code*

**NOTE!** Displays **are rotatable only in 90° angle increments.**

**Welding Branch Fitting to Pipe**

The probe of the FT3 must be installed perpendicular in the pipe to measure flow accurately. Use the following steps to ensure that the ¾" branch fitting is correctly welded to the pipe.

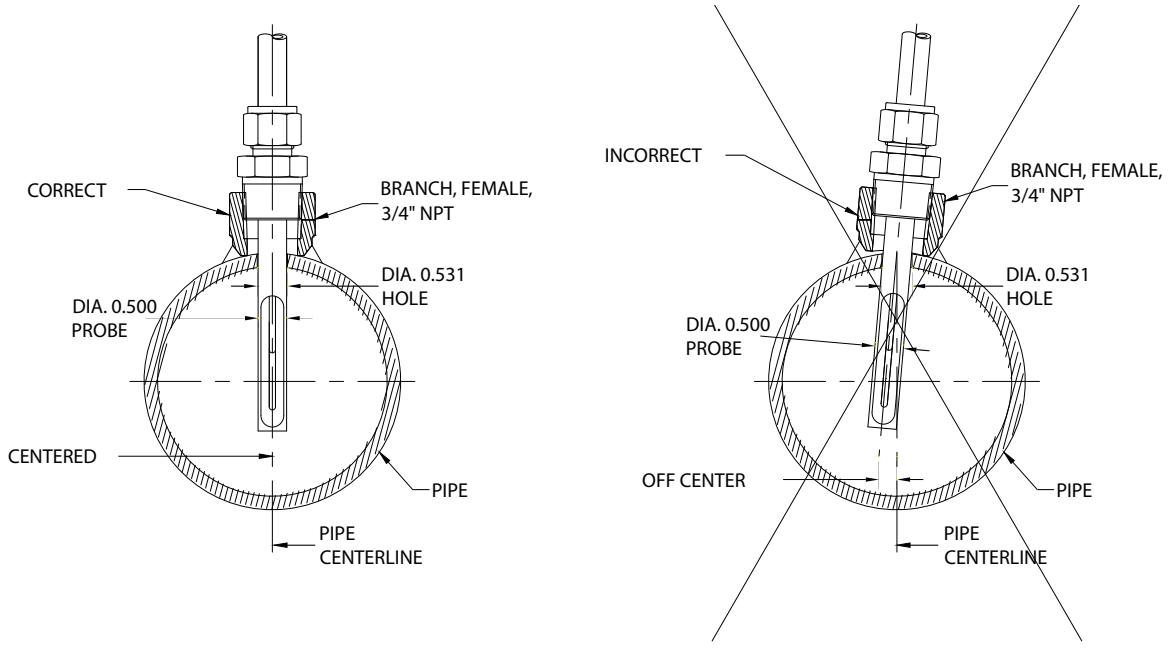
Directions:

1. Drill a 0.531" (17/32") hole inside the fitting through the wall of the pipe (1 wall only).
2. Assemble the compression fitting and branch fitting hand tight onto the probe of the FT3.
3. Insert the probe into the hole in the pipe and use the FT3 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 Fig. 2.4).
5. To verify that the correct hole position has been achieved, carefully slide the 0.50" sensor in and out of the branch fitting and 0.531" hole.

**WARNING!** Do not force the 0.50" sensor through the 0.531" hole. Forcing it through the hole can damage the probe!

6. Verify that the temporary weld of the branch fitting positions the probe window on the pipe's centerline.
   - Fig. 2.4 shows an incorrect welding of the branch fitting, causing the 0.50" sensor to be "off center".
7. Once the branch fitting is aligned properly, remove the 0.50" 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 24).
   - Do not tighten compression fitting until proper depth of flow meter is determined.

*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, the sensor window must be properly positioned within the pipe.

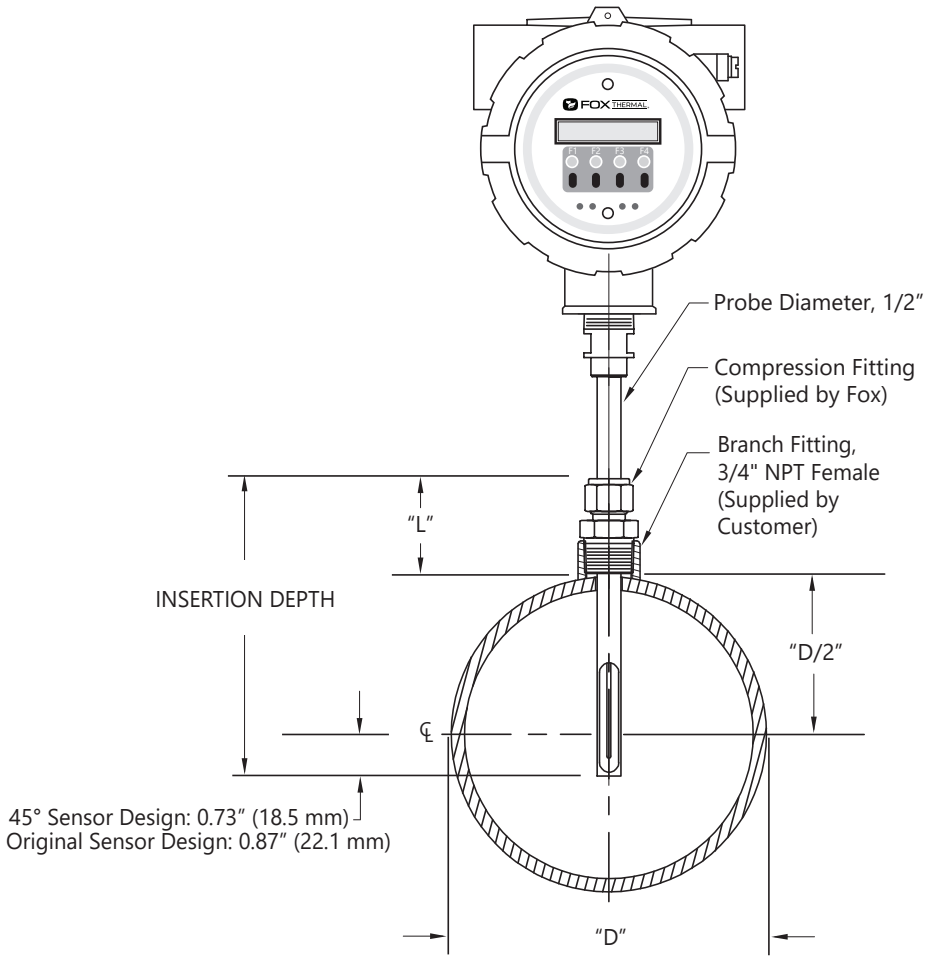
When installing the latest 45° sensor design, the end of the sensor should be 0.73" (18.5 mm) past the center of the pipe.

When installing an original sensor design, the end of the sensor window should be 0.87" (22.1 mm) past the center of the pipe. Reference sensor design figures on page 26.

Review Fig 2.5 below and use the following equations to calculate insertion depth. Insertion depth is measured from the top of the compression fitting to the bottom end of the probe.
For latest 45° sensor design, Insertion depth = *L +D/2 + 0.73*"
For original sensor design, Insertion depth = *L +D/2 + 0.87*"

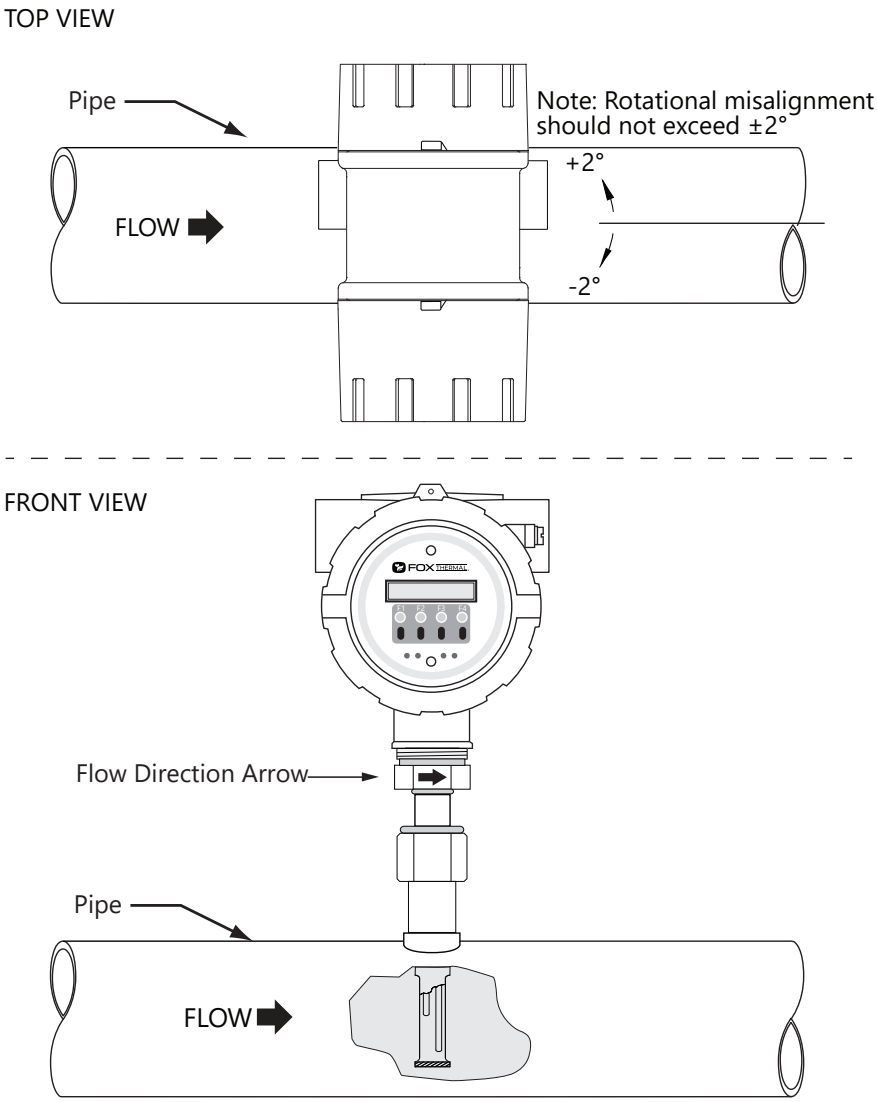
**CAUTION!** For a 1½" pipe, do not tighten compression fitting without 0.2" distance from wall or damage to probe will occur.

*Fig. 2.5: Insertion Sensor Depth in Pipe*



**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.

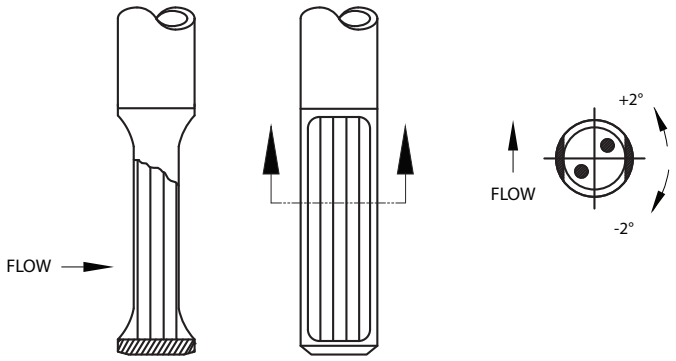
*Fig. 2.6: Orientation of Flow Meter*




**NOTE!** Some flow meters are shipped with the sensor elements that are offset (see Fig. 2.7). Others are shipped with sensors that have equal length elements (see Fig. 2.8). The sensor type supplied was selected at the factory to be the best suited for your application. Follow the appropriate sensor orientation instructions.

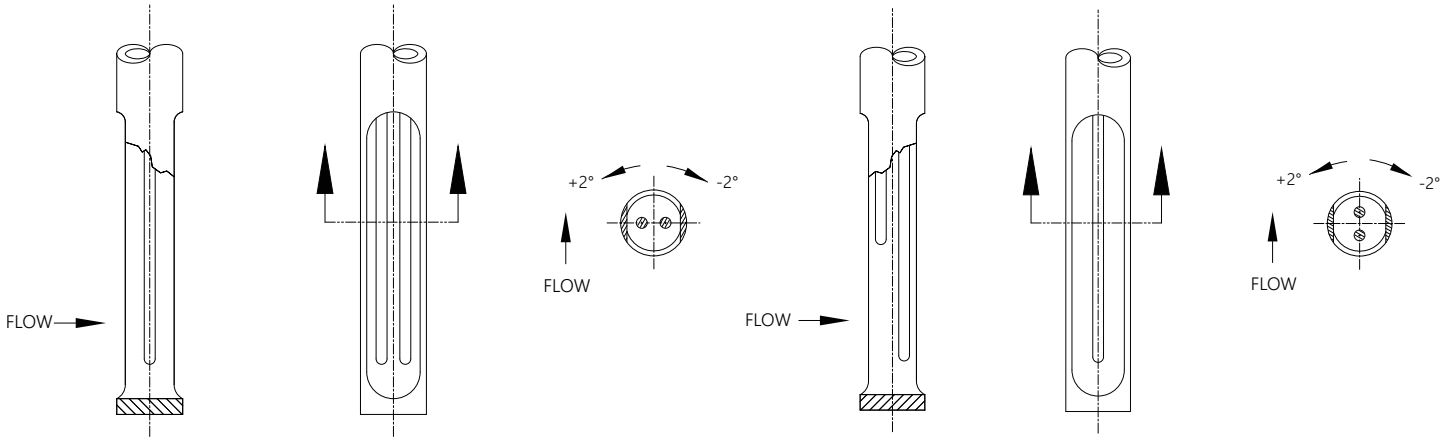
**Sensor Orientation - Latest 45° Design**
The sensor element tubes of the latest sensor design are connected at both ends and offset at 45 degrees in relation to the sensor window opening. Install the flow meter with the window opening facing the flow stream within ±2°.

*Fig. 2.7: Latest Design 45° Sensor Elements*




**Sensor Orientation - Original Design**
Unequal Length Sensor Elements - Install the shorter element upstream from the longer one.
Equal Length Sensor Elements - Install flow meter with both sensor elements facing the flow stream within ±2°.

*Fig. 2.8: Equal and Unequal Length Sensor Elements*



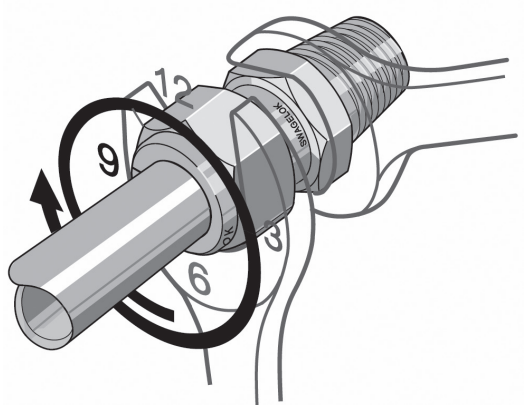

*Equal Length Sensor Elements* *Unequal Length Sensor Elements*

**Mounting Instructions - Compression Fittings**

FT3 insertion style flow meters are mounted through a 0.531" (17/32") hole and a ¾" 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 ¾" female NPT branch outlet.
- When installing the probe in a 2" pipe or larger, use the installation depth instructions (refer to Fig. 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 Fig. 2.9.

*Fig. 2.9: 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 Page 28.

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

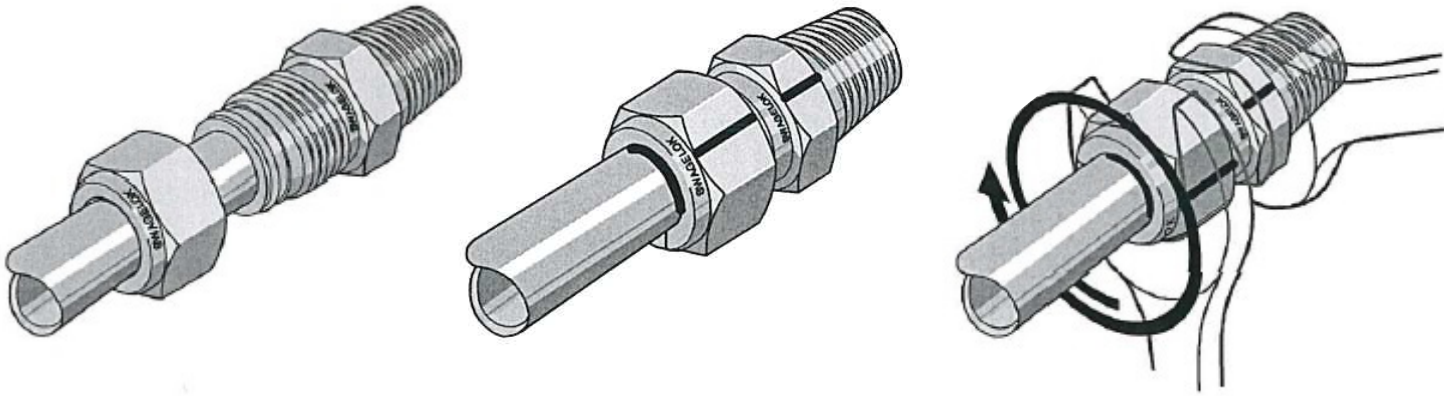
**CAUTION!** For a 1½" pipe, do not tighten compression fitting without 0.2” distance from wall or damage to probe will occur.

**CAUTION!** If the stainless steel or Teflon ferrules are not properly tightened, and/or the recommended pressure is exceeded, the ferrules can slip on the stainless steel tubing causing 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 Fig. 2.10).
- Verify that the probe is installed the correct depth in the pipe (refer to Fig. 2.5).
- 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 Fig. 2.10).
- Tighten the nut slightly (approximately 1/8 turn).

*Fig. 2.10: Proper Re-Tightening of the Compression Fitting Nut*

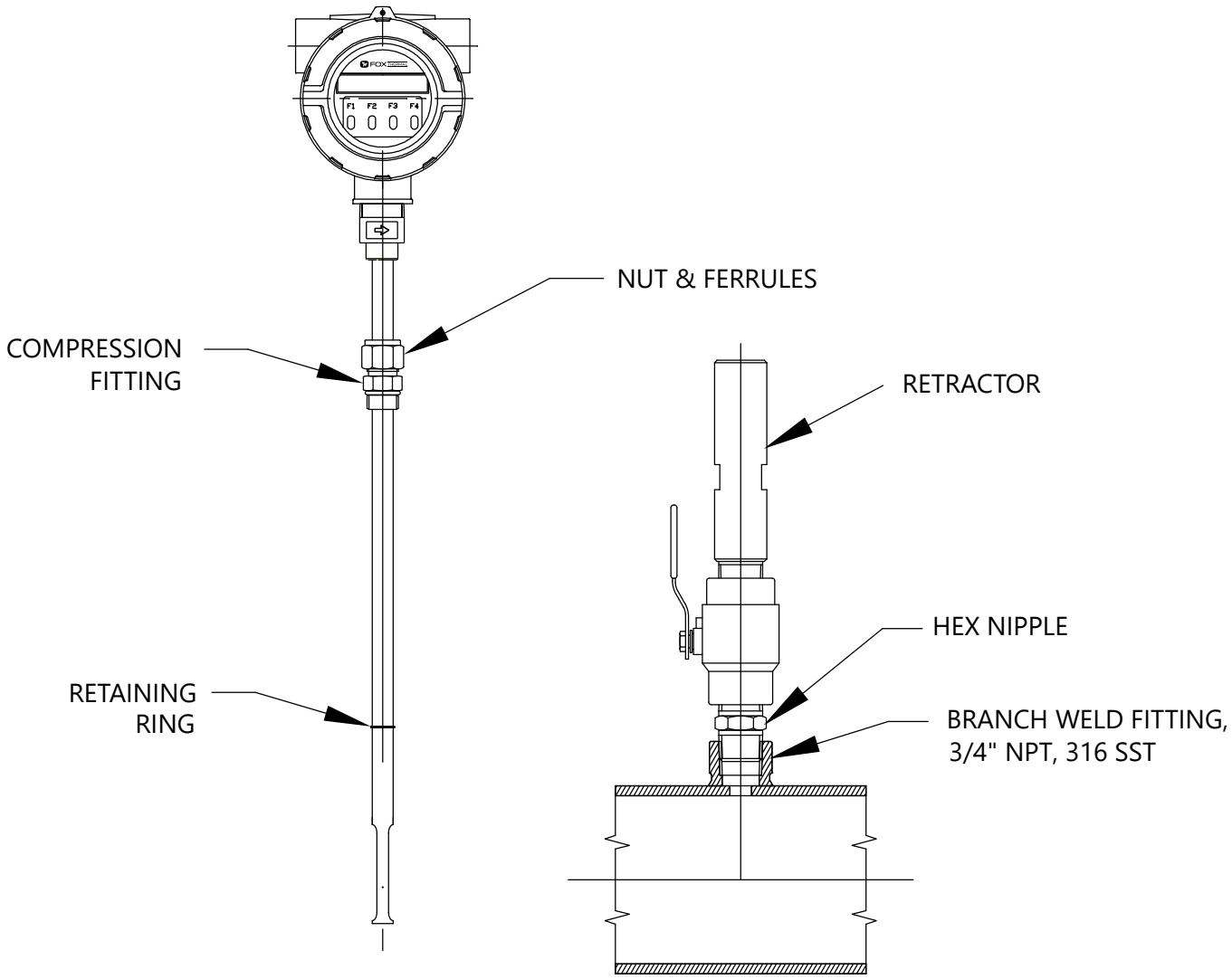


**CAUTION!** Do not use a gap inspection gauge with reassembled fittings.

**Installation of a New Retractor Assembly**

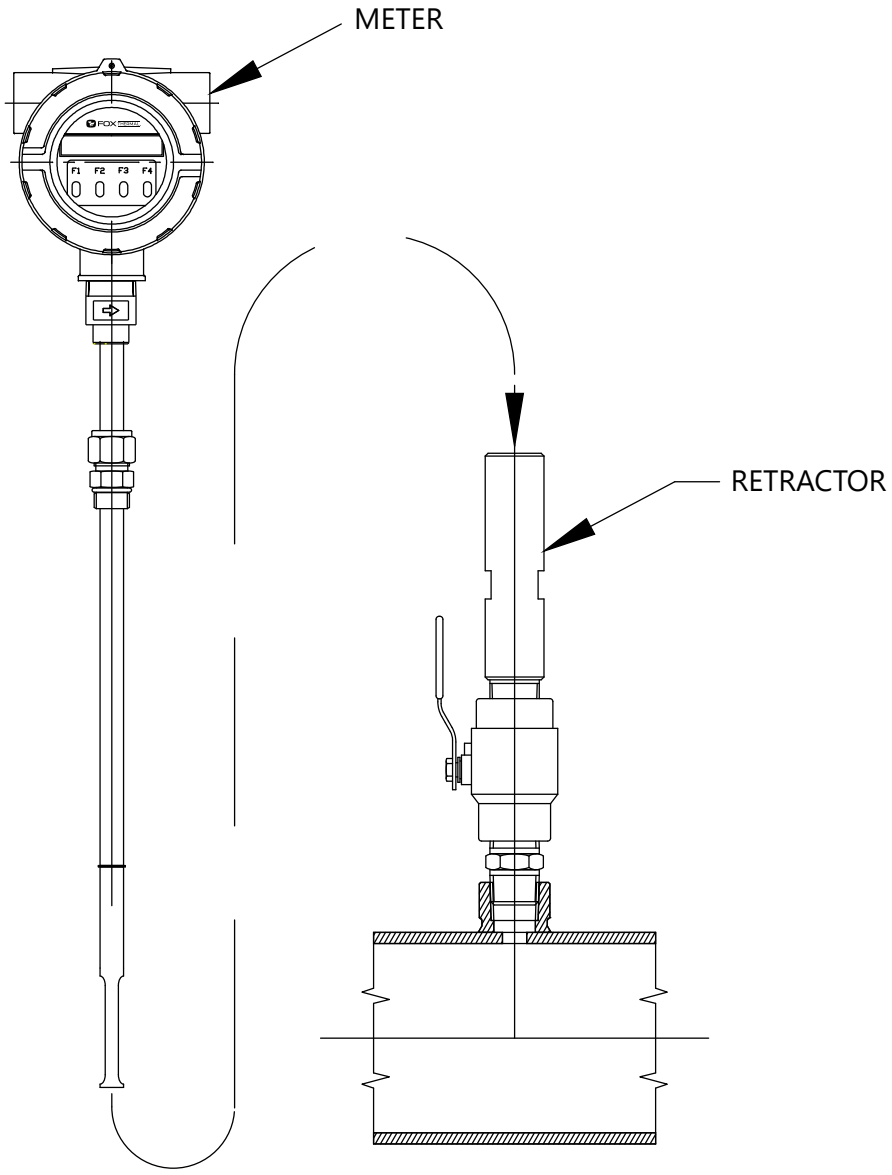
1. Remove meter probe from retractor assembly and leave the ball valve open.
2. Install the valve assembly on the pipe, by tightening the Hex Nipple with a 1-1/16" wrench.

*Fig. 2.11: Retractor Assembly Without Probe Installed*



3. 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. 2.12: Verify Probe Insertion*




4. The installation depth of the sensor in the pipe is dependent on the pipe size. To get the most accurate reading, the sensor window must be properly positioned within the pipe.

   When installing the latest 45° sensor design, the end sensor should be 0.73" (18.5 mm) past the center of the pipe.

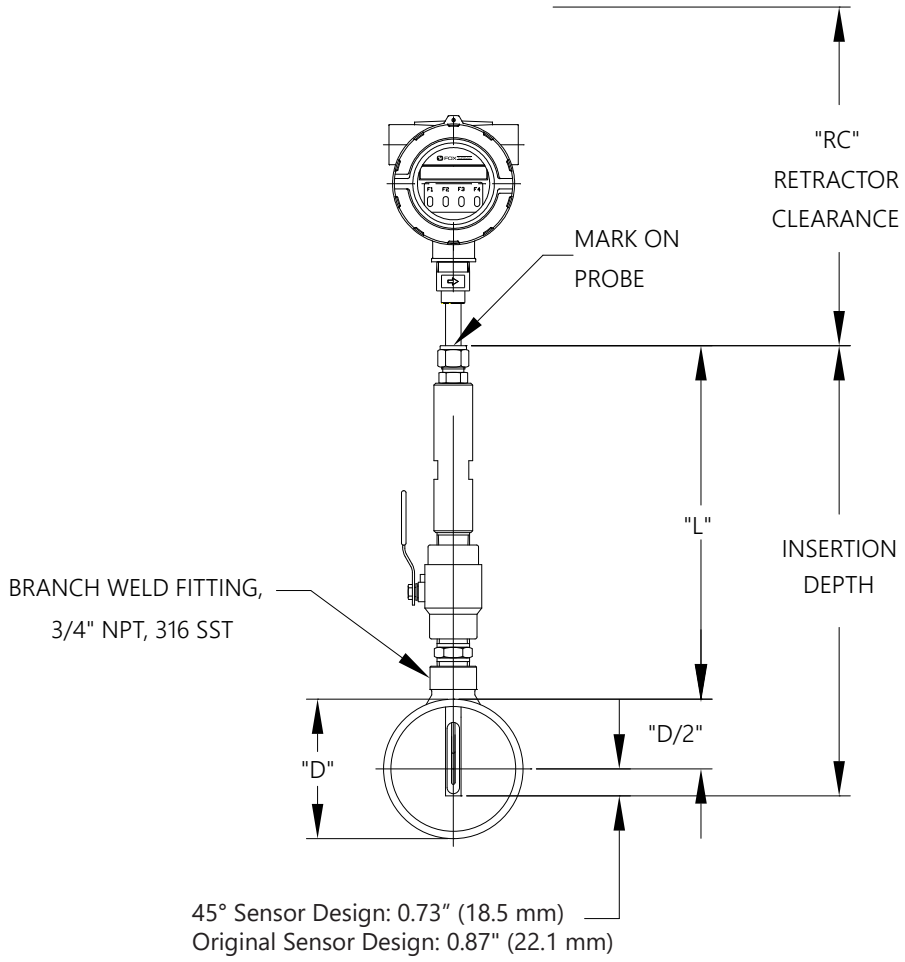
   When installing an original sensor design, the end of the sensor window should be 0.87" (22.1 mm) past the center of the pipe. Reference sensor design figures on page 26.

Review Fig 2.13 below and use the following equations to calculate insertion depth. Insertion depth is measured from the top of the compression fitting to the bottom end of the probe.
For latest 45° sensor design, Insertion Depth = *L + D/2 + 0.73*"
For original sensor design, Insertion Depth = *L +D/2 + 0.87*"

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

5. The Retractor Clearance table of Fig. 2.13 lists the space required to remove the meter from the retractor. Use the model code of your meter to determine the dimension.

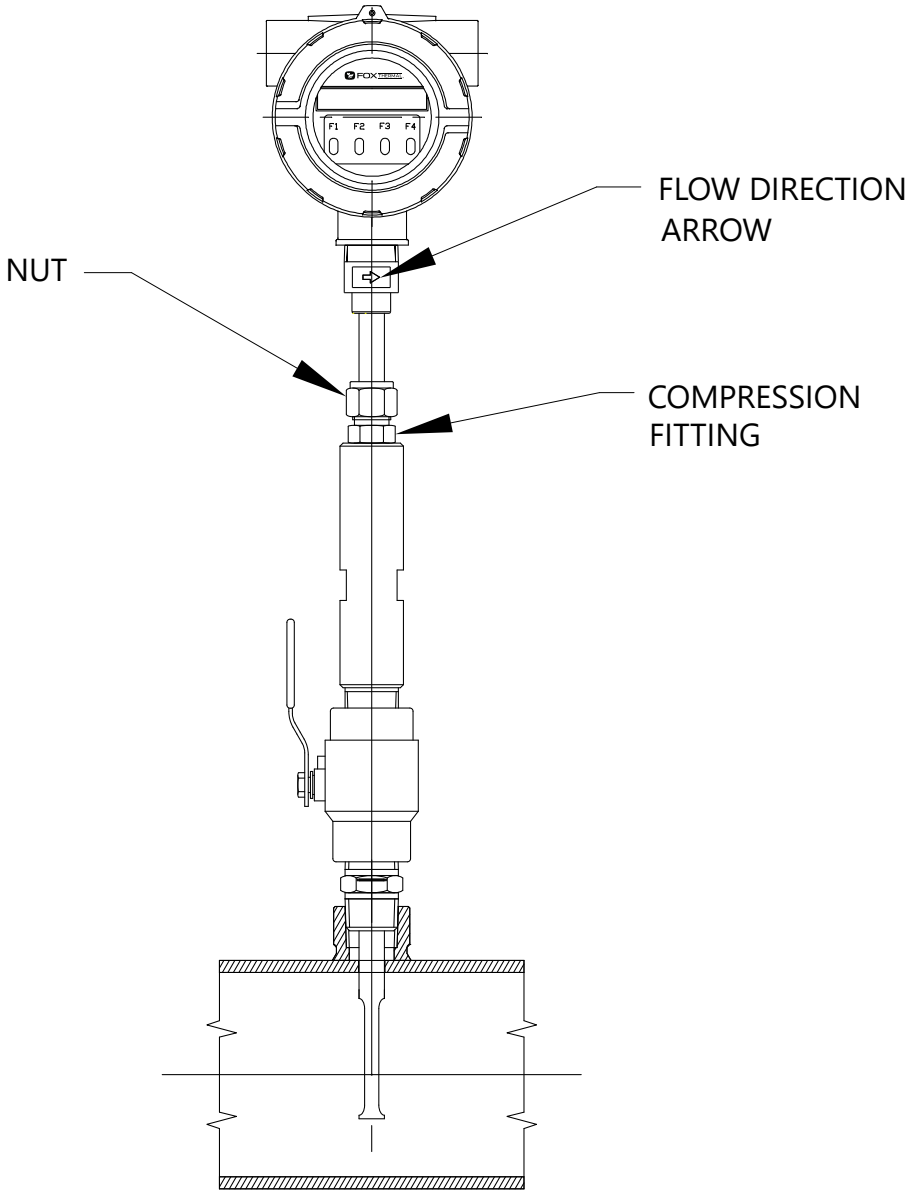
*Fig. 2.13: Determining and Marking Insertion Depth*




| RETRACTOR CLEARANCE | |
|---|---|
| CODE | "RC" DIMENSION |
| 15R | 27.3" (69.4 CM) |
| 18R | 30.3" (77.0 CM) |
| 24R | 36.3" (92.2 CM) |
| 30R | 42.3" (107.4 CM) |
| 36R | 48.3" (122.7 CM) |

6. Insert probe back into the retractor to the depth mark and hand-tighten the compression fitting.
7. Verify that flow direction indicator is in line with pipe and in the direction of flow.

*Fig. 2.14: Installed Retractor*




8. Fully tighten compression fitting (refer to the instructions on p. 27).

**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 113.

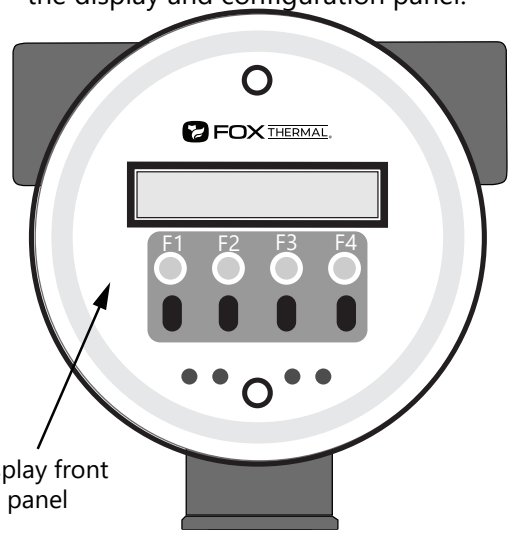
**Wiring Instructions**
To wire the FT3 connect the power and signal wires to the terminal blocks according to the label and instructions on the following pages.

*Fig. 3.1: FT3 Wiring Access*

**Front Enclosure Cap**

**No Wiring Access**

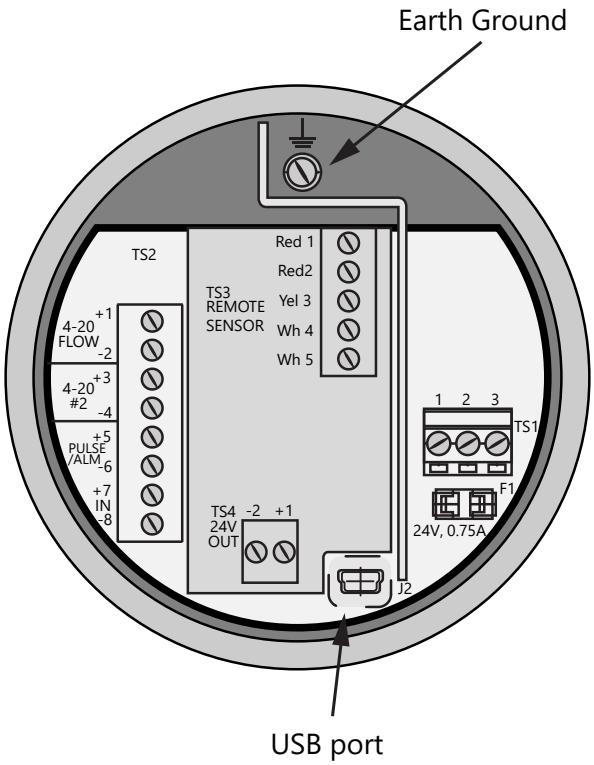
Unscrew front enclosure cap to access the mechanical buttons or change the orientation of the display and configuration panel.




**Rear Enclosure Cap**

**Wiring Access**

Unscrew the rear enclosure cap to access wiring terminals for power, 4-20mA and pulse outputs, switch input, USB port, remote sensor, and serial communication options.




Wire the FT3 by opening the rear enclosure cover, bringing customer supplied wires in through the conduit openings and connecting to the terminal blocks. The FT3 has two conduit openings to maintain separation between AC input power and output signal wiring (see Fig. 3.4 on Page 37 for more information). To eliminate the possibility of noise interference, use a separate conduit for AC power and cut all wires short for a minimum service loop.

### Wiring Precautions

**WARNING!**

- DO NOT OPEN THE ENCLOSURE WHEN ENERGIZED OR AN EXPLOSIVE ATMOSPHERE IS PRESENT.
- 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.
- Connect earth ground to a chassis ground screw on the inside of FT3 enclosure.
- An external power disconnect and 16A over-current protection are required for the AC and DC powered FT3.
- Do not install the FT3 enclosure near an igniter, igniter-controller or switching equipment.
- 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 steel material prior to working inside this flow meter.
- For the remote sensor option, the serial number of the electronics enclosure must match the remote sensor probe.
- Close any unused conduit openings using suitably certified plugs

### Power Wiring

For power wiring, use stranded copper wire, 16 to 20 gauge. If an external 24VDC power source is used, twisted pair shielded cable is recommended. 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. The cable shield should not be connected at the flow meter, it should be connected at the power supply AC ground terminal or instrumentation AC ground. Do not route the power and signal wires in the same conduit. Power wires must enter left-hand conduit entry. Signal and remote sensor (where applicable) must enter right-hand conduit entry.

**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 communication transmit and receive signals. The third wire is for the communication common signal. Belden number 310A 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.

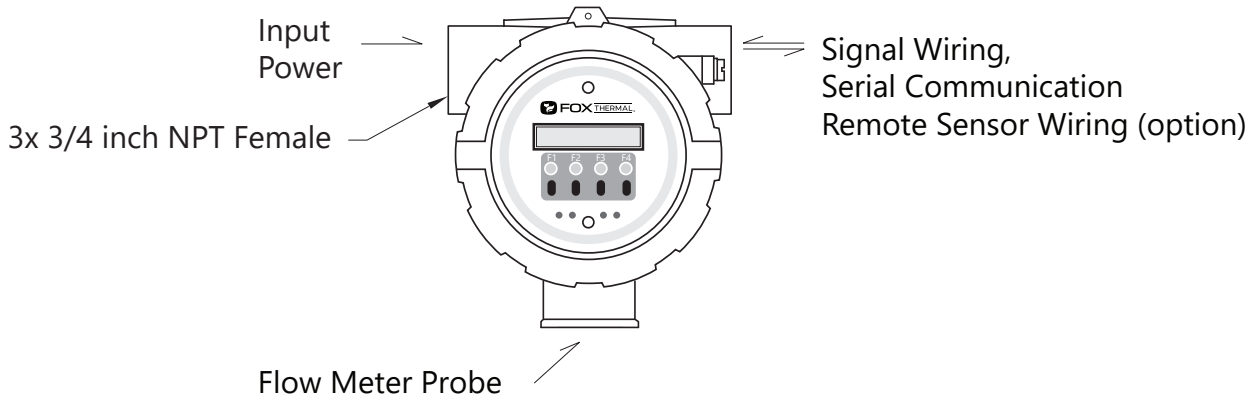
**NOTE!** Serial Numbers: If you have more than one meter, you must ensure that the serial numbers of the probe/remote enclosure, electronics enclosure, and flow body match one another. These items have been manufactured and claibrated to operate as a unit and connot be mismatched.

For remote sensor wiring, five wire shielded cable is required, the recommended wire gauge is 18 AWG. 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. Do not connect the shield at the electronics enclosure.

**FT3 Wiring - Conduit Openings**

**Installation Wiring**
Obtain the correct length for the FT3 power and signal wires using one of these methods:
- Trim the wires to extend 2.5 inches out of the enclosure after the conduit and wires are routed to the FT3 (preferred method).
- Trim the wires to extend 6 inches from the end of the conduit before it is attached to the FT3.

*Fig. 3.2: FT3 Wiring - Conduit Openings*

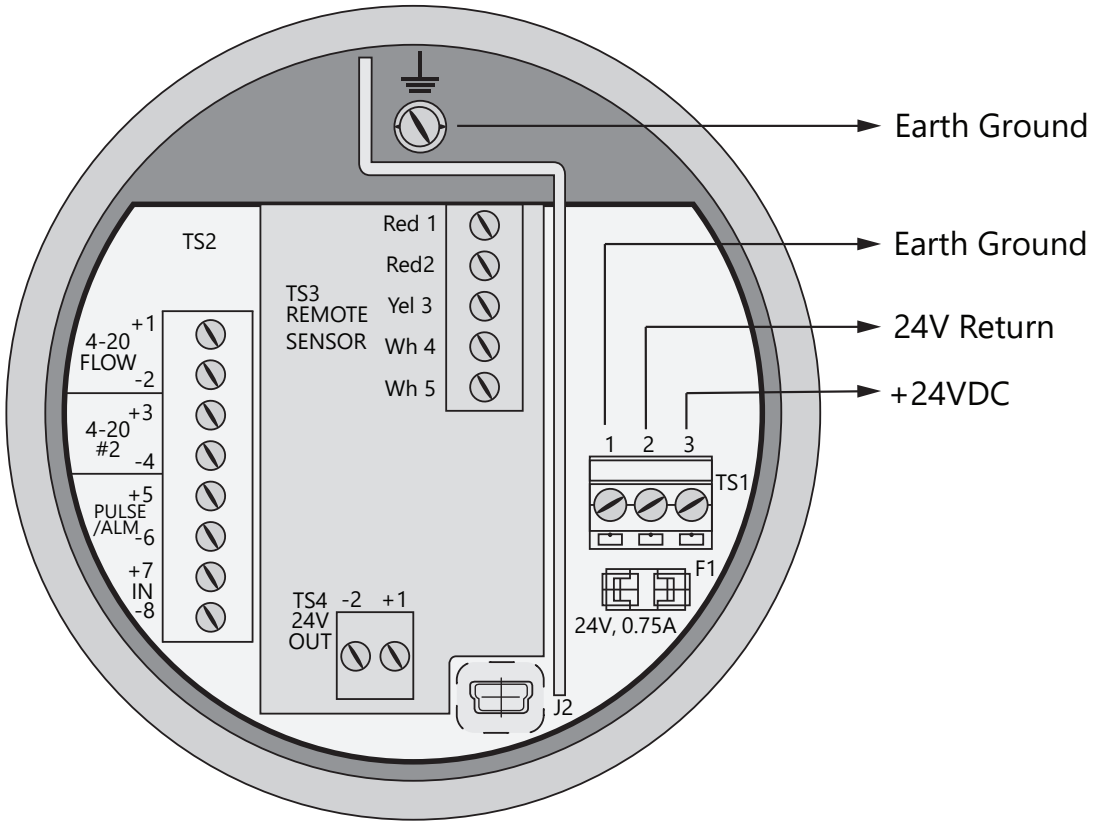


**Power Input Requirements: 24VDC**
External DC power supply must provide 24VDC ± 10%, at 0.7 Amps minimum.

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

*Fig. 3.3: Connections for 24VDC Supply*



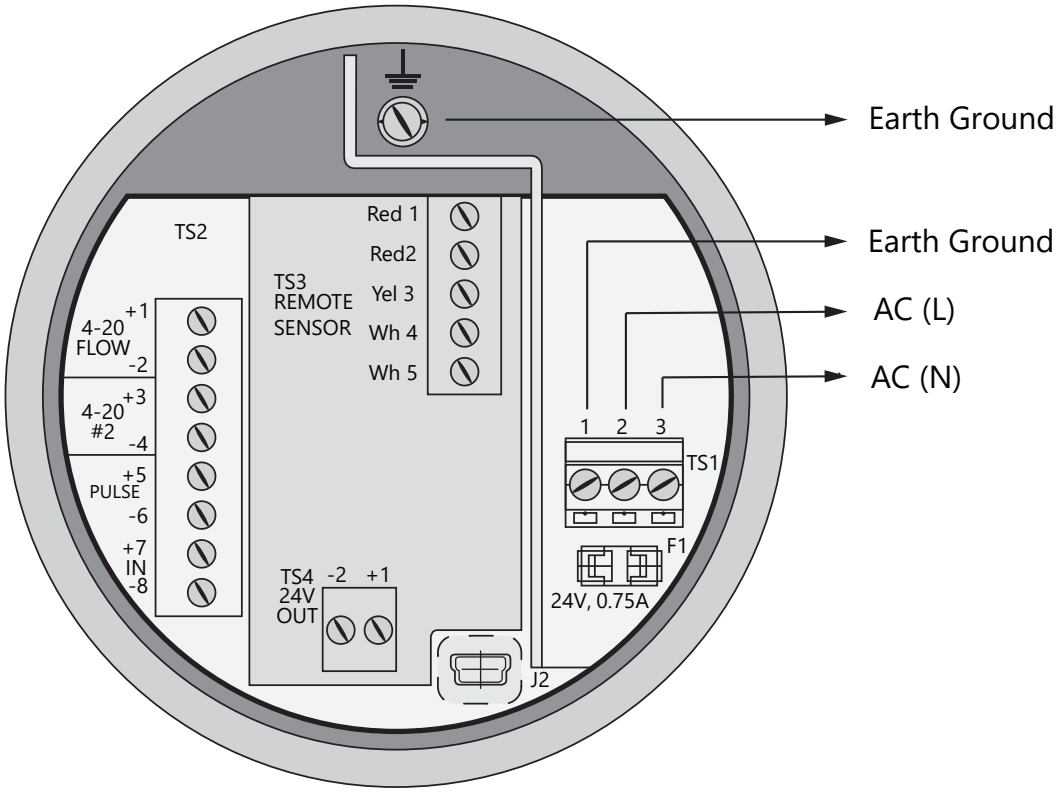

**CAUTION!** Supply connection wiring must be rated for at least 90°C.

**Power Input Requirements: 100 to 240VAC Supply**
If the FT3 has the AC power supply option, the AC power must provide 100 to 240VAC -15% / +10% (85 to 264VAC) at 0.2 Amps minimum.

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

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

*Fig. 3.4: Connections for optional AC Power*



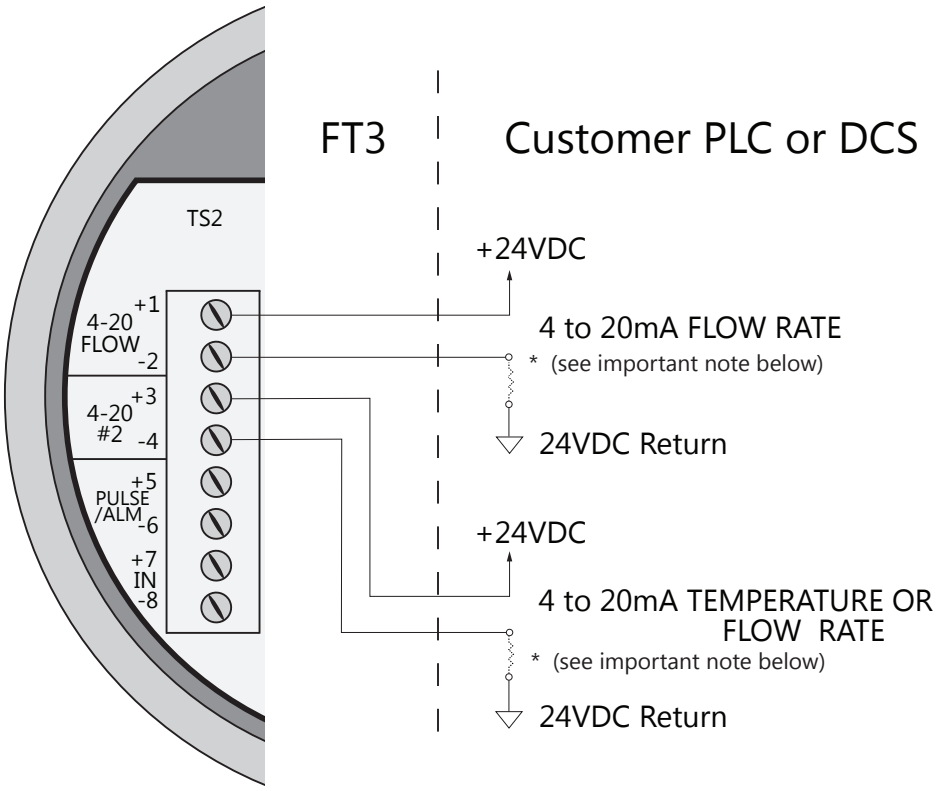

**CAUTION!** Supply connection wiring must be rated for at least 90°C.

### 4-20mA Output Wiring: Customer-Supplied Power Source

Bring the wiring in through the right hand conduit opening. Connect the 4-20mA flow rate and 4-20mA output #2 temperature or flow rate wiring as shown in the diagram below.

**CAUTION!** When using the 4-20mA output to control equipment in a failsafe application, see the wiring configuration on p. 40.

*Fig. 3.5: 4-20mA Output Wiring for Customer-Supplied Power Source*




**NOTE!**

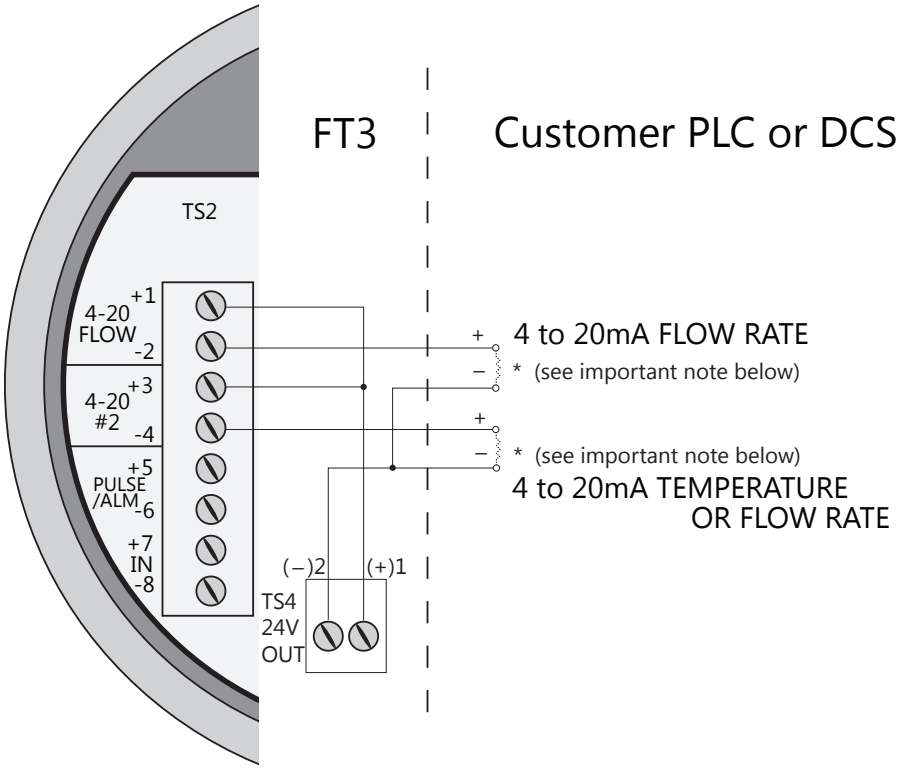
- When using a 12 volt power supply, the load resistor on the 4-20mA output must be 125 ohms or less to operate properly.
- When using 24 volt power, the load resistor is typically 250 ohms. A 250 ohm resistor in the 4-20mA circuit will result in a 1 to 5 volt signal to the PLC or DCS.
- When using a 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 Wiring: Loop Power Provided by FT3**

Bring the 4-20mA wiring in through the right hand conduit opening. Connect the 4-20mA wiring as shown in the diagram below.

**CAUTION!** When using the 4-20mA output to control equipment in a failsafe application, see the wiring configuration on p. 40.

*Fig. 3.6: 4-20mA Output Wiring for Loop Power Provided by FT3*




**NOTE!**

- This wiring option is only available with the isolated 24V output power option.
- 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.

**Setting Up the NE-43 Alarms**
The FT3 flow meter supports the NAMUR specification NE-43 for alarms on the 4-20mA output. See p. 55 for the 4-20mA ouput NAMUR operation.

**CAUTION!** Configure the FT3 with the following setup when using the 4-20mA output to control equipment in a failsafe application.

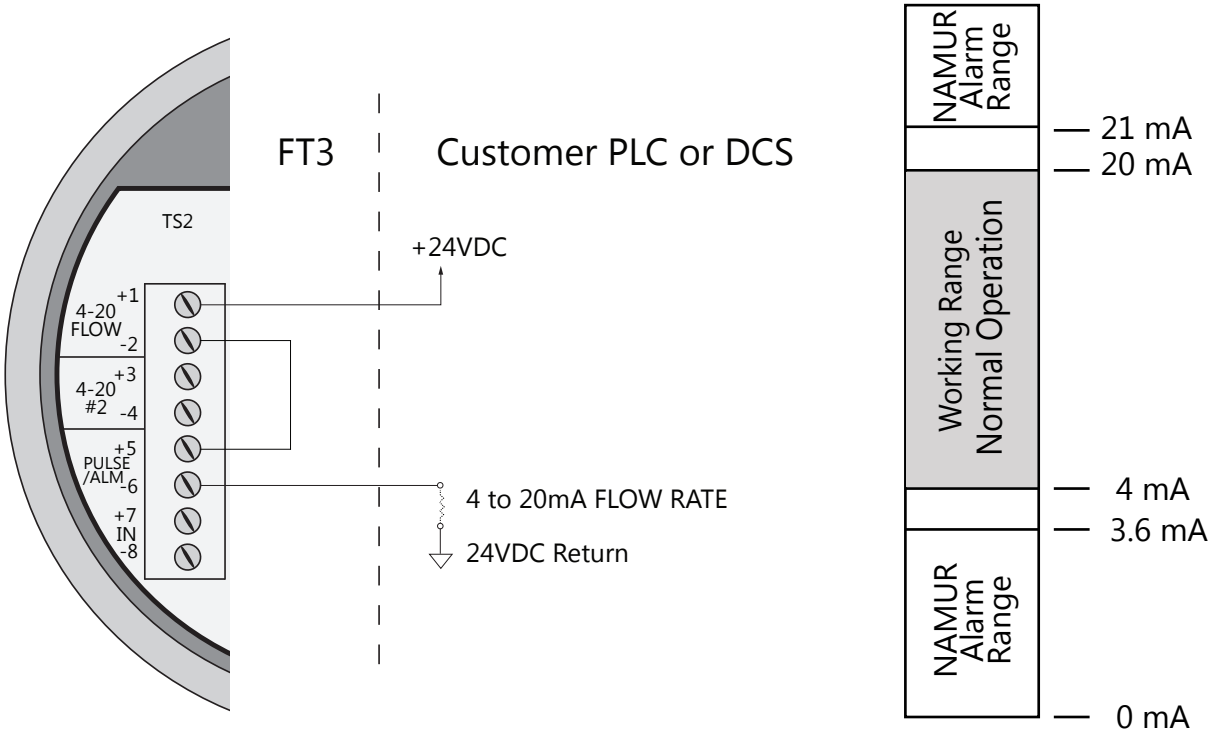
**4-20mA Failsafe Wiring: NAMUR NE-43**
When the 4-20mA output is used to control equipment in failsafe applications:

- Wire the 4-20mA output in series with the Alarm output as shown in Fig. 3.7.
- Configure the Pulse/Alarm output to Alarm and select System Alarm as shown in the "Alarm Output" on Page 58.

The System Alarm output is designed to allow current to flow during normal operation and interrupts current when power to the meter is lost or in a System Alarm condition.

In the 4-20mA Failsafe Wiring configuration of Fig. 3.7, the 4-20mA signal goes to 0mA if power to the FT3 is lost or a System Alarm occurs.

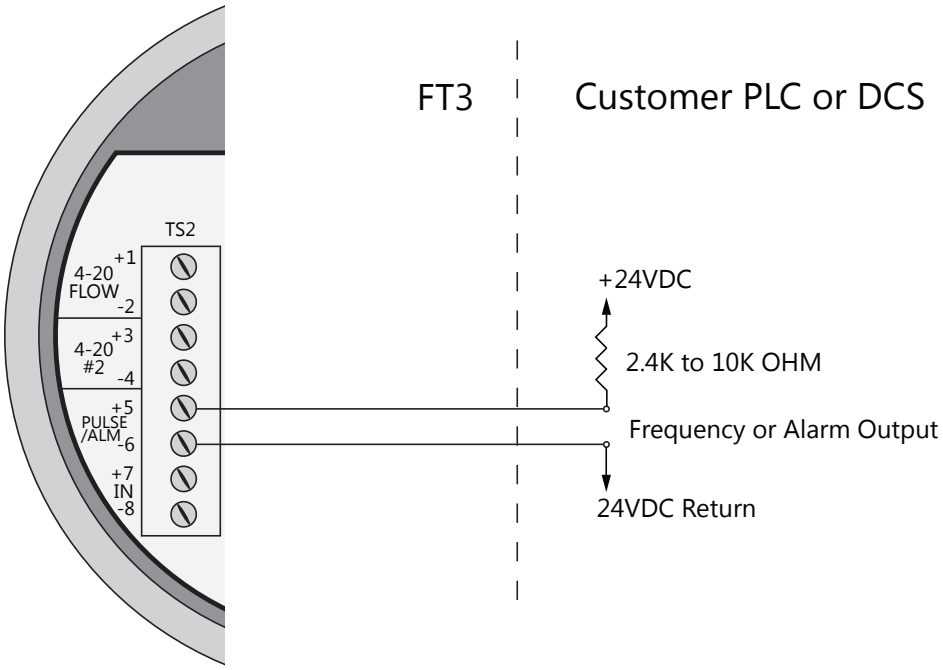
*Fig. 3.7: 4-20mA Failsafe Wiring and Range of 4-20mA Output for NAMUR Alarm*



**Pulse/Alarm Output Wiring**

Bring pulse/alarm wiring in through the right-hand conduit opening. Connect to TS2, 5(+) and 6(-). 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. Only one option, pulse or alarm, can be active at a time.

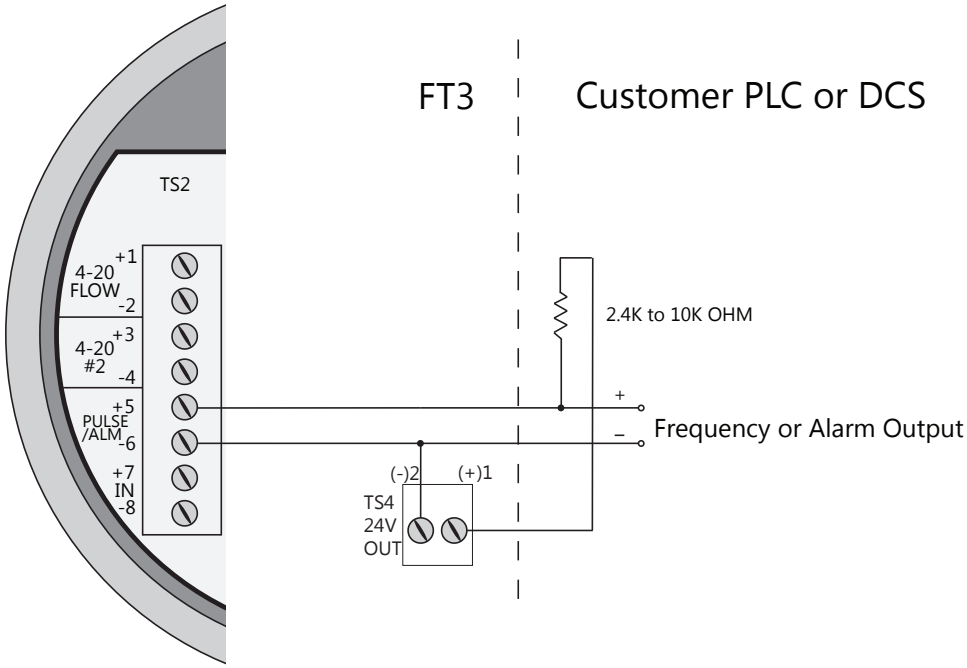
*Fig. 3.8: Pulse/Alarm Output Isolated (Recommended)*




**NOTE!**

- The FT3 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 (24 volts output).

*Fig. 3.9: Pulse/Alarm Output Local +24V Power Option*




**CAUTION!**
Do not exceed 42 mA total load on the 24V Output TS4 (ie including 4-20mA outputs).

**NOTE!**

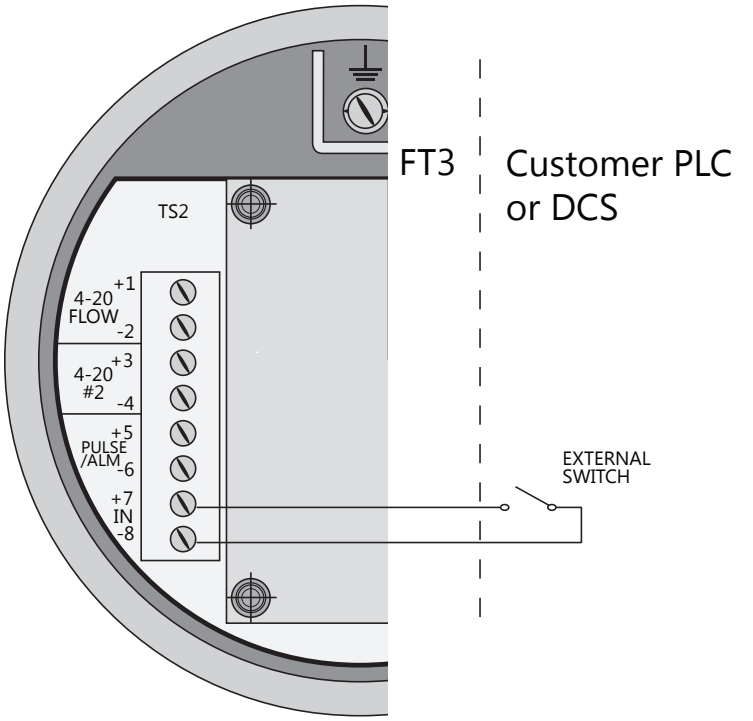
- This wiring option is only available with the isolated 24V output power option.
- The FT3 Pulse/Alarm output is typically used to drive digital circuitry or solid-state relays. The output of a solid state relay may, in turn, operate loads such as electromechanical relays or alarm indicators.
- The 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 (24 volts output).

**Remote Switch Wiring**

A remote switch can be used to reset the Totalizer and elapsed time, if enabled in the programming settings. There is no polarity requirement on these connections. Use TS2, 7(+) and 8(-).

When the 2 gas curve option is ordered, the switch can be used to switch between curves.

*Fig. 3.10: Remote Switch Wiring*



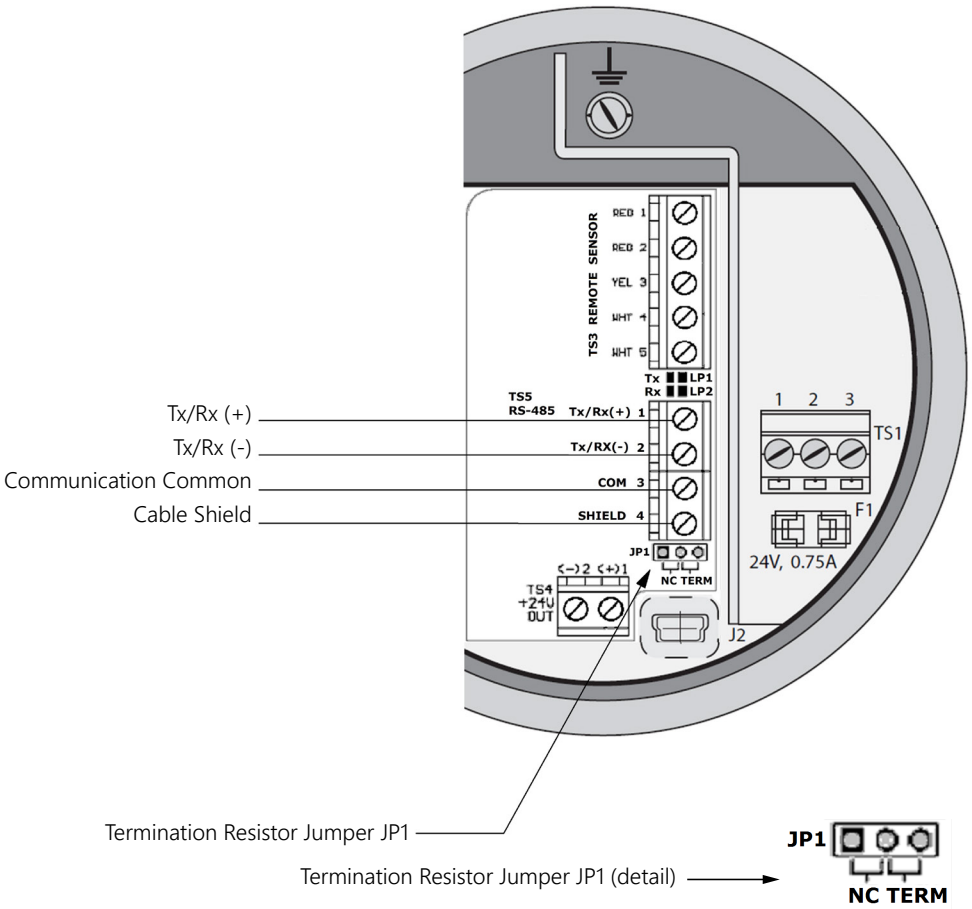
**Wiring for Modbus RTU (RS485)**
Wiring connections are made to terminal block TS5 for RS485 communication. Terminal block TS5 is located on the Modbus communication option board of the FT3.

The Tx/Rx+ signal connects to pin 1, Tx/Rx- connects to pin 2 and communication common to pin 3, and the cable shield to pin 4 as shown in Fig. 3.11.

**Termination Resistor**
Connect a termination resistor across the receive/transmit signals of the last device on the RS485 communication line. To connect the 121 ohm termination resistor on the FT3, set JP1 to the TERM position.

Disconnect the termination resistor on all other external RS485 devices. The termination resistor of the FT3 is disconnected by setting JP1 to the NC (Not Connected) position.

*Fig. 3.11: RS485 Wiring*



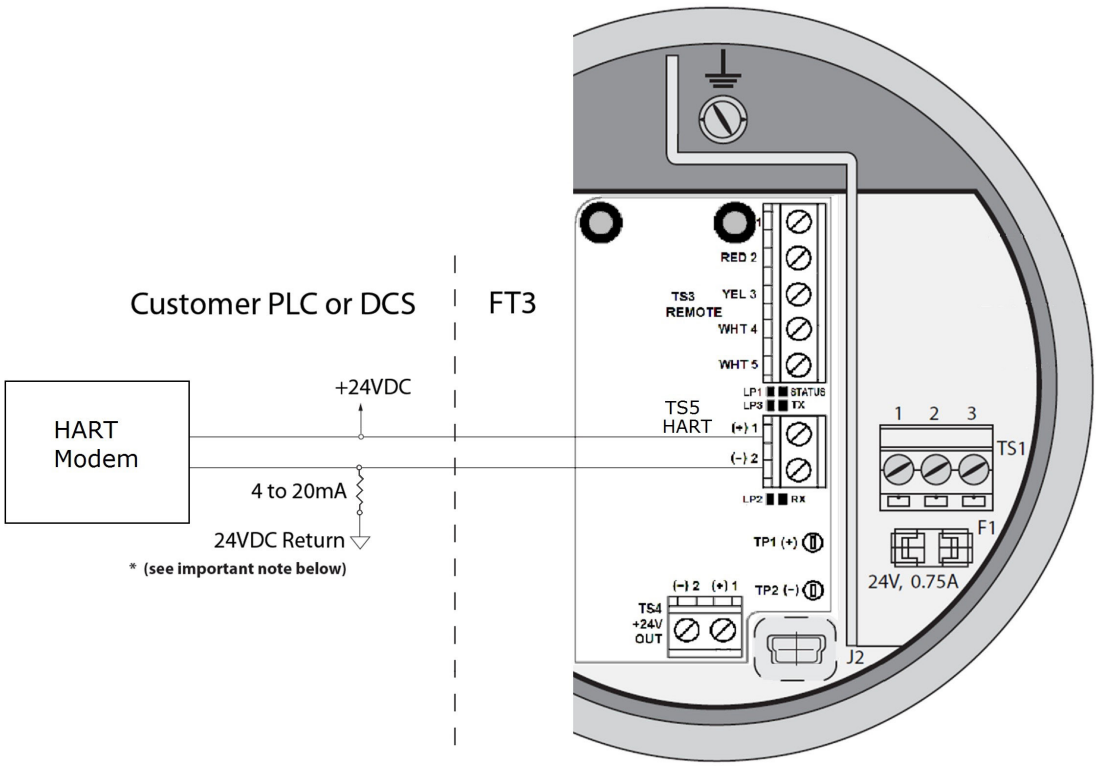

**NOTE!**

- JP1 jumper will either be in the NC (Not Connected) or TERM (terminated) position. It should be in the terminated position on the last meter in the series.

**HART 4-20mA Output Wiring: Customer-Supplied Power Source**

The 4-20mA current loop and HART modem connections are made on the terminal block TS5 pin 1(+) and pin 2(-). Terminal block TS5 is located on the HART communication option board of the FT3.

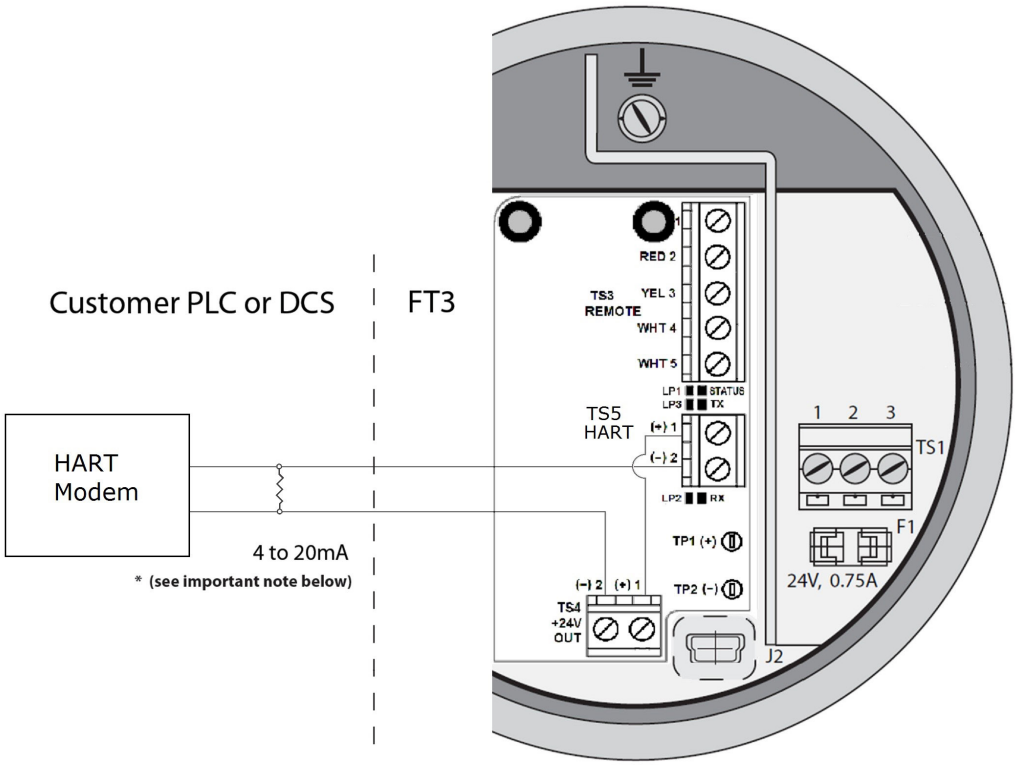
*Fig. 3.12: HART 4-20mA Output Wiring, Customer-Supplied Power Source*



**HART 4-20mA Output Wiring: Loop Power Provided by FT3**

The 4-20mA current loop and HART modem connections are made on terminal block TS5 pin 1 (+) and pin 2 (-). Terminal block TS5 is located on the HART communication option board of the FT3. Isolated 24 volt output power is available on terminal block TS4 pins 1 (+) and 2 (-) of the HART option board. This output can be used to power the 4-20mA loop if an external supply is not available..

*Fig. 3.13: HART 4-20mA Output Wiring, Loop Power Provided by FT3*

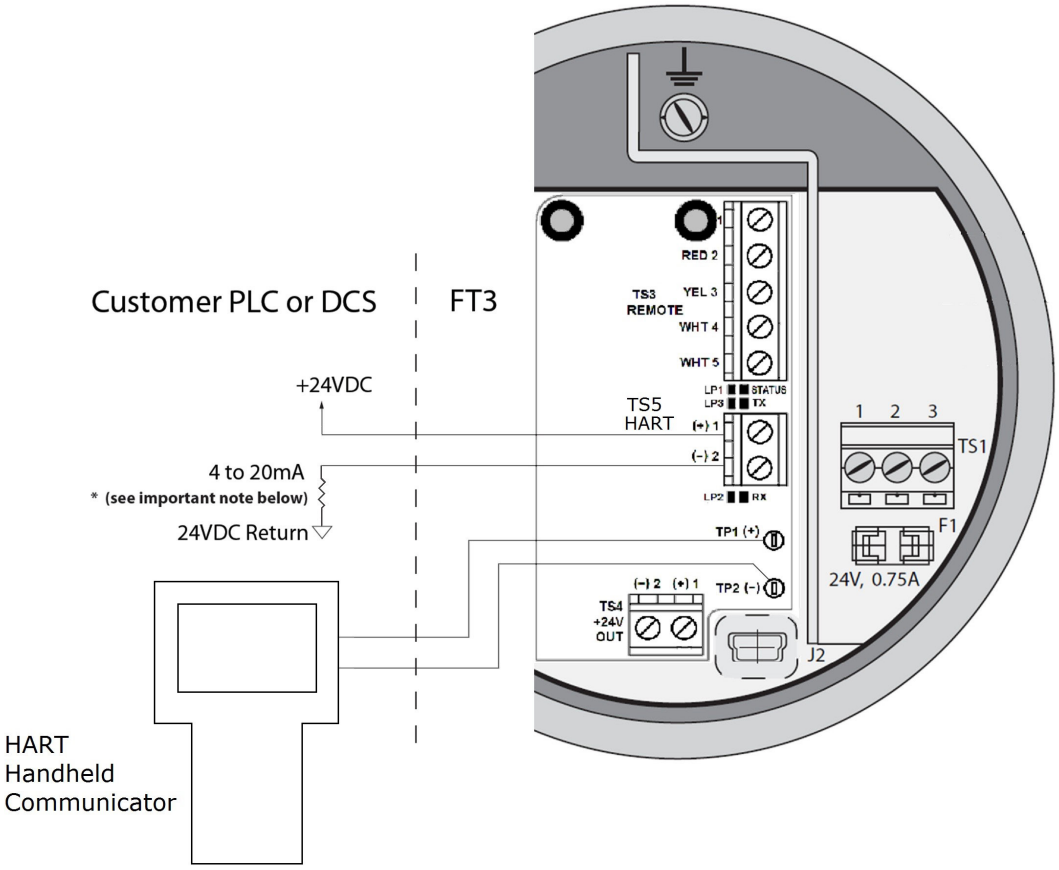


**HART 4-20mA Output Wiring: Handheld Communicator**

The 4-20mA current loop and HART modem connections are shown on p. 45 and p. 46.

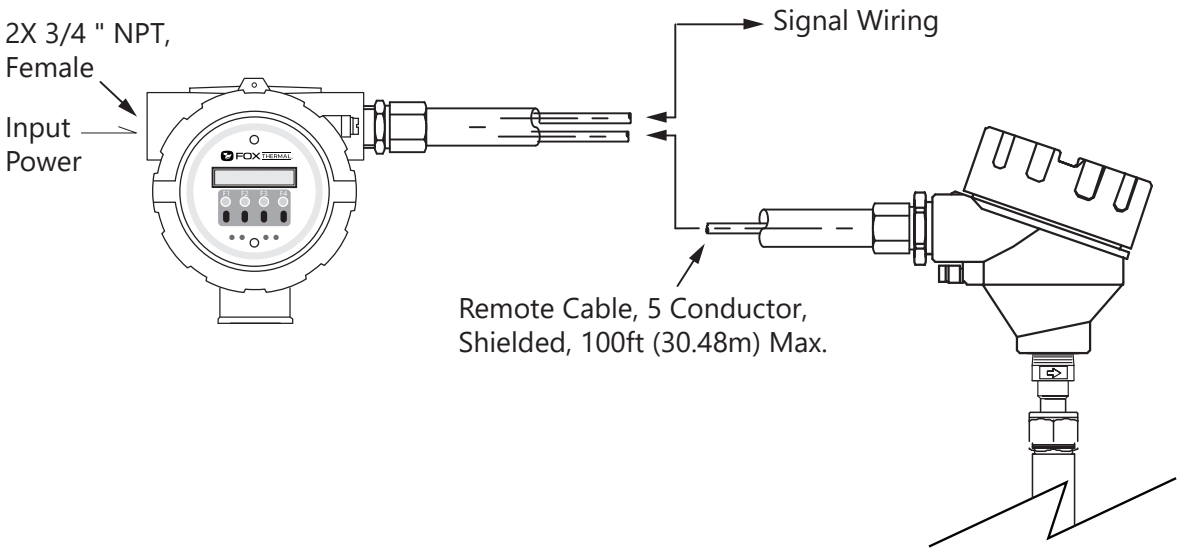
A handheld HART communicator can be connected to test points TP1 (+) and TP2 (-) with clip leads or to the 4-20mA terminal block.

*Fig. 3.14: HART 4-20mA Output Wiring, Handheld Communicator*



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

*Fig. 3.15: Remote Wiring*




Five 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).

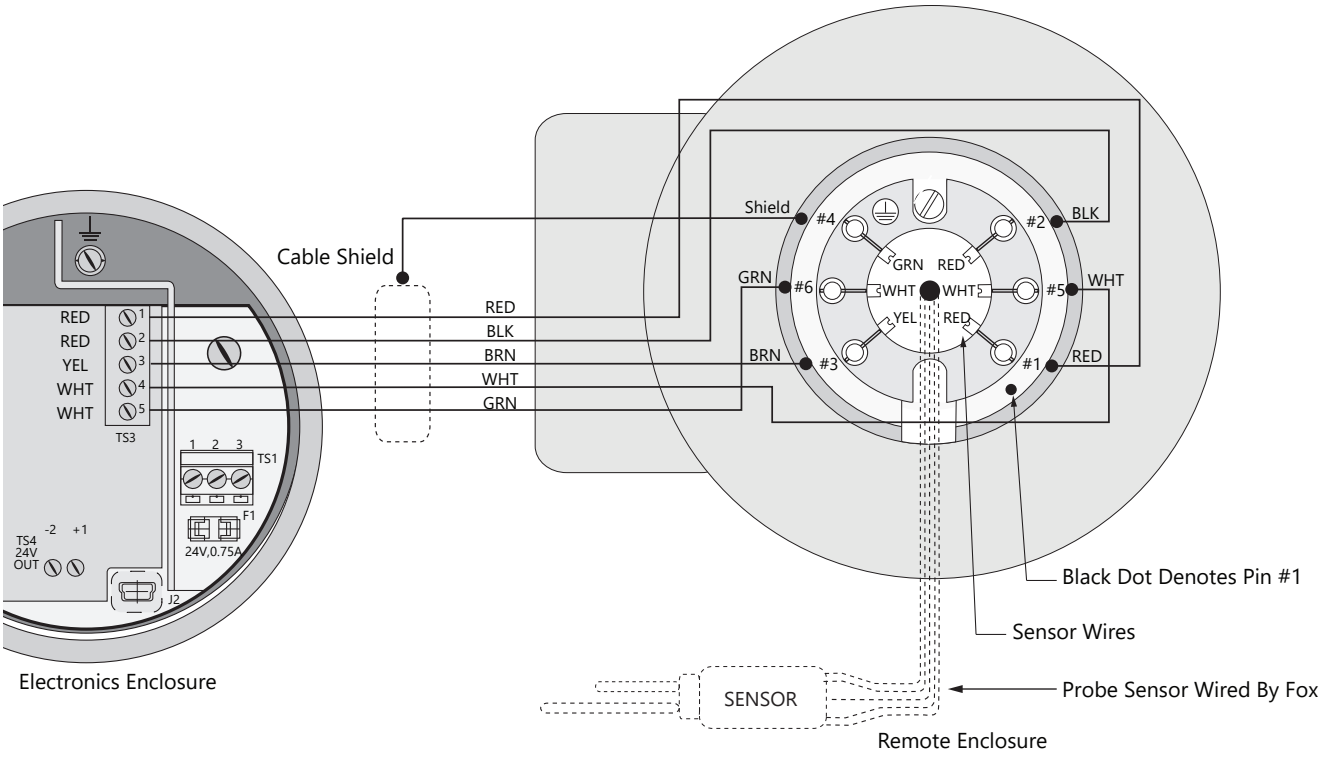
**NOTE!** Do not connect the cable shield at the electronics enclosure end. Connect the cable shield at the remote sensor terminal.

**NOTE!** The enclosures must be properly grounded with a quality earth ground. 16 gauge, stranded wire is recommended.

Use an extension cable to connect the terminals of the remote sensor enclosure to connector TS3 located behind the rear cap of the electronics enclosure as shown in Fig. 3.16 and Table 3.1 on the following page.

**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. 3.16: Remote Sensor Wiring*




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

*Table 3.1: Remote Sensor Cable Wiring*

| Electronics Enclosure Terminal Numbers | Extension Cable Wire Color | Remote Enclosure Terminal Numbers | Sensor Wire Color |
|---|---|---|---|
| 1 | Red | 1 | Red |
| 2 | Black | 2 | Red |
| 3 | Brown | 3 | Yellow |
| No Connection | Shield | 4 | Green |
| 4 | White | 5 | White |
| 5 | Green | 6 | White |

**Start Up Sequence**
The program automatically enters the Run/Measure mode after power up. The screen will show the software version of the FT3 during power up.

**USB Interface**
The USB interface is a standard feature which allows communication with a PC to monitor readings and configure settings. FT3 View™, is a free application program from Fox Thermal that connects to the USB interface and allows data monitoring, configuration setting, data logging to Excel, and an option to save and recall FT3 configuration data.

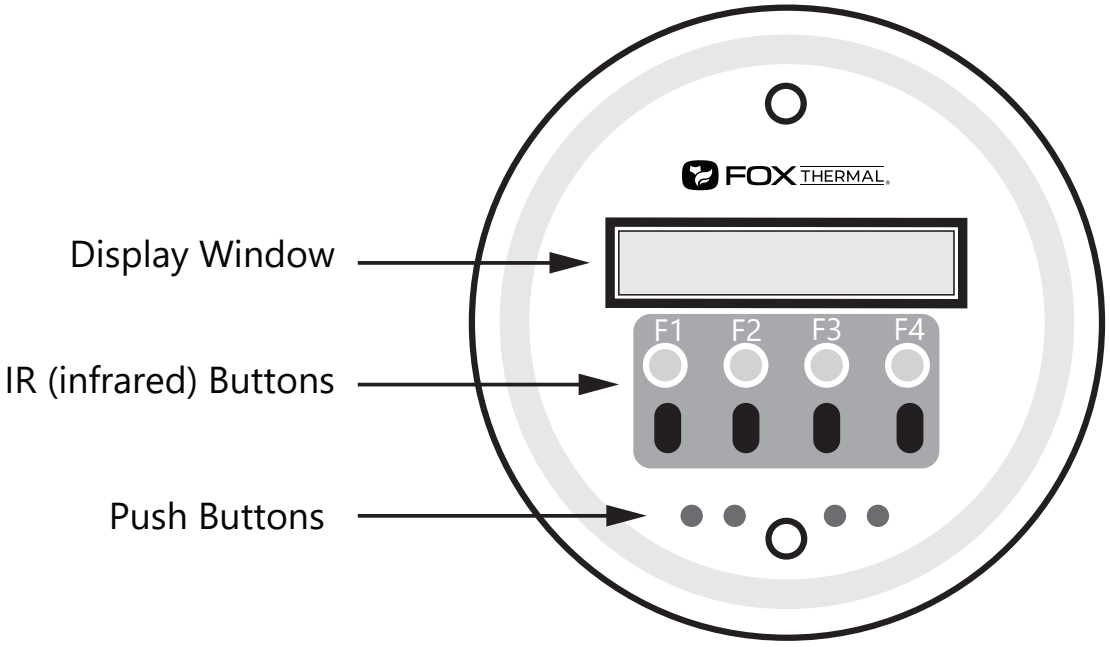
**FT3 Optional Display and Configuration Panel**
The meter can be programmed by using the optional display and configuration panel.

The FT3 display is a 2 line x 16 character display with 4 mechanical buttons and 4 IR (infrared) keys.

The mechanical buttons of the configuration panel can be accessed by removing the FT3 cap. Be sure to replace the cap after you are done configuring the FT3.

The IR keys and mechanical buttons perform the same function, but the IR keys can be used without opening the cover. The IR keys can be calibrated for better operation in the field or disabled (p. 89) when the meter is used in snow or ice in order to avoid false key detection.

*Fig. 4.1: FT3 Optional Display and Configuration Panel*

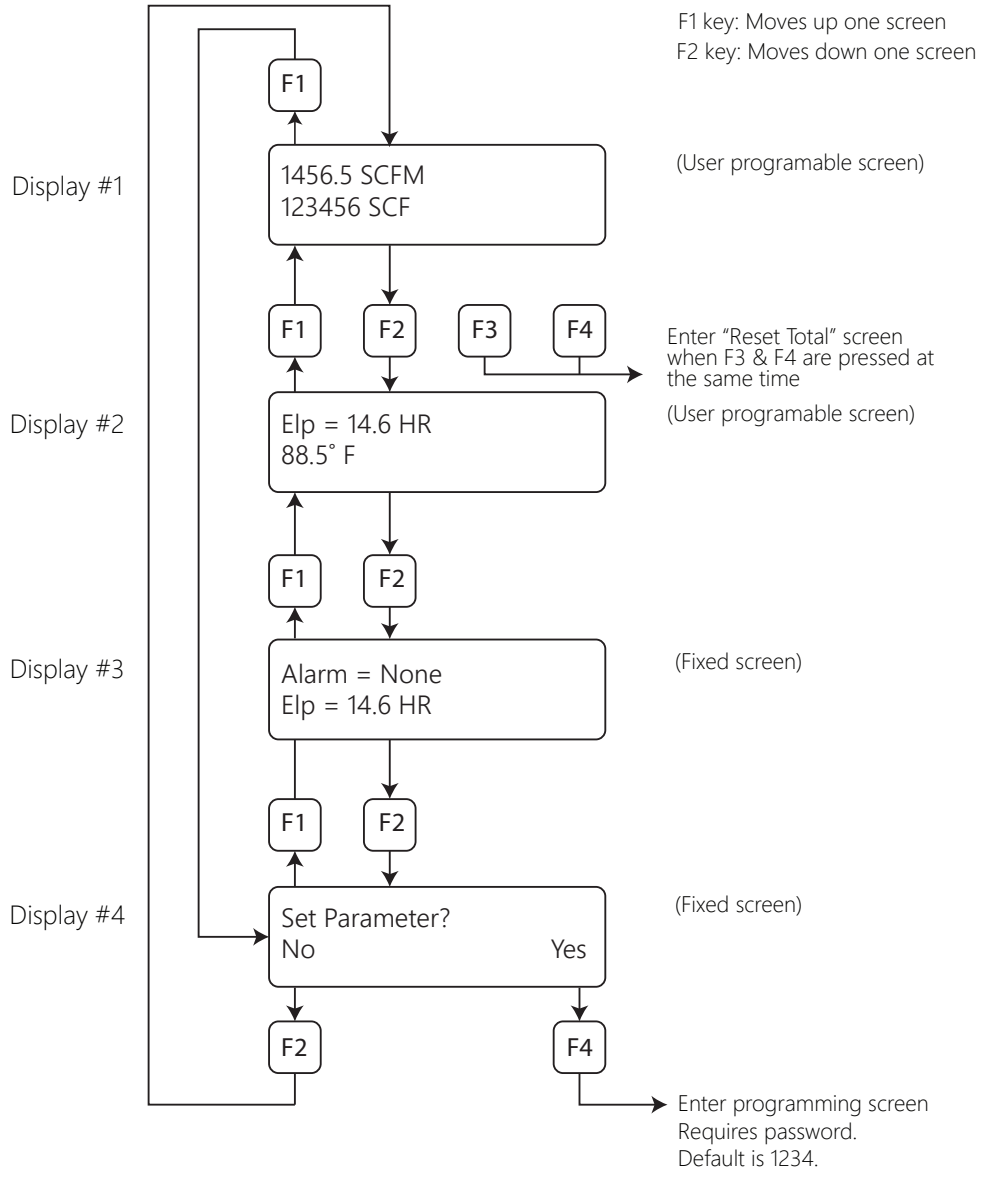


**Measurement Mode Display Screens**
In the measurement mode, there are four different display screens (display 1, 2, 3 and a prompt screen to enter the programming mode). Two display screens are user programmable (refer to Display Setup p. 63). Scrolling through the display is accomplished by pressing the **F1** or **F2** key to view the next or previous screen.

Pressing the **F1** and **F2** keys at the same time enters the Log Menu and Engineering Menu screens.

Pressing the **F3** and **F4** keys at the same time brings up the Reset Total screen prompt.

*Fig. 4.2: FT3 Measurement Mode Display Screen Navigation*



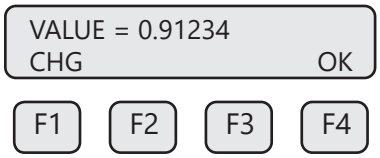
**FT3 Engineering Displays**
Pressing the F1 and F2 keys at the same time in the normal mode brings up the engineering displays. These displays show internal parameters of the FT3 which are used by Fox Thermal service technicians.

Use the F1 and F2 keys to navigate. Press F4 to exit.

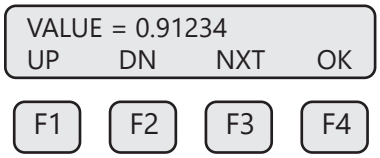
There are nineteen (19) screens (10 - 28) to view meter data:
Screen 10 - Flow rate measured by the meter, CSV of the sensor measurement circuit.
Screen 11 - Average CSV of the sensor measurement circuit, velocity flow in user-selected unit.
Screen 12 - Sensor filtered average voltage, velocity in meter/hour.
Screen 13 - TSI average count, TSV average count.
Screen 14 - TSI in volts, TSV in volts.
Screen 15 - TSI current in Amp, TSI resistance in ohm.
Screen 16 - RTD9 count, gas temperature in degrees C.
Screen 17 - Channel 1 4-20mA current loop count, channel 2 4-20mA current loop count.
Screen 18 - Frequency output count, active alarm codes.
Screen 19 - High and low flow alarm settings.
Screen 20 - High and low temperature alarm settings.
Screen 21 - Elapsed time of meter operation and the status in hexadecimal.
Screen 22 - FT3 electronics firmware version, optional display firmware version.
Screen 23 - Total number of power cycles, number of errors in total flow measurement.
Screen 24 - TSI resistance in ohm, RTD9 resistance in Ohm.
Screen 25 - Most recent CAL-V™ value, CAL-V™ last verify value.
Screen 26 - Bridge shutdown detection count.
Screen 27 - Zero CAL-CHECK™ pipe reference value, most recent Zero CAL-CHECK™ test difference.
Screen 28 - Zero CAL-CHECK™ bottle reference value, most recent Zero CAL-CHECK™ test difference.

**Programming: Data Entry using the Display and Configuration Panel**
There are 2 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**

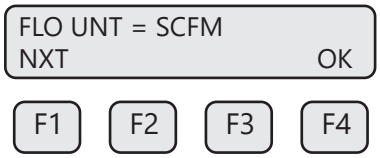



Press **CHG (F1)** key to change the value, **OK (F4)** to accept the value.



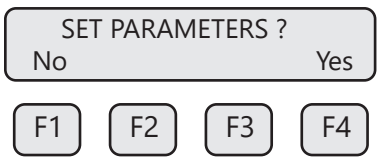

Press the **UP (F1) or DN (F2)** key to select a new digit or character, the cursor points to the selected digit. Press **NXT (F3)** to select the next digit and **OK (F4)** to accept the entry.

**To Select from a List**

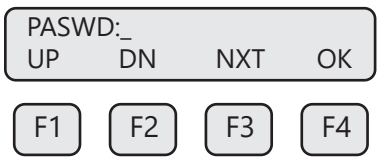



Press **NXT (F1)** key repeatedly until the correct selection is made and **OK (F4)** key to accept the entry.

**Entering the Programming Mode**
To enter the programming mode and access the SET PARAMETERS menu, press the **F1** or **F2** key in the normal running mode until the following screen is shown:



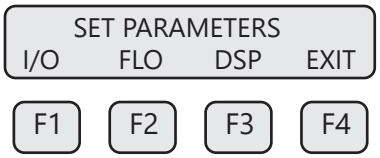

Press **YES (F4)** and the following screen will prompt user to enter password:




Enter the correct password, then follow the instructions for changing a value as specified above. The default Level 1 password is “1234”.

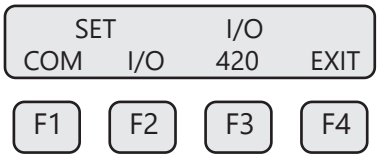
If the wrong password is entered, the message “Wrong Password” will display and then return to the programming entry screen.

**SET PARAMETERS Menu (Main Menu)**
If the password is accepted, the SET PARAMETERS menu will be shown:

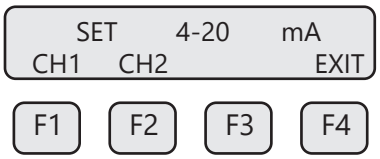



This is the screen for the programming mode. Press **EXIT (F4)** repeatedly until “Normal Mode” is seen briefly to exit the programming mode.

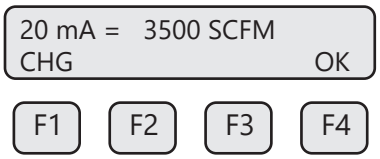
**Analog 4-20mA Outputs**
The following menu allows the scaling of the analog 4-20mA output. From the SET PARAMETERS menu, press **I/O (F1)** to move to the 4-20mA output selection.




In this screen press **420 (F3)** (screen appearance may vary according to options).



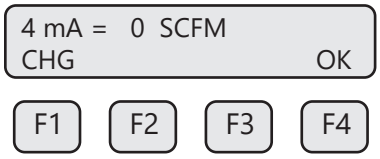

Select **CH1 (F1)** to program channel 1.




Enter the value for the 20mA and press **OK (F4)** key to accept the setting.

**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.

Then the following screen will display:




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

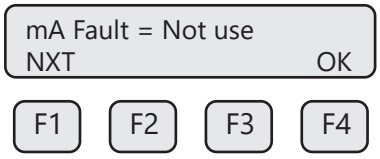
**NOTE!** 4mA is normally set to 0.

The following menu item allows the user to select an alarm level on the 4-20mA output when a serious issue is detected that is preventing the calculation of a correct flow value
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)

**CAUTION!** When using the 4-20mA output to control equipment in a failsafe application, use the wiring configuration and set the Pulse/Alarm Output to System alarm as shown in "Alarm Output" on p. 58.

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



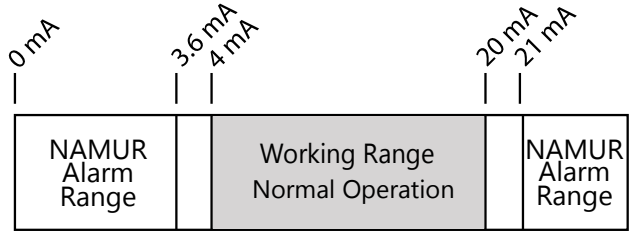

The following events will set the output to 3.6mA or 21mA if the alarm level is selected:

- Sensor resistance above high limit
- Bridge Shutdown

When the 4-20mA output is wired through the System Alarm, the following cause the output to go to 0mA:

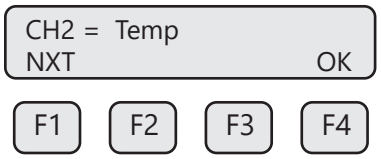
- Power to the Microprocessor is lost
- Sensor or electronics failure

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

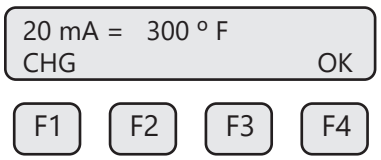


To exit the programming mode, press **(F4)** repeatedly until Normal Mode is seen.

Select **CH2 (F2)** to program channel 2. Channel 2 is programmable for flow (CH2=Flow) or temperature (CH2=Temp).

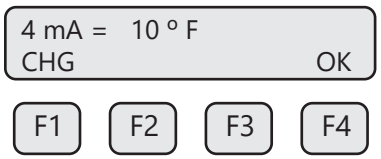



Press **NXT (F1)** to select Flow or Temperature and then press **OK (F4)**.




Enter the value for the 20mA and press **OK (F4)** key to accept the setting.

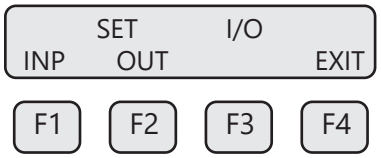
Then the following screen will display:



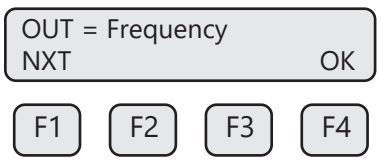

Enter the value for the 4mA and press **OK (F4).**

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

**Pulse/Alarm Output**
From the SET PARAMETERS menu, press **I/O (F1)**, then **I/O (F2).**




Press **OUT (F2)** to select output. The following screen will show:

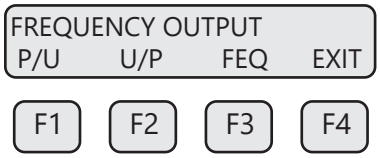



Press **NEXT (F1)** to cycle through output options until you have the selection for "OUT=Frequency" and press **OK (F4).**

The frequency output can be configured in once 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

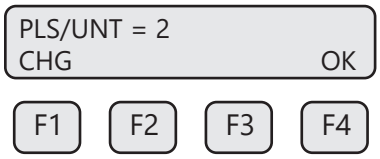
All of these approaches are equivalent.




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 frequency 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**
Press **P/U (F1)** and the following screen will show:

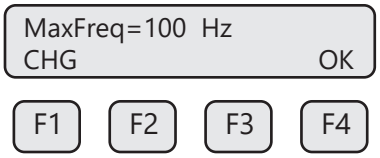



Press **CHG (F1)** to change the setting and then **OK (F4)** to accept entry. The value entered is in pulse per selected flow unit total (for example, 2 pulses per SCF).

**Entering data in Unit per Pulse**
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 (for example. 0.5 flow unit total per pulse)

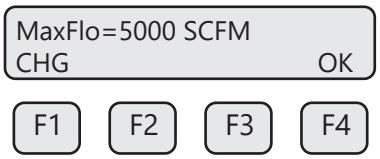
**Entering data with flow and maximum frequency**
Press **FEQ (F3)** and the following screen will show:




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

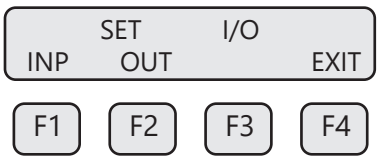
**CAUTION!** Maximum pulse rate (frequency) cannot exceed 100 Hz.

The next screen will show:

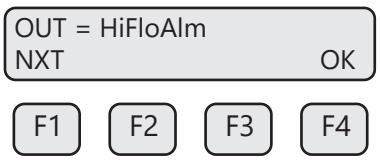



**NOTE!** If the flow rate exceeds the maximum pulse rate (frequency), the output will stay at 100 Hz and the FT3 will issue an alarm code.

**Alarm Output**
To program the Alarm output, press **I/O (F1)** key from the SET PARAMETERS menu. Then select **I/O (F2)** and the screen will show:




Then press **OUT (F2)** and the screen may show:

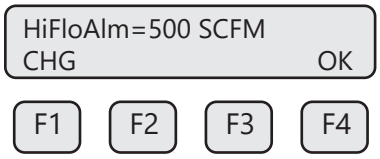



Then press **NXT (F1)** to select the correct alarm and press **OK (F4).**

Selections are:

Not used
Frequency
HiFloAlm = High Flow Alarm
LoFloAlm = Low Flow Alarm
HiTempAlm = High Temperature Alarm
LoTempAlm = Low Temperature Alarm
System Alm = System Alarm

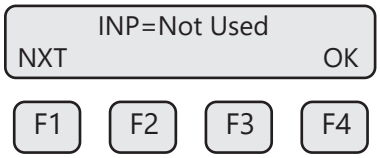
When the output is set to Alarm and there is no alarm condition, the output will be on (0 volts). When an alarm is active, the output is turned off (24 volts).




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.

**Contact Input Settings**
From the SET PARAMETERS menu, press **I/O (F1)** and then **I/O (F2)** and then **INP (F1)** 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
Switch Crv = Switch between calibration curve 1 and curve 2 (only if 2 gas curve ordered)

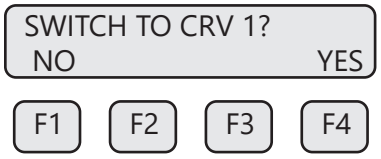
Press **EXIT (F4)** repeatedly until you exit programming mode.

**FT3 with 2 Gas Curves**
This section describes added features to the standard FT3 flow meter when using the 2 gas curves firmware option. The 2 Gas Curves firmware allows the use of two different calibration tables when running with different gases. One of two methods can be used to switch between the two calibration curves:

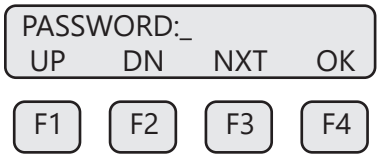
**1) Use of Contact Input:**
When the contact input is programmed for curve switching, an open contact will select curve #1 and a contact closure will select curve #2.

**2) Use of the Keypad:**
If the contact input is not programmed for curve switching, pressing **F2** and **F3** simultaneously will prompt an operator to manually switch curve upon entering a password and confirming the action by pressing the appropriate key.

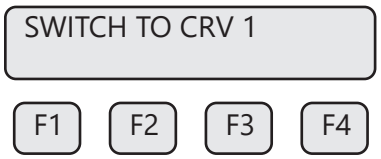
Pressing **F2** and **F3** simultaneously:



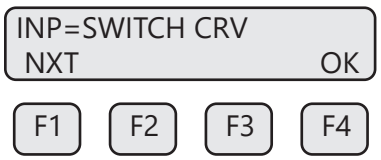

Password needs to be entered if active (default: 1234):




After entering a valid password, a brief confirmation message will be displayed for 1 second:




**Programming Contact Input for Curve Switching**
Enter the menu using steps outlined in "Contact Input Settings" section (p. 59) and select "Switch CRV". Please note that the flow meter needs to be programmed for 2 gas curves at the Fox factory before you can select this function. Flow meters are shipped with pre-programmed user requested settings.




Selections are: "Not used"
"Tot Reset"
"Switch Crv"

**NOTE!** Helpful hint: From normal display mode, press **F4** to view the current gas curve selection.

**Operation of the 2 Gas Curves**
To avoid confusion, only one of two techniques is enabled. If the contact input is assigned to switch gas curves, then the ability to switch using the **F2** and **F3** function keys on the front panel is disabled.

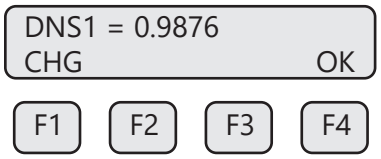
Two totalizers (Total 1 and Total 2) and two elapsed time counters are available on the display and through the USB serial communication. The reset function will reset all totalizers and elapsed time counter to zero.

In the event of a power failure, the software will remember the last curve in use. Upon powering up again, the FT3 unit will continue to use that curve.

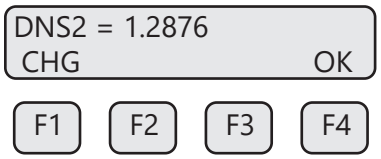
Switching between gas curves will require a password unless the password is set to "0", which disables it. The calibration certificates for order with 2 gas curves will identify which gas is Gas 1 and Gas 2. When measuring in mass units, a density value must be entered for each gas curve.

**Programming Densities for Curve 1 and Curve 2**
When the selected flow unit is mass/time, two different densities will be used for each curve if the meter has been programmed for 2 gas curves. To change the densities:

Go to the unit menu following "Unit Settings" section.



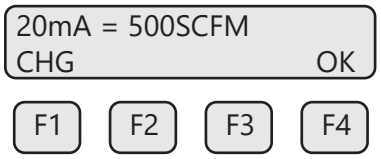

DNS1 is the density associated with curve 1. Change it as needed and press **OK (F4)**.




DNS2 is the density associated with curve 1. Change it as needed and press **OK (F4)**.

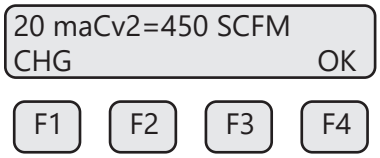
**Programming 4-20mA settings for Curve 1 and Curve 2**
When the meter has been programmed for 2 gas curves, 2 sets of 4-20mA settings for flow rate are used. To program these settings:

Go to the 4-20mA setting following the "Analog 4-20mA Settings" section.




20mA is the upper limit associated with curve 1. Change it as needed and press **OK (F4)**.

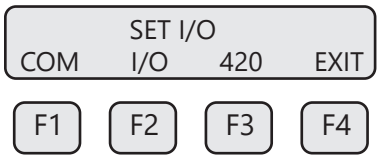

4mA is the lower limit associated with curve 1. Change it as needed and press **OK (F4)**.



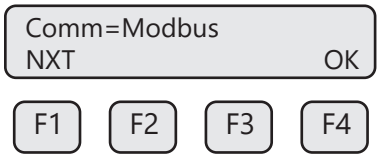

20 maCv2 is the upper limit associated with curve 2. Change it as needed and press **OK (F4)**.


4 maCv2 is the lower limit associated with curve 2. Change it as needed and press **OK (F4)**.

**Serial Communication Settings**
The Serial communication settings can be programmed by pressing **I/O (F1)** key from the SET PARAMETERS menu. The screen will show:




Press **COM (F1)** to select Serial communication.
The screen may show:

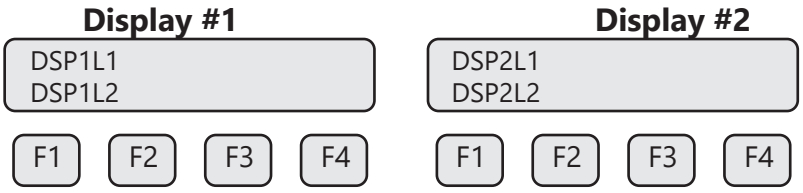



Options for serial communication are:
- Not Used
- Modbus
- HART

**NOTE!** Any selection other than "Not Used" requires the communication option for the selected communication type. If enabling a communication option, see the associated Communication section of this manual for specific programming information.

**Display Setup**

There are four display screens that you can cycle through in normal operating mode (see Fig. 4.2 on p. 51). 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.

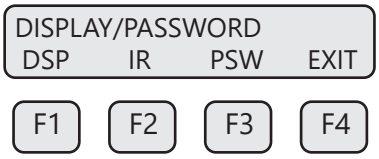



Selections are:

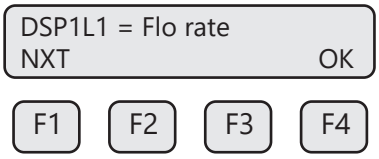
DSP1L1 = Display 1, Line 1
DSP1L2 = Display 1, Line 2
DSP2L1 = Display 2, Line 1
DSP2L2 = Display 2, Line 2

**To Program Display Screens #1 and 2**

From the SET PARAMETERS menu press **DSP (F3)** to select the DISPLAY menu:




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

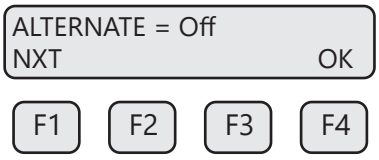



These are the selections for the Display 1, Line 1.

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 4 lines of the 2 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

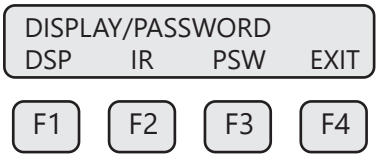
Press **OK (F4)** to accept selection. Press **EXIT (F4)** repeatedly until "Normal Mode" is seen briefly to exit the programming mode.

**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.

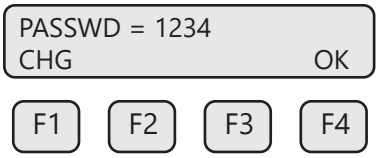
Default **Level 1** password is "1234", and **Level 2** password is "9111". The **Level 1** programmable password can be disabled by setting it to "0".

From the SET PARAMETERS menu press **DSP (F3)** to select the DISPLAY menu.

**To Program the Password**




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

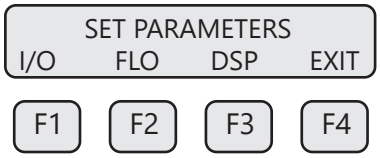



This screen displays the current **Level 1** password.
Press **CHG (F1)** key to change the password and enter new value.

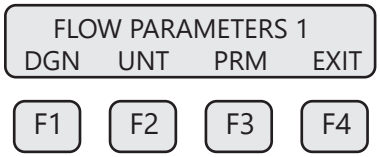
Press **OK (F4)** to accept new data and exit programming by pressing **EXIT (F4)** key repeatedly until out of the programming mode.

**NOTE!** Password can be number or letter characters up to 4 digits.

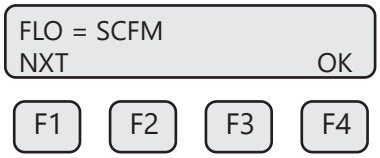
**Units Settings**
This menu is used to set the units for mass flow, temperature, and pressure as well as the setting of reference temperature and reference pressure. These values will be set at Fox Thermal using information supplied by the customer. These values can be changed to match a new application. The units setting is accessed from the SET PARAMETERS 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.

**Flow Units**

Selections for flow units are:

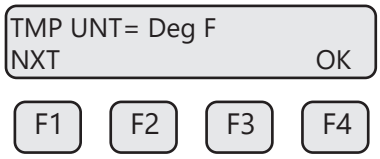
| | | | | |
|---|---|---|---|---|
| SCFM | KG/M | LBS/D | SM3/H | MSCFD (MCFD) |
| SCFH | KG/S | NLPH | SM3/D | MMSCFD (MMCFD) |
| NM3/H | LBS/H | NLPM | NM3/D | MCFD (MSCFD) |
| NM3/M | LBS/M | NLPS | SLPM | MMSCFM (MMCFM) |
| KG/H | LBS/S | SM3/M | SCFD | MT/H |
| SMPS | NMPS | SFPM | | |

**NOTE!** The totalizer must be reset immediately after changing the flow units setting.

**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. 74).

**WARNING!** The FT3 re-calculates area, 4 and 20mA values, maximum flow for the pulse output and zero flow cutoff when changing flow units except for velocity units. When going to or from velocity units, the FT3 will not recalculate these values and these values must be re-entered manually.

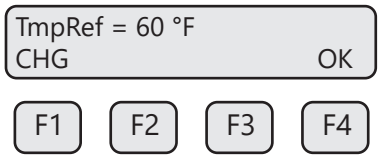
**Temperature Units**
After pressing **OK (F4)** to accept the Flow unit the display will prompt for the temperature unit setting:




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

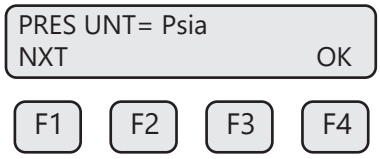
Selections for Temperature units are: Deg C or Deg F

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



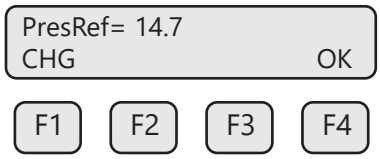

Press **CHG (F1)** to change the reference and **OK (F4)** to accept.

**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

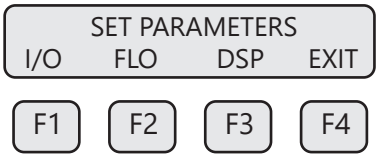
**Reference Pressure**
After the pressure unit selection is made, the display will show a menu to enter the reference pressure:



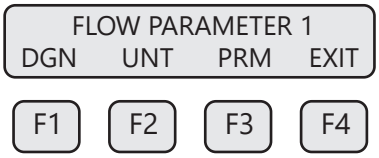

Press **CHG (F1)** to change it and **OK (F4)** to accept.

**Accessing Flow Parameters and Alarm Settings**
The FLOW PARAMETER 1 menu is used to set various flow parameter values. They are: Flow cutoff, pipe diameter, filter, high and low alarm for flow and temperature.

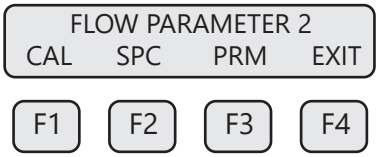
**NOTE!** The parameters in this menu are set to the customer specifications at the factory. They should only be changed when changing the application of the flow meter.




The FLOW PARAMETER 1 menu is accessed from the SET PARAMETERS menu by pressing **FLO (F2)**:



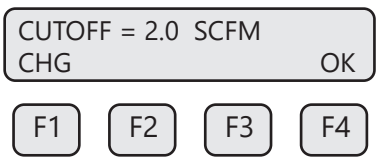

Then press **PRM (F3)**:




**NOTE!** The **CAL** and **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 Area**
Enter the pipe area in square meters or square feet and then press **OK (F4)**. Use square meter for metric flow unit selection.


**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.

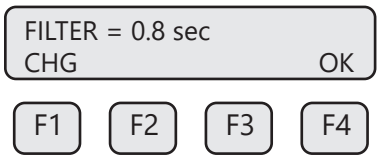
The filter value is also referred to as a dampening factor and is used to quiet the readings. The filter value is an exponential filter that dampens the noise and is used as follows:

Flow Value = (FA * new value) + (FB * average)
Where FA = filter value, FA + FB is equal to 1.0

A lower filter value will increase dampening of the flow rate and smooth the reading. A lower filter value will also slow the meter's response. For example, if we enter a filter of 0.8, the weight ratio for the new average is:

New average = (80% new sample) + (20% last average)
Filter range is 0.01 to 1.0, 0.01 being a high filter value and 1.0 = no filter.

| Filter | Response (Sec.) 65% of Target |
|---|---|
| 0.9 | 0.10 |
| 0.8 | 0.15 |
| 0.7 | 0.20 |
| 0.6 | 0.25 |
| 0.5 | 0.30 |
| 0.4 | 0.35 |
| 0.3 | 0.40 |
| 0.2 | 0.60 |
| 0.1 | 1.00 |
| 0.05 | 2.00 |
| 0.03 | 3.00 |
| 0.01 | 10.3 |

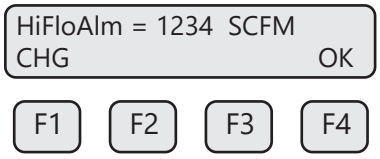



Enter the filter value and then press **OK (F4)**.

**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 FT3 View™. 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.

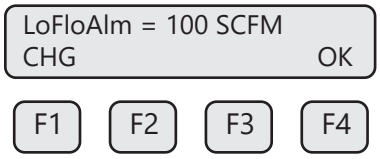
To set the parameters for a high flow rate alarm, press **CHG (F1)**:




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.

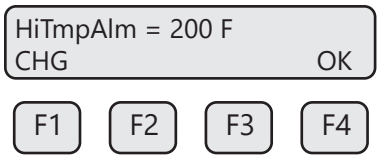
To set the parameters for a low flow rate alarm, press **CHG (F1)**:




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.

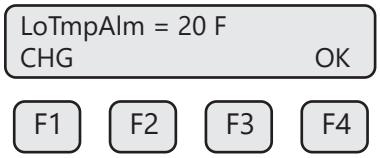
To set the parameters for a high temperature alarm, press **CHG (F1)**:




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)**:

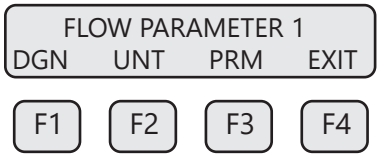



Press **OK (F4)** to accept the value.

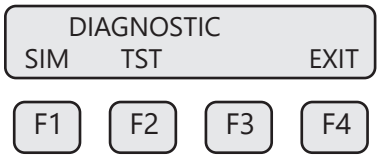
**Simulation**
This menu allows for simulation of flow rate and temperature. It should only be used for testing and demonstration purposes. **Make sure to return all of these simulation values to zero, before returning to the normal mode of operation.**

**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.

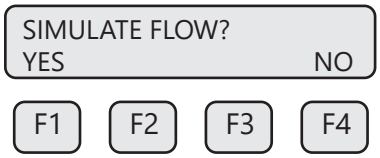
The DIAGNOSTIC menu used for Simulation is accessible from the SET PARAMETERS menu by pressing **FLO (F2)**:



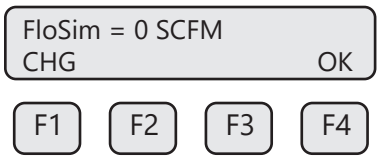

Pressing **DGN (F1)** will show:




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



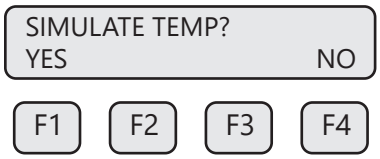
Pressing **YES (F1)** will show:



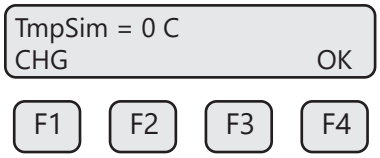

Enter the value and then press **OK (F4)**.

**NOTE!** Enter zero to disable this feature.

The screen will show:



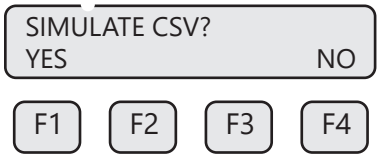

Pressing **YES (F1)** will show:



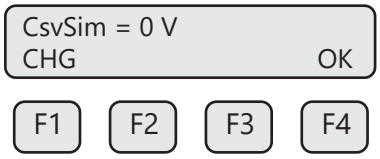

Enter the value and then press **OK (F4)**.

**NOTE!** Enter zero to disable this feature.

The screen will show:

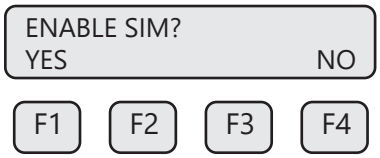



Pressing **YES (F1)** will show:




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

**NOTE!** This value is used to simulate the Current Sense Voltage (CSV) and should be set to zero for normal mode.

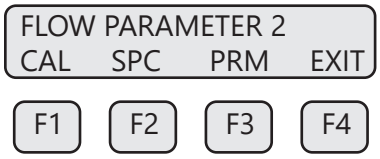



Press **YES** (**F1**) to start the simulation mode, otherwise press **NO** (**F4**). Upon pressing either key, the program will return to the FLOW PARAMETER 1 screen.

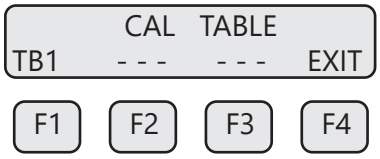
**NOTE!** Simulation Mode will be cleared if the power is cycled.

**Calibration Parameters**
This menu allows changing the factory calibrated setting of the flow meter and is accessible with a Level 2 password. Calibration parameter values are set for temperature and pressure at 0 degree C and 760 mmHg. These settings should normally never be changed except by Fox Thermal personnel at the factory.

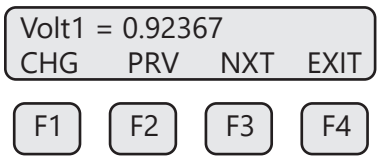
This calibration menu is entered from the SET PARAMETERS menu by pressing FLO, PRM, and CAL.



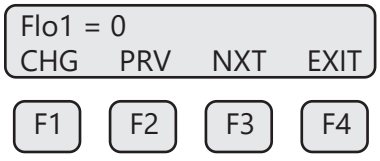

Press **CAL (F1)** then the display will show:




Press **TB1 (F1)** then the display will show:




Press **NXT (F3)** then the display will show:



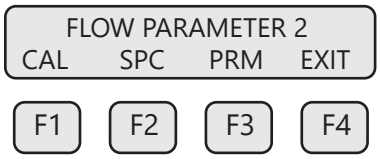

Use the **CHG (F1)** key to change the entry, **PRV (F2)** to move to the previous entry, **NXT (F3)** to move to the next entry and **EXIT (F4)** to return.

Pressing the **NXT (F3)** key will show the data point voltage and then mass velocity and then go to the next data point. The number after Volt (i.e., Volt1) or Flo (i.e., Flo1) indicated the data point number.

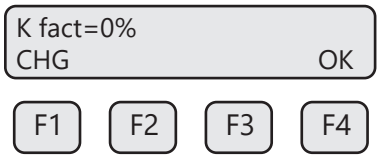
The calibration table can hold up to 20 data pair points. Each data point has a voltage and mass velocity associated with it.

**K Factor**
The K Factor allows the user to adjust the meter's calibration. The 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 PARAMETER 2 menu by entering a **Level 2** password "9111" and pressing the **SPC** key (**F2**).




The following screen will be displayed:

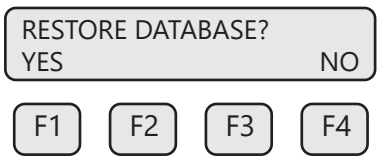



Press **CHG (F1)**. Add the correction factor and press **OK (F4)**.

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.

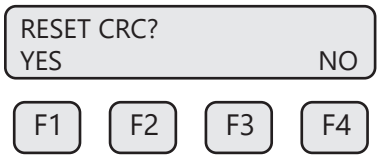
Upon pressing **OK (F4)**, an option to restore the database will follow.

**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:



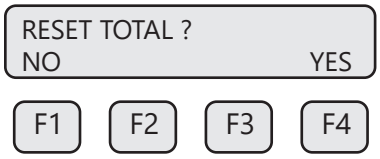

Press **YES (F1)** ONLY if you want to restore your database to the initial factory setting that the meter was shipped with. All current user-entered settings will be overwritten. The green LP3 LED will flash at a faster pace until the recall is performed. The "RESET CRC" screen will follow "RESTORE DATABASE". Upon pressing **NO (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 Fox Thermal Customer Service if you need assistance.




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.




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

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

**Totalizer Rollover:** The FT3 has an automatic roll-over function. The total flow count of the FT3 will roll over after 99,999,999,999. Except for:

| | |
|---|---|
| MSCFD: | 999,999,999 |
| MMSCFM: | 9,999,999 |
| MMSCFD: | 999,999 |

**Calibration of the Fox Thermal Model FT3 Thermal Flow Meter**
To ensure that all Fox Thermal 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 Fox Thermal Calibration Certificate.

**Calibration Validation**
Operators can verify the meter is running accurately in the field by performing two simple tests.

The first test, CAL-V™, tests the functionality of the sensor and its associated signal processing circuitry and can be done in the pipe and in normal processing conditions.

The second test, Zero CAL-CHECK™, ensures the repeatability and cleanliness of the sensor and can be performed in two ways: In situ or Out of Pipe. See Fig. 4.4 to understand Calibration Validation with these two tests.

*Fig. 4.4: Total Calibration Validation*

| CALIBRATION VALIDATION ON FOX MODEL FT3 | | |
|---|---|---|
| **CAL-V™** | **Zero CAL-CHECK™** | |
| **Sensor and Electronics Test** | **Sensor Test at Zero Flow vs. Field Baseline** | **Sensor Test at Zero Flow vs. Factory Baseline** |
| **IN SITU** | **IN SITU** | **OUT OF PIPE** |
| • Complete test of sensor elements and electronics<br>• In the pipe, under normal process conditions<br>• Operator-initiated via front panel, FT3 View™, or MODBUS<br>• Hold outputs at last value or go to zero; operator-selectable<br>• Test takes less than 5 minutes<br>• Test results in pass/fail message<br>• Data saved in meter for look-up anytime<br>• Calibration Validation Certificate can be generated if test is initiated using FT3 View™ software | • Customer-set zero flow baseline established under normal zero flow conditions<br>• Test compares sensor characteristics at zero flow with customer-set zero flow baseline<br>• Operator-initiated via front panel, FT3 View™, or MODBUS<br>• Use of packing gland assembly to retract probe is a convenient way to establish a zero flow condition<br>• Test takes less than 5 minutes after zero flow condition established<br>• Calibration Validation Certificate can be generated if test is initiated using FT3™ View software | • Test compares sensor characteristics at zero flow at ambient temperature and atmospheric pressure with factory characteristics<br>• Used when in situ zero flow condition cannot be established<br>• Operator-initiated via front panel, FT3 View™, or MODBUS<br>• Test takes less than 5 minutes after out of pipe set-up complete<br>• Calibration Validation Certificate can be generated if test is initiated using FT3 View™ software |

Fox Thermal has developed Calibration Validation, using the CAL-V™ and Zero CAL-CHECK™ tests to help our customers avoid sending the meter back for annual or biennial re-calibrations.

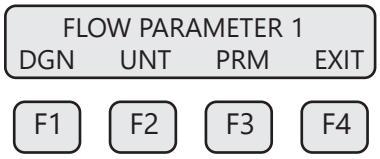
**CAL-V - Calibration Validation Test 1**
CAL-V™ ensures the repeatability, functionality of the sensor and its associated signal processing circuitry, and cleanliness of the sensor.

During the CAL-V™ 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.

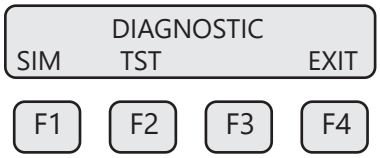
**NOTE!** If the CAL-V™ test is performed using the Fox Thermal FT3 View™ Software, at the completion of the test, a CAL-V™ Certificate may be printed for a record of the test. This certificate will display a pass/fail result.

**Performing the CAL-V™ Calibration Validation Test**

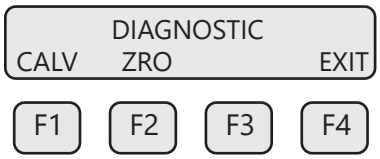
Press **FLO (F2)** from the SET PARAMETERS menu. The display will show:



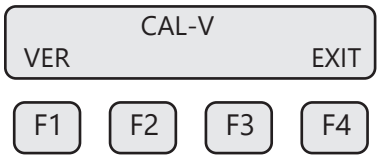

Press **DGN (F1).** The display will show:



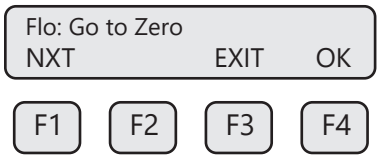

Press **TST (F2)**. The display will show:




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




Press **VER (F1)** to get to the go to zero screen. The display will show:

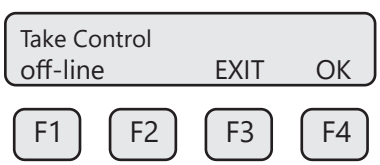



To select what the flow output will do during a CAL-V™, choose from these options:

- Go to Zero: Flow output will be zero during the test (i.e. 4mA)
- Hold Value: Flow will hold last value during the test

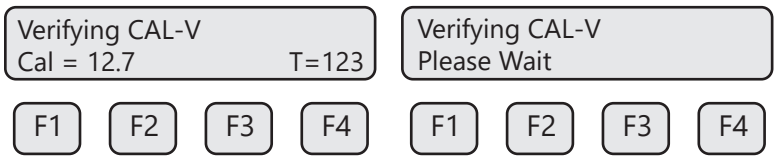
Select the option and press **OK (F4).**

**NOTE!** The FT3 will stop measuring flow when performing this test.



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

Press **OK (F4)** to start CAL-V™. The screen will show:




This test will take up to 4 minutes (less time if there is flow) and will show the Cal value changing as the power to the sensor is adjusted. The T=xxx is a count down timer indicating how much time is left to finish the test. A "Please Wait" message will be flashing on and off on line 2 during this test.

**CAL-V™ Test Results**

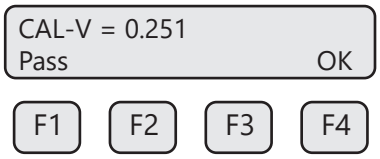
Upon test completion, the final CAL-V™ value will be displayed along with a Pass or Fail message:

- Pass: less than ±2.5
- Fail: equal to or greater than ±2.5

Recommended next steps if a "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 "Fail" result is displayed after repeating the test, please call Fox Thermal Service at (831) 384-4300 for assistance.




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

**CAUTION!**

- The CAL-V™ test is valid for checking the calibration accuracy of flow meters installed in the applications for which it was calibrated including the gas/gas mixture, calibration range, and pipe size shown on the calibration certificate.
- For applications with temperature exceeding 250°F (121°C), CAL-V™ test results may vary.
- Periodic inspection for damage and cleaning of the sensor elements is required.

**Zero CAL-CHECK™ - Calibration Validation Test 2**

The Zero CAL-CHECK™ test is a companion test to CAL-V™. Unlike CAL-V™, which may be performed in the pipe and at process conditions, Zero CAL-CHECK™ must be performed at zero flow to ensure a valid test result. This test is used to confirm that the flow meter still retains its original NIST-traceable calibration at zero flow and that the sensor is free of film or residue that may affect readings. The test

takes less than 5 minutes to complete. At the conclusion of the test, a Pass or Fail message will be displayed. Press **F4** at the conclusion of the test to return to normal measuring mode or to terminate the test.

There are a few ways that Zero CAL-CHECK™ is different than CAL-V™:

- The Zero CAL-CHECK™ test must be performed at a "no flow" condition (ie zero flow)
- If the Zero CAL-CHECK™ test is to be performed in the pipe, the field baseline must be set before an actual test can be performed (see "Setting Field Baseline for In Situ Zero CAL-CHECK™ Tests" on p. 79).
- If the Zero CAL-CHECK™ test is to be performed out of the pipe, the meter must be set upside-down (probe pointing up) and the PVC sensor protector that the meter was shipped with must be placed back over the sensor to achieve the factory baseline that the meter has been set with.

**Techniques for Achieving Zero Flow - In the Pipe**

In situ (in the pipe) Zero CAL-CHECK™ testing can be achieved in one of two common ways:

- Fox Thermal Retractor
  - The first in situ option is achieved through the use of a Fox Thermal retractor that may be ordered as an option for most inline- or insertion- type meters. The assembly allows the operator to retract and isolate the sensor from the process in order to conduct the Zero CAL-CHECK™ test. This is particularly beneficial for applications in which the process is not easily stopped.
- Pipe Bypass / Valving-Off
  - The second in situ option, if space allows, is to redirect the flow through a bypass pipe section or valve off the meter in order to isolate the meter's sensor in the place where it has been installed. While the flow is redirected, the Zero CAL-CHECK™ test can be performed. Once the test is complete, the valves to the bypass may be closed and flow may be directed back to the meter's sensor where flow monitoring can continue as normal.

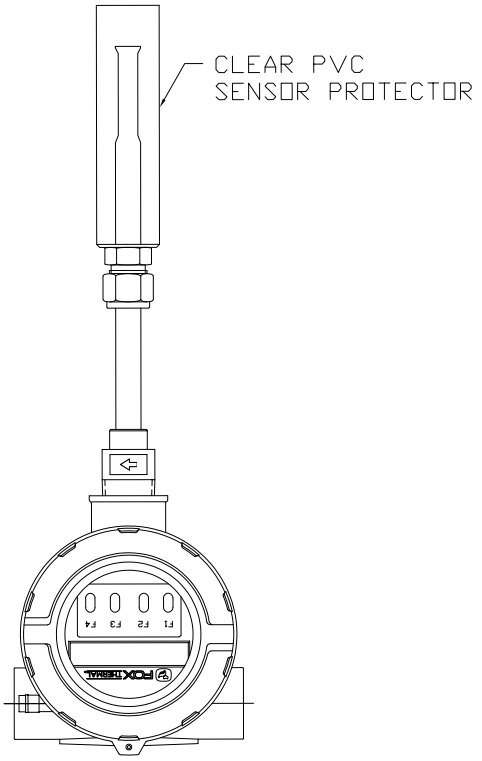
**Achieving Zero Flow - Out-of-Pipe**

If space limitations prevent in situ testing at zero flow as listed above, then out-of-pipe testing must be performed.

With this configuration, the meter must be removed from the process, the test performed, and then the meter returned to the process after testing has been completed.

Due to the high sensitivity of the PowerPro™ sensor, it is necessary to isolate the sensor once the meter has been removed from the pipe. Therefore, Fox Thermal provides a sensor cover when the meter is shipped to the customer. An alternative to the sensor cover is to use a bottle or other closed container in order to isolate the sensor and achieve the "no flow" condition necessary to perform the Zero CAL-CHECK™ test.

*Fig. 4.5: Fox Thermal-Supplied PVC Sensor Protector vs. Plastic Bottle*




**NOTE!** For best results:

- Use the factory-supplied PVC sensor protector shipped with the meter (see Fig. 4.5).
- Place the meter upside-down on a flat, solid surface before starting the test.
- Do not allow the meter to get moved - make sure the meter is stable and the sensor completely isolated.

**Using a Fox Thermal Retractor for Zero CAL-CHECK™**

The following are the instructions for using a Fox Thermal retractor to set the field baseline for - or performing - an in situ Zero CAL-CHECK™ test. If you are not using a Fox Thermal retractor, move ahead to "Starting the Field Baseline Set" on p. 83.

**NOTE!** If you need information on the installation of the Fox Thermal retractor, refer to "Installation of a New Retractor Assembly" on page 29.

*Fig. 4.6: FT3 and Parts of Fox Thermal Retractor*

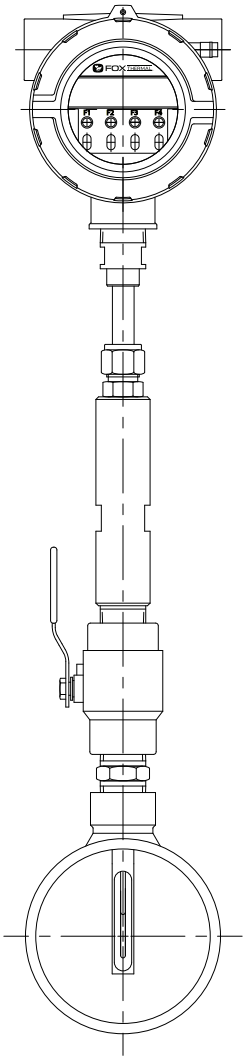
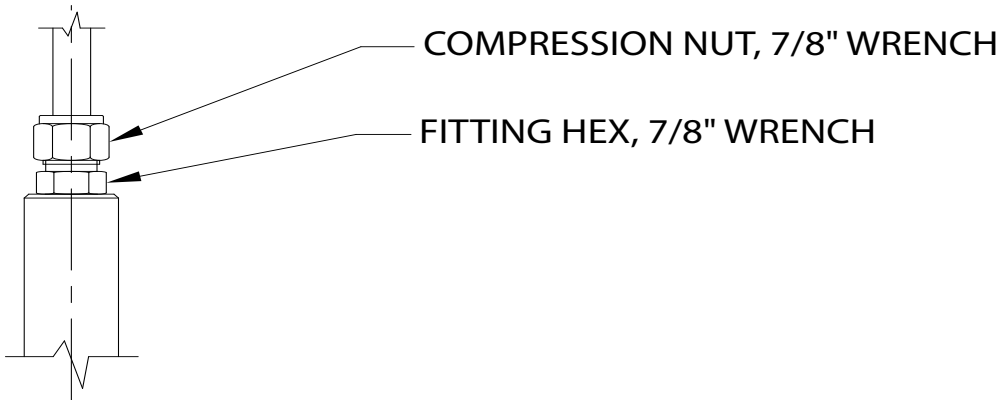


*Fig. 4.7: Close-Up:  Fittings of Fox Thermal Low Pressure Retractor*



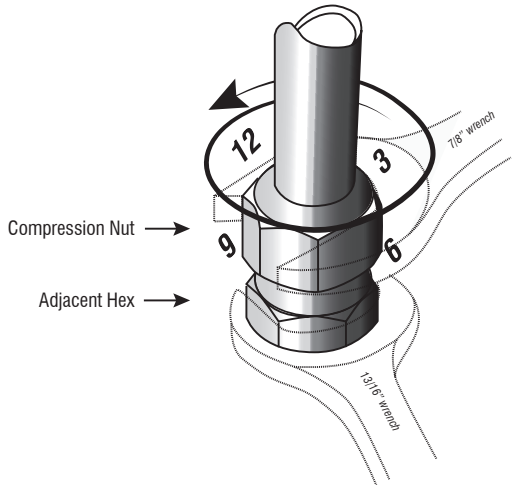
To isolate the sensor, it must be retracted from the pipe.

**WARNING!** SYSTEM MAY BE UNDER HIGH PRESSURE. Do not attempt to remove meters from a pipe pressurized above 60 psig without first relieving pressure in the pipe.

**WARNING!** When removing the flow meter, be sure to hold the electronics enclosure firmly by hand before unscrewing the compression fitting nut. Failure to do this will allow the pressure in the pipe to suddenly and rapidly force the meter from the pipe potentially causing serious injury. The meter could also be damaged resulting in a loss of gas from the pipe. The force required to hold the meter will be 0.20 times the pipe pressure. If you are unsure of your ability to hold the meter for any reason, do not loosen the compression fitting nut.

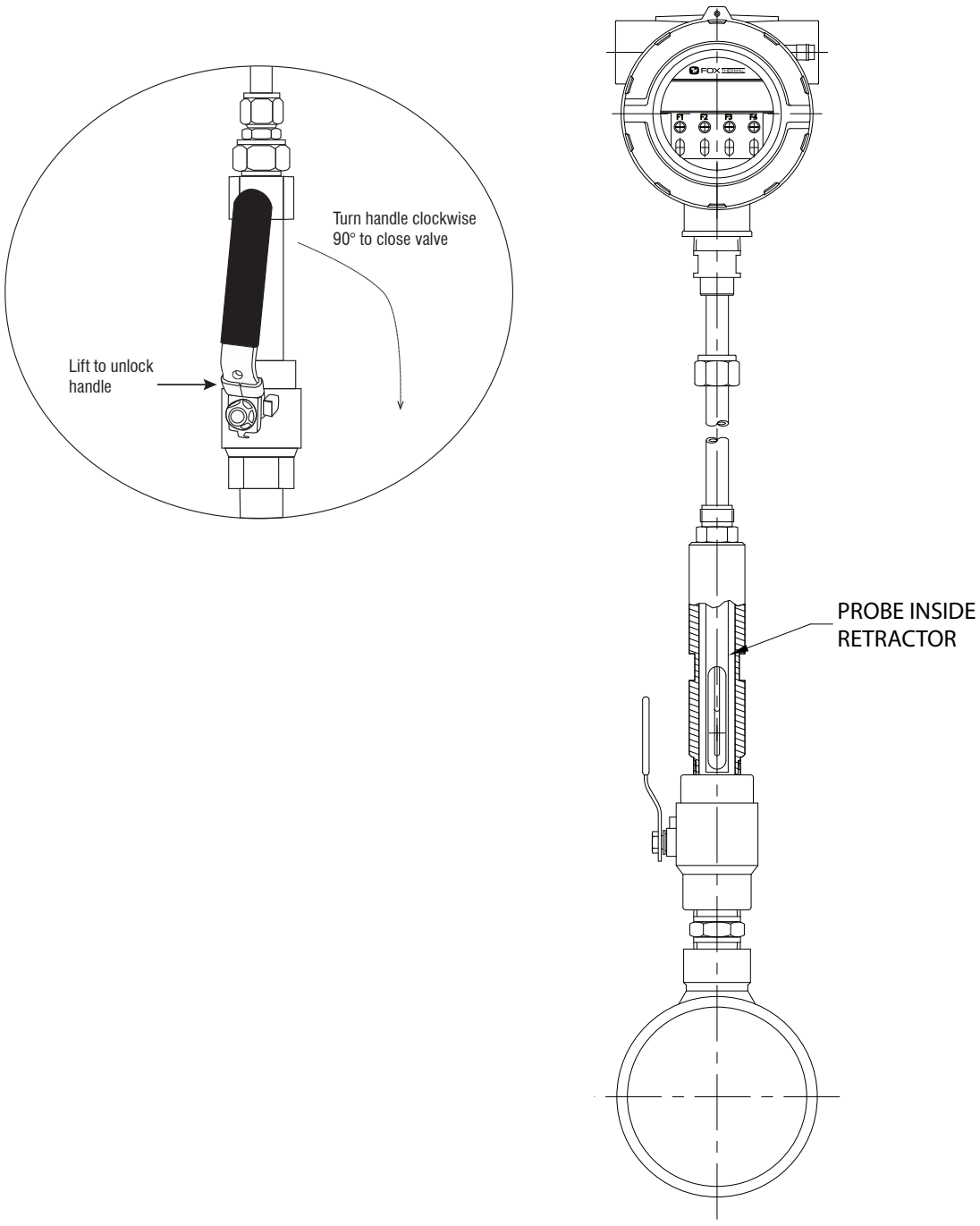
Loosen the compression nut of the compression fitting using two 7/8" wrenches. Once loosened, the probe will be able to slide out (see Fig. 4.8 below).

*Fig. 4.8: Loosening the Compression Fitting*




With one hand supporting the meter, slide the probe up through the retractor until the internal stop makes contact. Close the valve shut-off handle by turning the lever 90˚clockwise to isolate the sensor within the chamber of the retractor (see figure 4.9).

*Fig. 4.9: Isolating the Sensor in Retractor Chamber*



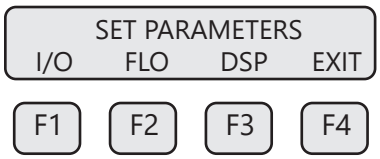

After diagnostic procedure is complete, the probe must be reinserting into the pipe to begin monitoring flow again. When the test has been completed, carefully open shut-off valve, slide the meter down until the ferrules rest in the fitting, and tighten the compression fitting nut on the fitting to seal the probe in the stream.

Check that the meter has returned to normal operation.

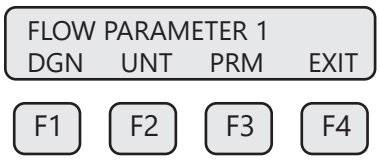
**Setting Field Baseline for In Situ Zero CAL-CHECK™ Tests**
After calibration of every FT3 meter, a lab technician sets the factory baseline for Zero CAL-CHECK™ tests. If you are planning on removing the meter from the process to perform the test, you do not have to set the baseline; however, if you plan to perform the test in situ (in the pipe) or using a Fox Thermal retractor, you must set the field baseline before performing the test.

When the sensor is isolated in zero flow, the FT3 meter is ready to either perform the Zero CAL-CHECK™ test or set the field baseline for future tests.

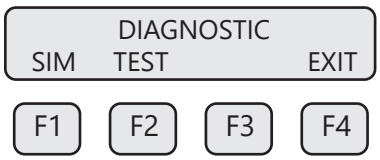
**Starting the Field Baseline Set**
After the meter has been installed and wired correctly (see Wiring section of this manual), power on the meter.
The meter should default to display #1. Press "**F1**" to program the meter. Press **Yes (F1)** to set parameters and you will be prompted to enter the password. Use a Level 2 password (9111). The display will show:



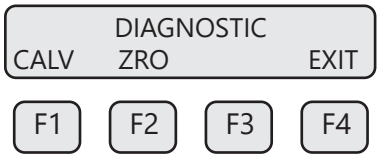

Press **FLO (F2)** to go to the FLOW PARAMETER 1 menu.




Press **DGN (F1)** to go to the DIAGNOSTIC menu.

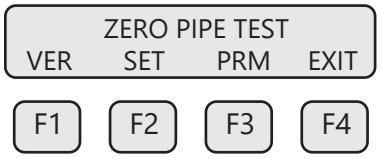



Press **TST (F2)** to get to the Diagnostic Test Sub-Menu.

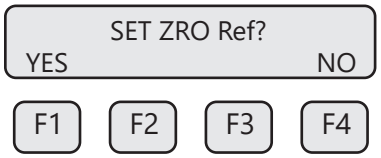



Choose **ZRO (F2)** for Zero CAL-CHECK™.

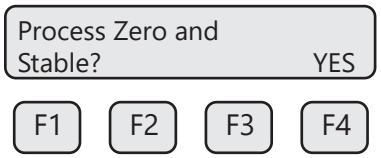

Choose **PIP (F1)** for in situ Zero CAL-CHECK™.




To set the field baseline, choose **SET (F2)**.

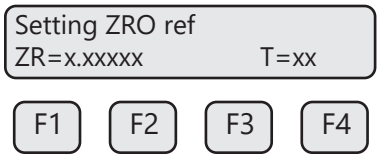



Choose **YES (F1)** to set the field baseline.




**NOTE!** At this point, you must make sure that there is a no flow condition in the pipe (see "Techniques for Achieving Zero Flow - In the Pipe" on p. 78). Also be sure that the meter will be stable for the duration of the setting process.

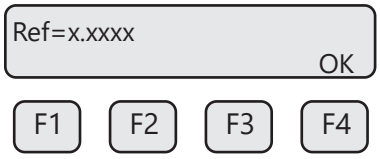
If there is no flow and the meter is stable, press **YES (F4)**. The display will show:




As the meter is setting the field baseline, the meter will display the reference value for the Zero baseline (ZR=xx.xxxx) and a countdown timer (T=xx) to approximate the time until the completion of the set. Depending on the meter configuration, the set may take between 5-15 minutes to complete.

**NOTE!** Do not interrupt the set by touching the meter or changing conditions in the pipe. Changing the meter setup may affect the accuracy of the baseline.

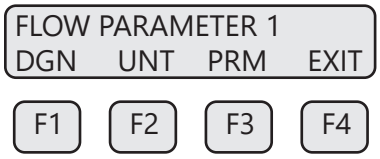
At the conclusion of the set, the display will show:



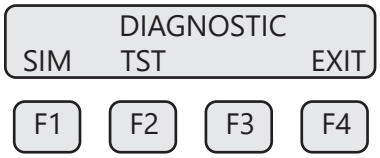

Press **OK (F4)** to return to the Zero CAL-CHECK™ menu.

The meter may now perform Zero CAL-CHECK™ tests at the field baseline at any time.

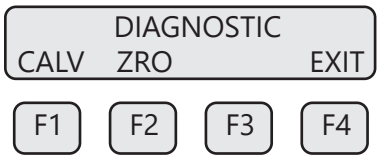
**Performing the Zero CAL-CHECK™ Calibration Validation Test - In the Pipe**
Press **FLO (F2)** from the SET PARAMETERS menu. The display will show:




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




Press **TST (F2)**. The display will show:



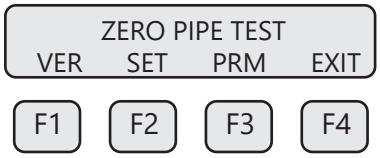

Press **ZRO (F2)** to enter the Zero CAL-CHECK™ menu.

If performing the test in the pipe, a "no flow" condition must be met. If performing the test in the pipe, a "no flow" condition must be created. If performing out of the pipe, the meter must be removed and the sensor covered by a bottle or the PVC sensor protector.

**NOTE!** For accurate readings and best test results:

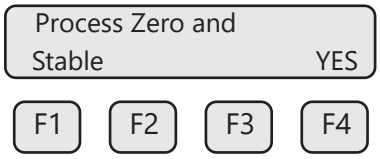
- Perform a visual inspection of sensor window for damage/deformity and condition of sensor elements before starting the test.
- The meter must be used in the same pipe size, with the same gas mixture, and in the same process conditions for which the meter was originally calibrated in the factory. Consult the original factory calibration certificate for details.

Press **PIP (F1)** to choose to perform the test **in the pipe.** The display will show:



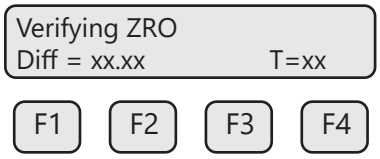

Press **VER (F1)** key to verify the Zero CAL-CHECK™.


Press **YES (F1)** key to verify the Zero CAL-CHECK™.

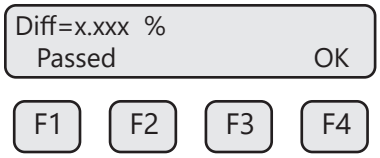



**WARNING!** If you are using "Pipe" test, you must verify that there is a no flow condition before proceeding. If you are performing the test in a bottle, be sure to isolate the sensor in a bottle - any air movement (even from a fan) can result in a false "fail" result.

Once process is stable, press **YES (F4)** key to begin the Zero CAL-CHECK™.



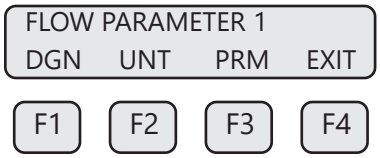

This test will take less than 5 minutes. The T=xx is a count down timer indicating how much time is left to finish the test.



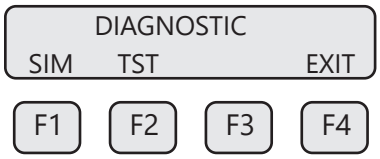

Upon test completion, the final percentage value will be displayed along with a Pass/Fail message.

**Performing the Zero CAL-CHECK™ - Out-of-pipe**
Remove the meter from the pipe and isolate in an area that will allow the test to go undisturbed (see Note below).

Press **FLO (F2)** from the SET PARAMETERS menu. The display will show:

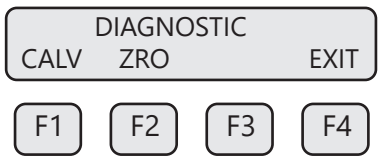



Press **DGN (F1).** The display will show:

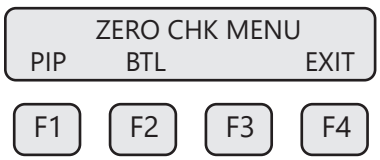



**NOTE!** For best results:
- Use the factory-supplied PVC sensor protector (see Fig. 4.5 on p. 79).
- Place the meter upside-down on a flat, solid surface before starting the test.
- Do not allow the meter to move during the test. Make sure the sensor is stable and the sensor is completely isolated throughout the test.

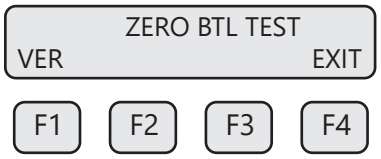
Press **TST (F2).** The display will show:



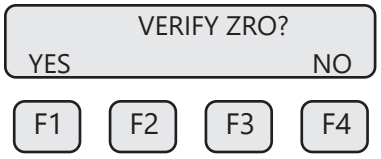

Press **ZRO (F2)** to choose the type of Zero CAL-CHECK™ test.



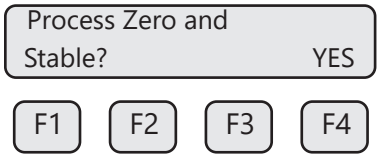
Press **BTL (F2)** to choose to perform the test out of the pipe. The display will show:




Press **VER (F1)** key to verify the Zero CAL-CHECK™.

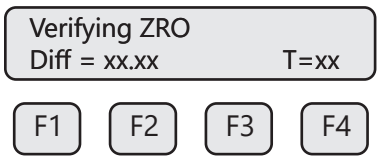


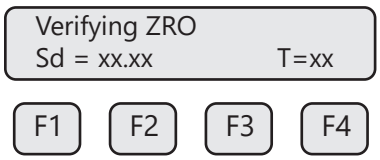

Press **YES (F1)** key to verify the Zero CAL-CHECK™.



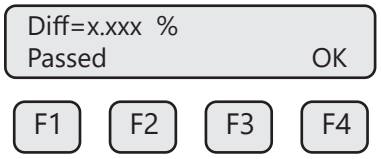

**WARNING!** You must verify that there is a no flow condition before proceeding. Be sure to isolate the sensor completely - any air movement (even from a fan) can result in a false "Fail" result.

Once process is stable, press **YES (F4)** key to begin the Zero CAL-CHECK™.



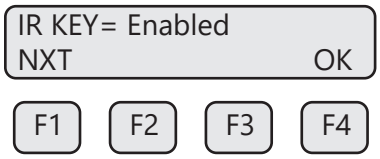




This test will take less than 5 minutes. The display will alternate between the standard deviation measurement value and the T=xx count down timer indicating how much time is left to finish the test.




Upon test completion, the final value will be displayed along with a Pass/Fail message.

**Enabling/Disabling the Infrared Keypad (IR keys)**
The IR keys may be disabled using this menu to avoid being triggered by frost or snow on the window. This menu is accessed by pressing **DSP (F3)** from the SET PARAMETERS menu then **IR (F2)**:




Press **NXT (F1)** key to enable or disable the IR keys.

**NOTE!** After selecting "Disable" and pressing **OK (F4)**, the IR keys will no longer operate. It will be necessary from now on to open the cover and operate the configuration panel using the mechanical push buttons. To return to the normal display mode, use the mechanical buttons to enable the IR keys.

**NOTE!** The IR keys are disabled for 1 minute when a mechanical key is used, to prevent accidentally activating the IR keys.

**Calibrating the Infrared Keypad (IR keys)**
The IR keys are calibrated in the factory before shipment, but conditions in the field may alter the way the keys read. To allow the IR keys to perform better, it may be necessary to calibrate the keys in the field.

Use your finger to activate the IR keys using this process.

**NOTE!** Your finger must activate each key approximately 0.1" to .5" from the surface of the glass.

To begin the IR key calibration process, turn off power to the FT3 and then turn on power while placing your fingers on the **(F3)** and **(F4)** IR keys at the same time. Activate IR key **(F1)** to confirm to begin the IR key calibration. Hold your finger over IR key **(F1)**. In 10 seconds the power level of the IR key **(F1)** will be displayed and automatically increase until activation is detected. This will be repeated for calibration of the **(F2)**, **(F3)** and **(F4)** keys.

To check the calibration values of the IR keys, turn off power to the FT3, then turn on power to the FT3 while placing your finger on the (**F1)** IR key. The display will show the values (example here):

**Scope - Modbus Communications**
This portion of the manual describes the Modbus implementation using RS485 serial communication physical layer for the Fox Thermal FT3 mass flow meter based on the Modicon Modbus Protocol (PI-MBUS-300 Rev. J). A Modbus-enabled FT3 includes "MB" in the model number.

**Modbus Protocol**
Modbus Protocol is an application layer messaging protocol that provides client/sever 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**
Orange LED indicator LP2 blinks when Modbus signals are received and yellow LP1 blinks when Modbus signals are transmitted. The LEDs are located on the Modbus communication board next to the wiring connections.

**Modbus Function Codes Supported by the FT3**
The FT3 supports the following commands:
1) Command 03: Read multiple registers
2) Command 04: Read single register.
3) Command 06: Write single register

**Read Multiple Registers (command 03)**
This command reads one or more 16-bit registers from the FT3 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 1 register

<0x01> <0x03> <0x00> <0x00> <0x00> <0x01> <0x0a> <0x84>

Response:
<0x01> <0x03> <0x02> <xx> <xx> <CRC high> <CRC low>

Where xx xx is the data register value.

*Table 5.1: FT3 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 | Total | User selected |
| 40004 | 32-bit int MSW | | |
| 40005 | 32-bit int LSW | Temperature x 10 | User selected |
| 40006 | 32-bit int MSW | | |
| 40007 | 32-bit int LSW | Elapsed time x 10 | Hours |
| 40008 | 32-bit int MSW | | |
| 40009 | 32-bit int LSW | Flow Velocity | Meters/hour |
| 40010 | 32-bit int MSW | | |
| 40011 * | 16-bit int | Flow x 10 | User selected /10 |
| 40012 * | 16-bit int | Flow x 100 | User selected /100 |
| 40013 * | 16-bit int | Total x 100 | User selected /100 |
| 40014 | 32-bit int LSW | Total2 (2 gas curves only) | User selected |
| 40015 | 32-bit int MSW | | |
| 40016 | 16-bit int | Status | |
| 40017 | 16-bit int | Status 2 | |
| 40018 | 16-bit int | Reserved | |
| 40019 | 16-bit int | Reserved | |

*To get the actual value of registers 40011-40013, divide the presented value by 10 or 100.

*Table 5.1: FT3 Modbus Holding (cont'd)*

| Modbus Register | Data Type | Description | Units |
|---|---|---|---|
| 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 | Total 2 (2 gas curves only) | 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 | Hours |
| 40029 | 32-bit float MSW | | |
| 40030 | 32-bit float LSW | Flow Velocity | Meters/hour |
| 40031 | 32-bit float MSW | | |
| 40032 | 32-bit float LSW | CAL-V Diff | CAL-V Diff |
| 40033 | 32-bit float MSW | | |
| 40034 | 32-bit float LSW | CAL-V Set | CAL-V Set |
| 40035 | 32-bit float MSW | | |
| 40036 | 16-bit int | Reserved | |
| 40037 | 32-bit int LSW | Total 24 hrs, Last total record | User selected |
| 40038 | 32-bit int MSW | | |
| 40039 | 16-bit int | Total 24 hrs, Current Day (0-6) | Day |
| 40040 | 16-bit int | Total 24 hrs, Current Hour (0-23) | Hour |
| 40041 | 32-bit int LSW | Total 24 hrs, Record day 1 | User selected |
| 40042 | 32-bit int MSW | | |
| 40043 | 32-bit int LSW | Total 24 hrs, Record day 2 | User selected |
| 40044 | 32-bit int MSW | | |
| 40045 | 32-bit int LSW | Total 24 hrs, Record day 3 | User selected |
| 40046 | 32-bit int MSW | | |
| 40047 | 32-bit int LSW | Total 24 hrs, Record day 4 | User selected |
| 40048 | 32-bit int MSW | | |
| 40049 | 32-bit int LSW | Total 24 hrs, Record day 5 | User selected |
| 40050 | 32-bit int MSW | | |
| 40051 | 32-bit int LSW | Total 24 hrs, Record day 6 | User selected |
| 40052 | 32-bit int MSW | | |
| 40053 | 32-bit int LSW | Total 24 hrs, Record day 7 | User selected |
| 40054 | 32-bit int MSW | | |
| 40055 | 32-bit int LSW | Total 24 hrs, Last Total | User selected |
| 40056 | 32-bit int MSW | | |
| 40057 | 32-bit float LSW | Zero Check Mean | Zero Check Mean value |
| 40058 | 32-bit float MSW | | |
| 40059 | 32-bit float LSW | Zero Check Stdev | Zero Check Standard Deviation |
| 40060 | 32-bit float MSW | | |

*Table 5.1: FT3 Modbus Holding (cont'd)*

| Modbus Register | Data Type | Description | Units |
|---|---|---|---|
| 40061 | 32-bit float LSW | Zero Check Pipe Ref | Zero Check Pipe Reference |
| 40062 | 32-bit float MSW | | |
| 40063 | 32-bit float LSW | Zero Check Pipe Diff | Zero Check Pipe Difference % |
| 40064 | 32-bit float MSW | | |
| 40065 | 32-bit float LSW | Zero Check Bottle Ref | Zero Check Bottle Reference |
| 40066 | 32-bit float MSW | | |
| 40067 | 32-bit float LSW | Zero Check Bottle Diff | Zero Check Bottle Difference % |
| 40068 | 32-bit float MSW | | |
| 40069 | 16-bit int | Zero Check Test Time | Zero Check Test Time (seconds) |

**NOTES!**

- In the table, LSW means Least Significant Word, and MSW means Most Significant Word. In this case a "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.
- 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

**Example:**
Request data register at starting address 0x0000 and specifying only 1 register:
<0x01> <0x03> <0x00> <0x00> <0x00> <0x01> <0x0a> <0x84>

**Command Response**
<0x01> <0x03> <0x02> <xx> <xx> <CRC high> <CRC low>
Where xx is the data register value.

**Read Single Register (Command 04)**
This command is used to report the status information.

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 Command 04, Modbus Address 30001*

| 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 | Velocity flow rate outside of calibration table | Check sensor wiring |
| 7 | Incorrect Settings | Check settings |
| 8 | In simulation mode | Set simulation value to 0 to disable |
| 9 | Pulse output is out of range | Check pulse 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 | Anybus error | Replace display board |
| 13 | Bridge Shut Down | Check sensor wiring |
| 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 Command 04, Modbus Address 30002*

| Bit | Definition |
|---|---|
| 0 | CAL-V in progress |
| 1 | ADC12<> ADC24 too far apart, internal calibration out of range |
| 2 | CAL-V Diff out of range |
| 3 | Curve #2 Selected (for 2 gas curves only) |
| 4 | Zero Check failed |
| 5 | CAL-V/Zero Check aborted |

**Write Single Register (Command 06)**
This command is used to perform miscellaneous functions such as clearing the totalizer and initiating diagnostic operations. The register address is 0x0a (10 decimal, Modbus=40011) and the data to write is described below.

Request:
<Meter Address> <Command code=06> <Register address high=0x00> <Register address low=0x0a> <Register data high=0x00> <Register data low =0x02> <CRC high> <CRC low>

Response:
<Meter Address> <Command code=06> <Register address =0x00> <Register address =0x0a> <Register data=0x00> <Register data =0x02> <CRC high> <CRC low>

Reset Total:
Address = 40011, data = 0x02
This command is used to clear the Totalizer and elapsed time registers

Reset 24 hours Total:
Address=40011, data = 180 (0xB4)
This command resets the 24 hours 7 days record including the day and hours counters

Reset 24 hour time:
Address=40011, data = 181 (0xB5)
This command resets the 24 hours day and hours counters.

24 hours Event:
Address=40011, data = 182 (0xB6)

This command generates a 24 hours event, the same way as when the 24 hours counter rolls over. This may be useful to record total over a shorter period.

CAL-V Verify:
Address=40011, data = 161 (0xA1)

This command initiates a "CAL_V Verify". This operation may take 4 minutes to complete and will stop the meter from calculating flow. The Status2 bit D0 may be monitored to check for completion.

Zero Check In-Pipe Verify:
Address=40011, data = 173 (0xAD)

This command initiates a "Zero Check In-Pipe Verify". This operation does not affect flow calculations. The register 40069 may be monitored to check for completion.

Zero Check In-Bottle Verify:
Address=40011, data = 176 (0xB0)

This command initiates a "Zero Check In-Bottle Verify". This operation does not affect flow calculations. The register 40069 may be monitored to check for completion.

Switch to Curve #1:
Address=40011, data = 170 (0xAA)

This command initiates a command to switch to gas curve 1 when configured for 2 gas curves. Make sure that the input contact is not programmed for curve switching

Switch to Curve #2:
Address=40018, data = 171 (0xAB)

This command initiates a command to switch to gas curve 2 when configured for 2 gas curves. Make sure that the input contact is not programmed for curve switching.

**Select Record (command 06, Preset Register, Modbus Address 40214)**
This command is used to select the next record that is going to be read from the data log buffer using command 03.
Address register = 40214
Data = xx. (xx = record select (hex 0-1e, decimal 0-30)

**NOTE!** Record 0 is the latest and 30 is the oldest.

Request:

<Meter Address> <Function code=06> <Register address high=0x00> <Register address low=0xd5> <Register data high=0x00> <Register data low =0xx> <CRC high> <CRC low>

Response:

<Meter Address> <Function code=06> <Register address =0x00> <Register address =0xd5> <Register data=0x00> <Register data =0xx> <CRC high> <CRC low>

**Read Record (command 03, Read Holding register)**
These registers are used to get the data for a single record. Before issuing that command, a preset command has to be sent to select the record to be read.

**NOTE!** The Record Number is an unsigned integer (0-65535) that is incremented every time a new record is stored and is not the same as the request record number (0-30).

Example:
Request:

Request data register at starting address 40200 and specifying 9 register to read the complete record

<0x01> <0x03> <0x00> <0xc7> <0x00> <0x09> <0x34> <0x31>

Response:

<0x01> <0x03> <0x12> <rec nb> <rec nb> <year><month><day><hour><min><sec><data index><data index><total val int><total val int><total val int><total val int><total val fp><total val fp><total val fp><total val fp><CRC high> <CRC low>

| Register Address | Modbus Address | Data Type | Comment |
|---|---|---|---|
| 0xc7 | 40200 | Record Number (16 bits integer) | Record Number |
| 0xc8 | 40201 | Year /Month (16 bits integer, BCD format yyyy mmmm) | Record Year/Month |
| 0xc9 | 40202 | Day/Hour (16 bits integer, BCD format dddd hhhh) | Record Day/Hour |
| 0xca | 40203 | Minute/Second (16 bits integer, BCD format mmmm 0000) | Record Minute/ sec=0 |
| 0xcb | 40204 | Data Index (16 bits integer, 0x00FA)) | Data Index = 250 |
| 0xcc | 40205 | Interval Total (16 bits unsigned integer, high register) | Interval Total (int) |
| 0xcd | 40206 | Interval Total (16 bits unsigned integer, low register) | Interval Total (int) |
| 0xce | 40207 | Interval Total (float upper 16 bits) | Interval Total (float) |
| 0xcf | 40208 | Interval Total (float lower 16 bits) | Interval Total (float) |

**Clear Data Log (command 06, Preset Register, Modbus Address 40213)**
This command is used to clear all records in the log.
Address register = 40213
Data = 0x57.

Request:

<Meter Address> <Function code=06> <Register address high=0x00> <Register address low=0xd4> <Register data high=0x00> <Register data low =0x57> <CRC high> <CRC low>

Response:

<Meter Address> <Function code=06> <Register address =0x00> <Register address =0xd4> <Register data=0x00> <Register data =0x57> <CRC high> <CRC low>

**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 significand 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 if 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 |

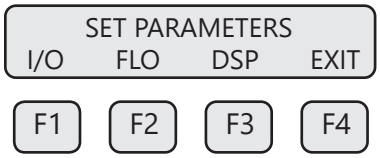
| **Second byte (LSB of lower register)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Data bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Value bit | S7 | S6 | S5 | S4 | S3 | S2 | S1 | S0 |

| **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 |

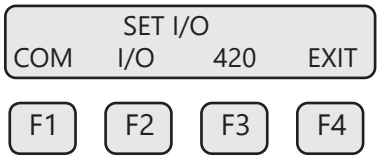
| **Fourth byte (LSB of higher register)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Data bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Value bit | E0 | S22 | S21 | S20 | S19 | S18 | S17 | S16 |

**Modbus Parameters**

To program the communication parameters, start at the SET PARAMETERS menu:

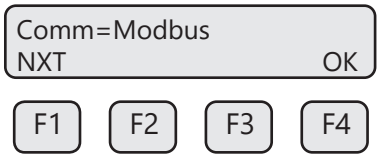



Then press **I/O (F1)** to set Inputs/Outputs:



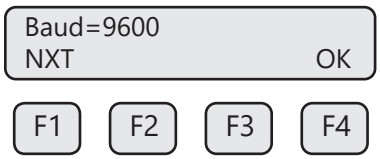

Then press **COM (F1)** to select communication parameters.

Set Bus protocol for Modbus:



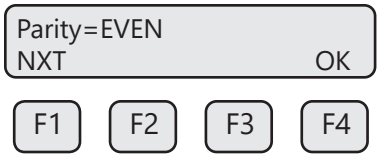

Press **NXT (F1)** repeatedly until Modbus is selected as shown and then press **OK (F4)** to accept the setting.

The following communication settings apply only to Modbus:



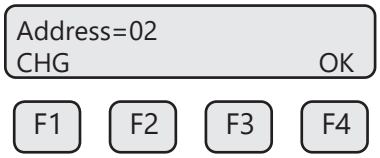

Press **NXT (F1)** repeatedly until the correct selection is shown then press **OK (F4)** to accept the setting.

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




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

Selections are: NONE
ODD
EVEN




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.

## Scope - HART Communications

The Fox Thermal model FT3 transmitter complies with HART Protocol Revision 7.1. A HART-enabled FT3 includes "BH" in the model number. 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 Smart Communications Protocol Specification. HCF_SPEC-12.

## Device Identification

| | | | |
|---|---|---|---|
| **Manufacturer Name:** | Fox Thermal Instruments | **Model Name:** | FT3 |
| **Manufacture ID Code:** | 24635 (603b hex) | **Device Type Code:** | 57583 (E0EF 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 FT3 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 FT3 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.

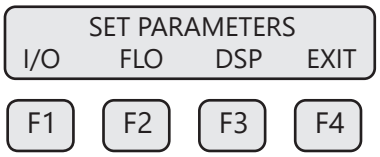
Channel 2 of the 4-20mA output may be configured for flow or temperature values when using HART.

**HART Indicators**
Green LED indicator LP3 cycles on and off to indicate that the FT3 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 on the HART communication board next to the wiring connections.

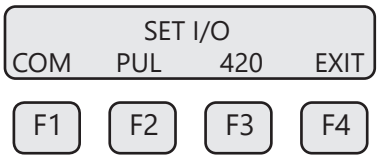
The orange LED indicator LP2 will be on continuously when HART communication is enabled and the 4-20mA wiring is not connected.

**FT3 HART Communication Setup**
HART communication must be selected in the FT3 Serial Communication menu for HART communication to operate. When this communication parameter is changed, power to the FT3 must be cycled for it to take effect.

**HART Parameters**
To program the communication parameters, press **I/O (F1)** key from the SET PARAMETERS menu.

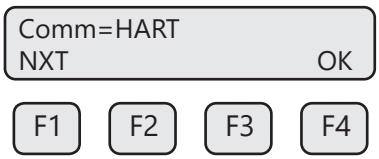



Choose **I/O (F1)** to access the communication output.




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.

**Device Variables**
This device does not expose any Device Variables.

**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 | Pulse 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** | Fox Thermal Instruments, FT3 |
| **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 |

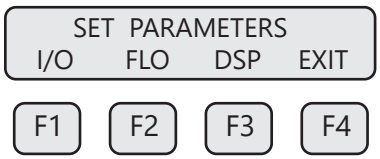
**Scope - Data Logger**
The model FT3 offers an option to have a data logger mounted on the Front Panel board that can be used to record FT3 data. A Data Logger-enabled FT3 includes "DL" in the model number. Data that may be recorded includes interval totals (i.e. a previous 24-hour total) based on selected flow units (i.e. total mass flow or total volumetric flow). This data may be recorded at a rate specified by the customer ranging from 1 second to 1 month in hour/minute/second intervals.

This section of the manual contains the operation instructions for the FT3 data logger. The FT3 data logger supports 31 records with a start/sync time of midnight set as a default. When the number of samples exceeds 31, the oldest data will be overwritten. Only the most recent 31 records are kept.

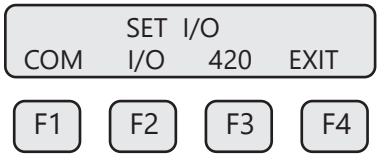
**Model FT3 Data Logger Features**
The following features are included in the data logger option available on the Fox Thermal model FT3 thermal gas mass flow meter:

- 31 separate 24-hour daily totals with date and time stamp
- Data can be accessed over Modbus RTU (RS485) and the engineering display
- After 31 days, old data will be overwritten; however, the most recent 31 daily totals will always be available
- The operator may set the start time through the front panel (the default start time for the 24-hour total will be midnight)
- Operator may set the local time through the front panel
- Field retrofits with data loggers require exchanging the existing display board for the display board with the data logger feature and upgrading the main FT3 board firmware (upgrade kit available)

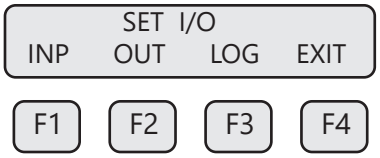
**Data Logger Setup Menu**
Using the keypad on the front panel, enter the programming mode:




Press **F1** for **(I/O)**. The screen will show:

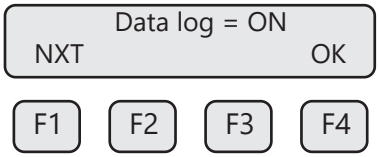



Press **F2** for **(I/O)**. The screen will show:



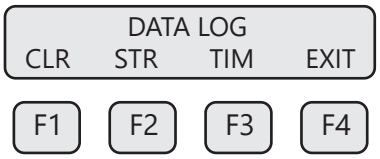

**NOTE!** If the hardware does not detect a real time clock, the **LOG** menu key will not be displayed.

Press **F3** for **(LOG)**. The screen will show:

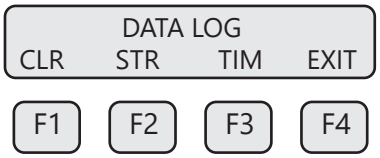



The default is set with the data logger enabled, press **F1 (NXT)** to turn the data logger ON or OFF (the default is ON).

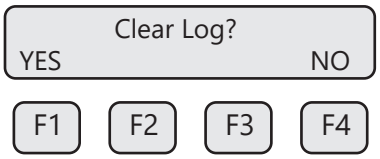
Press **F4 (OK)** to continue.




**Clearing the Data Log**
From the data log menu, press **F1 (CLR)**.




The screen will show:

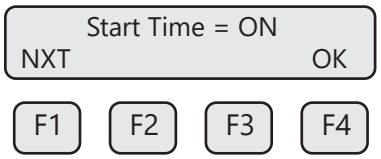



Press **F1 (YES)** to confirm or **F4 (NO)** to cancel.

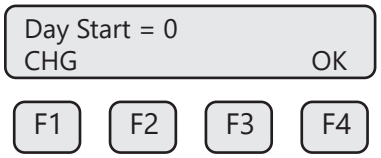
**Setting the Start/Sync Time**
The start/sync time is used to start or syncing a data log sample. When a match is detected between the real time clock and the start/sync time, the interval is reloaded. The Data Logger will be set to the default of zero (midnight) and only the hour, minute, and second will be used for the trigger.

For example:
A settting of "day=00, hour=00, minute=00" will reload the interval every day at midnight.

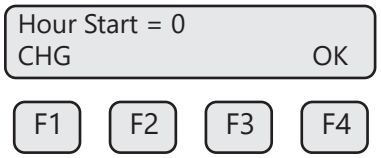
From the data log menu, press **F2 (STR)**. The screen will show:



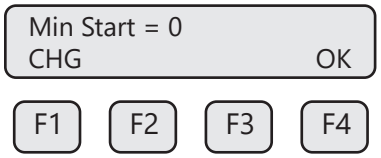

Press **F1 (NXT)** to turn ON or OFF the Start/Sync Time and then press **F4 (OK)**:



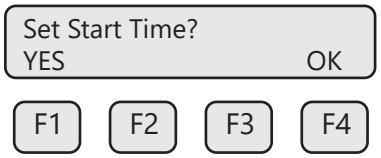

Press **F4 (OK)**.




Set the hour for which you want to start/sync time. When the Hour Start is set to zero, the default will be for midnight. **Press F4 (OK).**



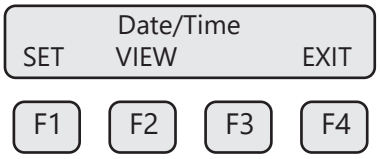

Set the minute for which you want to start/sync time. Press **F4 (OK)**.



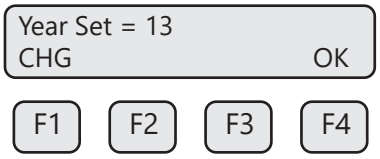
Press **F1 (YES)** to set the start/sync time for Day:Hour:Minute.

**NOTE!** Make sure that the specified time has not been reached yet.

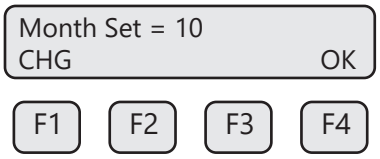
**Setting the Real Time Clock**
From the Data Log menu, press **F3 (TIM)**. The screen will show:



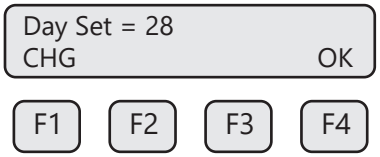

Press **F1 (SET)**:



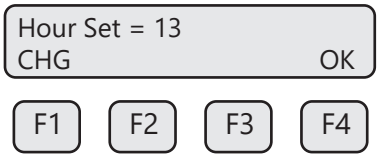

Press **F1 (CHG)** to change the years, **F4 (OK)** to continue.



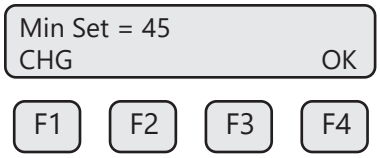

Press **F1 (CHG)** to change the month, **F4 (OK)** to continue.



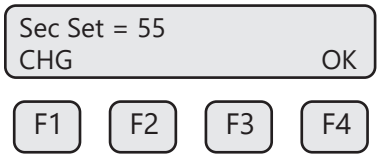

Press **F1 (CHG)** to change the day/date, **F4 (OK)** to continue.



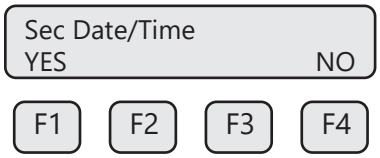

Press **F1 (CHG)** to change the hours, **F4 (OK)** to continue.




Press **F1 (CHG)** to change the minutes, **F4 (OK)** to continue.




Press **F1 (CHG)** to change the seconds, **F4 (OK)** to continue.

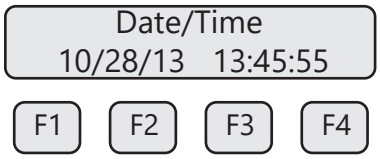



Press **F1 (YES)** to set the Date and Time.

**NOTE!** All real time clocks on FT3 data loggers are set to a default of California's Pacific Standard Time. To sync the real time clock to your local time exactly, set the time slightly ahead of your local, current time and wait for the current time to reach the set value before pressing the **F1 (YES)** key to set the time.

**Viewing the Real Time Clock**

From the Data Log Menu, Press **F3 (View)** or press **F1** and **F3** at the same time from the regular mode.




The current real time is displayed on line 2 and is updated every second. Press **F4** to exit.

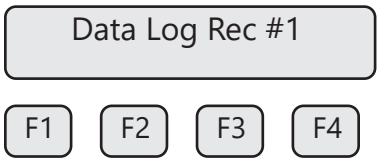
**NOTE!** The seconds will only be displayed if there is enough room available to do so.

**NOTE!** Time is displayed in military time.

**Displaying Data Log Records**

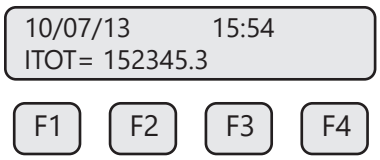
The data logger supports 31 records, record #1 being the latest recorded value and 31 being the oldest.

From the normal operating mode, press F1 and F4 keys at the same time:




**NOTE!** Record #1 is the most recent interval total, record #31 is the oldest.

This display screen will appear for only 1 second and will then show:




The Date and Time is displayed on line 1 and the interval total on line 2. The interval total is based on the flow units selected in the meter (total mass flow or total volumetric flow).

Pressing **F2** will display the next record, **F1** will display the previous record.

Press **F4** to exit to the normal mode at any time.

**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 Fox Thermal Customer Service for technical assistance at (831) 384-4300.

**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. 136.

**Flow Calibration and Calibration Validation**

To ensure high accuracy of your model FT3 Flow Meter, Fox Thermal provides a full NIST traceable calibration. It is recommended that the meter's accuracy be checked annually by performing the CAL-V™ and Zero CAL-CHECK™ Calibration Validation tests.

**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.

**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 compression fitting without first closing the ball valve and bleeding off pressure inside of the retractor.

**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**

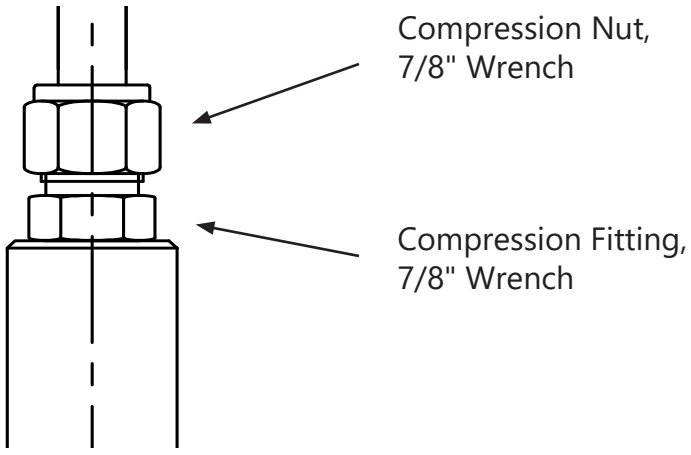
1. Disconnect power from the meter.

**NOTE!** At 125 psig of max system pressure, the probe will have approximately 25 lbs. of force pushing it out.

2. Loosen the compression fitting nut using two 7/8" wrenches.
3. With one hand supporting the meter, unscrew the compression nut and slide the probe out of the retractor until the internal stop halts the travel of the probe.
4. Close the ball valve all the way.

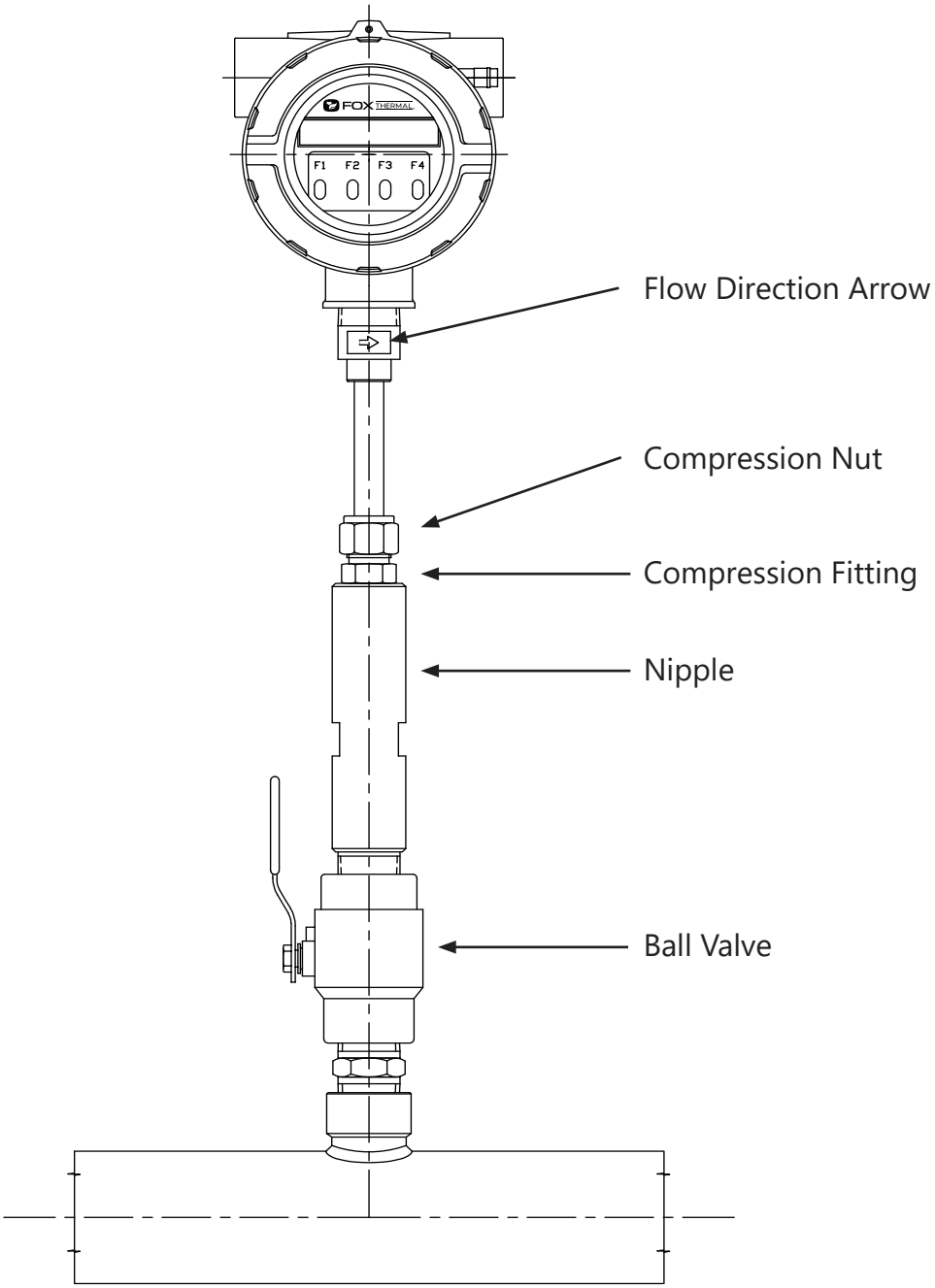
**CAUTION!** At this point there is still pressure inside of the retractor.

*Fig. 7.1: Close Up of Compression Nut and Compression Fitting for Retractor*



**Step 2 - Remove the Probe from the Retractor Body**

*Fig. 7.2: Identification of Retractor Parts for the FT3*




5. Continue supporting the meter while performing the following steps.
6. If the meter is to be completely removed from the system, disconnect the wiring to the meter.
7. Using a 7/8" wrench, slowly loosen the compression fitting approximately one turn or less until the pressure in the retractor is completely relieved.
8. After relieving the pressure, unscrew the compression fitting from the end of the nipple.

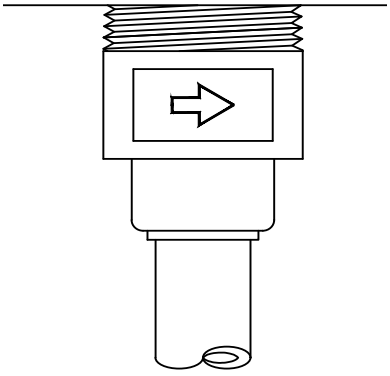
9. Carefully slide the probe out of the retractor along with the fitting while supporting the meter as it comes out. Be careful while handling the meter so the sensor does not get damaged.

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

**WARNING!** Never stand where your body or any part of it is in front of the meter. An injury may occur if the probe is forced outward by the system pressure.

1. Apply a thin film of anti-seize compound on the compression fitting threads, if needed.
2. Push the probe into the retractor and tighten the compression nut by hand. Align the probe with the flow by rotating the probe until the flow direction arrow on the probe fitting is aligned with the centerline of the pipe, and points in the direction of flow (see Fig. 7.3).

*Fig. 7.3: Flow Direction Arrow*



3. Tighten the compression nut onto the compression fitting using a 7/8” wrench on the nut and a 7/8” wrench on the fitting.
4. Pressurize the system and check the retractor for leaks. Tighten any of the fittings that may need it or seal any leaks that require it.
5. The system may be wired at this point. Refer to the wiring section of this manual for wiring instructions for the electronics enclosure. Power may be applied only after the meter has been properly wired according to the manual, and it is safe to do so.

**Troubleshooting**

**CAUTION!** The electronics and sensor supplied by Fox Thermal 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 FT3 flow meter, call Fox Thermal Customer Service Department, Technical Assistance at (831) 384-4300.

| Problem | Possible Cause(s) | Action(s) |
|---|---|---|
| Meter keeps power cycling | 1. Power supply<br>2. Malfunction in flow meter<br>3. Electromagnetic Interference (EMI) | 1. Measure power supply voltage to verify it is stable and within operating range (refer to power supply specs on p. 124).<br>2. Check meter power cycles.<br>3. Press and release **F1** and **F2** at the same time; the display will enter Engineering screens.<br>4. Press **F1** to get to screen #23; record power cycle value.<br>5. Press **F4** to return to normal operation; monitor meter until problem returns.<br>6. Return to screen #23 to see if power cycles have increased; microprocessor is resetting due to EMI electrical noise entering the meter.<br>7. Check Power input and output cables grounding and routing.<br>8. Return flow meter to Fox Thermal for repair (refer to p. 136 for shipping instructions). |
| Flow measurement is erratic or fluctuating | 1. Very turbulent flow<br>2. Sensor dirty<br>3. Sensor broken<br>4. Probe not mounted securely<br>5. Malfunction in flow meter<br>6. Meter installed incorrectly | 1. Increase dampening (see filter settings in "Flow Parameters" on p. 67)<br>2. Clean sensor (Refer to Maintenance section, p. 112)<br>3. Return flow meter to Fox Thermal for repair (Refer to p. 136 for shipping instructions)<br>4. Remount probe (see Installation section, p. 21); must be mounted securely without vibration. If vibration persists, choose a new mounting location without vibration.<br>5. Return flow meter to Fox Thermal for repair (Refer to p. 136 for shipping instructions)<br>6. Re-install meter according to instructions (Refer to installation section, p. 21) |

| Problem | Possible Cause(s) | Action(s) |
|---|---|---|
| Display Error | 1. Loose or damaged ribbon cable<br>2. Damaged electronics<br>3. Ambient temperature | 1. Visual inspection.<br>2. Return the meter or display for repair.<br>3. Operate meter between -20 to 70°C |
| Flow measurement seems low | 1. Probe not oriented properly<br>2. Sensor dirty | 1. Orient probe per installation sections: Insertion (p. 25)<br>2. Clean sensor (p. 112) |
| Unit will not power-up | 1. No power input<br>2. Bad fuse | 1. Check for correct power supply voltage at TS1 on main board.<br>2. Check fuse (F1) located next to TS1 on main board.<br><br>If fuse is OK and unit still won't power up, call Fox Thermal for additional assistance |
| Meter does not read up to full scale | Calibration table may be corrupted | 1. Check the calibration table for a corrupted location.<br>2. Enter the password 9111.<br>3. From the Flow Parameters 2 menu screen, select **CAL (F1)**<br>4. Select **NXT (F1)** to cycle through calibration table to verify entries match the calibration certificate.<br>5. Check for CRC error code. |

**Installation Problems**

The following is a summary listing of problems that may be encountered with the installation of the FT3 thermal mass flow meter.

1. *Improper wiring connections.*
   Refer to Fig. 3.1 to 3.16 and "Wiring Precautions" in Wiring section (p. 33 to p. 49) for further guidance.
2. *Inadequate power source.*
   For FT3 models specified for 24VDC operation, the input voltage must be 24VDC ±10%. A 20 Watt power supply or greater is recommended for powering the FT3 to ensure it operates properly under all temperature ventilation, and power on conditions. If the voltage supplied at the input terminals of the FT3 is not within the range of 21.6VDC to 26.4VDC, a variety of problems can occur including a dim display, inaccurate flow readings or faulty 4-20mA, pulse and communication interface.
3. *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 Fig. 2.6 (p. 25). 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 Fig. 2.5 (p. 24).
   - 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 Fox Thermal for assistance.
   - Ensure that pipe inside diameter in the meter matches data on the Fox Thermal Calibration Certificate. The pipe inside diameter is programmed into the flow meter through the front panel (see Flow Parameters, p. 67).
4. *Erratic flow reading (especially a flow reading spiking high).*
   This may be a symptom of moisture in the flow stream. Fox Thermal flow meters are designed to work in relatively dry gas applications only. Contact Fox Thermal to discuss resolutions to this problem.
5. *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 Fox Thermal. 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 Fox Thermal Customer Service with this information.
6. *Display and/or 4-20mA signal reading above zero flow when no flow is occurring in the pipe.*
   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 Fox Thermal 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 Fox Thermal Customer Service for alternatives.
7. *Mismatched serial numbers.*
   If you have more than one meter, you must ensure that the serial numbers of meter, remote, and/or flow body match one another. These items have been manufactured and calibrated to operate as a unit and cannot be mismatched.

**Troubleshooting CAL-V™**
If the FT3 meter fails a CAL-V™ Calibration Validation test, follow the steps below:

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 Fox Thermal Technical Assistance at 831-384-4300 for more information.
   - Try cleaning the sensor and try the test again under higher gas flow conditions.
3. If the meter continues to fail, contact Fox Thermal Technical Assistance at 831-384-4300 for more information.

**Troubleshooting Zero CAL-CHECK™**
If the FT3 Meter fails a Zero CAL-CHECK™ Calibration Validation test, there are a few reasons that could be the cause:

1. The sensor may be dirty or damaged
   - Visually inspect the meter for damage. If damage is found, meter may need to be serviced. Contact Fox Thermal technical assistance at 831-384-4300 for more information
   - Try cleaning the sensor and try the test again
   - If the meter fails again, move to #2

2. The sensor may not be properly covered/isolated
   - Out-of-pipe:
     - Wind currents (fans in room included) could be affecting the sensor
     - For best results, be sure to use the factory-supplied PVC sensor cover (see Fig. 4.5 on Page 79)
     - If the factory-supplied PVC sensor cover is unavailable, use a clean dry plastic beverage bottle
   - In Pipe:
     - If using the retractor, be sure that the shut-off valve has been closed
     - Make sure that there is a "no flow" or zero flow condition on the meter's sensor
   - Try the test again
   - If the meter fails again, move to #3

3. The meter may not have stabilized properly
   - Make sure the meter is not being affected by vibrations or other movement
   - Allow the meter to stabilize without being moved or touched for 15 minutes
   - Try the test again
   - If the meter continues to fail, contact Fox Thermal technical assistance at 831-384-4300

**Alarm Codes**

| Alarm Code | Reason | Action |
|---|---|---|
| 13 | Flow rate above high limits | Refer to the PARAMETER MENU 2 section on p. 67 of this Manual to verify limit is within range. Check ALM = HiFloAlm under PRM. |
| 14 | Flow rate below low limits | Refer to the PARAMETER MENU 2 section on p. 67 of this Manual to verify limit is within range. Check ALM = LoFloAlm under PRM. |
| 15 | Temperature above high limits | Refer to the PARAMETER MENU 2 section on p. 67 of this Manual to verify limit is within range. Check ALM=HiTempAlm under PRM. |
| 16 | Temperature below low limits | Refer to the PARAMETER MENU 2 section on p. 67 of this Manual to verify limit is within range. Check ALM = LoTempAlm |
| 22 | Sensor out of range | Refer to the ENGINEERING DISPLAY MENU on p. 16 of this Manual and the Fox Thermal factory Calibration Certificate to check CSV voltage. Compare Display 10 value to Calibration Certificate CSV voltage and verify it's within range. |
| 23 | Velocity out of calibration table range | Refer to the ENGINEERING DISPLAY MENU on p. 16 of this Manual and the Fox Thermal factory Calibration Certificate to check CSV voltage. Compare Display 10 value to Calibration Certificate CSV voltage and verify it's within range. |
| 24 | Check settings | One or more internal settings are corrupted or out of spec. Contact Fox Thermal Service for instructions to verify settings. |
| 25 | Simulation mode | Meter is in Simulation Mode. Refer to the PARAMETER MENU 1 section on p. 70 of this Manual. Use the SIM Section under Diagnostics to return to normal operation. |
| 26 | Frequency output over range | Refer to the DIGITAL OUTPUT MENU on p. 56 of this Manual. Verify the Frequency Output settings are within limits. |
| 32 | 4-20mA for flow rate is out of range | Refer to the MAIN MENU on p. 54 of this Manual. Use the Set I/O section to verify range limits under FLO Set 4-20mA. |
| 33 | 4-20mA for temperature is out of range | Refer to p. 54 of this Manual. Use the Set I/O section to verify range limits under FLO Set 4-20mA. Channel #2 can be set for flow or temperature. |
| 34 | Busy | Meter is recalculating new parameters. |
| 35 | Sensor Bridge Shutdown | The FT3 sensor readings are not correct. Check the sensor wiring to the FT3 electronic enclosure and remote enclosure.. |
| 36 | Database CRC Error | Refer to the PARAMETER MENU 2 section on p. 74 of this Manual to reset CRC. Use SPC section of menu to reset CRC. Contact Fox Thermal Service Department for possible causes. |

**Alarm Codes (cont'd)**

| Alarm Code | Reason | Action |
|---|---|---|
| 37 | Totalizer Error Detected | See "Reset the Total and Elapsed Time" on p. 74 for steps to clear Error Code. Contact Fox Thermal for possible causes. |
| 38 | CAL-V™ in progress | Wait until the CAL-V™ or Cal Set is finished. |
| 39 | ADC12 versus ADC24 too far | The tolerance between the 2 analog to digital converters is out of specification. Recalling manufacture default parameters using the Restore Database command on p. 11 may correct the problem. |
| 40 | CAL-V™ Diff Fail | The CAL-V™ Diff Failed. Check sensor wiring and verify that the sensor's resistance is correct. Call Tech Support. |
| 41 | Zero CAL-CHECK™ Fail | Allow meter to stabilize for 15 minutes and perform the test again. If another "Fail" test results, call Tech Support. |

**Performance Specs**

Flow Accuracy:
- ±1% of reading ±0.2% of full scale
  - Accuracy specification applies to customer's selected flow range
  - Maximum range: 15 to 60,000 SFPM (0.07 to 280 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 (1/2" size): 6" (152mm) upstream and downstream
    - Inline Meters (all other sizes): 8 diameters upstream; 4 downstream

Flow Repeatability: ±0.2% of full scale

Flow Response Time: 0.9 seconds (one time constant)

Temperature Accuracy: ±1.8° F (±1.0° C) -40 to 250º F (-40 to 121º C); 60 SFPM minimum

Calibration:
- Factory Calibration to NIST traceable standards
- CAL-V™ and Zero CAL-CHECK™: In situ, operator-initiated calibration validation

**Operating Specs**

Units of Measurement (field selectable):
SCFM, SCFH, NMPS, NM3/M, NM3/H, NM3/D, NLPS, NLPM, NLPH, SCFD, MSCFD, MMSCFD, MMSCFM, SMPS, SM3/D, SM3/H, SM3/M, LB/S, LB/M, LB/H, LB/D, KG/S, KG/M, KG/H, SLPM, SFPM, MT/H, MCFD

Gas Pressure (maximum at 100º F):
- Insertion meter: 500 psig (34.5 barg)
- 316 SS inline meter with NPT ends: 500 psig (34.5 barg)
- 316 SS inline meter with 150 lb. flanges: 230 psig (15.86 barg)
- Carbon steel inline meter with NPT ends: 500 psig (34.5 barg)
- Carbon steel inline meter with 150 lb. flanges: 285 psig (19.65 barg)

Hot Tap/Retractor Assembly: 125 psig (8.62 barg)

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

**NOTE!** When Teflon ferrule option ordered, gas pressure is 60 psig (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.

Relative Humidity: 90% RH maximum; non-condensing

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

**Operating Specs (cont'd)**

Temperature:

ST sensor: -40 to 250°F (-40 to 121°C)
HT sensor: -40 to 650°F (-40 to 343°C)
Enclosure (without display or AC power supply): -40 to 158°F (-40 to 70°C)
Enclosure (with display and/or AC power supply): -4 to 158°F (-20 to 70°C)*
Remote Sensor Enclosure: -40 to 212ºF (-40 to 100°C)
*__NOTE!__ Display dims below -4˚F (-20˚C), function returns once temperature rises again.

Flow Velocity Range:

15 to 60,000 SFPM (0.07 to 280 NMPS)
Turndown: up to 1000:1; 100:1 typical

| Maximum Flow Ranges for Insertion Flow Meters | | | |
|---|---|---|---|
| **Pipe Diameter** | **SCFM** | **MSCFD** | **$NM^3/hr$** |
| 1.5" (40mm) | 0-840 | 0-1,220 | 0-1,325 |
| 2" (50mm) | 0-1,400 | 0-2,020 | 0-2,210 |
| 2.5" (63mm) | 0-2,000 | 0-2,880 | 0-3,150 |
| 3" (80mm) | 0-3,100 | 0-4,440 | 0-4,890 |
| 4" (100mm) | 0-5,300 | 0-7,650 | 0-8,360 |
| 6" (150mm) | 0-12,000 | 0-17,340 | 0-18,930 |
| 8" (200mm) | 0-20,840 | 0-30,020 | 0-32,870 |
| 10" (250mm) | 0-32,800 | 0-47,250 | 0-51,740 |
| 12" (300mm) | 0-46,600 | 0-67,180 | 0-73,500 |

**NOTE!** To determine if the FT3 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. Check Fox Thermal website for velocity calculator.

| Maximum Flow Ranges for Inline Flow Meters | | | |
|---|---|---|---|
| **Size** | **SCFM** | **MSCFD** | **$NM^3/hr$** |
| 0.5" | 0-125 | 0-180 | 0-200 |
| 0.75" | 0-220 | 0-320 | 0-350 |
| 1" | 0-360 | 0-520 | 0-570 |
| 1.25" | 0-625 | 0-900 | 0-990 |
| 1.5" | 0-840 | 0-1,220 | 0-1,325 |
| 2" | 0-1,400 | 0-2,020 | 0-2,210 |
| 2.5" | 0-2,000 | 0-2,880 | 0-3,150 |
| 3" | 0-3,100 | 0-4,440 | 0-4,890 |
| 4" | 0-5,300 | 0-7,650 | 0-8,360 |
| 6" | 0-12,000 | 0-17,340 | 0-18,930 |

**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 (7,900 NM3/H) air may require third party calibration. Contact Fox Thermal.

**Operating Specs (cont'd)**

Input Power:

24VDC ⎓ (±10%), 0.7 Amps (standard DC power)

100 to 240VAC ∼ (±10%/-15%), 50-60Hz, 0.2 Amps (with AC power option)

Note: Fluctuations of AC and DC power supply are not to exceed ±10% of rating.

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.

4-20mA Channel 2:

- Standard isolated 4-20mA output configured to indicate either flow or temperature; fault indication per NAMUR NE43.

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.
- FT3 View™: 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, Hastelloy C276 optional

Enclosure:

NEMA 4X (IP67), aluminum, dual ¾" FNPT conduit entries. Cabling to remote enclosure: 5-conductor, 18 AWG, twisted, shielded, 100 feet maximum.

Flow Meter Installation:

Fox Thermal-supplied compression fitting connects to customer-supplied ¾" female branch outlet welded to pipe.

**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 and FMc: Approved
Class I, Division 1, Groups B,C,D;
Class II, Division 1, Groups E,F,G;
Class III, Division 1; T3C, Ta = - 40˚C to +70˚C;
Class 1, Zone 1, AEx/Ex d IIB + H2 (T6, T4, or T1*); Ta= -20˚C to +70˚C; Type 4X (IP67)

ATEX (FM12ATEX0034X): Approved
II 2 G Ex db IIB + H2 (T6, T4, or T1*) Gb Ta = - 20˚C to +70˚C; IP67
II 2 D Ex tb IIIC (T85˚C, T135˚C, or T450˚C*) Db Ta = - 20˚C to +70˚C; IP67

IECEx (IECEx FMG 12.0010X): Approved
Ex db IIB + H2 (T6, T4, or T1*) Gb Ta = - 20˚C to +70˚C; IP67
Ex tb IIIC (T85˚C or T135˚C*) Db Ta = - 20˚C to +70˚C; IP67**

ATEX and IECEx Standards:

| | | | |
|---|---|---|---|
| EN 60079-0 | EN 60079-31 | IEC 60079-0 | IEC 60079-31 |
| EN 60079-1 | EN 60529 +A1 | IEC 60079-1 | IEC 60529 |

| Model Code | | Temp. Code Marking - Zones (Gas) | | Temp. Code Marking - Zones (Dust) | |
|---|---|---|---|---|---|
| Enclosure | Sensor Type | Main Enclosure | Remote Enclosure | Main Enclosure | Remote Enclosure** |
| E1 | ST | T4 | N/A | 135°C | N/A |
| E2 | ST | T4 | N/A | 135°C | N/A |
| E3 | ST | T6 | T4 | 85°C | 135°C** |
| E4 | ST | T6 | T4 | 85°C | 135°C** |
| E3 | HT | T6 | T1 | 85°C | 450°C** |
| E4 | HT | T6 | T1 | 85°C | 450°C** |

*Temperature code ratings for Zones are dependent on external process temperature factors and equipment enclosure configuration. See the table above for specific temperature code ratings.

**The IECEx dust rating does not apply to the Remote Enclosure.

**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 enclosure.

*Fig. 8.1: Insertion Meter with Retractor Dimensions*
Dimensions shown in inches (millimeters).

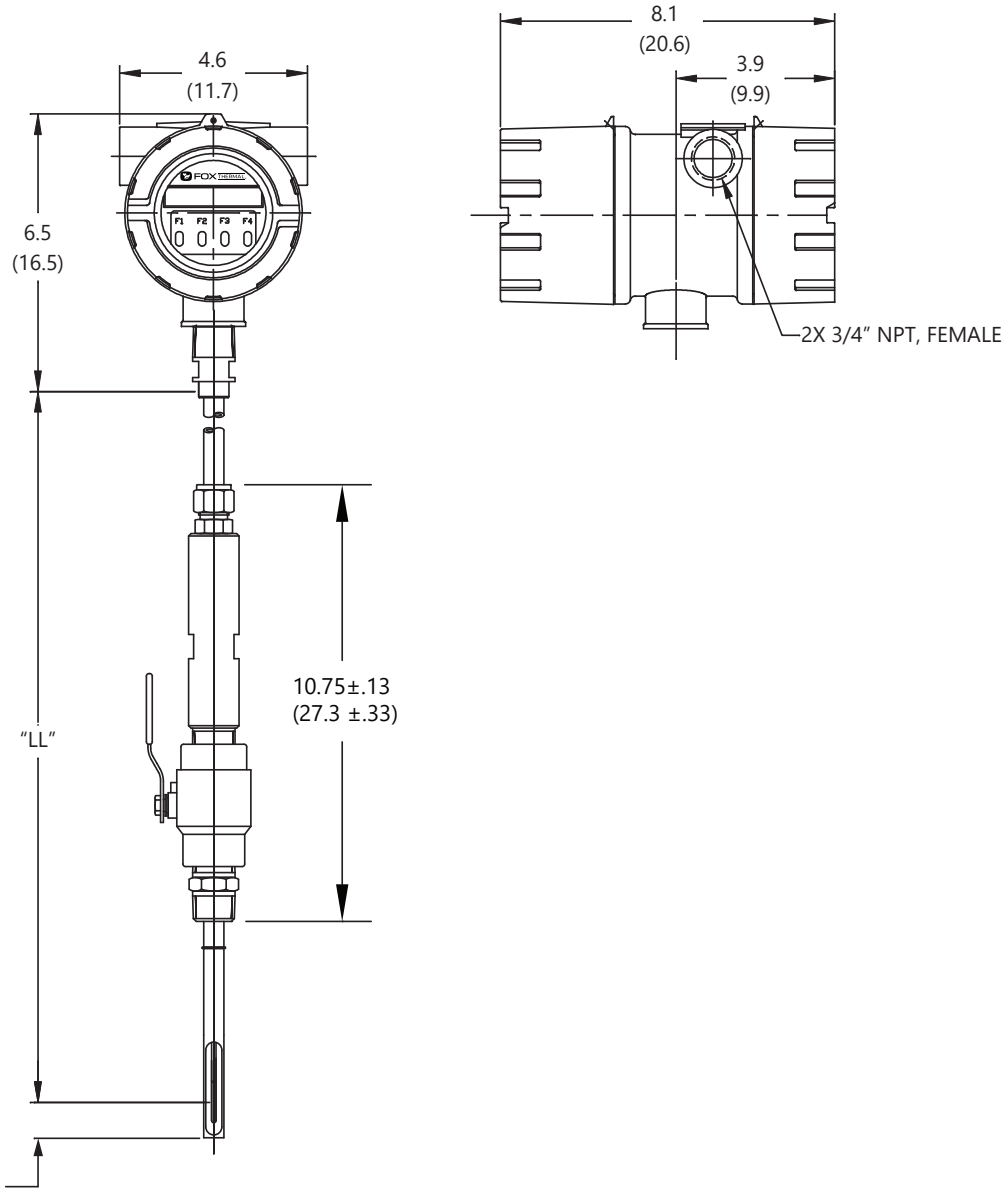



*Table 8.1: Insertion Meter with 316 stainless steel probe*

| **Probe Size** | Probe Size | Dimension "LL" ± .10 |
|---|---|---|
| [model code] | [inches] | [inches / millimeters] |
| 15R | 15" | 15.0" (381mm) |
| 18R | 18" | 18.0" (457mm) |
| 24R | 24" | 24.0" (609mm) |
| 30R | 30" | 30.0" (762mm) |
| 36R | 36" | 36.0" (914mm) |

*Fig. 8.2: Remote Insertion Meter with Retractor Dimensions*

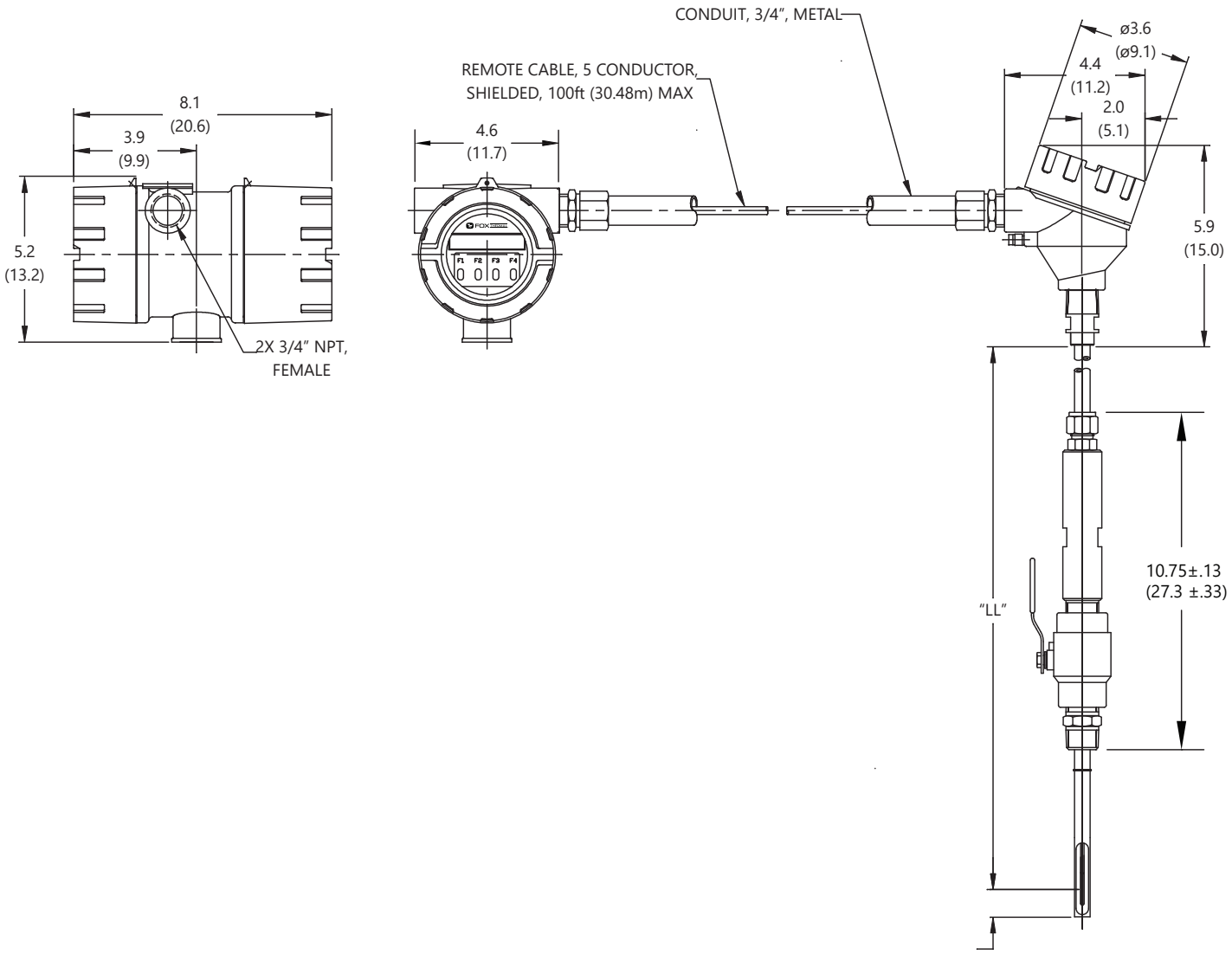



*Table 8.2: Remote Insertion Meter with Retractor*

| Probe Size | Probe Size | Dimension "LL" ± .10 |
|---|---|---|
| [model code] | [inches] | [inches / millimeters] |
| 15R | 15" | 15.0" (381mm) |
| 18R | 18" | 18.0" (457mm) |
| 24R | 24" | 24.0" (609mm) |
| 30R | 30" | 30.0" (762mm) |
| 36R | 36" | 36.0" (914mm) |

*Fig. 8.3: Remote Mounting Kit Dimensions*

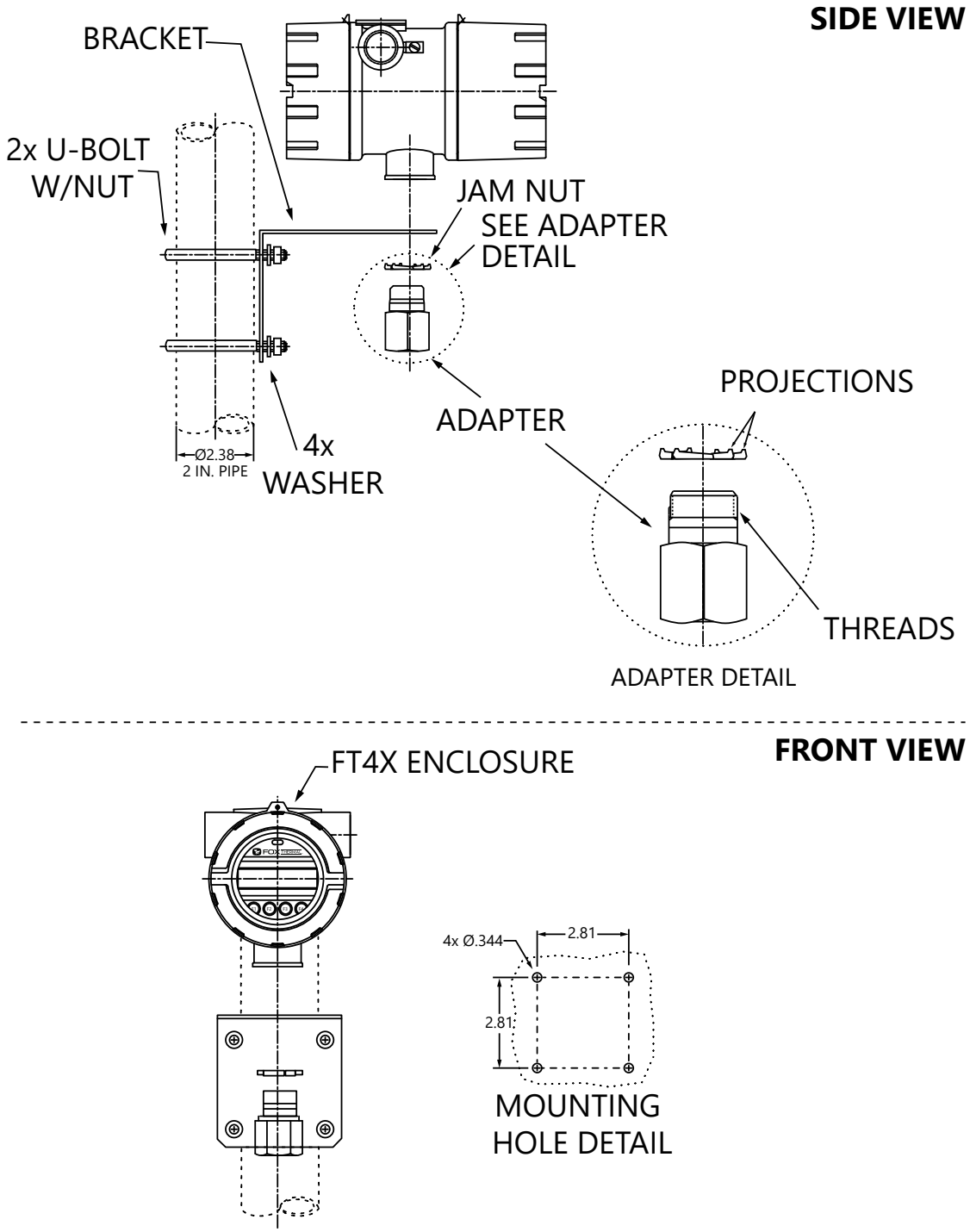


*Fig. 8.4: Insertion Meter Dimensions*

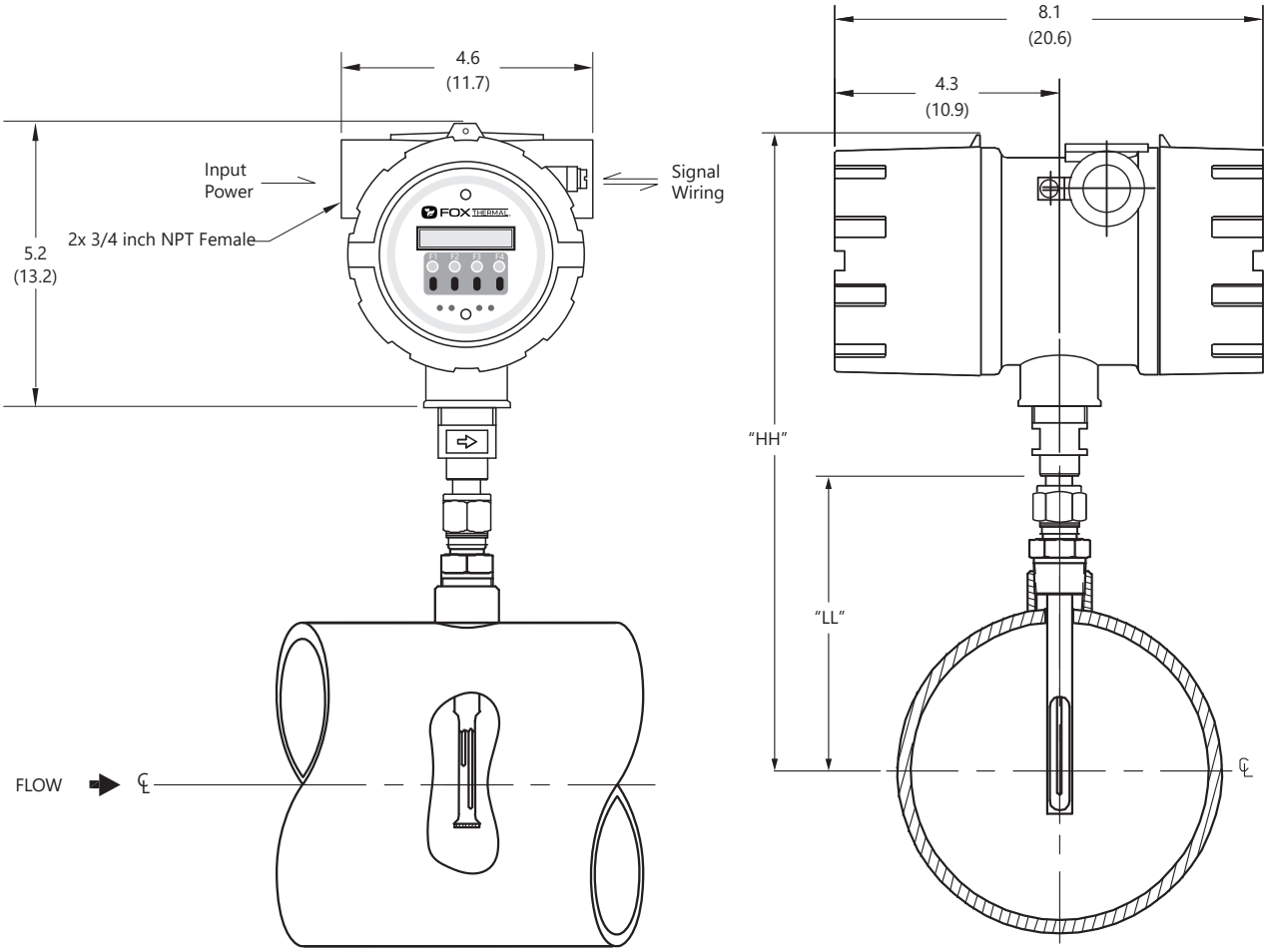



*Table 8.4: Insertion Meter with 316 stainless steel probe*

| Probe Size [model code] | Probe Size [inches] | Dimension "LL" ± .10 [inches / millimeters] | Dimension "HH" ± .10 [inches / millimeters] |
|---|---|---|---|
| 06IE | 6" | 6.0" (152mm) | 12.9" (318mm) |
| 09I | 9" | 9.0" (229mm) | 15.5" (394mm) |
| 12I | 12" | 12.0" (305mm) | 18.5" (470mm) |
| 15I | 15" | 15.0" (381mm) | 21.5" (546mm) |
| 18I | 18" | 18.0" (457mm) | 24.5" (622mm) |
| 24I | 24" | 24.0" (610mm) | 30.5" (775mm) |
| 30I | 30" | 30.0" (762mm) | 36.5" (927mm) |
| 36I | 36" | 36.0" (914mm) | 42.5" (1080mm) |

*Fig 8.5: Insertion Remote Meter Dimensions*

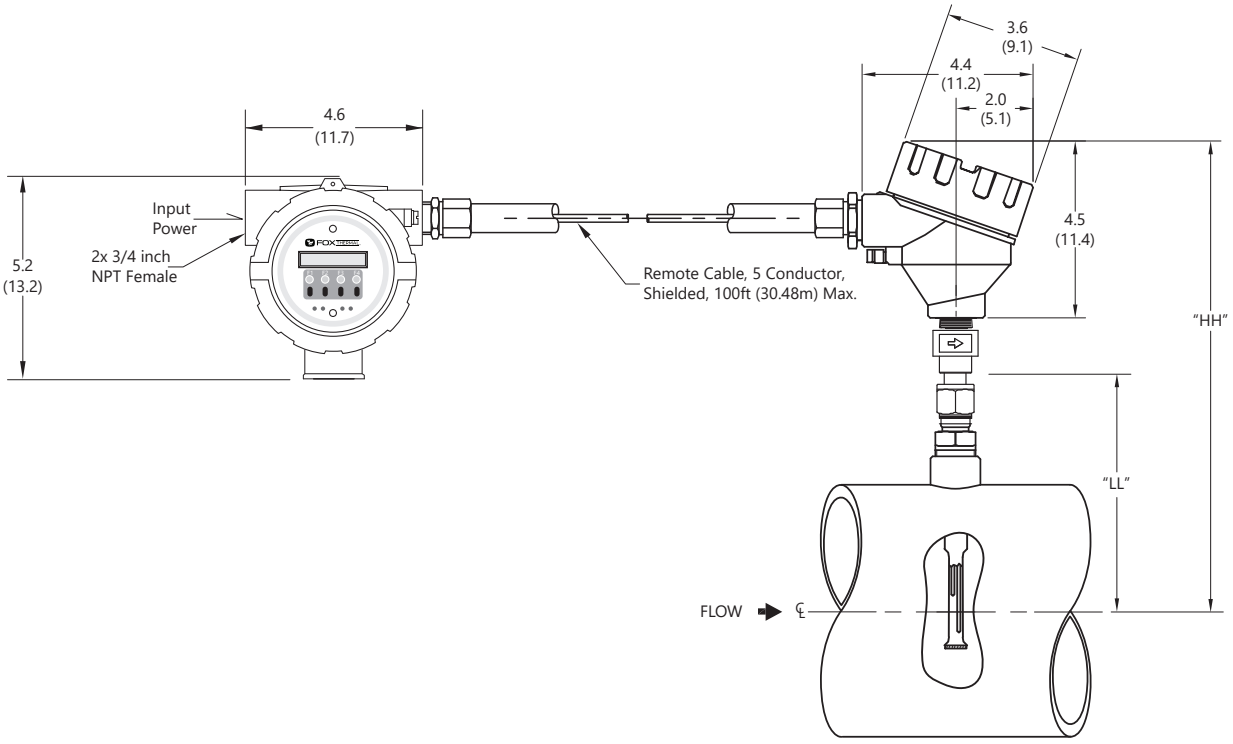



*Table 8.5: Insertion Remote Meter with 316 stainless steel probe*

| Probe Size | Probe Size | Dimension "LL" ± .10 | Dimension "HH" ± .10 |
|---|---|---|---|
| [model code] | [inches] | [inches / millimeters] | [inches / millimeters] |
| 06IE | 6" | 6.0" (152mm) | 11.9" (302mm) |
| 09I | 9" | 9.0" (229mm) | 14.9" (379mm) |
| 12I | 12" | 12.0" (305mm) | 17.9" (455mm) |
| 15I | 15" | 15.0" (381mm) | 20.9" (531mm) |
| 18I | 18" | 18.0" (457mm) | 23.9" (607mm) |
| 24I | 24" | 24.0" (610mm) | 29.9" (760mm) |
| 30I | 30" | 30.0" (762mm) | 35.9" (912mm) |
| 36I | 36" | 36.0" (914mm) | 41.9" (1064mm) |

*Fig. 8.6: Inline Meter with Flow Body and NPT End Connections Dimensions*

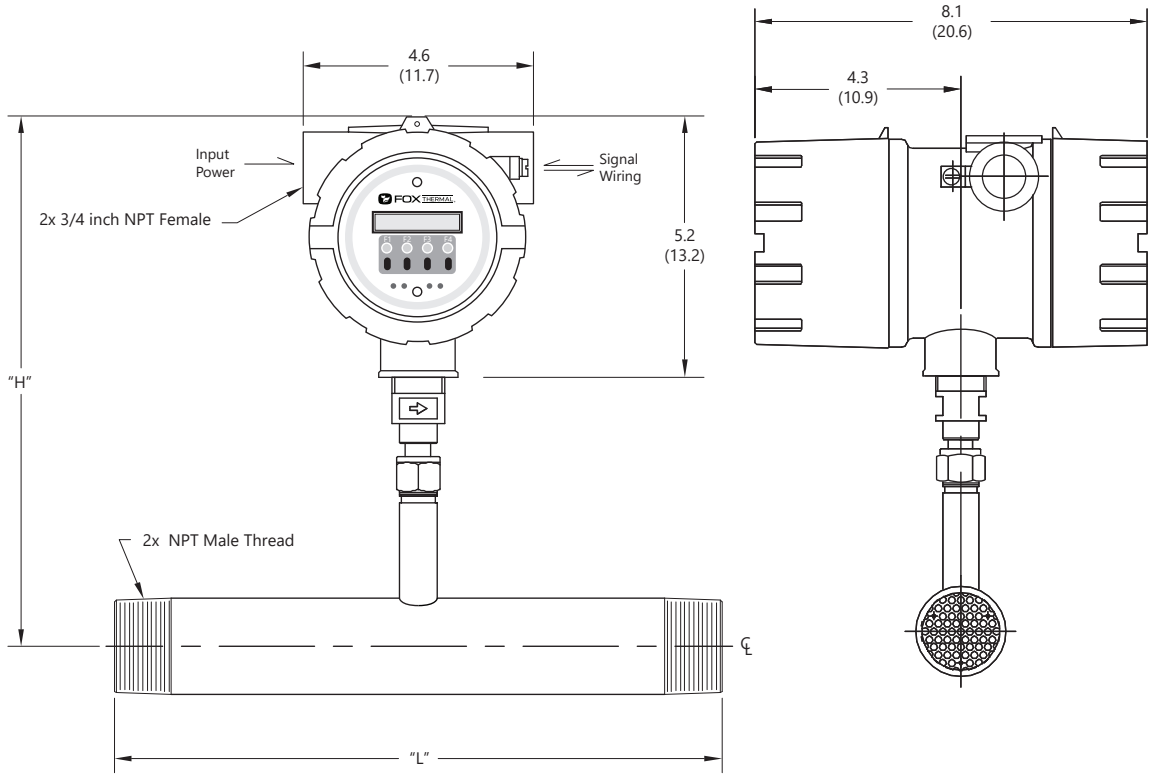



*Table 8.6: Inline Meter with Flow Body and NPT End Connections*

| Body Size | Body Size | Dimension "L" ± .10 | Dimension "H" ± .10 |
|---|---|---|---|
| [model code] | [inches] | [inches] | [inches / millimeters] |
| 05P * | 0.50" | 12" | 10.5" (267mm) |
| 075P * | 0.75" | 12" | 10.5" (267mm) |
| 10P * | 1.00" | 12" | 10.5" (267mm) |
| 125P * | 1.25" | 12" | 10.5" (267mm) |
| 15P * | 1.50" | 12" | 10.5" (267mm) |
| 20P ** | 2.00" | 12" | 10.5" (267mm) |
| 25P ** | 2.25" | 18" | 10.6" (269mm) |
| 30P ** | 3.00" | 18" | 12.5" (318mm) |

**Available in 316 stainless steel only.*
***Available in 316 stainless steel or A106 Grade B Carbon steel pipe.*

*Fig 8.7: Inline Remote Meter with Flow Body and NPT End Connections Dimensions*

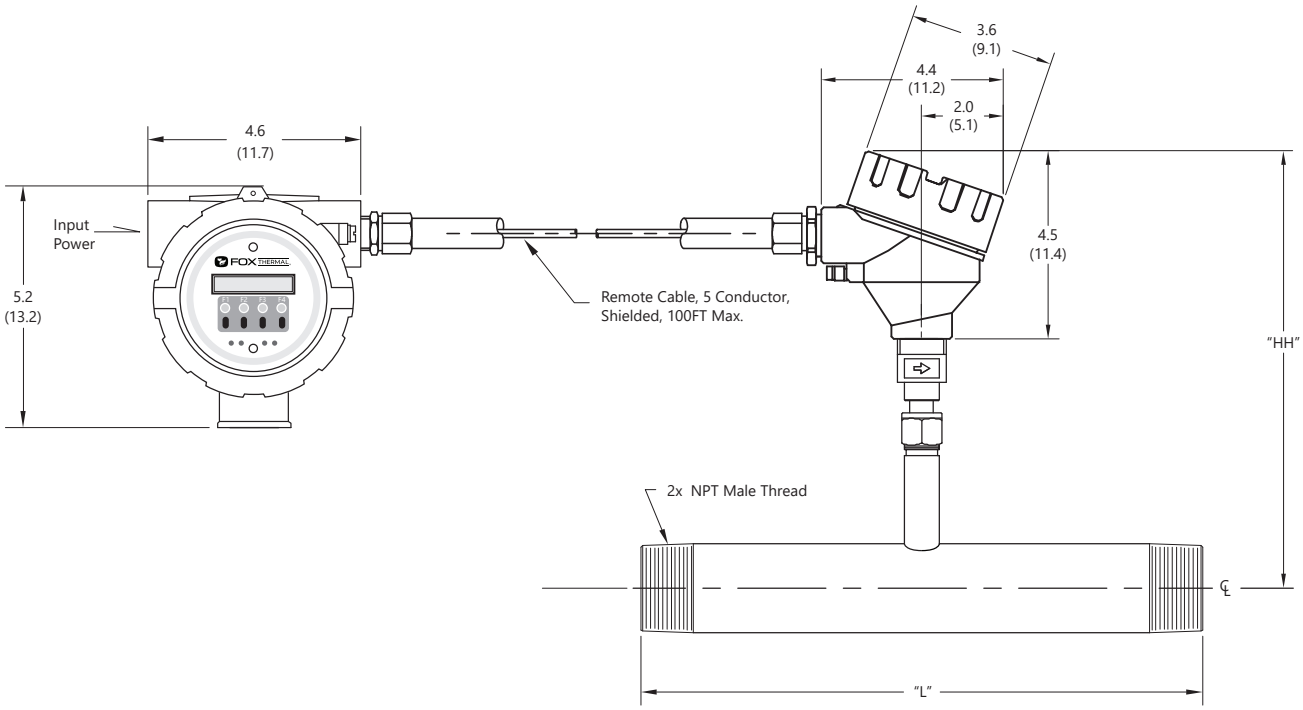



*Table 8.7: Inline Remote Meter with Flow Body and NPT End Connections*

| Body Size | Body Size | Dimension "L" ± .10 | Dimension "HH" ± .10 |
|---|---|---|---|
| [model code] | [inches] | [inches] | [inches / millimeters] |
| 05P * | 0.50" | 12" | 10.5" (267mm) |
| 075P * | 0.75" | 12" | 10.5" (267mm) |
| 10P * | 1.00" | 12" | 10.5" (267mm) |
| 125P * | 1.25" | 12" | 10.5" (267mm) |
| 15P * | 1.50" | 12" | 10.5" (267mm) |
| 20P ** | 2.00" | 12" | 10.5" (267mm) |
| 25P ** | 2.50" | 18" | 10.6" (269mm) |
| 30P ** | 3.00" | 18" | 12.5" (318mm) |

**Available in 316 stainless steel only.*
***Available in 316 stainless steel or A106 Grade B Carbon steel pipe.*

*Fig. 8.8: Inline Meter with Flow Body and 150 lb. RF Flange End Connections Dimensions*

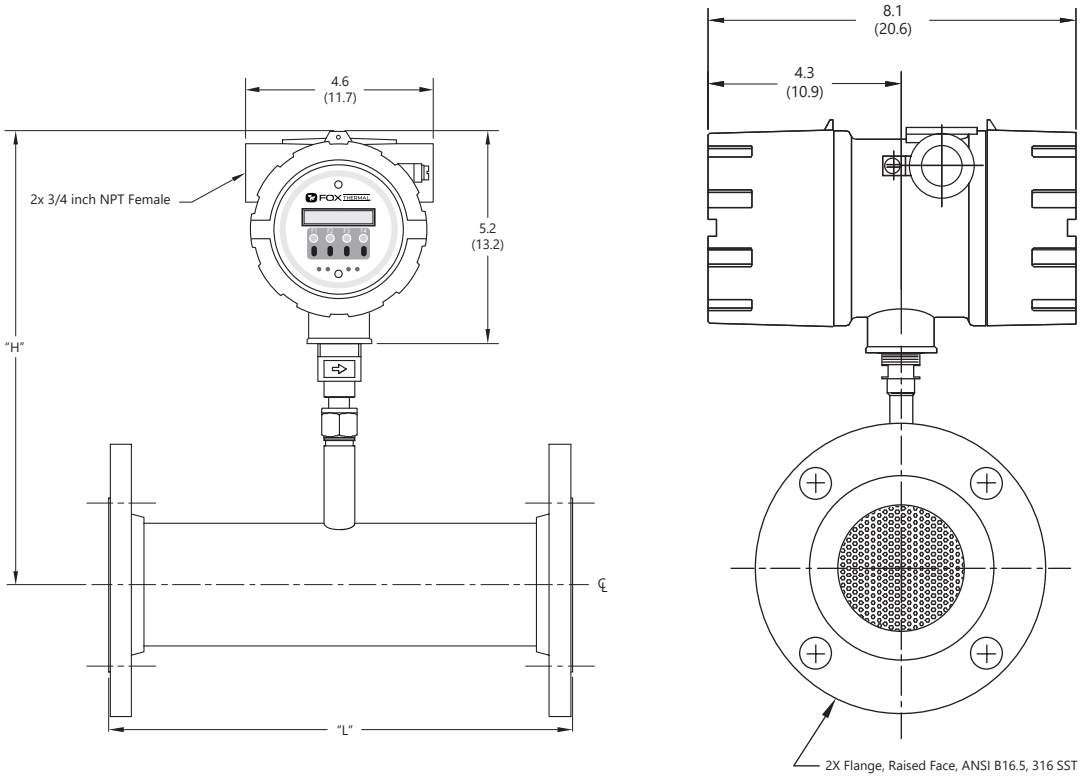



*Table 8.8: Inline Meter with Flow Body and 150 lb. RF Flange End Connections Dimensions*

| Body Size | Body Size | Dimension "L" ± .10 | Dimension "H" ± .10 |
|---|---|---|---|
| [model code] | [inches] | [inches] | [inches / millimeters] |
| 05F * | 0.50" | 12" | 10.5" (267mm) |
| 075F * | 0.75" | 12" | 10.5" (267mm) |
| 10F * | 1.00" | 12" | 10.5" (267mm) |
| 125F * | 1.25" | 12" | 10.5" (267mm) |
| 15F * | 1.50" | 12" | 10.5" (267mm) |
| 20F ** | 2.00" | 12" | 10.5" (267mm) |
| 25F ** | 2.50" | 18" | 10.6" (269mm) |
| 30F ** | 3.00" | 18" | 12.5" (318mm) |
| 40F ** | 4.00" | 18" | 12.5" (318mm) |
| 60F ** | 6.00" | 24" | 12.5" (318mm) |

**Available in 316 stainless steel only.*
***Available in 316 stainless steel or A106 Grade B Carbon steel pipe.*

*Fig 8.9: Inline Remote Meter with Flow Body and 150 lb. RF Flange End Connections Dimensions*

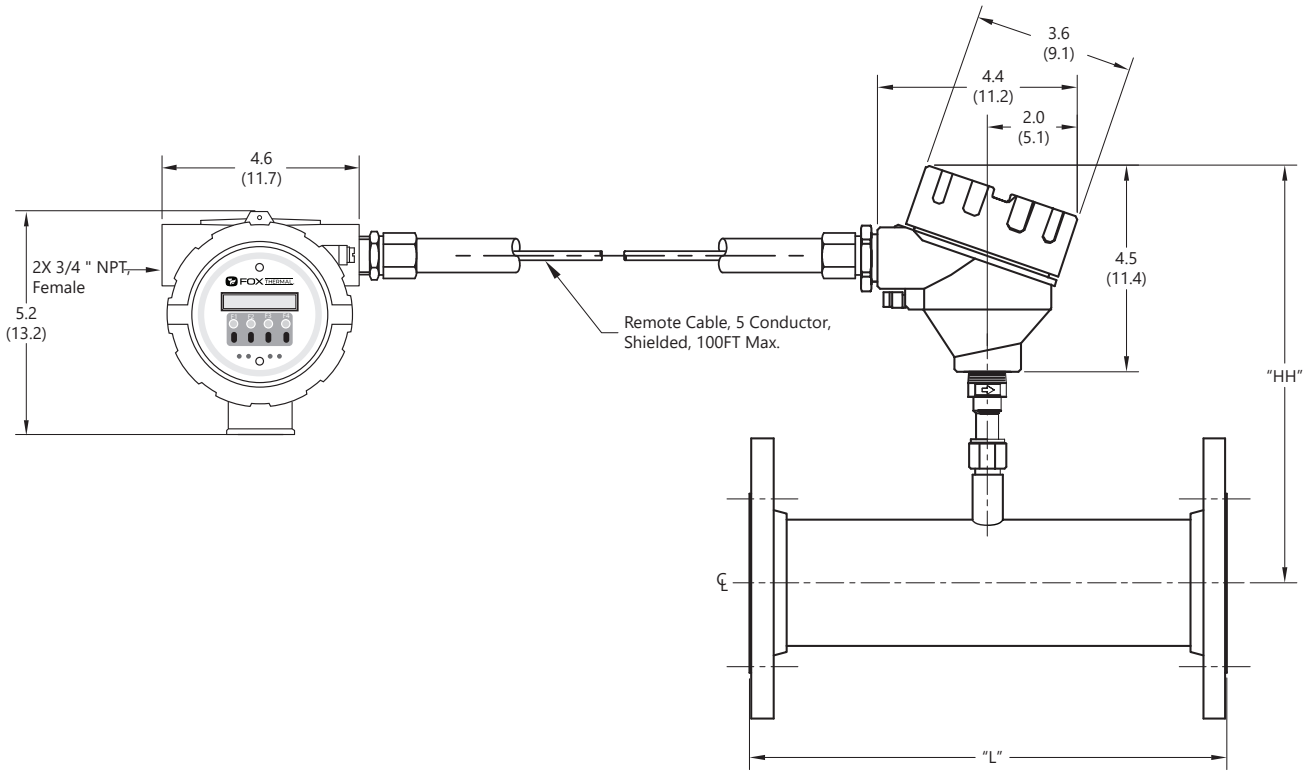



*Table 8.9: Inline Remote Meter with Flow Body and 150 lb. RF Flange End Connections Dimensions*

| Body Size [model code] | Body Size [inches] | Dimension "L" ± .10 [inches] | Dimension "HH" ± .10 [inches / millimeters] |
|---|---|---|---|
| 05F * | 0.50" | 12" | 10.5" (267mm) |
| 075F * | 0.75" | 12" | 10.5" (267mm) |
| 10F * | 1.00" | 12" | 10.5" (267mm) |
| 125F * | 1.25" | 12" | 10.5" (267mm) |
| 15F * | 1.50" | 12" | 10.5" (267mm) |
| 20F ** | 2.00" | 12" | 10.5" (267mm) |
| 25F ** | 2.50" | 18" | 10.6" (269mm) |
| 30F ** | 3.00" | 18" | 12.5" (318mm) |
| 40F ** | 4.00" | 18" | 12.5" (318mm) |
| 60F ** | 6.00" | 24" | 12.5" (318mm) |

**Available in 316 stainless steel only.*
***Available in 316 stainless steel or A106 Grade B Carbon steel pipe.*

## Warranty Statement and Terms and Conditions

### Limited Warranty - All Products

Fox Thermal warrants that for a period of one year following the date of original shipment of Fox's products that the product will conform to Fox's standard written specifications applicable to such product and will be free from defects in workmanship. For more details, view the Limited Warranty section in the Terms and Conditions of Sale. Find that document at this link:

**https://www.foxthermal.com/pdf/terms-and-conditions.pdf**

### Consumable and Fragile Material Warranty

Fox warrants that consumable materials, supplied by Fox either as part of an instrument or system, or separately, will be free from defects in material and workmanship at the time of shipment. A list of key consumables and expected lifetimes may be found in the applicable Seller equipment operation and maintenance manual.

### Terms and Conditions of Sale

For more details about Fox's warranty statement and exclusions, please download the Terms and Conditions of Sale document. Find that document at this link:

https://www.foxthermal.com/pdf/terms-and-conditions.pdf

**Returning Your Meter**
The Fox Thermal Customer Service Department
(PH: 831-384-4300 or service@foxthermal.com) can help you through the process of returning a meter for service.

If it becomes necessary to return a Fox Thermal flow meter for service or recalibration, please follow these steps:

1. A Return Material Authorization (RMA) Number must be obtained from the Fox Thermal Customer Service Department prior to returning any Fox Thermal meter(s).
2. Please have your meter's serial number(s) available.
3. Read and complete the Fox Thermal RMA Customer Information Form. Be sure to initial the decontamination statement as well as provide complete return shipping instructions (we cannot deliver to post office boxes).
4. The entire flow meter must be returned, including all electronics (unless specifically instructed to do otherwise). **ALL** serial numbers must match their corresponding meters. This is especially necessary when returning flow body models.
5. Clean and decontaminate all wetted parts before returning to Fox Thermal.
6. Ship the meter to the following address:

   Fox Thermal Instruments, Inc.
   399 Reservation Road
   Marina, CA 93933
   Attn: Service Dept.
   [RMA Number]

**NOTE!** Be sure to review all of the information on the Customer Information Form before sending your meter to the Fox Thermal Customer Service Department. The Fox Thermal Shipping/Receiving Department cannot accept meters that have not been prepared appropriately.

**What to expect while your meter is being serviced**
Depending on the type of service required when returning your Fox Thermal meter, there are varying turnover times for servicing a meter. The average time needed to service the meter is 7-10 days (not including shipping or peak production times).

If you have already shipped your meter to Fox Thermal for servicing and would like to check the status of your meter, please fill out our online Service Order Status form located at www.foxthermal.com and you will hear from a Customer Service Rep within 1 business day of your requested update.

Rush recalibration service is available for a fee. Restrictions apply.

## Glossary of Terms and Definitions

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

## Index

**Wiring**

**Troubleshooting Tips**

**Definition of Terms**

**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.**

CE

**Indicates compliance with the applicable European Union Directives for Safety LVD (Low Voltage Directive), EMC (Electromagnetic Compatibility Directive), and PED (Pressure Equipment Directive).**

IP67

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

FOX® THERMAL

Make Downtime a Thing of the Past

**THERMAL MASS FLOW METERS**
**NON-STOP PERFORMACNE**

SALES@FOXTHERMAL.COM

**Address**
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Marina, CA 93933 USA

**Phone**
831.384.4300

**Worldwide**
foxthermal.com