Precision Flow
Insertion Mass Flow Meter

Instruction Manual

BULLETIN F-41-PFS

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Warnings and Cautions

Warning! Agency approval for hazardous location installations varies between flow meter models. Consult the factory for specific flow meter approvals before any hazardous location installation. For explosion proof installations, you must use solid metal conduit and follow NFPA (or your local code) approved wiring methods.

Warning! All flow meter connections and fittings for pipe tapping must have the same or higher pressure rating as the main pipeline.

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

Warning! All wiring procedures must be performed with the power Off.

Warning! To avoid potential electric shock, follow National Electric Code safety practices or your local regulations when wiring this unit to a power source and to peripheral devices. Failure to do so could result in injury or death.

Warning! Do not power the flow meter with the sensor jumper wires disconnected. This could cause over-heating of the sensors and/or damage to the electronics.

Warning! Before attempting any flow meter repair, verify that the line is depressurized.

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

Caution! Before making adjustments to the Smart Electronics device, verify the flow meter is not actively monitoring or reporting to any master control system. Adjustments to the electronics will cause direct changes to flow control settings.

Caution! Adjusting zero or span will affect meter calibration.

Caution! Printed circuit boards are sensitive to electrostatic discharge. To avoid damaging the board, follow these precautions to minimize the risk of damage:

- before handling the assembly, discharge your body by touching a grounded, metal object
- handle all cards by their edges unless otherwise required
- when possible, use grounded electrostatic discharge wrist straps when handling sensitive components

Chapter 1 Introduction

Series PFS Smart Air Velocity Transmitter

Dwyer's Series PFS Smart Mass Flow Meter provides a reliable solution for inert gas flow measurement applications. The meter's thin-film sensor offers long-term reliability and fast 100 millisecond response to changes in flow rate. The instrument's Smart electronics provides outstanding diagnostic and field-adjustment capabilities.

The versatile microprocessor-based transmitter integrates the functions of flow-range adjustment, meter validation and diagnostics in a probe-mounted NEMA 4X (IP65) housing. Mass flow rate and totalized flow, as well as other configuration variables are displayed on the meter's optional 2 x 12 LCD display. The meter provides an optical/galvanic isolated flow output, two alarm outputs and one contact input for range or gas selection. The programmable transmitter is easily configured via RS-232 and Dwyer's Smart Interface software or through three push buttons built into the device.

The Series PFS is suitable for pipes or ducts from one inch up to 48 inches (DN50 up to DN1200). The Series PFS Mass Flow Meter's simple installation combines with an easy-to-use interface that provides quick set up, long term reliability and accurate mass flow measurement over a wide range of conditions.

Using This Manual

This manual provides information needed to install and operate the Series PFS Smart Insertion Mass Flow Meter. The four chapters of this manual cover these areas:

- Chapter 1 includes the introduction and product description
- Chapter 2 provides installation and wiring instructions
- Chapter 3 describes system operation and programming
- Chapter 4 covers troubleshooting and repair

The product specifications are found in Appendix A.

Note and Safety Information

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

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

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

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

Receipt of System Components

When receiving a Dwyer mass flow meter, carefully check the outside packing carton for damage incurred in shipment. If the carton is damaged, notify the local carrier and submit a report to the factory or distributor. Remove the packing slip and check that all ordered components are present. Make sure any spare parts or accessories are not discarded with the packing material. Do not return any equipment to the factory without a Return Material Authorization (RMA, see Chapter 4).

Technical Assistance

If you encounter a problem with your flow meter, review the configuration information for each step of the installation, operation and setup procedures. Verify that your settings and adjustments are consistent with factory recommendations. Refer to Chapter 4, Troubleshooting, for specific information and recommendations.

If the problem persists after following the troubleshooting procedure outlined in Chapter 4, contact Dwyer Instruments by fax or by E-mail (see cover). For urgent phone support you may call (800) 879-8000 or (219) 879-8868 between 8:00 a.m. and 5:00 p.m. CST. When contacti ng Technical Support, make sure to include this information:

- the model number, the flow range, and purchase order number
- the software version (visible at start up)
- the problem you are encountering and any corrective action taken

The Series PFS Flow Sensing Principle

Dwyer's thin-film sensor consists of two sensing elements- a velocity sensor and a temperature sensor that automatically corrects for changes in gas temperature. The transducer electronics heats the velocity sensor to a constant temperature differential above the gas temperature and measures the cooling effect of the gas flow. The electrical power required to maintain a constant temperature differential is directly proportional to the gas mass flow rate.

The fast-response sensor is located at the tip of a 0.375 inch (3/8″) diameter, 304 stainless steel probe. The Smart electronics are packaged in a weather-proof NEMA 4X (IP65) enclosure mounted either directly on the sensing probe or remotely up to 100 feet away.

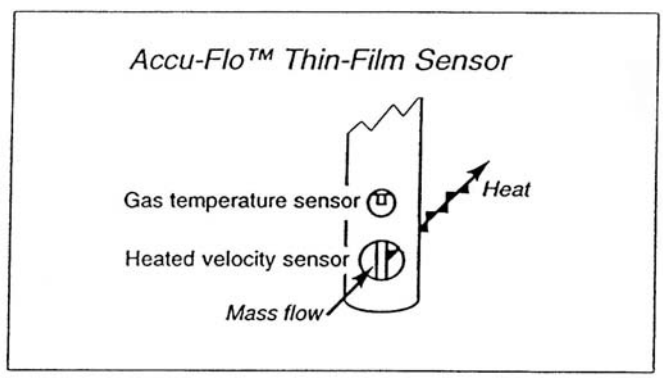


Figure 1-1. Series PFS Sensor Assembly

Smart Electronics Features

Instrument Validation

Two simple tests offer full "field-validation" of your Smart mass flow meter. The first test checks the system electronics, linearization and microprocessor functionality and is performed by injecting a known input value and confirming that the flow meter outputs the expected value. The second test verifies that the instrument's primary sensing elements have not drifted or shifting from their original calibration and is accomplished by measuring the resistance of the velocity and temperature sensors and comparing the results to the NIST-traceable calibration data provided with the flow meter. Together, these tests confirm that your meter is working correcting and the calibration variables did not drift, shift or change values.

Dual Range or Dual Gas Calibration (Optional)

Select one of two factory calibrated flow ranges using a simple external customer-supplied single contact closure.

User Full Scale Flow Rate

Field-configure from 50% to 100% of the factory full scale setting (factory full scale is normally set to 125% of the user-specified maximum flow rate). This adjustment can be made for each flow range.

Alarms

Program high and low or window alarm limits independently for each flow range. The solid state contacts are isolated with one common.

K-Factor Correction

Change the calibration correction factor to compensate for flow profile disturbances or specific application conditions. The K-factor is a multiplication factor applied to the linearized flow signal. You may set the K-factor individually for each flow range.

Dual Output Signals

Smart flow meters offer two separate linear output signals proportional to flow, 0-5 VDC (0-10 VDC optional) and 4-20 mA. The 4-20 mA output can be field-configured as an active loop powered by the flow meter or an optically isolated passive loop requiring an external power supply.

Totalizer
With the optional LCD display, actual mass flow appears on line 1 and the totalized flow on line 2 both in the user-specified engineering units. The totalizer counts only the selected range and when ranges are switched, the value of the non-selected range is stored in memory. You may reset the totalizer using the membrane buttons or by using a handheld magnet.

Zero and Span Outputs
Validate and adjust the settings to ensure output circuits are correct.

Time Response Delay
Select from a low response for faster tracking to a high response for a smoother output.

Enclosure Options
Flow meter electronics are available mounted directly to the flow body, or remotely mounted up to 100 feet away. The electronics housing may be used indoors or out, including wet environments.

Display options include a 2 x 12 character LCD display of mass flow rate including totalized mass, or a single-digit LED located on the device printed circuit board. Local operation and reconfiguration is accomplished using the three push buttons operated via finger touch. Smart electronics include nonvolatile memory that stores all configuration information. The memory allows the flow meter to function immediately upon power up, or after an interruption in power.

Smart Interface™ Software
Dwyer's Smart Interface Windows™-based software is available for connecting your PC directly to the mass flow meter. An RS-232 serial cable along with floppy disks containing the program and system files are available from the factory. See the Smart Interface User Guide included with the software for operating instructions. (Order code for this package is PFS60.)

Chapter 2 Installation

Installation Overview
Installing the Series PFS Air Velocity Transmitter is simple and straightforward. Install the flow meter at a location with a consistent flow profile that meets the recommended piping requirements. Locate the sensor head at the pipe's centerline. The flow meter is factory calibrated to the specific pipe size shown on the meter's Certificate of Calibration. This eliminates calculating the average flow across the pipe to determine the correct insertion depth. (If the pipe size differs from the meter's calibrated size, return the meter to the factory for re-calibration.)

Warning! Agency approval for hazardous location installations varies between flow meter models. Consult the factory for specific flow meter approvals before any hazardous location installation.

Site Selection
Before installing the flow meter, verify the installation site allows for these considerations.

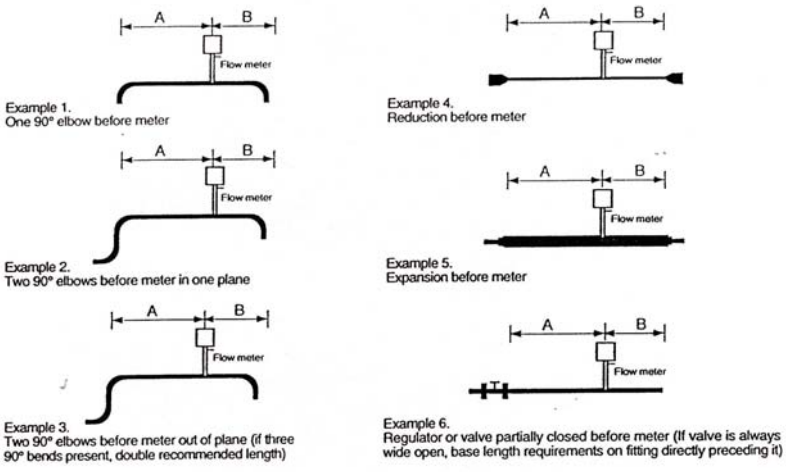
1. Line pressure and temperature does not exceed the flow meter rating. Temperature should not vary more than 200°F (100°C) around the calibration temperature. Line pressure should not vary more than 50 psi (3.4 bar) around the calibrated pressure.
2. The location meets the required minimum number of pipe diameters upstream and downstream of the sensor head. (see Figure 2-1 for piping requirements).
3. Safe and convenient access with adequate overhead clearance. Also, verify the meter is located where the gas is clean and dry.
4. For remote installations, verify the supplied cable length is sufficient to connect the flow meter sensor to the remote electronics. (Do not extend or shorten the supplied cable between the probe and the electronics.)

Also, before installation check your flow system for anomalies such as:

- leaks
- valves or restrictions in the flow path that could create disturbances in the flow profile that might cause unexpected flow rate indications
- heaters that might cause rapid excursions in the measured temperature

Unobstructed Flow Requirements

Select an installation site that will minimize possible distortion in the flow profile. Valves, elbows, control valves and other piping components may cause flow disturbances. Check your specific piping condition against the examples shown below. In order to achieve accurate and repeatable performance install the flow meter using the recommended number of straight run pipe diameters upstream and downstream of the sensor.



Example	A Upstream[1] Requirements	B Downstream[2] Requirements
1	10 D	5 D
2	15 D	5 D
3	25 D	10 D
4	10 D	5 D
5	20 D	5 D
6	25 D	10 D

(1) Number of diameters (D) of straight pipe required between upstream disturbance and the flow meter.
(2) Number of diameters (D) of straight pipe required downstream of the flow meter.

Figure 2-1. Recommended Pipe Length Requirements for Installation

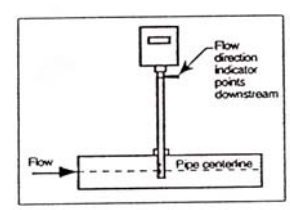
Installation

Use the following data as a guide to prepare the pipe for flow meter insertion. Refer to a standard code for all pipe tapping operations. The following instructions are general in nature and intended for guideline purposes only.

1. Turn off the flow of process gas. Verify that the line is not pressurized.
2. Confirm that the installation site meets the minimum upstream and downstream pipe diameter requirements. See Figure 2-1.
3. Use a cutting torch or sharp cutting tool to tap into the pipe. The pipe opening must be at least .375 inches in diameter. (Do not attempt to insert the sensor probe through a smaller hole.)
4. Remove all burrs from the tap. Rough edges may cause flow profile distortions that could affect flow meter accuracy. Also, obstructions could damage the sensor assembly when inserting into the pipe.
5. Mount the 3/8 inch compression fitting on the pipe. Make sure this connection is within ±5° perpendicular to the pipe centerline.

Warning! All flow meter connections and fittings must have the same or higher pressure rating as the main pipeline.

6. When installed, cap the fitting. Run a static pressure check on the connection. If pressure loss or leaks are detected, repair the connection and re-test.
7. Insert the sensor probe through the compression fitting into the pipe. The correct insertion depth places the larger hole in the probe at the pipe's centerline. Do not force into the pipe.



8. Align the sensor head using the flow direction indicator. Adjust the indicator parallel to the pipe and pointing downstream in the direction of flow.
9. Tighten the compression fitting to lock the flow meter in position. When the compression fitting is tightened, the position is permanent (unless using Teflon ferrules).

Warning! To avoid serious injury, DO NOT loosen the compression fitting under pressure.

Enclosure Options

The NEMA 4X enclosure contains an integral wiring compartment with one dual strip terminal block for power and signal connections and one dual strip terminal block for sensor connections. The enclosure has one 1/2 inch female NPT conduit entry. The terminal designations are labeled inside the enclosure cover.

Warning! All wiring procedures must be performed with the power Off.

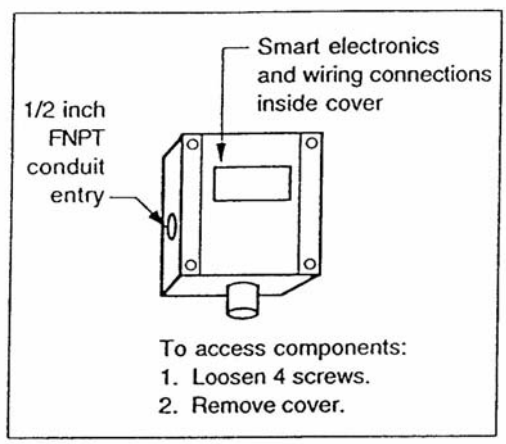


Figure 2-2. Wiring Access

Enclosure Options

Depending on the flow meter configuration, connect 11 to 18 VDC or 18 to 30 VDC (625 mA load, maximum) to the terminals marked PWR+, PWR-. Confirm power configuration before applying power. See the flow meter nameplate for input power rating.

Warning! To avoid potential electric shock, follow National Electric Code safety practices or your local code when wiring this unit to a power source and to peripheral devices.

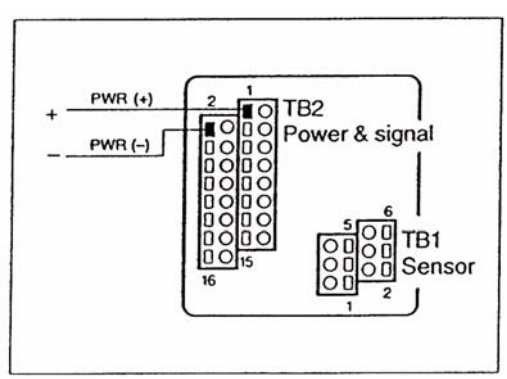


Figure 2-3. Input Power Connections

Output Signal Wiring

All flow meters are equipped with either a calibrated 0-5 VDC (0-10 VDC optional) or a calibrated 4-20 mA output signal. These linear output signals represent 0-100% of the flow meter user full scale.

DC Output Wiring

The 0-5 VDC (0-10 VDC optional) signal can drive a load of 1000 Ohms. The optional 0-10 VDC output signal is not available for power sources below 15 VDC. Depending on the flow meter configuration, connect 0-5 VDC or 0-10 VDC to the terminals marked Vout (+) and Vout (-).

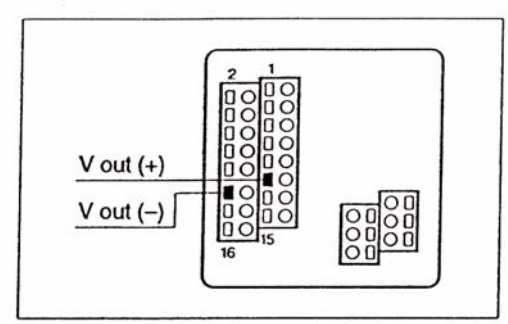


Figure 2-4. VDC Output Wiring Connections

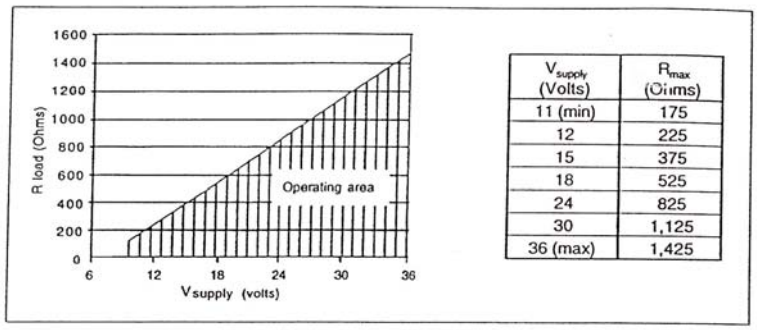
4-20 mA Output Wiring

The 4-20 mA current loop output can be self-powered by the flow meter's power supply (non-isolated) or externally powered (isolated) requiring a separate 12 to 36 VDC power supply. The maximum loop resistance (load) for both types of current loop outputs are dependent upon the supply voltage and are given in Figure 2-5.

R_{load} is the total resistance in the loop, including the wiring resistance. To calculate R_{max}, the maximum R_{load} for the loop, use the maximum loop current, 20 mA. The voltage drop in the loop due to resistance is 20 mA times R_{load} and this drop is subtracted from the input voltage. Thus:

R_{max} the maximum load resistance = 50 x (V_{supply} - 7.5V)

To use an external power supply for an isolated 4-20 mA output, connect as shown in Figure 2-6. For an internally powered non-isolated 4-20 mA output, connect as shown in Figure 2-7.



V_{supply} (Volts)	R_{max} (Ohms)
11 (min)	175
12	225
15	375
18	525
24	825
30	1,125
36 (max)	1,425

Figure 2-5. Load Resistance Versus Input Voltage

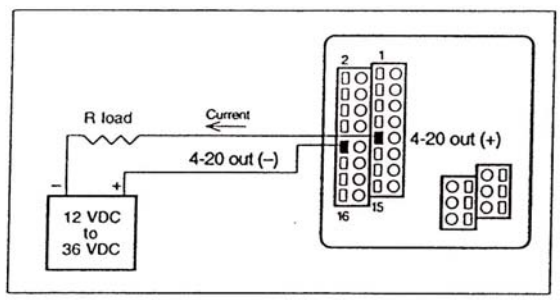


Figure 2-6. Isolated 4-20 mA Current Loop Connections

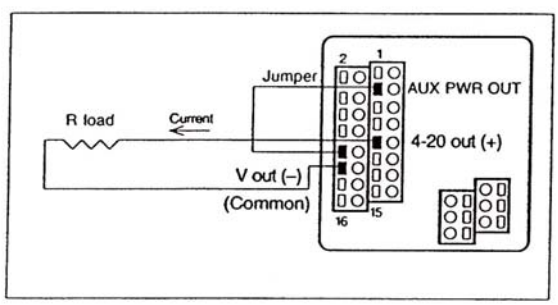


Figure 2-7. Non-isolated 4-20 mA Current Loop Connections

Alarm Output Wiring

Two alarm outputs (Low Alarm and High Alarm) are included on the flow meter terminal block. The alarm outputs relays are normally-open-single-pole-relays with a common ground.

There are two connection options for alarm outputs-the first with a separate power supply (isolated) and the second using the flow meter power supply (non-isolated). Use a separate power supply if a specific voltage is needed for the alarm output. Use the second (non-isolated) configuration if the voltage at the flow meter's power supply is an acceptable driver voltage for the load connected. (Take into account that the current used by your alarm loads have to come from the flow meter's power supply.) In either case, the voltage of the alarm output is the same as the voltage supplied to the circuit.

To use an external power supply for an isolated alarm output, connect as shown in Figure 2-8. To use the internally powered, non-isolated alarm output connect as shown in Figure 2-9. For a window alarm connect both outputs together.

Warning! Before operation, verify that the voltage and current do not exceed the flow meter's contact specifications.

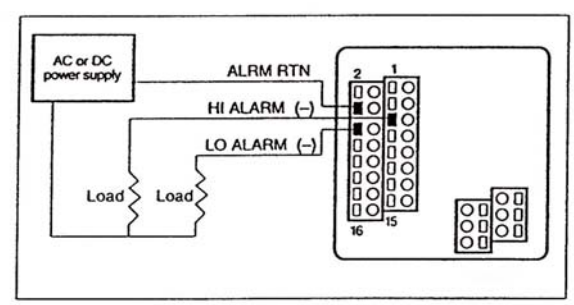


Figure 2-8. Isolated Alarm Output Connections

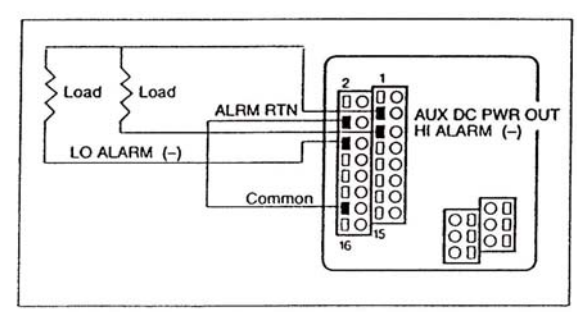


Figure 2-9. Non-isolated Alarm Output Connections

Remote Sensor Probe Wiring

Use only factory supplied cables when connecting the sensor probe to a remotely mounted flow meter enclosure. The electronics, sensors and interconnecting cables supplied by Sierra Instruments are calibrated as a complete precision air velocity transmitter circuit. Changing the length of cables or interchanging sensors or sensor wiring will affect the accuracy of the flow meter. You cannot add or subtract wire length without returning the meter to the factory for recalibration. To connect the sensor probe to a remotely mounted electronics enclosure, see Figure 2-10. To make wiring connections from a sensor probe junction box to a remotely mounted enclosure, see Figure 2-11.

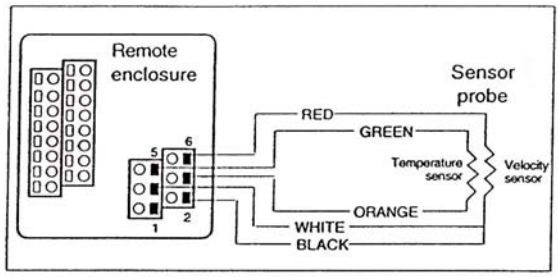


Figure 2-10. Remote Electronics Enclosure to Sensor Connections

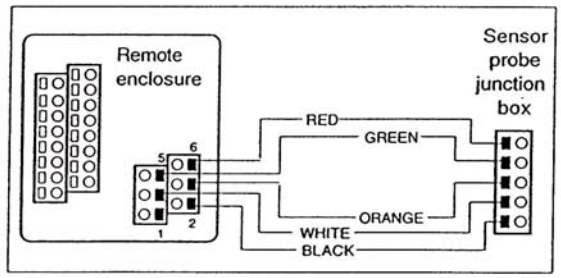


Figure 2-11. Sensor Junction Box to Remote Enclosure Connections

Range Selection Wiring

If your meter is equipped with an optional second range calibration, connect a contact switch as shown below. When the switch is closed the device changes to Range 2. Open the switch to return to Range 1.

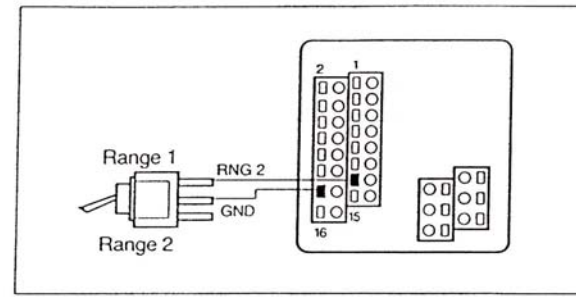


Figure 2-12. Range Selection Wiring

Chapter 3 Operation

Using the Smart Electronics Basic Features

Three push buttons allow selection and adjustment of the basic user functions. Use the push buttons to enter alarm parameters, change the user full scale, adjust the K-factor, adjust the time response speed or reset the totalizer. You may view parameters using the optional LCD front panel display or by selecting functions on the single-digit LED and viewing the 0-5 VDC output with a digital voltmeter (DVM).

Before making any changes or adjustments, press the FUNCTION key to view and record the factory settings. When pressing FUNCTION the optional LCD display prompts for a password. If you only want to view the parameters, press FUNCTION again skipping the password. If you want to make changes, at the password prompt, press the UP arrow until 11 is displayed. Press FUNCTION to continue.

When entering new parameters, the Smart electronics will return to the Run Mode after 12 seconds of no activity with the new settings immediately in effect. When using the single-digit LED for programming, if the unit "times-out" press FUNCTION again to resume adjustments (only on units without a LCD front panel display).

Caution! Before making any adjustment to the Smart electronics device, verify the flow meter is not actively monitoring or reporting to any master control system. Any adjustment to the electronics will cause direct changes to flow control settings.

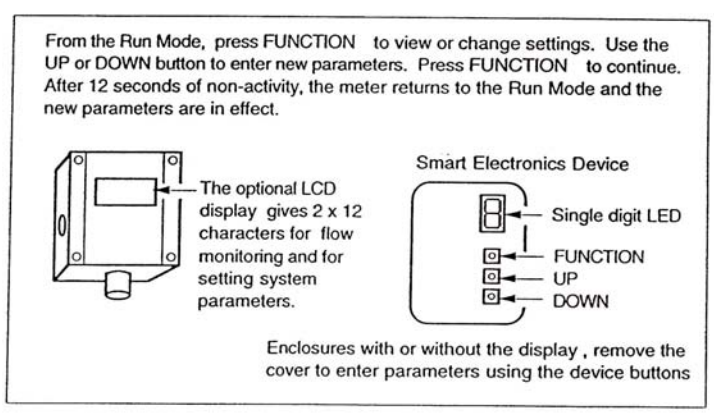
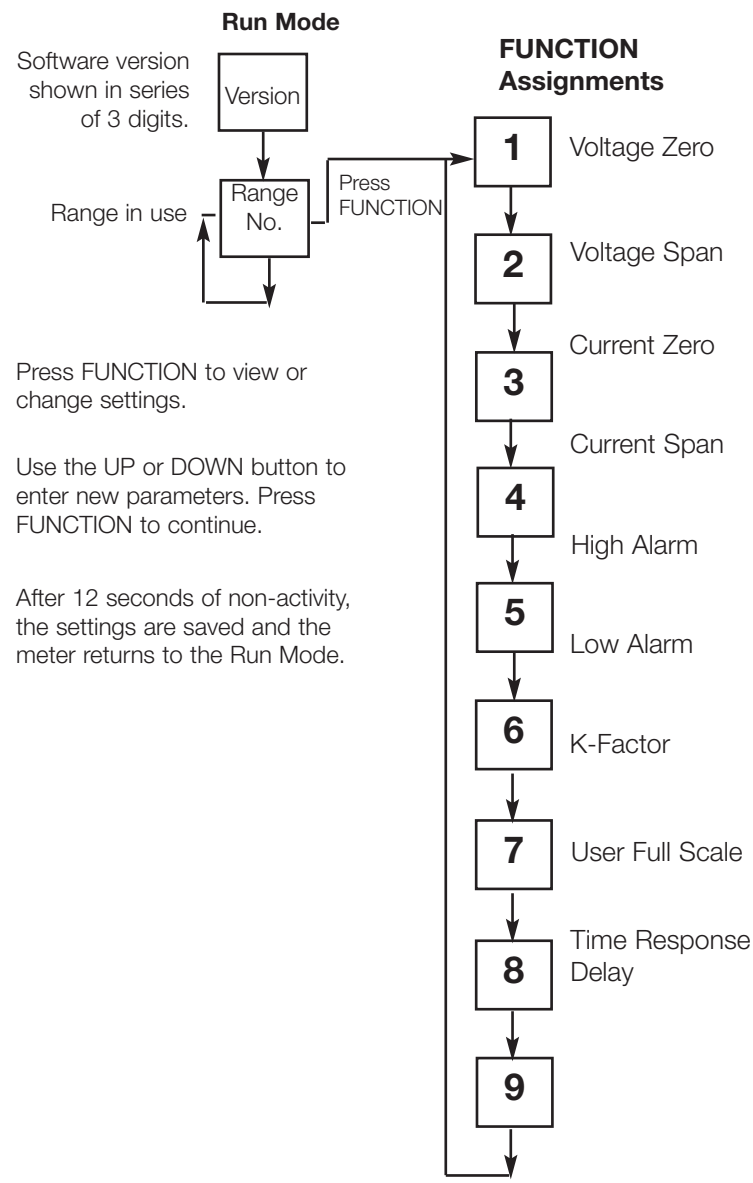


Figure 3-1. Display/Keypad Commands

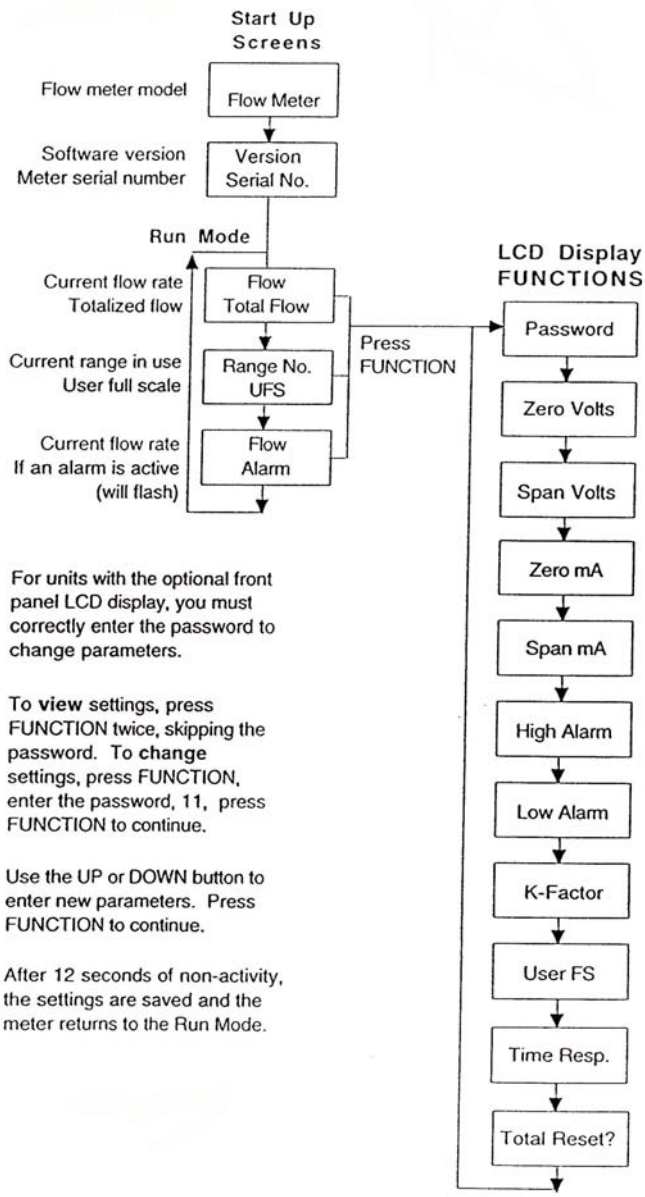
Flow Meter Start Up

When applying power to a flow meter equipped with the optional LCD display you will see the product name, the software version, unit serial number, the current flow rate, the totalized flow, the range number and the user full scale (UFS). Any active alarm will flash on the screen every few seconds. For meters not equipped with the optional display, when power is applied the on-board single-digit LED flashes the revision number of the software in a series of 3 digits, followed by the range number.

Using the Single-Digit LED for Programming



Using the LCD Display for Programming



For units with the optional front panel LCD display, you must correctly enter the password to change parameters.

To **view** settings, press FUNCTION twice, skipping the password. To **change** settings, press FUNCTION, enter the password, **11**, press FUNCTION to continue.

Use the UP or DOWN button to enter new parameters. Press FUNCTION to continue.

After 12 seconds of non-activity, the settings are saved and the meter returns to the Run Mode.

Entering Alarm Parameters

Use the High Alarm and Low Alarm function to set or adjust alarm trip points. The alarms have a minimum hysteresis of 3% to avoid "chattering." When setting a window alarm, the alarm setpoints must be at least twice the hysteresis value apart. We suggest at least a 10% separation between window alarm setpoints. If you choose not to use the high alarm for a specific alarm function, Sierra recommends that you set the high alarm at 100% of the user full scale setting which creates an "over-range" indicator. Your flow meter will continue to indicate flow and generate a signal if the flow is over the maximum range, but will not operate within the specified accuracy.

Caution! The flow meter must not be reporting or measuring gas flow during adjustments.

Entering Alarms with the LCD Display

Enter alarms setpoints directly in engineering units.

1. Select the desired range. Press FUNCTION, enter the password. Press FUNCTION until *High Alarm* or *Low Alarm* appears on the display.
2. Use the UP or DOWN arrow keys to enter the high or low alarm setpoint value in engineering units.
3. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new parameters are in effect.

Entering Alarms without the LCD Display

When using a DVM to set alarms, the setpoint is a percentage of the flow meter's user full scale.

VOLTS = (ALARM PERCENT x 5.0)

If you want to alarm at 25% of user full scale, used in Step 3 below, press the UP or DOWN button until 1.25 VDC is present on the DVM. If you want to alarm at 75% of user full scale, press the UP or DOWN button until 3.75 VDC is present on the DVM.

1. Set the DVM to voltage mode and connect between Vout+ and Vout- on the flow meter terminal block.
2. Select the desired range. Press the FUNCTION button until a solid "5" (high alarm) or solid "6" (low alarm) appears on the LED.
3. Adjust the UP or DOWN button until the DVM indicates the desired setpoint voltage as described above.
4. Press FUNCTION again to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new alarm parameters are in effect.

K-Factor Adjustment

Entering a K-factor adjusts the meter's output signal without affecting the factory calibration curve. Use the K-factor calibration offset for *additional* flow profile compensation (the factory includes an initial flow profile correction in the calibration curve of the unit).

Caution! The flow meter must not be reporting or measuring gas flow during adjustments.

Entering a K-factor with the LCD Display

A K-factor value of 1.000 means the output value is not affected and is the factory default setting. You may enter any number from 0.500 to 5.000.

1. Select the desired range. Press FUNCTION enter the password. Press FUNCTION until *K-factor* appears on the display.
2. Use the UP or DOWN arrow keys to enter the desired K-factor value in engineering units.
3. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new K-factor is in effect.

Entering a K-factor without the LCD Display

A K-factor value of 1.000 VDC means the output value is not affected and is the factory default setting. You may enter any value from 0.500 to 5.000 VDC in Step 3 below. If the device indicated output is 3.0 VDC and you know it should be 3.8 VDC then you could "force" the output to the desired 3.8 VDC by adjusting the K-factor to indicate 1.27 VDC (1.27 = 3.8/3.0). Use this formula to determine the desired K-factor voltage:

VOLTS = DESIRED/INDICATED

1. Set the DVM to voltage mode and connect between Vout+ and Vout- on the flow meter terminal block.
2. Select the desired range. Press the FUNCTION button until a solid "7" appears on the LED.
3. Adjust the UP or DOWN button until the DVM indicates the desired K-factor value as described above.
4. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new K-factor is in effect.

User Full Scale Adjustment

The user full scale (UFS) feature adjusts the flow meter output range anywhere within 50% to 100% of the factory full scale (FFS). This feature allows you to re-range the voltage or current output of the meter to accommodate different flow rates. When entering a new user full scale setting for Range 2, it cannot be less than 10% of the Range 1 user full scale setting.

Caution! The flow meter must not be reporting or measuring gas flow during adjustments.

Changing the User Full Scale with the LCD Display

The factory full scale is shown on the flow meter label. If you want a UFS equal to the FFS, adjust the display to match the FFS. If you want to use 50% of FFS, adjust the display to read 50% of the FFS.

1. Select the desired range. Press FUNCTION enter the password. Press FUNCTION until *User Full Scale* appears on the display.
2. Use the UP or DOWN arrow keys to enter the desired UFS value in engineering units.
3. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new UFS is in effect.

Changing the User Full Scale without the LCD Display

If the FFS is set to 11,000 sfpm and UFS is set to output 5.0 VDC, or 100%, the flow meter will indicate 5.0 VDC when 11,000 sfpm is present on the probe. If you want 6,000 sfpm for UFS, used in Step 3 below, adjust the UFS to 6000/11000 or 54.55% of factory full scale. Adjust the voltage to 2.73 VDC (2.73 = 5 x .5455). Use this formula to determine the desired UFS voltage:

VOLTS = 5 x User Full Scale/Factory Full Scale

1. Set the DVM to voltage mode and connect between Vout+ and Vout- on the flow meter terminal block.
2. Select the desired range. Press the FUNCTION button until a solid "8" appears on the LED.
3. Adjust the UP or DOWN button until the DVM indicates the desired user full scale as described above.
4. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new UFS is in effect.

Time Response Delay Adjustment

Changing the Time Response Delay with the LCD Display

1. Press FUNCTION, enter the password. Press FUNCTION until *Time Response* appears on the display.
2. Use the UP or DOWN button to adjust the time response delay from 0.10 to 7.2 seconds.
3. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new time response setting is in effect.

Changing the Time Response Delay without the LCD Display

1. Set the DVM to voltage mode and connect between Vout+ and Vout- on the flow meter terminal block. Select the desired range. Press the FUNCTION button until a solid "9" appears on the LED.
2. Adjust the UP or DOWN button until the DVM indicates the desired voltage (as shown in the following table).

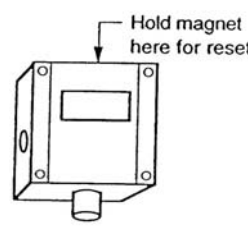
Volts Indicated on DVM	Time Response (Seconds)	Volts Indicated on DVM	Time Response (Seconds)	Volts Indicated on DVM	Time Response (Seconds)	Volts Indicated on DVM	Time Response (Seconds)
0.5	0.1	1.0	0.3	1.5	0.5	2.0	0.7
2.5	1.2	3.0	1.8	3.5	2.4	4.0	3.6
4.5	4.8	5.0	7.2				

3. Press FUNCTION to advance to the next option, or after 12 seconds of non-activity the meter returns to the Run Mode and the new time response delay setting is in effect.

Totalizer Reset

If your device is equipped with the optional LCD display, reset the totalizer using the keypad. If you are unable to open the flow meter enclosure, use a magnet to reset the totalizer as shown below.

1. Select the desired range. Enter the pass word. Press FUNCTION until *Total Reset?* appears on the display.
2. Press the UP button and then the DOWN button until the display reads "Resetting Totalizer."



Using the Smart Electronics Advanced Features

Zero and span (Function 1 through 4) can be used to validate system operation and calibrate the digital to analog signals on the Smart electronics device. Additionally, these functions can compensate for resistance in long signal cables connected to your data collection or indicating system.

Caution! Adjusting zero or span will affect meter calibration.

You must use a certified digital voltmeter to adjust zero and span as the voltmeter acts as a standard. We recommend recording the current values as shown on the LCD display or DVM before making any changes to the zero and span settings. Note: when adjusting zero the voltage signal will be driven to 0 VDC and when adjusting span the voltage signal will be driven to 5 VDC (or 10 VDC).

Voltage Zero Adjustment

If needed, use Zero Volts (Function 1) to adjust the 0-5 VDC output to 0.0 VDC, or optional 0-10 VDC to 0.0 VDC.

1. Set the DVM to voltage mode and connect between Vout+ and Vout-.
2. Press FUNCTION, enter the password (if so equipped). Press FUNCTION until *Zero Volts* appears on the LCD display or a solid "1" appears on the LED. Adjust the UP or DOWN button until the DVM indicates between 0 and .01 VDC (no less than 0.005). The Smart electronics device cannot drive negative values.
3. After 12 seconds of non-activity, the meter returns to the Run Mode and the new parameter is in effect.

Voltage Span Adjustment

If needed, use Span Volts (Function 2) to adjust the 0-5 VDC output to 5.0 VDC, or optional 0-10 VDC to 10 VDC.

1. Set the DVM to voltage mode and connect between Vout+ and Vout-.
2. Press FUNCTION, enter the password (if so equipped). Press FUNCTION until *Span Volts* appears on the LCD display or a solid "2" appears on the LED. Adjust the UP or DOWN button until the DVM, indicates between 4.99 and 5.01 VDC. (For 0-10 VDC devices, the target value is 9.99 to 10.01.)
3. After 12 seconds of non-activity, the meter returns to the Run Mode and the new parameter is in effect.

Note: when adjusting zero the current signal will be driven to 4 mA and when adjusting span the current signal will be driven to 20 mA. We recommend recording the current values before making any changes to the current zero or span settings.

Current Zero Adjustment

If needed, use Zero mA (Function 3) to adjust the 4-20 mA output to 4.0 mA.

1. Disconnect the 4-20 mA (+) loop wire. Set the DVM to current mode and connect the positive lead to the wire you just disconnected. Connect the negative lead to the 4-20 mA (-) on the flow meter terminal block.
2. Press FUNCTION, enter the password (if so equipped). Press FUNCTION until *Zero mA* appears on the LCD display or a solid "3" appears on the LED. Adjust the UP or DOWN button until the DVM indicates between 3.95 and 4.05 mA. Set DVM back to voltage mode when adjustment is complete.
3. After 12 seconds of non-activity, the meter returns to the Run Mode and the new parameter is in effect.

Caution! Adjusting zero or span will affect meter calibration.

Current Span Adjustment

If needed, use Span mA (Function 4) to adjust the 4-20 mA output to 20.0 mA.

1. Disconnect the 4-20 mA (+) loop wire. Set the DVM to current mode and connect the positive lead to the wire you just disconnected. Connect the negative lead to 4-20 (-) on the flow meter terminal block.
2. Press FUNCTION, enter the password (if so equipped). Press FUNCTION until *Span mA* appears on the LCD display or a solid "4" appears on the LED. Adjust the UP or DOWN button until the DVM indicates between 19.95 and 20.05 mA. Set DVM back to voltage mode when adjustment is complete.
3. After 12 seconds of non-activity, the meter returns to the Run Mode and the new parameter is in effect.

Instrument Validation

System electronics are verified by injecting a known input value and confirming that the flow meter outputs the expected value. This test confirms that the microprocessor, analog to digital and digital to analog converters, the linearizer and the display are working properly. Sensor validation is accomplished by measuring the resistance of the velocity and temperature sensors and comparing the results to the NIST-traceable calibration data provided with the flow meter. These tests confirm that your meter is working correctly and the calibration variables did not drift, shift or change values.

To perform the instrument validation procedures you will need these items:

- certified digital multimeter with minimum 4 character resolution, accuracy of at least ±0.1% or range
- Calibration Certificate supplied with the flow meter
- small pot adjusting tool (screwdriver)

Before beginning the validation procedures, review Figure 3-2 and Figure 3-3 to familiarize yourself with the component locations.

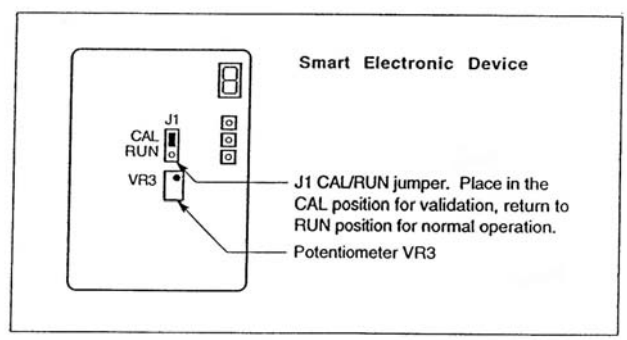


Figure 3-2. Electronics Validation Component Locations

Electronics Validation Procedure

Caution! Before beginning this procedure, make sure the flow meter is not actively monitoring or reporting to any master control system. Any adjustment to the electronics will cause direct changes to flow control settings.

1. Verify the flow meter is off line from any remote communications. Make sure the meter's user full scale setting is the same as the factory full scale setting. If not, enter the user full scale value as needed.
2. Locate the Calibration Certificate supplied with the flow meter. Record in Table 3-1 the five bridge voltage values, the output (VDC or mA) values and the indicated flow values.
3. Remove power from the flow meter. Remove the cover of the flow meter enclosure to access the wiring terminal block and the Smart electronics device.
4. Set the multimeter to the 20 volt range. Connect to BV (+) and BV (-) terminals on the flow meter terminal block.
5. Move the J1 Cal/Run jumper on the Smart electronics device to the CAL position.
6. Locate potentiometer VR3 on the Smart electronics device. Turn on power to the flow meter.
7. Adjust potentiometer VR3 until the multimeter matches the first bridge voltage point (the value must be ±0.002 VDC of the bridge voltage point).
8. Record the resulting flow shown on the optional LCD display in Table 3-1. If not using a display or if you prefer to validate one of the analog output signals, move the multimeter + connection to Vout (+). Record the resulting output voltage in Table 3-1. If using a 4-20 mA calibrated meter, set the multimeter to read current and connect the meter to read the mA signal in your connected loop. Record the resulting current output in Table 3-1.
9. Repeat Step 7 and Step 8 to record the results of the remaining four bridge voltage validation points.
10. Compare the results recorded in Table 3-1. Indicated values must be within the flow meter's stated accuracy shown on the Calibration Certificate.

11. When data collection is complete, turn off power to the flow meter. Disconnect the multimeter from the flow meter terminal block.
12. Place the J1 Cal/Run jumper in the RUN position. Make sure the jumper is securely in place before resuming flow meter operation. Replace the flow meter cover.

Calibration Certificate Readings				Validation Test Results			
Sample Point	Bridge Voltage	Indicated Flow	Output (V or mA)	Indicated Flow (LCD)	Flow Meter Stated Accuracy	Output (V or mA)	Flow Meter Stated Accuracy
0%							
25%							
50%							
75%							
100%							

Table 3-1. Electronics Validation Results

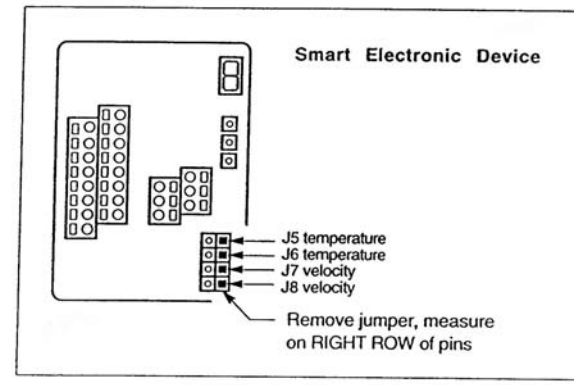


Figure 3-3. Sensor Validation Component Locations

Sensor Validation Procedure

 **Warning!** Do not power the flow meter with the sensor jumper disconnected. This could cause over-heating of the sensors and/or damage to the electronics.

1. Locate the Ro temperature (measured resistance at 0°C) value and the Alpha Ro value shown on the Calibration Certificate supplied with the flow meter.
2. **Turn off power to the flow meter. Allow a 6 minute cool-down before continuing.**
3. Remove the cover of the flow meter enclosure to access the sensor connection points. Remove the four-position jumper from J5, J6, J7 and J8. (See Figure 3-3 on previous page for location.)
4. Set the multimeter to read Ohms in the 2K range. Connect the multimeter to the left-side terminals of J5 and J6 (temperature sensor). Measure the resistance between J5 and J6 and record the temperature sensor resistance (in Ohms) in Table 3-2.
5. Connect the multimeter to left-side terminals of J7 and J8 (velocity sensor). Measure the resistance between J7 and J8 and record the velocity sensor resistance (in Ohms) in Table 3-2.
6. Use the measured resistace values and the Ro and Alpha Ro values from the Calibration Certificate to calculate the temperature for each sensor as follows:

$$T = \frac{R - R_0}{\text{Alpha} \times R_0}$$

Where
T = degrees Celsius
R = measured sensor resistance
R_0 = resistance at 0°C (from the Calibration Certificate)
Alpha = value unique to each sensor (from the Calibration Certificate)

7. Compare the results recorded in Table 3-2. The sensors are validated if they are within 10 degrees Celsius of each other.

8. Disconnect the multimeter and replace the four-position jumper on the sensor terminals. **Make sure the jumper is securely in place before applying power.** Replace cover.

Temperature Sensor Resistance	T (from equation)
Velocity Sensor Resistance	T (from equation)

Table 3-2. Sensor Validation Results

Chapter 4 Troubleshooting & Repair

Troubleshooting the Flow Meter

Begin hardware troubleshooting by verifying the following facilities issues are correct. These areas impact system operation and must be corrected prior to performing any flow meter inspections.

 **Warning!** Before attempting any flow meter repair, verify that the line is not pressurized.

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

1. Verify the incoming power to the flow meter is present and of the correct voltage and polarity.
2. Check the flow meter wiring for correct connections as described in Chapter 2.
3. Verify the flow meter is installed with the correct number of upstream and downstream pipe diameters as shown on page 2-2.
4. Verify the flow direction indicator is correctly aligned pointing downstream of flow.
5. Make sure there are no leaks in the line being measured.

After verifying the factors above, follow the troubleshooting procedures outlined on the next page. If you need to return the flow meter to the factory, see the page 4-3 for Return Material Authorization (RMA) and shipping instructions.

Problem	Possible Cause	Solution
Velocity measurement is erratic or fluctuating	Very erratic or non-uniform flow	Follow installation requirements shown in Chapter 2
	Flow meter installed with less than required minimum pipe diameters upstream and downstream	Follow installation requirements shown in Chapter 2
	Insertion sensor probe not mounted securely	Sensor probe must be mounted securely without vibration
	Sensor component broken	Return to factory for replacement
	Malfunction in system electronics	Return to factory for evaluation
	Ground loop	Check wiring, see Chapter 2
Velocity measurement seems too high or low	Sensor assembly not aligned correctly to flow	Correct alignment with the flow indicator pointing downstream in the direction of flow
	Sensor probe not inserted to the proper depth	Verify sensing point is located on the centerline of the pipe
No response to flow from sensor assembly	No power	Turn on power to the flow meter
	Printed circuit assembly defective	Return to factory for evaluation
	Sensor failure	Return to factory for evaluation
	Low flow cutoff too high	Correct low flow cutoff programming using the Smart Interface software
	Flow rate below meter's minimum flow rating	Contact factory for instructions
	Flow has exceeded the maximum range of the flow meter	Reduce flow below the maximum range shown on the meter's nameplate or contact the factory for re-calibration advice

Appendix A Product Specifications

Performance Specifications

Accuracy	±1% of full scale
Repeatability	±0.2% of full scale
Temperature Coefficient	±0.02% of reading per °F within ±50°F of customer specified conditions ±0.03% of reading per °F within ±50°F to 100°F of customer specified conditions ±0.04% of reading per °C within ±25°C of customer specified conditions ±0.06% of reading per °C within ±25°C to 50°C of customer specified conditions
Pressure Coefficient	Negligible when within ±50 psi (±3.4 bar) of customer specified conditions
Response Time	100 milliseconds to 63% of final velocity value

Operating Specifications

Gases	Air, nitrogen and other non-combustible, non-corrosive gases
Mass Flow Rates	0 to 200 sfpm (0 to 1 nmps) minimum, 0 to 20,000 sfpm (0 to 100 nmps) maximum for air and nitrogen (maximum full scale varies with gas)
Dual Calibration	User-selectable dual ranges or two different gases (the user full scale for Range 2 two cannot be less than 10% of the full scale for Range 1)
Gas Pressure	150 psig (10 bar) maximum
Pressure Drop	Negligible
Gas & Ambient Temperature	Gas……-40° to 250°F (-40° to 120°C) Ambient…32° to 120°F (0° to 50°C)
Power Requirements	11 to 18 VDC (regulated), 625 mA maximum 18 to 30 VDC (regulated), 625 mA maximum
Output Signal	Linear 0-5 VDC or 0-10 VDC proportional to point mass flow rate or velocity, 1000 Ohms minimum load resistance, or Linear 4-20 mA proportional to point mass flow rate or velocity, 700 Ohms maximum resistance (power supply dependent), optically isolated (isolation is an input-to-output isolation of 1500 VAC for 1 minute)
Alarms	User-adjustable low, high or window alarms Deadband adjustable with Smart Interface™ software Relay rating……Maximum 42 VAC or 42 VDC, 140 mA, 27 Ohm maximum on-resistance, optically isolated (isolation is an input-to-output isolation of 1500 VAC for 1 minute)
Display	Alphanumeric 2 x 12 digit backlit LCD Adjustable variables via on-board membrane buttons or with Smart Interface software Adjustable variables……Full scale adjustment (50 to 100%) Time delay response (0.1 to 7.2 seconds) Correction factor setting (0.5 to 5) Zero and span adjustments
Totalizer	Eight digits (99,999,999) in engineering units, resetable by user
Software	Smart Interface™ Windows™-based software, minimum 8 MB of RAM, preferred 16 MB of RAM, RS-232 communication

Physical Specifications

Wetted Materials	Probe: 304SS; Sensor: high temperature glass filled polyester-plastic epoxy and ceramic
Enclosure	NEMA 4X (IP65) powder-coated cast aluminum enclosure
Mounting (optional)	3/8″ tube compression fitting with 1/2″ male NPT
Certifications	CE approved