INSTALLATION, OPERATION AND MAINTENANCE MANUAL

Model ST98 Flowmeter

Firmware Revisions 2.XX
Doc. No. 06EN003291 Rev. A

US PATENTS PENDING

8/5/99REV. -
3/9/00REV. A

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REVISIONS

REV.	DESCRIPTION	DATE	AUTHOR
-	INITIAL RELEASE	08/05/99	ROY SANDERS
A	See Change Bars. Major changes are due to new 2.xx Software and Revised circuit boards to Rev. A or Later.	03/01/00	ROY SANDERS

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Symbols

The following symbols are used throughout the manual to draw attention to items or procedures that require special notice or care.

Caution: Warns of possible **personal danger** to those handling the equipment.

Alert: May cause possible **equipment damage**.

Note: Contains important information.

1. General Information

Description

The model ST98 is a thermal mass flowmeter for air or gas measuring applications. The ST98 consists of a flow element, a flow transmitter, and an enclosure. An in-line flow element is used for smaller diameter pipe or tubing sizes and, for pipe sizes greater than 2-1/2 inches (40 mm bore), an insertion flow element is used. The flow element's process connections can be threaded or flanged.

The ST98 flow transmitter accepts AC or DC input power and the output signal can be set for either a standard range current or voltage. A display is optional. An RS-232C serial I/O port provides setup, monitoring and troubleshooting access using either *FCI*'s model FC88 Programmer or a PC-compatible computer.

The ST98 enclosures provide environmental protection for the flow transmitter. The flow transmitter can be integrally mounted with the flow element or remotely separated from it. Hazardous location local and remote enclosures are optional.

Theory of Operation

The flow element of the model ST98 uses the thermal dispersion operating principle: A low-powered heater produces a temperature differential between two resistance temperature detectors (RTDs) by heating one of the RTDs. Mass flow rate changes cool the heated RTD and cause a proportional change in the temperature differential between the RTDs. The instrument's flow transmitter converts the RTD temperature differential into a scaled output signal and an optional indicated display value.

The signal from the unheated RTD is used to provide an indication of the air or gas temperature on the optional display.

Insertion Sensing Element

The sensing element consists of two thermowells (hollow tubes) that when inserted into the flow process allows an unimpeded flow inside the process line. A heated RTD is inserted into the top thermowell. A reference RTD (with no heater) is inserted into the bottom thermowell. In order to correctly orient the sensing element a flow arrow has been etched onto a machined flat portion of the sensing element. See Figure 1-1 for a view of the sensing element.

The element is inserted into the process media through a hole drilled into the process line.

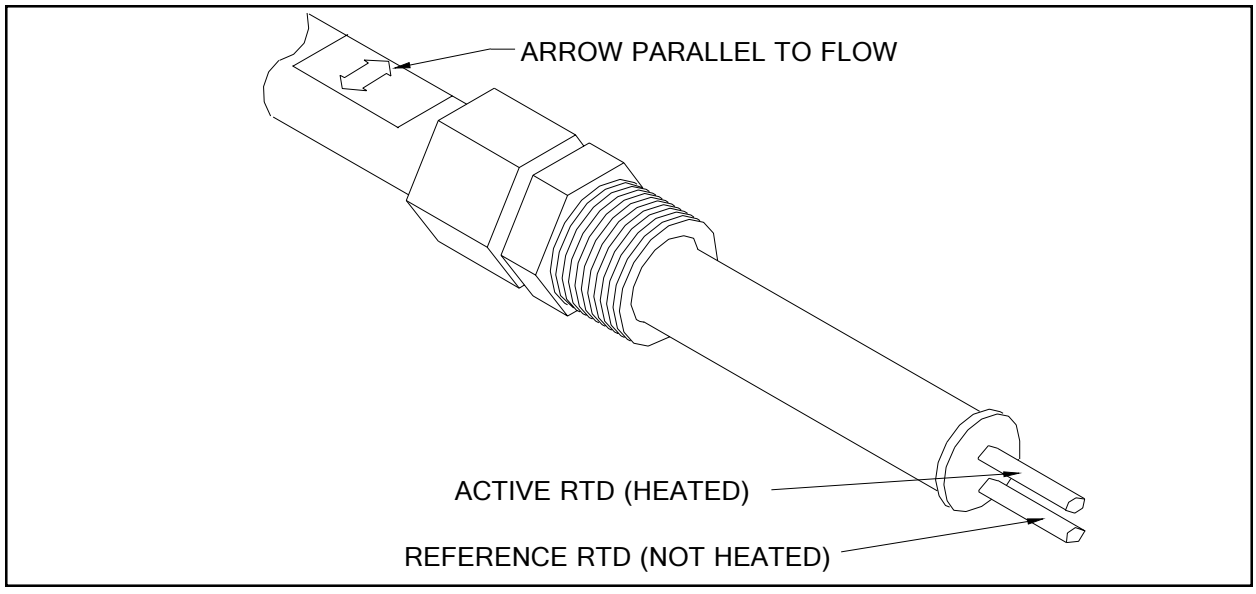


Figure 1-1 View of the Sensing Element

In-Line Sensing Element (Flow Tee)

The in-line sensing element is made in the same way as the insertion type of flow element is. To correctly orient the in-line sensing element, a flow arrow has been etched onto one side of the sensing element.

The in-line flow element is inserted in the process line with the flow arrow pointing in the same direction of flow. See Figure 1-2 for a cutaway view of the in-line element.

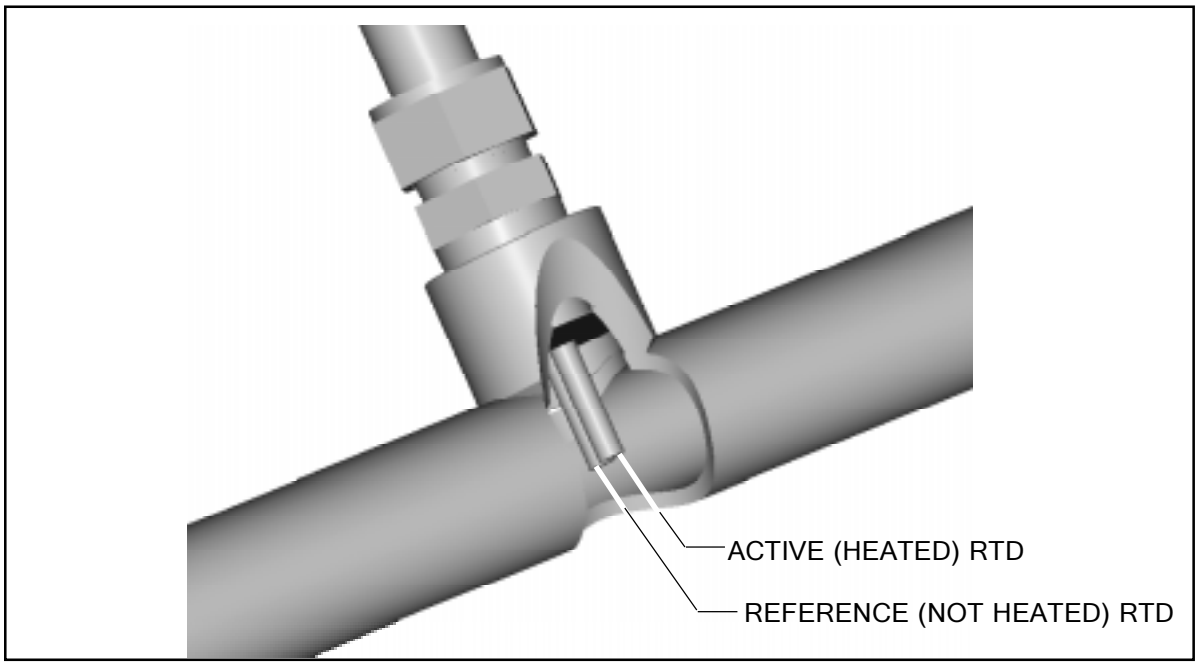


Figure 1-2. Cut-Away View Of The In-Line Flow Element Tube

Transmitter Electronics

The transmitter electronics convert the sensing element's RTD temperature differential into a flow signal that is read on a display . The transmitter also produces an analog output flow signal suitable to interface with process controls. The output is a representation of the amount of flow or temperature present in the process. The flow output is transmitted on a source milliamp output and / or voltage output. Both the flow output and process temperature can be displayed on an optional LCD display.

There are 2 kinds of enclosures available for the electronics:

1. Standard:
   Polyester Coated Carbon Steel Rated NEMA/CSA Type 4X (equivalent to IP66) and Division 2 (Ex n), Rating is pending. (This is a 6 X 6 X 4 Inch Square Enclosure.) (152.4 X 152.4 X 101.6 mm)
2. Optional:
   Aluminum rated for Hazardous Location use Class I and II, Division 1 and 2, Group B, C, D, E, F, G (previously referred to as NEMA 7 and EEx d IIc) resists the effects of weather and corrosion.
   (This is a 4.8 X 9.31 Inch Cylindrical Enclosure.) (121.8 X 236.47 mm)

Instrument Configuration

The instrument can be in integral arrangement (the electronics and the sensing element are combined in one enclosure), or the instrument can be in a remote arrangement (the electronics and sensing element are in separate enclosures).

In the case of a remote enclosure, the standard configuration of the sensing element (local) enclosure is an aluminum rated for Hazardous Location use Class I and II, Division 1 and 2, Group B, C, D, E, F, G (previously referred to as NEMA7) and EEx d IIC and resists the effect of weather and corrosion. The dimensions are 4.68 X 4.82 inches (119 X 122 mm) and is cylindrical in nature.

Technical Specifications

- **Process Connection**

  Insertion Configuration:

  Soft Seal or Metal Ferrule (Can be Stainless Steel or Hastelloy C):

  3/4 inch male NPT or Flanged

  Inline Configuration:

  1.0 inch tubing, 1.0, 1.5 or 2.0 inch SCH 40 pipe, Female NPT, Male NPT, Butt Weld or Flanged.

- **Insertion U-Length**

  Beginning as low as 1.0 inch (25.4 mm) to 21 inches (533 mm).

- **Sensing Element Material**

  All wetted surfaces are 316 Stainless Steel, with all-welded construction. Hastelloy C-276 is optionally available.

- **Operating Temperature**

  Control circuit:

  Ambient temperature configuration:

  0 to 140°F (-18 to 60°C).

  Sensing element:

  Standard temperature configuration:

  -40 to 350°F (-40 to 177°C).

- **Operating Pressure**

  0 to 250 psig [0 to 17 bar(g)]. (Derated with Teflon ferrule.)

- **Flow Range**

  Insertion:

  0.75 to 600 SFPS (0.006 to 0.23 NMPS)

  Inline:

  0.0062 to 1850 SCFM (0.01 to 3140 Nm^3/h)

- **Signal Output**

  4-20 mA, 700 ohms maximum load
  0-5, 1-5 and 0-10 Volts DC 100K ohms minimum load

- **Accuracy**

  Flow accuracy:

  ±1 % reading + 0.5% full scale

  Temperature accuracy:

  ±2°F (display only, flow rate must be greater than 1 SFPS).

- **Repeatability**

  ±0.5% of reading.

- **Input Power**

  A.C. Input: 100-240 VAC 50/60 Hz. 17 Watts Maximum 120 mA Maximum.

  D.C. Input: 22-30 VDC 250 mA Maximum 7.5 Watts Maximum.

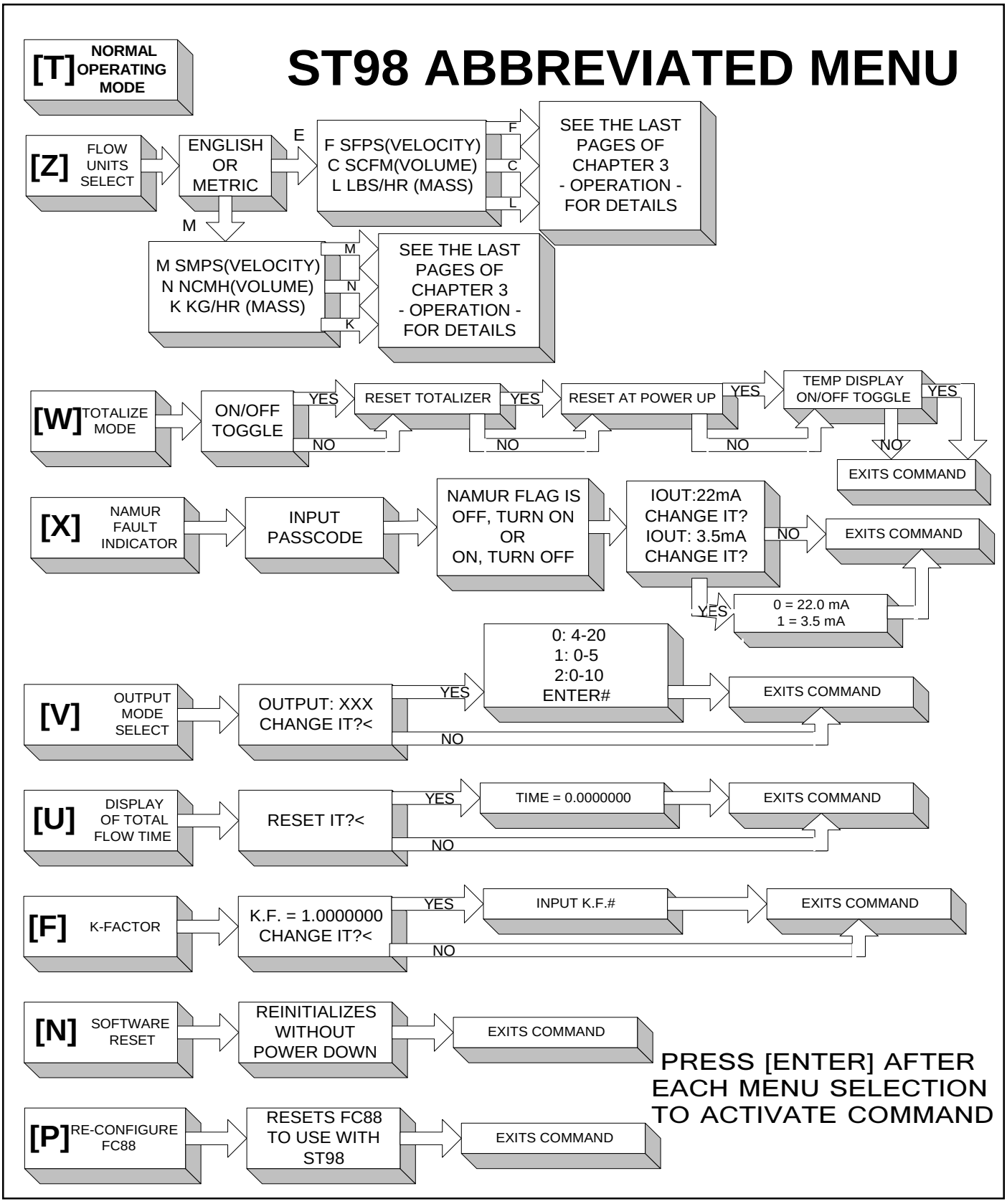
- **Pending Approvals**

  FM, CSA, CENELEC, CE Marking
  (EMC Directive 89/336/EEC)

Quick Start Menu (Abbreviated)

The following menu shows how to use the most frequently accessed functions of the instrument. For a complete menu and explanation see Chapter 3 - Operation.

Table 1-1. Quick Start Menu (Abbreviated Menu, See Chapter 3 For Full Details)



2. Installation

Receiving/Inspection

- Unpack carefully.
- Verify that all items in the packing list are received and are correct.
- Inspect all instruments for damage or contaminants prior to installation.

If the above three items are satisfactory, proceed with the installation. If not, then stop and contact a customer service representative.

Packing/Shipping/Returns

These issues are addressed in Appendix C - Customer Service.

Factory Calibration Note

The instrument is factory calibrated to the flow range specified in the order. There is no need to perform any verification or calibration steps prior to installing and placing the instrument in service.

Pre-Installation Procedure

Caution: Only qualified personnel should install this instrument. Install and follow safety procedures in accordance with the current National Electrical Code. Ensure that power is off during installation. Any instances where power is applied to the instrument will be noted in this manual. Where the instructions call for the use of electrical current, the operator assumes all responsibility for conformance to safety standards and practices.

Alert: The instrument is not designed for weld-in-place applications. Never weld to process connection or a structural support.

Damage resulting from moisture penetration of the enclosure(s) is not covered by product warranty.

The flow transmitter contains electrostatic discharge (ESD) sensitive devices. Use standard ESD precautions when handling the circuit board assemblies. See below for ESD details.

Use Standard ESD Precautions

Use standard ESD precautions when opening an instrument enclosure or handling the flow transmitter. FCI recommends the use of the following precautions: Use a wrist band or heel strap with a 1 megohm resistor connected to ground. If the instrument is in a shop setting there should be static conductive mats on the work table and floor with a 1 megohm resistor connected to ground. Connect the instrument to ground. Apply antistatic agents to hand tools to be used on the instrument. Keep high static producing items away from the instrument such as non-ESD approved plastic, tape and packing foam.

The above precautions are minimum requirements to be used. The complete use of ESD precautions can be found in the U.S. Department of Defense Handbook 263.

Prepare or Verify Flow Element Location

Prepare the process pipe for installation or inspect the already prepared location to ensure that the instrument will fit into the system.

Mount the flow element at least 20 diameters downstream and 10 diameters upstream from any bends or interference in the process pipe or duct to achieve the greatest accuracy.

Verify Dimensions

The ST98 Insertion Models have an adjustable insertion length ferrule until it is locked into position. Verify all dimensions before locking the fitting in place. See the appropriate figures in Appendix A.

Note: Two types of ferrules are available. One type of ferrule is made from Teflon. This can be tightened and loosened repeatedly at different places on the flow element. The other type of ferrule is made from Stainless Steel. This ferrule can only be tightened in one place on the flow element. The Stainless Steel Ferrule makes an indentation into the flow element for a more firm fit.

The ST98 In-Line Model's flow element has a tube or pipe length and diameter that is specified at the time of order. This dimension should be double checked with the process line.

Verify Flow Direction for Flow Element Orientation and Placement

The insertion ST98 flow element comes with flat areas machined on the flow element near the enclosure end of the flow element. Etched on the flow element is a flow arrow indicating the direction of flow. See Figure 2-1.

Align the ST98 flow element during installation so the flat areas are parallel to the direction of the process media flow, and the flow arrow points in the direction of process media flow.

A flow direction arrow is etched on the in-line ST98 tube or pipe and should be pointing in the direction of flow.

Failing to install the flow element correctly will reduce the accuracy of the flow meter.

Verify The Serial Number Of The Flow Element and the Electronics

The ST98 flow element has a serial number near the flat machined area or flow arrow. The same number is on the main electronics circuit board, and on the tag of the electronics enclosure. These numbers have to match because the flow element and the electronics are a matched set. Failure to observe serial numbers will cause inaccurate readings.

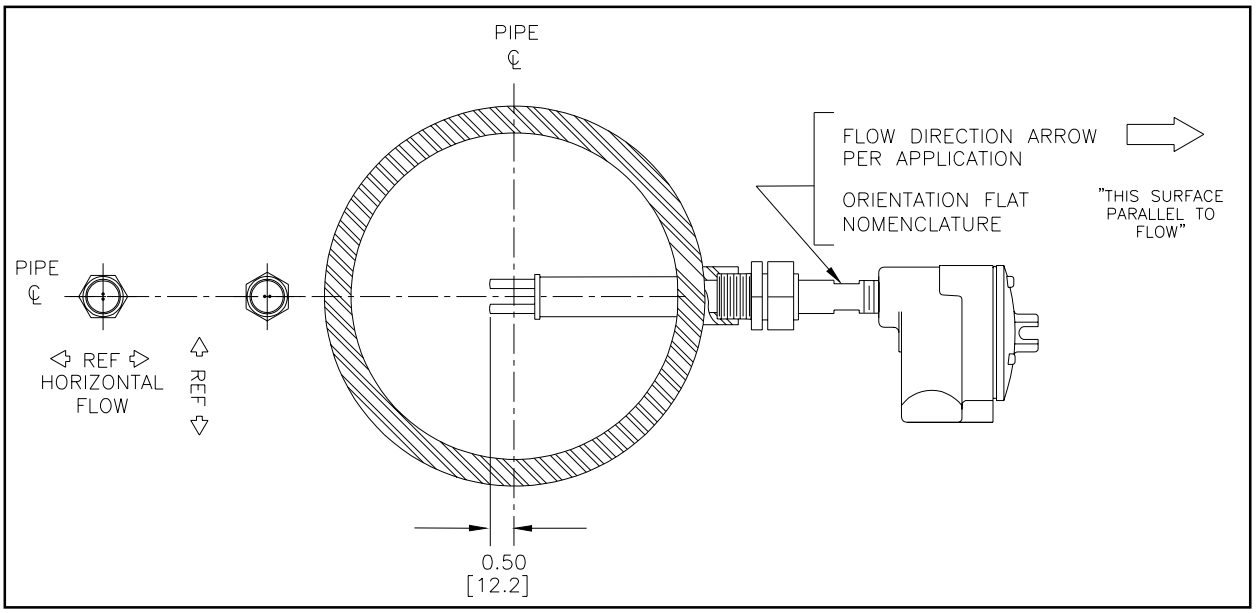


Figure 2-1. Model ST98 Insertion Flow Element (Remote) Showing Orientation

Install Insertion Flow Element

Note: The instrument accuracy will be reduced if the media flow is reversed from the flow direction of the flow arrow machined on the flow element or if the flats are not parallel, within ±1° of the flow direction.

Install the flow element as specified for the process connection type used.

Compression Fitting Mounting (Insertion Mounting Only)

1. Determine the inside diameter of the process pipe at the predetermined location. Calculate 1/2 of the inside diameter. Add 0.50 inch (12.7 mm) to the dimension. Add the pipe wall thickness. Mark the flow element at this length.
2. Insert the flow element fitting into the process pipe and tighten per ANSI B16.5 torque specifications. Use appropriate sealants as required. Measure the length of the ferrule that is above the pipe. Mark this dimension above the first mark on the flow element.
3. Position the flow element in the process pipe so that the last mark is above the ferrule. The flow element is now placed at 0.50 inch (12.7 mm) past the center of the process pipe as shown in Figure 2-1.
4. Adjust the flow element so the flats are parallel to flow ±1°, and the flow arrow is in the direction of flow.
5. Ensure that the insertion length is correct before tightening the compression fitting. Readjustment of the metal ferrule is not possible after tightening because the fitting crimps onto the flow element pipe. The Teflon ferrule is readjustable.
6. Hold the fitting body steady with a backup wrench and tighten the nut one and one-quarter turns past what is hand tight. Now the flow element is sealed and locked into place.

Caution: Be sure there is no pressure in the process line before the instrument is removed.

To remove the flow element, loosen the nut (Step 6) and unscrew the ferrule (Step 2).

NPT Pipe Thread Mounting (Insertion Mounting Only)

Alert: DO NOT change the orientation of the flow element in the enclosure more than 180° as the interconnecting RTD and heater wiring could be stressed and damaged. DO NOT apply any torque to the flow element enclosure - only apply to NPT pipe surface itself.

Note: When mounting the flow element to the process pipe, it is important that a lubricant/sealant is applied to the male threads of all connections. A lubricant/sealant compatible with the process environment should be used. All connections should be tightened firmly. To avoid leaks do not overtighten or cross-thread connections.

The pipe thread configuration is similar to what is shown in Figure 2-1. Apply sealant compatible with the process media to male threads. Carefully insert into process mount. Threads are right-handed. Tighten with an open-end wrench on the hexagonal surface provided. Rotate until snug and continue to turn until flat is horizontal to process flow.

Flanged Ferrule Mounting (Insertion Mounting Only)

1. One of the configurations that can be ordered is a flange that has NPT threads. The flange can be screwed onto the instrument's ferrule. If the flange is sperate from the ferrule screw on the flange and apply a lubricant/ sealant to the male threads and torque using ANSI B16.5 specifications. If the flange is already present, proceed to the next step.
2. Measure the U-Length of the flow element (from the flange face to the end of the flow element). Subtract 0.50 inch (12.7 mm) from the U-Length. The process' flanged mating surface for the flow element should be high enough above the pipe for proper mounting of the flow element as follows: Measure the inside diameter

of the process pipe at the predetermined location. Calculate 1/2 of the inner diameter. Add the pipe wall thickness. Add the length the customers flange is above the pipe. The length above the pipe should be adjusted to match the U-Length minus the 0.50 inch (12.7 mm) dimension.

3. Apply the appropriate gasket and/or sealant to flange mount faces as required.
4. Attach the process mating flange with care. The mating surface should be oriented so the flow element flats are parallel to flow, within ±1°, and the flow arrow on the flow element should be pointing in the same direction as the flow.
5. Attach with a bolt, two flat washers, lock washer and nut for each bolt hole; apply lubricant/sealant to the male threads and torque. Refer to ANSI B16.5 specifications.

In-Line Mounting

There are several different ways the in-line model ST98 instrument can be mounted into the process line. The different ways the flow element can be mounted are as follows:

- Threaded male NPT mount
- Threaded female NPT mount
- Raised face flange mount
- Butt Weld mount

Figure 2-2 shows a Butt Weld, 2 inch Schedule 40 pipe, in-line model ST98:

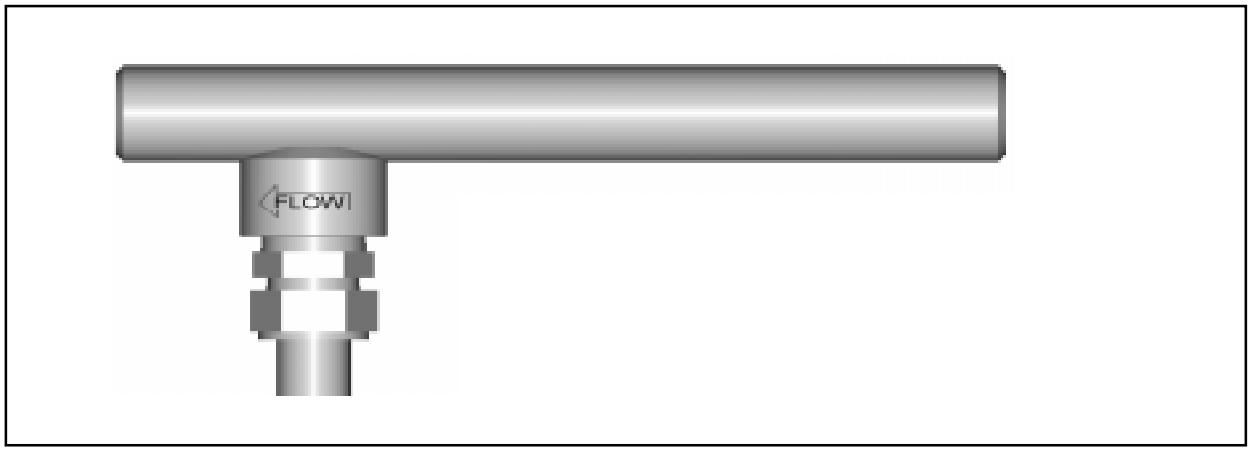


Figure 2-2. Model ST98 In-Line Butt Weld Mount

Mount the in-line Model ST98 as follows:

1. Verify that the process media flow is in the same direction as the flow arrow (see Figure 2-2).
2. For flange mounted instruments, apply the appropriate gasket and / or sealant to flange mounts as required.
3. For NPT mounted instruments, apply the appropriate sealant to the threads as required.
4. Mate (or weld the Butt Weld instrument) the instrument to the process line.
5. For flange mounts, attach the instrument with a bolt, two flat washers, lock washer and a nut for each bolt hole. Apply lubricant/sealant to the male threads of bolts or to the NPT threads and torque. Refer to ANSI B16.5 torque specifications.

Install Flow Transmitter

Alert: In applications where the flow element is located in an explosive environment, isolate the conduit before it leaves the environment. A potting Y may be used to provide the isolation.

Note: FCI recommends installing an input power disconnect switch and fuse near the flow transmitter to interrupt power during installation, maintenance, calibration, and troubleshooting procedures.

Make all electrical connections through the 3/4 inch NPT ports in the enclosure. Run all electrical cables through appropriate conduit or protective sheathing.

Caution: Ensure that all power is off before wiring any circuit.

Minimum Wire Size

If the instrument is used in the remote configuration, a shielded, 8 conductor cable should be used between the local and remote enclosure. Table 2-1 shows the smallest (maximum AWG number) copper wire that should be used in the cable and in other wiring. Use a lower gauge of wire for less of a voltage drop. Contact FCI concerning greater distances than those listed in the table. The sensing element cable for the remote option must be shielded. The maximum wire size of the non-power connectors in the instrument is 16 AWG. The maximum wire size of the power connectors in the instrument is 12 AWG.

Note: All 8 conductors for the sensing element must be used for proper operation of the flow meter.

Table 2-1. Maximum AWG Number

Connection	Maximum Distance for AWG					
	10 ft. (3 m)	50 ft. (15 m)	100 ft. (31 m)	250 ft. (76 m)	500 ft. (152 m)	1000 ft. (310 m)
Input Power	20	18	18	16	16	14
Sensing Element Cable (Remote Instrument)	24	24	24	18	16	16
Analog Output	24	24	24	18	16	16

Aluminum Enclosure Installation (Cylindrical Enclosure)

1. To wire the instrument remove the customer connection cover from the instrument by loosening the Allen head screw at the base of the cover. Unscrew the cover shown in Figure 2-3.
2. Install conduit between the local (if used) and the remote enclosure, the power source and customer monitoring circuits. Provide watertight hardware and apply thread sealant to all connections to prevent water damage.
3. Connect the milliamp and/or DC voltage output to the termination (customer connection) board as required. Refer to Figure 2-4 for connection information.
4. Connect the operating power to the customer termination board by removing the input wiring kit from the strain relief bracket (see Figure 2-4 for the bracket location). This kit contains a filter bead and three cable ties. For remote instruments only, the kit also contains 2 wire terminals for a ground wire to be placed between the flow element enclosure and the electronics enclosure.
5. Strip the incoming power wires to approximately 5/16 of an inch.
6. Attach the filter bead over the safety ground wire as shown in Figure 2-4 using 2 cable ties to secure the bead on the wire. The last cable tie should be about 3 inches from the end of the wire.
7. Attach the power wires to Terminal Strip TS1 (for AC) or TS4 (for DC) as shown in Figure 2-4. Secure the wires going to the Terminal Strip with a cable tie, secured to the cable tie bracket on the customer connection board.
8. For remote instruments only, (the flow element is in a separate enclosure from the electronics): Loosen the Allen head screw on the electronics cover. Unscrew the cover.

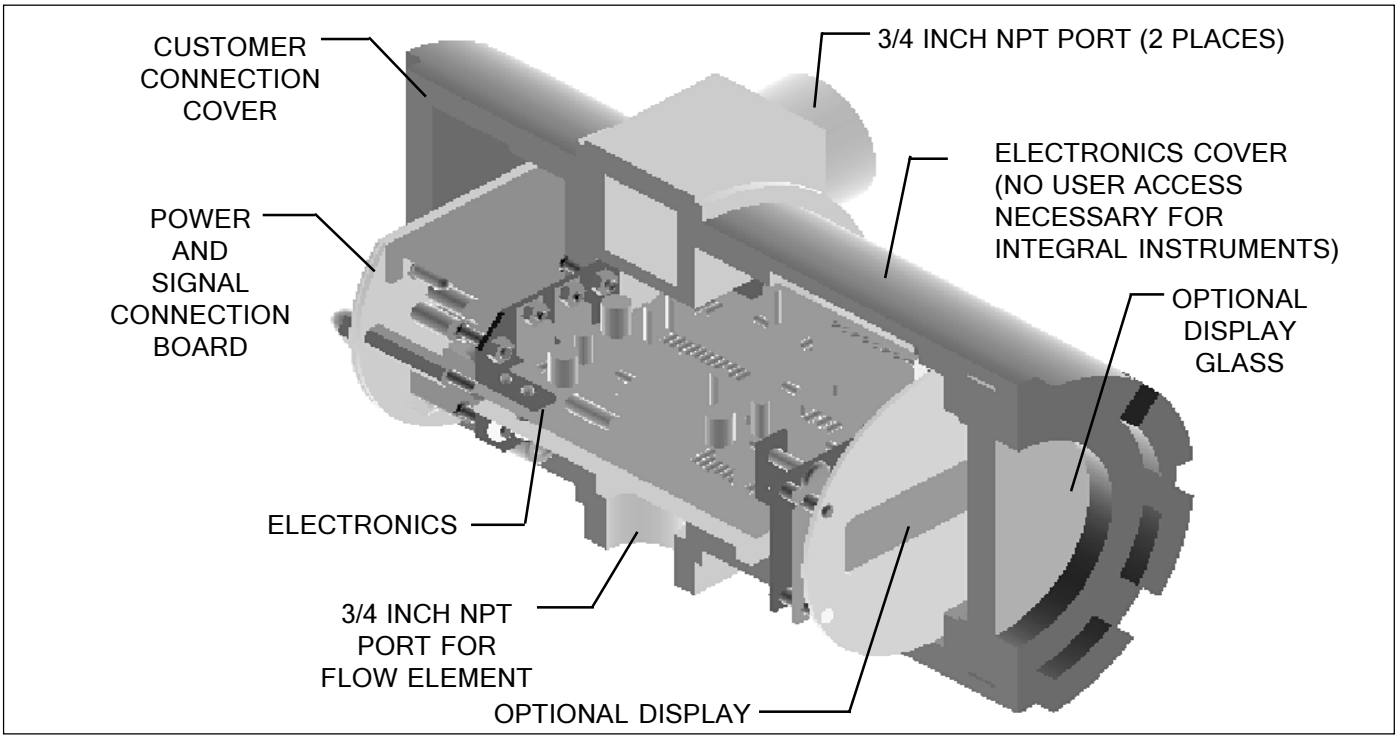


Figure 2-3. Circuit Board Placement

9. For remote instruments only: The flow element wires should be routed through the 3/4 inch NPT port for the flow element as shown in Figure 2-3. Connect the flow element wires to TS2 on the electronics assembly according to Figure 2-5. Connect the cable shield to HTR RTN. Leave the other end of the shield floating. A 14 AWG ground wire should also be routed between the enclosures (wire terminals are supplied in the kit).

Note: Connecting the shield in any other way will decrease the accuracy of the instrument. See Figure 2-4 for the wiring diagram.

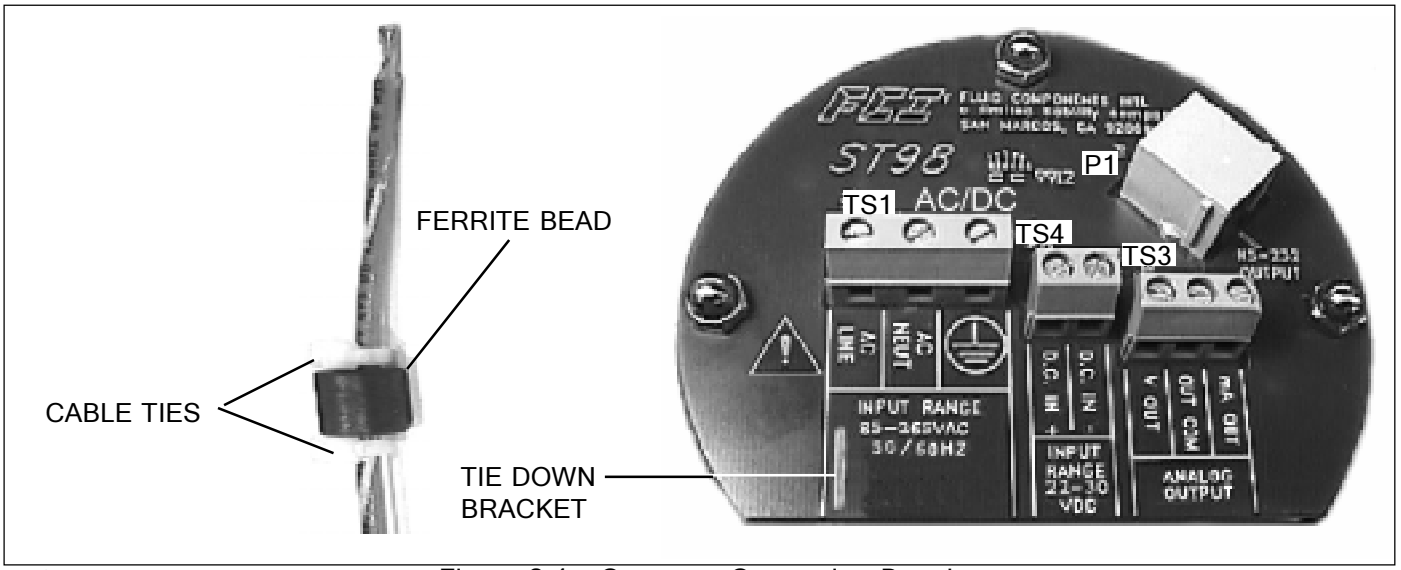


Figure 2-4. Customer Connection Board

Caution: Be sure an earth ground wire is connected to the ground terminal (see Figure 2-4). On a remote configuration, connect an earth ground wire to the ground screw in the local enclosure. This is for the purpose of safety.

10. If a wire comes loose from the instrument during installation, refer to Chapter 5 - Troubleshooting for a complete instrument wiring diagram.

11. For remote instruments only: Screw on the electronics cover and tighten the Allen head screw.
12. Screw on the customer connection cover and tighten the Allen head screw.
13. There are enough threads on the flow element so the flow transmitter enclosure can be rotated for ease of viewing the display LCD if the option is present. Be sure the flow arrow still points in the direction of flow and the flat is parallel to the flow.
14. Verify proper installation. Ensure that the assemblies are secure and the wiring is correct.

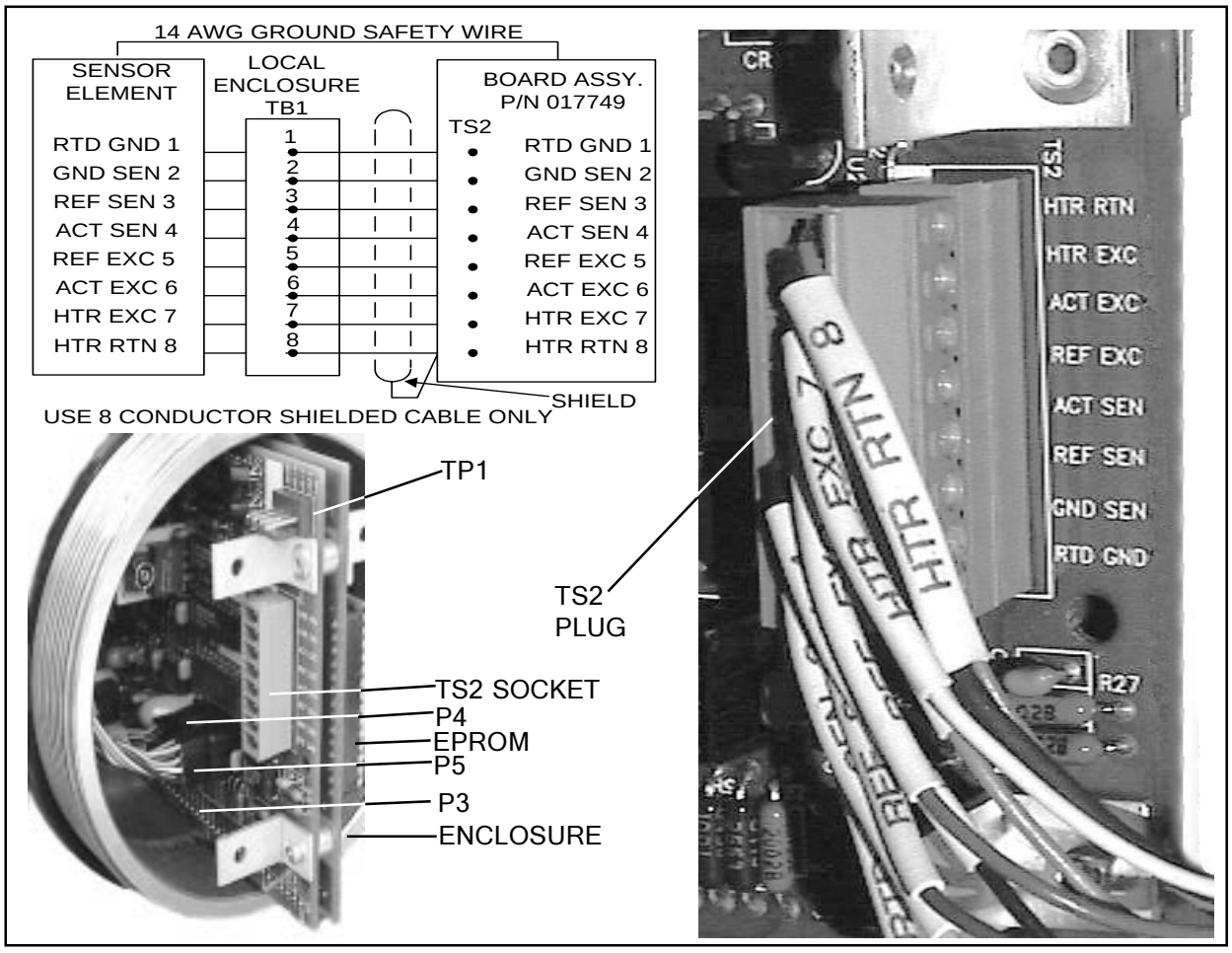


Figure 2-5. Remote Wiring Diagram

Caution: Ensure that all power is off before wiring any circuit.

Carbon Steel Enclosure Installation (6 X 6 Carbon Steel Enclosure)

1. To wire the instrument loosen 3 cover hold down screws and open the cover. See Figure 2-6.
2. Install conduit between the local (if used) and the remote enclosure, the power source and customer monitoring circuits. Provide watertight hardware and apply thread sealant to all connections to prevent water damage .
3. Connect the milliamp and/or DC voltage output to the termination (customer connection) board as required. Refer to Figure 2-4 for connection information.
4. Connect the operating power to the customer termination board by removing the input wiring kit from the strain relief bracket (see Figure 2-4 for the bracket location). This kit contains a filter bead and three cable ties. For remote instruments only, the kit also contains 2 wire terminals for a ground wire to be placed between the flow element enclosure and the electronics enclosure.
5. Strip the incoming power wires to approximately 5/16 of an inch.
6. Attach the filter bead over the safety ground wire as shown in Figure 2-4 using 2 cable ties to secure the bead on the wire. The last cable tie should be about 3 inches from the end of the wire.

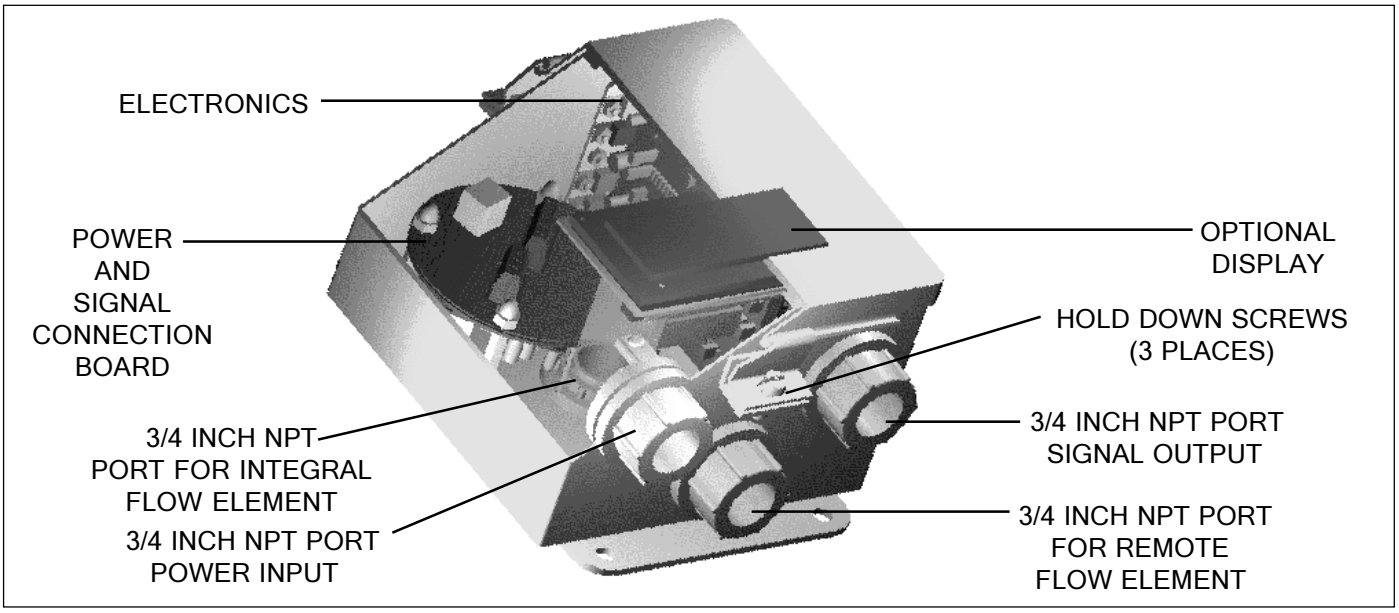


Figure 2-6. Optional Carbon Steel Enclosure

7. Attach the power wires to Terminal Strip TS1(for AC) or TS4 (for DC) as shown in Figure 2-4. Secure the wires going to the Terminal Strip with a cable tie, secured to the cable tie bracket on the customer connection board.

8. For remote instruments only, (the flow element is in a separate enclosure from the electronics): The flow element wires should be routed through the 3/4 inch NPT port for the flow element as shown in Figure 2-6. Connect the flow element wires to TS2 on the electronics assembly according to Figure 2-5. Connect the cable shield to HTR RTN. Leave the other end of the shield floating.

Note: Connecting the shield in any other way will decrease the accuracy of the instrument. See Figure 2-5 for the wiring diagram.

Caution: Be sure a grounded wire is connected to the ground terminal (see Figure 2-4) or to the enclosure ground screw. This is for the purpose of safety.

9. If a wire comes loose from the instrument during installation, refer to Chapter 5 - Troubleshooting for a complete instrument wiring diagram.

10. Close the cover and tighten the hold down screws.

11. There are enough threads on the flow element so the flow transmitter enclosure can be rotated for ease of viewing the display LCD if the option is present. Be sure the flow arrow still points in the direction of flow and the flat is parallel to the flow.

12. Verify proper installation. Ensure that the assemblies are secure and the wiring is correct.

Remote Hardware Location (Option)

The outline dimensions shown in Appendix A show the physical dimensions for the proper mounting of the flow element and transmitter electronics enclosure. Select a location for the flow transmitter within 1000 feet (310 M) of the flow element. Pigtail flow elements can not be located more than 10 feet (3 M) from the flow transmitter. This location should be easily accessible with enough room to unscrew the enclosure top at any time. Secure the enclosure to a surface capable of providing support. Use appropriate hardware to secure the enclosure.

Note: In cases where a pigtail flow element cable must be extended, a 9 position terminal strip must be used. All 8 conductors and the shield wire must have an exclusive terminal landing for proper operation. See Table 2-1 for the minimum wire gauge to use.

Wiring the In-Line Flow Element (Option)

Electrically the in-line flow element is the same as the model ST98 insertion flow element. Wire the instrument using the local enclosure or remote enclosure and/or the pigtail wiring methods above.

Serial Communication (Hyper Terminal Hook-Up)

The RJ-12 (P1) connector on the customer connection board provides RS-232 communication with the user. An FC88 Communicator can be plugged in for periodical re-configuration and/or diagnostics, or personal computer can be plugged in instead of the FC88 Communicator. See Figure 2-4 for the location of P1. This connection is a RJ-12 communication (phone) jack. Figure 2-7 represents the connection between the serial port and the host device.

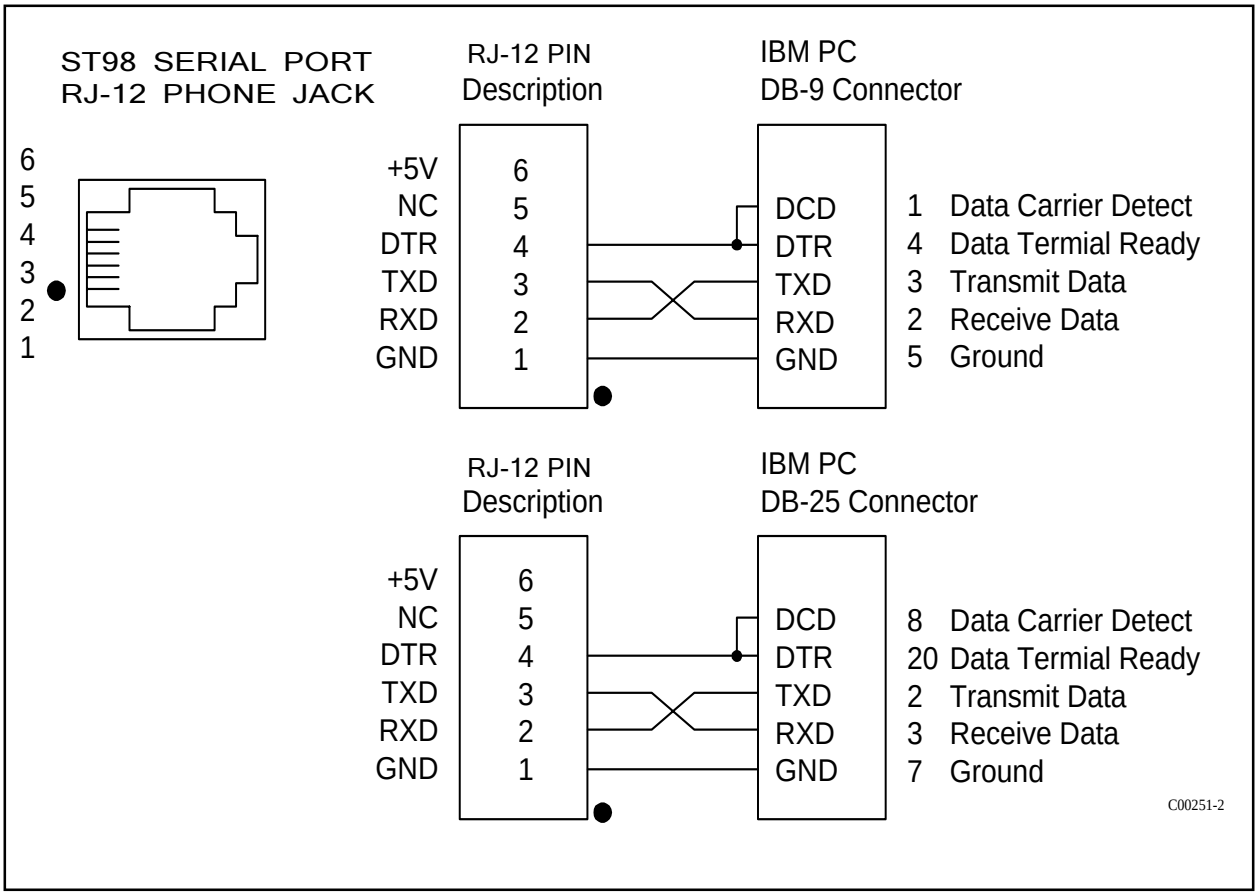


Figure 2-7. Wiring Diagram, DB-9 and DB25 PC Connectors

FCI recommends using the ST98 PC Interface Kit P/N: 014108-01 to connect the flow transmitter to a personal computer. The Kit includes operation instructions and an adaptor for the RJ-12 to serial connection. Connect one end of the interface kit to the RJ-12 port and the other end to a DB pin connector. Plug the connector into the COM1 or COM2 port in the back of the computer terminal.

See instructions on how to use the serial communications in the next chapter.

Remote Enclosure Bracket Installation

The remote enclosure can be rotated at various points around a 360° axis and bolted in place using 1/4-20 hardware. See Figure 2-8.

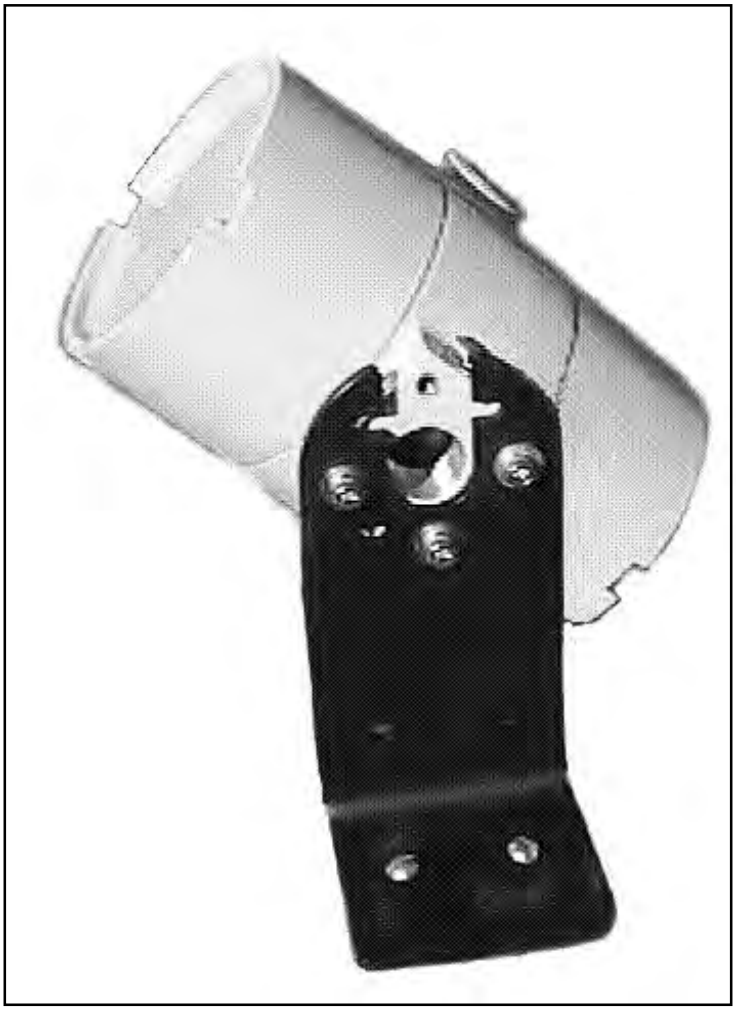


Figure 2-8. Remote Bracket Installation

Apply Power

The input power should not be turned on until the installation has been completed with all connections verified, power and signal connection board assembly screwed down and the instrument ready to operate. Be sure any external circuit breakers are on.

3. Operation

Alert: The flow transmitter contains electrostatic discharge (ESD) sensitive devices. Use standard ESD precautions when handling the flow transmitter. See Chapter 2, Installation for ESD details.

Introduction

The instrument has been configured and calibrated to customer specifications. Each instrument contains distinct operating limits and units of measurement. This chapter will show how to determine and manipulate the configuration of the instrument.

Start Up

Verify the wiring before applying power. Verify the correct power connections have been made to the flow transmitter. If the instrument does not have a display, plug in an FC88 Hand Held Communication unit or other compatible communication device into P1 of the customer connection board.

1. Apply power.
2. When operating power is applied to the instrument the following messages will be displayed:

   "FCI ST98",
   "Initialization!",
   "Heater On!"

3. Wait 5 minutes for the instrument to warm-up and stabilize.
4. The instrument automatically enters the flow metering mode. The instrument's display (if present), and /or the FC88 display will show the normal operation.

Note: If the FC88 does not display the monitored results properly, press [P] to re-configure the FC88 to the operation of the ST98.

The flow meter displays an output signal that is representative of the calculated current process media flow.

If the display does not appear, or is out-of-range for the expected values, turn the power off and proceed to Chapter 5 -Troubleshooting.

Using an FC88 Communicator

An FC88 is a hand held communicator that is plugged into the flow meter which controls the various functions of the ST98. Plug in the FC88 to P1 of the customer connection board. See Figure 2-4 for details.

This instrument is convenient, compact, and obtains its operating power from the flow transmitter. It provides a keypad for operator input and a display for system output.

Menu Control and Organization

Most entries require at least two key strokes; a letter and the [ENTER] key, or one or more numbers and the [ENTER] key. All user entries begin at the Input Mode?< prompt except when the instrument is in the Main Function Mode (just press the letter and [ENTER] to make an entry).

A user entry is indicated by brackets [ ] being placed around the entry. Y/N refers to Yes (Y), save or change parameter or No (N) do not save or change parameter unless otherwise specified.

Backspaces are made using the backspace [BKSP] key.

Some entries are case sensitive between numbers and letters. Be sure the SHIFT key is pressed to indicate the correct case. A square after the prompt caret indicates the FC88 is in lower case. A slightly raised rectangle in the same spot indicates the FC88 is in the upper case.

It is recommended that the FC88 be plugged into the instrument before power is applied. If the FC88 is plugged in while the instrument power is on and the FC88 does not respond, press [ENTER], if there is no response press [P], if there is still no response Press [N].

Note: Some entries require a pass code (942) to continue programming the instrument. The instrument will prompt the user when this is necessary. Do not change any parameters that require this code unless there is an absolute understanding of the instrument's operation. Incorrect changes can cause an inaccurate or a non-operational instrument. The figures in the "Delta "R" Table would need to be re-input.

The user can not exit some routines unless all entries are completed or the power is recycled.

The top level of the menu is shown below. Press the large letter in the Figure 3-1 to activate a command.

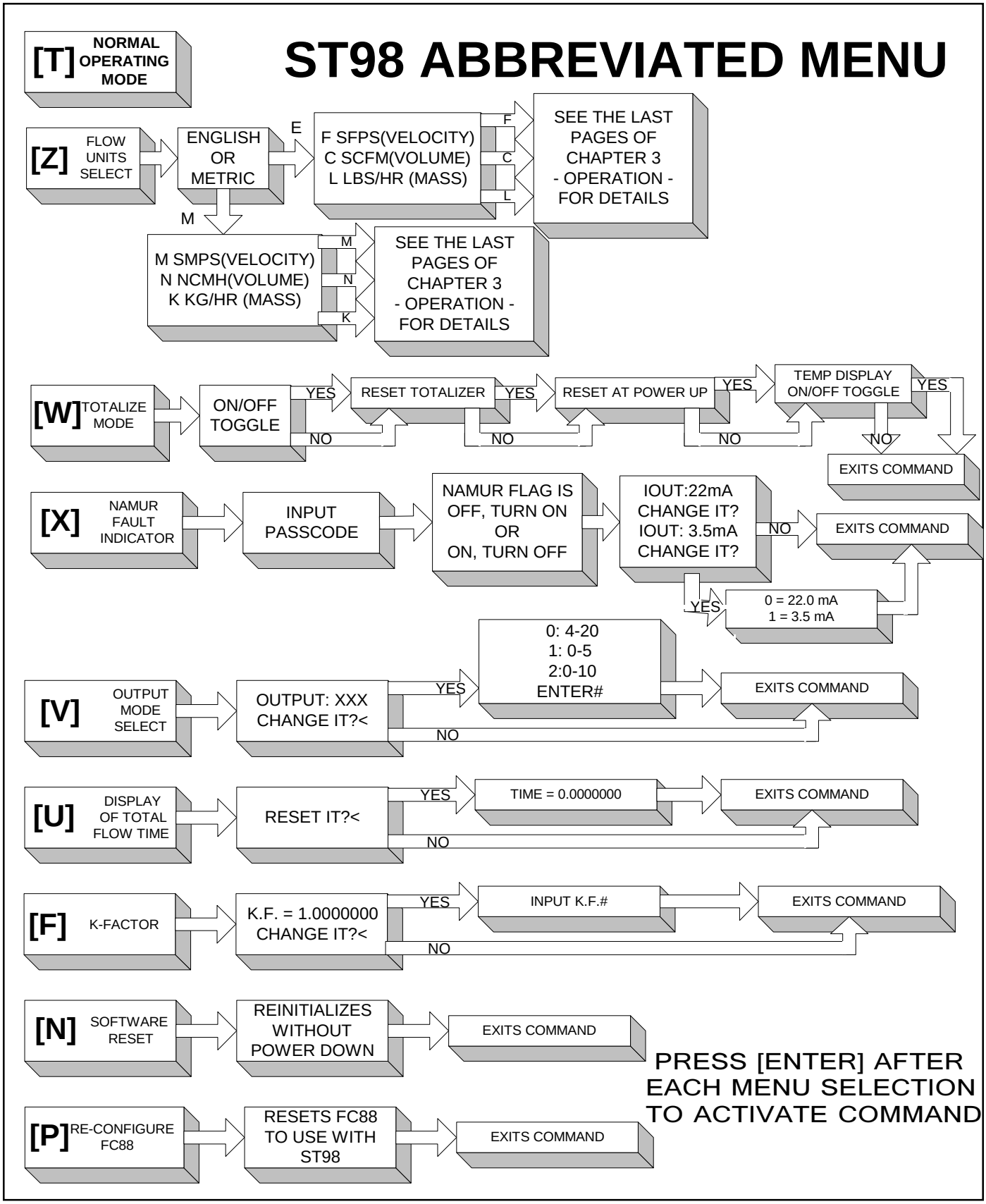
A	**Analog Input** Rotate through the 8 analog input channels	N	**Software Reset** Re-initialize instrument without removing power
B	**Sensor Balance** Balance or rebalance Flow Element	O	**Select Sensor Heater Current** HIGH (90 mA) or LOW (75 mA)
C	**Calibrate Display** Display A/D Delta-R and Ref-R data values	P	**Re-configure FC88 Unit** Reset the FC88 hand held to ST98 format
D	**Diagnostic** Check out functional conditions of the unit	Q	**Undefined**
E	**Sensor Current Select** Displays 2.0 mA - 1k ohm	R	**Delta-R, Ref-R, CB Temp, -8/+20 V** Display Delta-R, Ref-R resistor values, etc.
F	**K-Factor** K-Factor entered by user.	S	**Save/Restore USER Save and FACTORY** Calibration data saved and restored
G	**EEPROM PW = available when needed** EEPROM byte locations - read/ write.	T	**Normal Operating Mode** Display flow rate, temperature, totalized flow
H	**Heater** Toggle heater circuit - OFF/ ON.	U	**Display Total Flow Time** Total time (min) in T mode since last reset
I	**Output Current Adjust** Manually set output: 4-20 mA, display output load	V	**NAMUR Output Fault Indicator** NAMUR flag, select fault indicator
J	**Serial/Customer Numbers** Enter Serial No. and Customer Order No.	W	**Totalizer Mode** Enable totalized flow w/wo temperature
K	**Constants Setup** Setup curve fit, TC parameters, and other data	X	**NAMUR Output Fault Indicator** Toggle NAMUR flag(on/off) select fault indicator
L	**Calibrate Outputs** Outputs - Heater Current, 4 mA, 20 mA levels.	Y	**Undefined**
M	**Min/Max A/D Limits** Set minimum and maximum A/D limits	Z	**Flow Units Select** Select flow units (3 English , 3 Metric)

Figure 3-1. Menu Selections Chart

Quick Start Menu (Abbreviated)

The following menu shows how to use the most frequently accessed functions of the instrument. See Figure 3-1 for the complete menu. A complete menu explanation follows this Table.

Table 3-1. Quick Start Menu (Abbreviated Menu, See Chapter 3 For Full Details)



Detailed Menu Description

This section describes the menu of commands. The commands are listed in alphabetical order with no order of priority.

Note: Menu Commands are initiated by pressing the appropriate character key followed by the ENTER key.

COMMAND:

A. Analog Input

Summary:

Permits the user to display the Analog To Digital (A/D number) of the eight analog input channels. The A/D number has a span of 0-4096 counts which is proportional to 0-4 V at the input to the A/D converter. Channels 0 through 3 receive a signal voltage that has been amplified by a factor of nine. Channels 4 through 7 are not amplified.

These numbers can help a technician determine the cause of a problem with the installation or operation of the flowmeter. FCI recommends making a note of these readings.

Description:

When command [A] [ENTER] is pressed, the instrument will respond by displaying the signal for Channel 0. Continually pressing the [ENTER] key displays the rest of the channels and will rotate back to channel 0 following the Channel 7 selection. This command is useful in trouble shooting incorrectly wired instruments and open flow elements. This is a view only selection, the user has no other input commands.

Channel Number	Signal Name	Purpose and Symptom
0	ACT_SEN - REF_SEN ***Raw Delta-R x Gain (»9)***	Raw flow signal with a gain of 9, used for high flow rate.
1	-8 Volt Supply Monitor	Check for -8 Volt Supply limits.
2	Sensed mA Output Load Monitor	Used in calculating the output load in ohms.
3	+20 Volt Supply Monitor	Check for +20 Volt Supply limits.
4	ACT_SEN - REF_SEN *Raw Delta-R*	Raw flow signal with gain of 1, used for lower flow rate.
5	HTR_SEN - GND *Sensed Heater Voltage*	Check the condition of the heater.
6	Circuit Board Temperature Monitor	Check for Circuit Board Temperature limits.
7	REF_SEN - GND_SEN *Sensed Ref-R*	Used to measure the reference sensor for process temp.

Example:

Pressing [A] [Enter] displays “Ch(0): xxxx”
[Enter] displays “Ch(1): xxxx”
[Enter] displays “Ch(2): xxxx”
[Enter] displays “Ch(3): xxxx”
[Enter] displays “Ch(4): xxxx”
[Enter] displays “Ch(5): xxxx”
[Enter] displays “Ch(6): xxxx”
[Enter] displays “Ch(7): xxxx”
[Enter] displays “Ch(0): xxxx”

Note: Pressing [Q] [ENTER] at any time will exit this menu item and display “Input mode ?<”.

COMMAND:

B. Sensor Balance

Summary:

Permits the instrument's flow element to be balanced or rebalanced. **A passcode must be entered.** This function has already been performed at the factory. This function should only be performed if there is a new flow element installed or a re-calibration is necessary.

Description:

For the instrument to function properly, the flow element and electronics need to be balanced. Balancing means that at the same temperature, the RTD's in the flow element should be at the same resistance. Due to physical differences in the RTD's, the current needs to be adjusted for one of the RTD's so that they will both have the same voltage. The differential should be as close to zero as possible. A passcode is necessary to enable this command. The instrument will either balance itself or it can be done manually.

Note: Use M (Manual) command when the circuit board or flow element has been replaced and where the balance value representing the digitized current used for balancing has been written down.

If the Heater was ON prior to sensor balancing, be sure to turn the Heater back ON after the RTD's have been balanced.

Example:

Pressing [B] [ENTER] will display "**Enter Code #**"
Press in the passcode [ENTER]. "**Enter temp. #**" will be displayed.
After the temperature is entered, "**Auto or Manual?**" and "**Enter A or M**<" are displayed.
Pressing [A] [ENTER] will display "**xxx xxxx Balancing**". Then "**Balanced!**" will appear on line 1 and "**Saved! xxx**" will appear on line 2.
If [M] [ENTER] is pressed instead of [A] [ENTER], the prompt "**Enter Balance #**" will be displayed. Once the balance value [xxx] is entered, the balanced value entered appears on line 1 and "**Saved!**" is displayed on line 2. After a couple of seconds "**Saved! xxx**" will be displayed on line 1 and "**Input mode?**<" will be displayed on line 2. (*Typical Balance values are; 234-237. Factory Balance # is on in the Delta R Table.)*

COMMAND:

C. Calibrate Display

Summary:

Displays A/D Delta-R and Ref-R. Data values are useful for calibration. The instrument is calibrated at the factory. This function does not need to be performed unless the instrument has been repaired or needs to be re-calibrated.

Description:

The flow element RTD's need to be interpreted by the electronics as a function of flow-rate. This is done by recording the raw signal A/D values at certain flow points and then curve-fitting the points using an equation to linearize the output at the calibrated flow-rate. This command makes it possible to view both the raw A/D Delta-R value, which is the difference between the Active and Reference RTD, and the Ref-R value, which is for the Reference RTD. This is a view only selection, the user has no other input commands.

Example:

Pressing [C] [ENTER] will display "**d= xxxx R= xxxx**". The display is updated continuously.

Note: Pressing [ENTER] at any time will exit this menu and display "**Input mode?**<"

COMMAND:

D. Diagnostic

Summary:

Permits the user to check the functional conditions of the instrument.

Description:

This mode displays all of the critical and peripheral variables that are stored in RAM (operational data area). By pressing the [Enter] or the [U]/[+] key, the data is displayed in an ascending order. By pressing the [P]/[-] key, data is displayed in a descending order. Pressing the [Q] key at any time will exit the Diagnostics menu. The ST98 functional data in RAM is saved in the USER area of the Non-Volatile Memory (NVM). The user has the option to save user data to the USER Save area of NVM at any time. At completion of the FCI calibration, the data was saved to the FACTORY area of NVM. Each of these data areas may be viewed by the user (Refer to Menu item 'S' for more detail on saving and restoring the NVM data areas).

Example:

At BOOTUP or RESET, the following is displayed: **"Initialization!"**, with **"FCI ST98"** flashing, followed by **"Heat On!".**

Pressing D [Enter] will display "**USER Displayed**" followed by "**Change it ?** <". If 'N' or [Enter] is pressed, USER data is displayed. If **[Y]** is pressed**, "1=USER Save"** followed by "**2=FACTORY**" is displayed. Pressing a '1' or '2' will cause the respective NVM data to be displayed: **"Version X.XX"** (also displayed at BOOTUP or RESET).

The rest of the values will be displayed by pressing the [**Enter**] key after each value.

"Serial Number ",
"xxxxxxxxx",
"Customer Number",
"xxxxxxxxx",
"Curve fit: x",

NOTE: Curve fit = 0, is for "**single poly fit**"; Curve fit = 2, is for "**two poly fit**"

The following values are typical:

If Curve fit = 2 was chosen, the instrument will display "**two poly fit**" on line 1 and "**Brkpt: 1432**" on line 2.

"**Poly Segment 1**" are "**C1** = 79.3892", "**C2** = -2.362808", "**C3** = 28.23582",
"**C4** = -104.3832", "**C5** = 1.070937".

"**Poly Segment 2**" are **"C1** = 69.04044", "**C2** = -8.793838, "**C3** = 206.3617", "**C4** = -1544.267", "**C5** = 39.06467".

"**Balance:** 237", "**Outz:** 432", "**Outf:** 2144", "**Heater_I**: 3070", "**Factor:** 1.00000", "**Eu:** 70 (F)", "**Tot:** 0",
"**Tottemp:** 0", "**Tflow**: 0.000000", "**Rollover:** 1E6", "**Roll cnt:** 0", "**Outmode:** 0", "**Max A/D:** 6500",
"**Min A/D:** 200", "**Kfactor:** 1.0000", "**Zero:** 0.0000", "**Sensor: 0**", "**Tslp:** 0.23759989", "**Refr:** 1800.00",
"**Caltemp:** 70.00", "**Toff:** -351", "**Tcslp:** 0.17139990", "**Tcslp0:** 0.00000", "**Tcslp2:** 0.000000",
"**Maxflow:** 150.00", "**Minflow:** 1.5000", "**Density:** 0.07491590", "**Line_size0**: 1.0000000",
"**Line_size1**: 0.0000000", "**F.S.:** 128.0000".

Note: Pressing [Q] [ENTER] at any time will exit this menu item and display "**Input mode ?**<".

COMMAND:

E. Sensor Current Select

Summary:

None.

Description:

None.

Example:

Pressing [E] [ENTER] will always display "**2.0 ma - 1k ohm**".

COMMAND:

F. K-Factor

Summary:

Permits the user to enter a K-Factor.

Description:

If the user determines that the flow rate output should be "biased", a user supplied K-Factor can be applied to modify the final flow reading from the calibrated flow rate.

Example:

Pressing [F] [ENTER] will display "**K.F. = 1.0000000**" on line 1 and "**Change it?**<" on line 2. Pressing [N] [ENTER] will display "**Input mode?**<". Pressing [Y] [ENTER] will display "**Enter K.F.#**". Press in the new K-Factor. Press [ENTER]. The new factor is saved and "**Input mode ?**<" is displayed.

COMMAND:

G. EEPROM

Summary:

For maintenance only. **A passcode must be entered.**

Description:

EEPROM byte locations can be read or modified.

Example:

N/A

COMMAND:

H. Heater

Summary:

Permits the user to toggle the heater circuit **OFF** and **ON**.

Description:

Useful whenever the heater needs to be turned off and on manually, i.e., while balancing the flow element or trouble shooting the instrument.

Example:

Pressing [H] [ENTER] will display "**Heater OFF!**" or "**Heater ON!**" on line 1 depending on which state was last active. "**Input mode ?**<" is displayed on line 2.

COMMAND:

I. Output Current Adjust

Summary:

Permits the user to manually vary the output from **4 mA** to **20 mA** by entering a value of 0 to 1000.

Description:

This diagnostic command allows the user to vary the output for troubleshooting purposes, Entering 0 will set the output current to 4 mA. Entering 500 sets the output to 12 mA. Entering 1000 sets the output to 20 mA. Also displayed is the output load in ohms.

Example:

Pressing [I] [ENTER] will display "**Enter # (**0-1000)". Pressing [0] will display "**4 mA**" followed by "**Load: xxx ohms**".

COMMAND:

J. Serial Number, Customer Order Number

Summary:

For FCI Calibration personnel only. **A passcode must be entered.**

Description:

None.

Example:

N/A.

COMMAND:

K. Constants Setup

Summary:

Permits the instrument to be placed in setup mode. **A passcode must be entered.**

Description:

In order for the instrument to function properly, certain constant values and curve fitting parameters must be supplied to be able to compute a verifiable flow rate for display. This command consists of four sections and is password protected. Section (1) is available whenever default constant values need to be reloaded into the EEPROM (the default data is automatically loaded at boot-up if a new or "cleared" EEPROM is detected). Section (2) consists of selecting the best curve fit equation in order to linearize the input signal. The two Curve Fit selections are: **0 = 2nd order polynomial** and **2 = two 2nd order polynomials**. Section (3) consists of making available the temperature compensation factors for modification. (Section 4) allows for the maximum flow and minimum flow parameters to be modified along with the standard density of the medium of calibration.

Example:

Pressing [K] [Enter] will display "**Enter Code #**". Press in the passcode. Pressing [Enter] will display "**Defaults? <**". Pressing 'Y' [Enter] will setup the required initial values, pressing an 'N' or [Enter] will skip to the next prompt , "**Curve Fit = x**", "**Change it ?<**". Pressing a 'Y' will display "**0=Poly, 1=Log**" on first line and "**2=Two Seg Poly**" on the second line to allow choosing one of the three. If "**Two Seg Poly**" is selected, then "**Brkpt xxxx**" is displayed on the first line and "**Change it?<**" is displayed on second line. Pressing 'Y' will display "**Enter Brkpt #**". Pressing an 'N' or [Enter] will skip to the next prompt , "**Input Coeffs?<**" and pressing a 'Y' will display "**c1 = xxxxxxx**" so the coefficients can be entered for either "**0=Poly, 1=Log**" selections. If "**2=Two Seg Poly**" is selected, "**Segment one ?<**" is displayed. Pressing a 'Y' will display "**c1 = xxxxxxx**" followed by "**Change it?>**". If 'Y' is pressed, a coefficient value must be entered or else the next coefficient will be displayed, etc. After coefficients are entered or 'N' or [Enter] is

pressed, the next prompt is "**Segment two?**<", Again, pressing a 'Y' will display "**c1 = xxxxxx**" so the coefficients can be entered. After the coefficients are entered or an [N] [ENTER] or [Enter] is pressed, the next prompt is "**Input Tempcos?**<". Pressing a [Y][ENTER] will display the following prompts:

"**tslp** 0.237599", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value.

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**Ref. R:** 1480", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value.

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**Caltemp:** 68", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value.

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**toff:** 357.0000", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value, a

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**tcslp: 0.1713999**", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value, a

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**tcslp0:** 0.0000000", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value, a

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**tcslp2:** 0.00000", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value, a

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**Max. Flow =** 150.00000", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value,

Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**Min. Flow =** 1.5000000", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value.
Pressing [N] [ENTER] or [Enter] will go to the next prompt which is,

"**dens.** = 0.074914", "**Change it?** <". Pressing a [Y][ENTER] will allow the user to input a new value.
Pressing [N] [ENTER] or [Enter] will go to the next prompt which is "**Input Mode?**<".

Note: Pressing [Q] [ENTER] at any time will exit this menu item and display "**Input Mode?**<".

COMMAND:

L. Calibrate Outputs

Summary:

Permits user to calibrate the outputs - 4 mA level, 20 mA level and heater current. **A passcode must be entered.** The instrument is calibrated at the factory. This command does not need to be done unless the instrument needs a re-calibration.

Description:

In order for the user to calibrate the output currents, a digital-to-analog converter (DAC) is set to the correct values so that on power-up, all the currents are reset properly each time. This is accomplished by monitoring the output currents while adjusting input to the DAC until the correct output values are reached. Both course and fine adjustment controls are available for calibration.

Example:

Pressing **[L]** [ENTER] will display "**Enter Code #**". Press in the passcode. Press [ENTER]. "**L, U, H, Q** (quit) or **D** (done)> will be displayed. "**L**" is for the **4 mA** adjustment, "**U**" is for the **20 mA** adjustment, '**H**' is for the heater current adjustment, **"Q"** is for exiting the menu at any time, and **"D"** is for exiting the menu when the user is finished entering parameters. After making a selection, "**[ENTER] to save**" is displayed on line 1, and "**(U)up (P)down**" is displayed on line 2. If [ENTER] is pressed, "**L, U, H or D (Done)**>" is displayed. If [U] or [P] is pressed, "**(F)fast/slow**" is displayed on line 1 and "**DAC: xxxxx**" is displayed on line 2, where 'xxxxx' is an increasing or decreasing **DAC** count. Pressing [U] or [P] will increase or decrease the DAC count in the fast mode. Repeated pressing of [U] or [P] in the slow mode will increase or decrease the DAC count in increments. To change to from fast action to slow action, press the [F] key - repeated key presses will toggle from fast to slow to fast etc. To accept the DAC value for the selected output current, press [ENTER]. When all outputs have been calibrated, press [D] (done) - the final DAC count values will be displayed and a **Reset** command will be invoked.

Note: **ADJUSTMENT of the HEATER will affect the CALIBRATION.** Notify FCI Customer Service for assistance. It is necessary to use precision instruments to perform this calibration.
Pressing **[Q]** [ENTER] at any time will exit this menu item and display "**Input mode?**<.

COMMAND:

M. Min/Max A/D Limits

Summary:

Permits minimum and maximum limits to be imposed on the A/D output data when calculating flow rate. **A passcode must be entered.**

Description:

Depending on the raw A/D input, there may be instances when the linearization of the data produces what is known as a 'fishhook' at either end of the flow rate spectrum. This effect may make the displayed flow to appear increasing or decreasing opposite to the actual flow rate. The correct selection of constraint values will eliminate the undesired effect.

Example:

Pressing **[M]** [ENTER] will display "**Enter Code #**"

Press in the passcode. Press [Enter] "**Max A/D:** xxxx" and "**Change it ?**<" will be displayed. If [Y] [ENTER] is pressed, "**Enter Max A/D #**" will be displayed. Entering new the maximum A/D calibrated will remove the high end 'fishhook'. After the value is entered or [N] [ENTER] is pressed, "**Min A/D:** xxxx" and "**Change it ?**<" will be displayed. If [Y] [ENTER] is pressed, "**Enter Min A/D #**" will be displayed. Entering the new minimum A/D number calibrated will remove the low end 'fishhook'.

Note: Pressing **Q** [ENTER] at any time will exit this menu item and display "**Input mode?**<".

COMMAND:

N. Software Reset

Summary:

Permits the instrument to be initialized without removing power.

Description:

Sometimes it becomes necessary to initialize the instrument. (i.e. when entering new constants, troubleshooting, or when power interruption is not practical.)

Example:

Pressing [N] [ENTER] will display "**Restart - Wait!**" followed by the initialization display: "**FCI ST98**", "**Initialization!**", "**Heater ON!**", "**Version x.xx**" and "**Scale = 1.00000**".
Finally, "**Input mode**<", is displayed.

COMMAND:

O. Select Sensor Heater Current

Summary:

Permits the user to select the correct flow element heater current. **A passcode must be entered.**

Description:

The user must select the correct heater current for the flow element in use. After entering the Passcode, the current value is displayed followed by "**Change it?**". If [N] [ENTER] is pressed, "**Input mode?**<" will be displayed, if [Y] [ENTER] is pressed, "**2 = 90mA LO#**" followed by "**3 = 75mA LO**", followed by "**4 = 90mA MD**" followed by "**5 = 75mA MD**" are displayed. After a choice is made, the heater will be turned **ON** and "**Input mode?**<" will be displayed.

If a display with LO is chosen, software flags are set to inform the user if temperature values are over range (below -50 or above 350 °F). If a display with MD is chosen, the higher temperature range software flags set.

The "LO" and "MD" designation refers to the temperature range of the sensing element. "LO" is the standard range (-50 to 350°F). "MD" is the medium range (-100 to 500°F). "MD" is not available with early production units. The "LO" and "MD" selections set up the proper over temperature and under temperature limits so the temperature error message indicates correctly.

Example:

Pressing [O] [Enter] - Refer to the description.

Note: If the FC88 is displaying "**4 = 90mA MD**" and "**5 = 75mA MD**" and the user needs to see the value for 2 or 3, press [ENTER]. The values of 2 and 3 will be re-displayed for a few seconds.

Pressing [Q] [ENTER] at any time will exit this menu item and display "**Input mode?**<".

COMMAND:

P. Re-configure the FC88 Unit

Summary:

Permits the hand-held FC88 unit to be reset without having to manually program the FC88.

Description:

Sometimes it becomes necessary to re-initialize the hand-held unit due to inadvertent keystroke entries or if the FC88 had been used on another instrument. (i.e. FlexMasster.)

Example:

Pressing [P] [ENTER] will display "**FC88 Reset**". After a few seconds delay "**Input mode ?**<" will be displayed.

Note: If the FC88 has been used on a device using 80 characters (four line display), the character '-' will be displayed instead of '**P**' until the FC88 has been reset to use 32 characters (two line display).

COMMAND:

Q. Undefined

COMMAND:

R. Delta-R, Ref-R, CB Temp, -8 V and +20 V Supply

Summary:

Displays **A/D Delta-R** and **Ref-R** as resistance values, Circuit Board Temperature, -8 Volt Supply, and +20 Volt Supply.

Description:

The user may select to view any of the four displays available; A/D Delta-R, and Ref-A/D counts as resistance, the Circuit Board Temperature, the -8 Volt, or the +20 Volt supply. These readings are for reference only and should not be used to check the calibration.

Example:

Pressing R [Enter] will display "**RES=1, TEMP=2**" followed by "**-8V=3, +20V=4**". If "1" is selected, the display is continually updated with "**Resistance**" on the first line and "**r=xxx R=xxxx**" on the second line. Selection "2" displays "**CB Temperature**" followed by "**xx.x degrees x**" which is updated continuously. Selection "3" displays "**-8 Volt Supply**" followed by "**-8.xxx volts**" which is updated continuously. If "4" is selected, "**+20 Volt Supply**" followed by "**+20.xxx volts**" which is displayed continuously.

Note: Pressing [ENTER] at any time will exit this menu item and display "**Input mode?**<".

COMMAND:

S. Save and/or Restore USER-Save, FACTORY

Summary:

Permits the user to save normal operational data to a User-Save area of the EEPROM. Also permits the User to restore normal operational data from the User-Save or FACTORY area of the EEPROM. Calibration data is saved in the FACTORY area of the EEPROM with the factory calibration before the meter leaves FCI. The factory data can not be changed in the field.

Description:

None.

Example:

Pressing S [Enter] will display "**Restore User**" followed by "**from USER SAVE?** ". If 'Y' is pressed, "**Restore Page(x)**" is displayed, followed by "**Please wait**", "**Completed!**", and then "**Restart**!". If 'N' is pressed, "**Restore User**" is displayed, followed by "**from FACTORY?**". The same information is displayed as restore from User Save. If no data exists in either area, "**Data Empty!!!**" is displayed. Next, "**Save USER?**" is displayed. If 'Y' is pressed, "**USER Save Pg(x)**" followed by "**Please wait**" and then "**Completed!**" is displayed. This is followed by "**Save FACTORY**?". If 'Y' is pressed, the prompt "**Enter Code #"** asks the user to enter the password and, if correct, "**FACTORY Pg(x)**", "**Please wait**", and finally "**Completed!**" are displayed.

COMMAND:

T. Normal Operating Mode

Summary:

Permits the user to displays the flow rate and media temperature or the flow rate and totalized flow.

Description:

This is the default operating mode and displays the flow rate (default units of measure are SFPS). Another display is the totalized flow that is multiplexed with the temperature readout. The default units will not permit a totalized flow to be displayed.

Example:

T [ENTER] will display "53.0 **SFPS**" on line 1, and "70.8 **Degrees F**" on line 2 (example based on default units).

Note: If another function needs to be accessed, just press the letter and [ENTER] to go the command. "**Input mode?**<" will not be displayed in the normal operating mode.

COMMAND:

U. Display Total Flow Time

Summary:

Total time the unit has been operating in the Normal Operating mode since the last reset.

Description:

This function operates in conjunction with the totalize mode for computing the totalized flow. This function can be reset by the user. The time units are in minutes.

Example:

Pressing [U] [ENTER] will display "**Time =** 3456.3305" on the first line. "**Reset it?** <" is displayed on the second line. Pressing a [Y] [ENTER] will reset the total time to 0. Pressing a [N] [ENTER] or [Enter] will keep the current time. Next, "Tot: xxxxxx" is displayed on the first line. "**Reset it?** <" is displayed on the second line. Pressing [Y] [ENTER] resets the totalizer value to zero. Pressing [N] [ENTER] keeps the current totalizer values.

COMMAND:

V. Output Mode Select

Summary:

Permits the user to select one of the three (3) output modes.

Description:

Output mode menu selection:

Menu Setting	mA Output	V Output
0 = 4-20 mA	4 -20 mA	1-5 Vdc
1 = 0-5 Vdc	0-20 mA	0-5 Vdc
2 = 0-10 Vdc	Do Not Use	0-10 Vdc

Example:

Pressing V [ENTER] will display "**Output: xxxxxxx**" on the first line and "**Change it ?**<" displayed on the second line. xxxxxxx will either be "**4 - 20mA**", "**0 - 5 Volts**", or "**0 - 10 Volts**" depending on previous selection. Pressing [N] [ENTER] or [ENTER] after the "**Change it?**<" prompt will give "**Input mode ?**<". Pressing [Y] [ENTER] will display "**0: 4-20, 1: 0-5**, **2: 0-10 #**". Entering one of the values (0, 1, or 2) selects the desired output and "**Input mode ?**<" is displayed.

Note: Selecting 1, 2, or 3 may require a wiring change on the Customer Connection circuit board.

COMMAND:

W. Totalizer Mode

Summary:

Permits the instrument to display a totalized flow with or with out intermittent display of temperature.

Description:

The instrument must be in one of the following flow units (SCFM, Lbs/Hr, NCMH, Kg/Hr) (see command Z) to display the totalized flow. Totalized flow can be reset to zero at any time or whenever power is interrupted.

Example:

Pressing W [ENTER] will display "**Totalizer is** <" on the first line. "**ON, turn OFF ?**" or "**OFF, turn ON ?**" is displayed on the second line (depending on the initial state). Pressing a [Y] [Enter] will change the totalizer state. Whether the state is changed or a [N] [ENTER] or [ENTER] is pressed, "**reset Totalizer**" and "**at this time ?**" are displayed. Pressing [Y] [ENTER] will zero the totalizer. Pressing [N] [ENTER] or [ENTER] gives no change. Next displayed is "**reset Totalizer**" and "**during Powerup**?". Pressing [Y] [ENTER] sets a flag where pressing [N] [ENTER or [ENTER] displays "**Temp display is**" followed by "**ON, turn OFF ?**" or "**OFF, turn ON?**" (depending on the initial state). Pressing [Y] [ENTER] will change states and display "**Input mode ?**<".

Note: Totalizer data is saved in the EEPROM approximately every 15 minutes.

COMMAND:

X. NAMUR Output Fault Indicator

Summary:

Permits the user to toggle the Fault Detection on and select the NAMUR Fault detection indicators. **A password must be entered.**

Description:

Faults, i.e., heater short or open conditions, detected by the instrument will send an alarm to the host system by one of two methods: If the output mode is "4-20 **mA**", the user may indicate the fault by setting the output "**alarm**" to 22.0 **mA** or 3.5 **mA**; if the output mode is "0-5 **Volts**" or "0-10 **Volts**", the output "**alarm**" is pulsed from zero (0) volts to one (1) volt about once every 7 seconds. (The voltage mode is not a NAMUR requirement.) The NAMUR Fault Detection system is enabled by the NAMUR OFF/ON flag.

Example:

Pressing X [ENTER] will display "**Enter Code** #". Enter the passcode. Press [Enter], "**NAMUR flag is**" displayed on the first line and "**ON, turn OFF?**" or "**OFF, turn ON?**" is displayed on the second line (depending on the initial state). Pressing [Y] [ENTER] will change the Fault flag state; Pressing [N] [ENTER] or [ENTER], creates no change. If the output mode is "4-20 **mA**", and Alarm output of "22 **mA**" or "3.5 **mA**" can be selected. If the output mode is "0-5 **Volt**s" or "0-10 **Volts",** **"VOUT: 0 Volts**" is displayed followed by **"Input mode?**<". Pressing [Q] [ENTER] at any time will exit this menu and display **"Input mode?**<".

COMMAND:

Y. Undefined.

COMMAND:

Z. Flow Units Select

Summary:

Permits user to select one of six flow units - three (3) English and three (3) Metric. Output is automatically scaled by selecting new full scale and new zero.

Description:

Depending on the flow units desired, the user should select one of the following;

	Velocity	**Volume**	**Mass**
English	S**F**PS	S**C**FM	**L**B/HR
Metric	S**M**PS	**N**CMH	**K**G/HR

The user can also scale the output based on the calculated maximum flow rate and the new full scale that is chosen. The volume and mass flow units require specific line size dimensions. Typically, flow rate ranges are 100:1 but can be adjusted to 10:1 by entering a new full scale and/or zero level. In this mode, the instrument will not accept

any turn down ratios lower than 10:1. If an attempt is made to enter a lower value, an error will be displayed and an opportunity to reenter is given.

Example:

Note: Pressing [Q] [ENTER] at any time will exit the menu. All data will return to the original values prior to entering this menu.

Velocity (English)

Pressing [Z] [ENTER] will display "**E for English or**" followed by "**M for Metric**". Press an [E] [ENTER] and the next prompt is "**F SFPS, C SCFM**" followed by "**or L LBS/HR**". Press an [F] [ENTER] and the next prompt is "**Max = xxx.xxxxxx**" followed by "**Change F.S. ?**<". Press [Y] [ENTER] and enter a new value, or else press [N] [ENTER] or [ENTER]. The next prompt is "**Zero = x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Save ?**<". Press [Y] [ENTER] and the new values are saved to the EEPROM. The last prompt is "**Input mode ?**<".

Volume (English)

Pressing [Z] [ENTER] will display "**E for English or**" followed by "**M for Metric**". Press an [E] [ENTER] and the next prompt is "**F SFPS, C SCFM**" followed by "**or L LBS/HR**". Press [C] [ENTER] and the next prompt is "**R round duct or**" followed by "**S rectangular** <". Press [R] [ENTER] and the next prompt is "**Diameter: inches**" "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. If [S] [ENTER] is pressed, the next prompt is "**Inches Wide**" "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Inches High**". "x.xxxxxx" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Max = xxx.xxxxxx**" followed by "**Change F.S. ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Zero = x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Save ?**<". Press [Y] {ENTER] and the new values are saved. The last prompt is "**Input mode ?**<".

Mass Flow (English)

Pressing Z [ENTER] will display "**E for English or**" followed by "**M for Metric**". Press [E] [ENTER] and the next prompt is "**F SFPS, C SCFM**" followed by "**or L LBS/HR**". Press [L] [ENTER] and the next prompt is "**R round duct or**" followed by "**S rectangular** <". Press [R] [ENTER] and the next prompt is "**Diameter: inches**" "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. If [S] [ENTER] is pressed, the next prompt is "**Inches Wide**" "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Inches High**", "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is **"Max = xxx.xxxxxx**" followed by "**Change F.S. ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Zero = x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is **"Save ?**<". Press [Y] [ENTER] and the new values are saved. The last prompt is "**Input mode ?**<".

Velocity (Metric)

Pressing [Z] [ENTER] will display "**E for English or**" followed by "**M for Metric**". Press an [M] [ENTER] and the next prompt is "**M SMPS, N NCMH**" followed by "**or K KG/HR**". Press an [M] [ENTER] and the next prompt is "**F.S. = xxx.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Zero = x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Save ?**<". Press '**Y**' and the new values are saved. The last prompt is "**Input mode ?**<".

Volume (Metric)

Pressing [Z] [ENTER] will display "**E for English or**" followed by "**M for Metric**". Press an [M] [ENTER] and the next prompt is "**M SMPS, N NCMH**" followed by "**or K KG/HR**". Press an [N] [ENTER] and the next prompt is "**R round duct or**" followed by "**S rectangular** <". Press [R] [ENTER] and the next prompt is "**Diameter: Mn**" "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. If [S] [ENTER] is pressed, the next prompt is "Mn **Wide**" **"x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Mn High**", "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Max = xxx.xxxxxx**" followed by "**Change F.S. ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Zero = x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Save ?**<". Press [Y] [ENTER] and the new values are saved. The last prompt is "**Input mode ?**<".

Mass Flow (Metric)

Pressing [Z] [ENTER] will display "**E for English or**" followed by "**M for Metric**". Press an [M] [ENTER] and the next prompt is "**M SMPS, N NCMH**" followed by "**or K KG/HR**". Press [K] [ENTER] and the next prompt is "**R round duct or**" followed by "**S rectangular** <". Press [R] [ENTER] and the next prompt is "**Diameter: Mn**" "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. If [S] [ENTER] is pressed, the next prompt is "**Mn Wide**" "x.xxxxxx" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Mn High**", "**x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Max = xxx.xxxxxx**" followed by "**Change F.S. ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Zero = x.xxxxxx**" followed by "**Change it ?**<". Press [Y] [ENTER] and enter a new value or else press [N] [ENTER] or [ENTER]. The next prompt is "**Save ?**<". Press [Y] [ENTER] and the new values are saved to the EEPROM. The last prompt is "**Input mode ?**<".

Note: Pressing [Q] at any time will exit the menu. All data will retain the original values prior to entering the menu.

Using Procomm Software (Option)

If the Procomm software was ordered the customer will receive a 3-1/2 inch floppy disk. Make a back up copy of the disk that is compatible to the PC.

1. Insert the backup copy into the disk drive.
2. At the dos prompt (A: or B:) type in PROCOMM. This will execute the program.
3. After a few moments the Procomm logo will appear. Pressing any key will remove the logo.
4. Press the Caps Lock button and check the Caps Lock light to ensure it is on.
5. Press Alt-P to ensure that communication settings are set for COM1 or COM2, 9600 Baud, 8 Bit, 1 Stop Bit, and No Parity. Press the ESC key to exit.
6. Press the ENTER key. The screen should read "Input Mode? or Port # #".
7. Enter any of the AF Series single letter commands to execute a function.

Some additional Procomm commands to know:

Alt-X	Exit	Alt-V	View Files	PgUp	Send Files	PgDn	Receive Files
Alt-Z	Colors	Alt-C	Clear Screen				

Using Windows Terminal

If the PC has Windows installed, use the program, Terminal, to communicate with the flowmeter. Terminal is usually located in Accessories. Double-click on the Terminal Icon to execute the program.

1. Go to Settings.
2. Click on Communications.
3. Set for COM1 or COM2, 9600 Baud, 8 Bit, 1 Stop Bit, and No Parity. Press OK.
4. Press the ENTER key to see the Input Mode? prompt.
5. Enter any of the ST98 single letter commands to execute a function.

5. Troubleshooting

Caution: Only qualified personnel should attempt to test this instrument. The operator assumes all responsibilities for safe practices while troubleshooting.

Alert: The electronics contains electrostatic discharge (ESD) sensitive devices. Use standard ESD precautions when handling the electronics. See Chapter 2, Installation for ESD details.

Quick Check

Verify the serial numbers of the flow element and electronics match.
Verify all cables are seated firmly.
Verify all customer connections are correct.
Verify the wiring is per the wiring diagram in Chapter 2.
Verify the installation is correct as shown in Chapter 2.
Check customer fuses and power switches.
Press [P] to reconfigure the FC88 to the proper 2 line display.
Press [N] to reset the software.

General Function Check

Once the flow meter has been installed and turned on, the instrument can be checked for proper operation by performing the NAMUR functional checks. The following tools will be required for this check.

Tools Needed - General Function Check -

FC88 Communicator or Computer with Interface Kit - Contact a Field Representative or Customer Service to purchase an FC88 or computer interface kit.
Digital Multimeter (DMM)
Allen Wrench 1/16 Inch (for aluminum, circular enclosure)
Medium size flat blade Screwdriver (for steel, square enclosure)

NAMUR Fault Indication

NAMUR NE43 is a German fault detection standard that lets the user know if there is a fault within the instrument. The fault indicator can be turned on or off with the **X** menu function as described in Chapter 3 - Operation.

When the indicator is on and a fault is detected the 4-20 mA output will be driven to less than or equal to 3.5 mA, or 22 mA or greater, depending upon what the user chooses. If a voltage output was selected, the output will be driven from 0 to 1 volt every 7 seconds. The voltage fault indicator is not part of the NAMUR NE43 standard.

When the NAMUR Fault indication is turned on (Menu **X**), the faults will be displayed when the instrument is in the normal operation mode (Menu **T**).

In a few cases there may be two error indications when there is only one fault. A single fault can cause multiple problems with the instrument, therefore there are more than one fault indications. The fault indications shown in the **T** mode are prioritized in the order of where the problem will most likely be found.

Example: Error codes are: "Sensor Error" "Overtemp Head"
There is most likely a sensor element wiring problem that is creating an over temperature fault situation.

Procedure

Open the enclosure to expose the customer connection board.

Connect the FC88 or computer to the RS-232 Jack (P1).

Set the FC88 communicator or computer to display the **T** mode.

Turn on the NAMUR fault flag (menu **X**).

Compare the fault indication from the **T** mode with Table 5-1. Follow the instructions provided in the table.

Table 5-1. NAMUR Fault Listing

Indicated Faults	Possible Causes
Nothing displayed on the FC88 or the optional display. No display on the FC88 no display on the optional display.	Power is not applied to the instrument. Power is not correctly applied to the customer connection board. There is a green LED that lights when AC power is applied. It is on the back side of the customer circuit board behind P1 (it is hard to see). If it is blinking remove power and contact customer service.
No display on the FC88. There is a display on the optional LCD display.	Press [P] [ENTER] on the FC88 to reset it. If there is no response connect it to another ST98 (if present) to verify operation. Replace the cable between the ST98 and the FC88 if there is no operation. If no operation contact customer service.
No fault indicated. Output mA or Vout operates correctly.	Verify the NAMUR option is activated [X] [ENTER]. If there is no fault indicated, verify the heater is on [H] [ENTER]. If there is no fault indicated, proceed to the installation and Application Verification procedure.
No fault indicated but the 4-20 mA (or Voltage) output is not transmitting.	Go to the Instrument Output Check procedure.
Sensor Error.	Wiring to the sensing element may be incorrect. One or more of the sense or excitation wires may be disconnected or shorted. The active or reference RTD is either open or shorted. Check the wiring (see Appendix A) and the sensor resistance as shown later in this chapter.
OverTemp Head!!	The process temperature has exceeded the maximum temperature rating of the flow element (350°F). Verify the temperature of the process. If the temperature is over 350°F, remove the flow element from the process. Damage to the flow element will occur. Contact customer service.
UnderTemp Head!!	The process temperature has exceeded the minimum temperature rating of the flow element (-50°F). Verify the temperature of the process. If the temperature is under -50°F, remove the flow element from the process. Damage to the flow element will occur. Contact customer service.
Open Heater!!	The flow element's heater has exceeded the maximum resistance allowed (approximately 170 ohms) or is disconnected. This limit also includes the cable resistance in remote installations. The heater fault flag will come on in cases when the heater is turned off (using the menu key [H] [ENTER]). Check the wiring and the sensor resistance.
Shorted Heater!!	The flow element's heater has exceeded the minimum resistance allowed (approximately 90 ohms) or it is shorted. This limit also includes the cable resistance on remote installation. The heater fault flag will come on in cases when the heater is turned off (using the menu key [H] [ENTER]). Check the wiring and the sensor resistance.

Application Verification

After verifying that the flow meter is functioning, review the application parameters as shown below to verify the calibration matches the process media.

Equipment Needed

Flow Instrument Calibration Data
Process Parameters and Limits

Check Serial Numbers

Verify that the serial number of the flow element and the flow transmitter electronics are the same. The flow element and the flow transmitter are a matched set and cannot be operated independently of each other.

Check the Instrument Installation

Review the information in Chapter 2 - Installation, to verify correct mechanical and electrical installation.

Verify that the flow element is mounted at least 20 diameters downstream and 10 diameters upstream from any bends or interference in the process pipe or duct.

Check for Moisture

Check for moisture on the flow transmitter. Moisture on the flow transmitter may cause intermittent operation.

Check for moisture on the flow element. If a component of the process media is near its saturation temperature it may condense on the flow element. Place the flow element where the process media is well above the saturation temperature of any of the process gases.

Check Application Design Requirements

Application design problems may occur with first time application instruments, although the design should also be checked on instruments that have been in operation for some time. If the application design does not match field conditions, errors occur.

1. Review the application design with plant operation personnel and plant engineers.
2. Ensure that plant equipment such as pressure and temperature instruments conform to the actual conditions.
3. Verify operating temperature, operating pressure, line size, and gas medium.

Verify Standard Versus Actual Process Conditions

The flowmeter measures the mass flow rate. The mass flow rate is the mass of the gas flowing through a pipe per time. Other flow meters, such as an orifice plate or a pitot tube, measure the volumetric flow rate. The volumetric flow rate is the volume of gas per time. If the readings displayed do not agree with another instrument, some calculations may be necessary before comparing them. To calculate the mass flow rate, the volumetric flow rate, and the pressure and temperature, the point of measurement must be known. Use the following equation to calculate the mass flow rate (Standard Volumetric Flow rate) for the other instrument:

Equation:

$$Q_S = Q_A \times \frac{P_A}{T_A} \times \frac{T_S}{P_S}$$

(Metric: Where bar(a) and °K are used for pressure and temperature.)

Where:

Q_A = Volumetric Flow Q_S = Standard Volumetric Flow
P_A = Actual Pressure T_A = Actual Temperature
P_S = Standard Pressure T_S = Standard Temperature

PSIA and °R are used for pressure and temperature units.

Example: (Metric: P_S = 1.01325 bar(a)

Q_A = 1212.7 ACFM Q_S = 1485 SCFM T_S = 21.1°C (294.1K))
P_A = 19.7 PSIA T_A = 120°F (580°R)
P_S = 14.7 PSIA T_S = 70°F (530°R)

$$\left(\frac{1212.7\ \text{ACFM}}{1}\right)\left(\frac{19.7\ \text{PSIA}}{580^\circ\ \text{R}}\right)\left(\frac{530^\circ\ \text{R}}{14.7\ \text{PSIA}}\right) = 1485\ \text{SCFM}$$

Verify the Calibration Parameters

The instrument uses a set of predetermined calibration parameters to process flow signals. Most of these parameters should not change. A data package located at the rear of this manual contains the "ST98 Delta R Data Sheet". This contains the calibration ST98 parameters stored in the flow transmitter at the factory. To verify that these parameters have not changed, complete the following:

1. Identify the appropriate Delta R Data sheets by serial number of the instrument.
2. Press [D] [ENTER] to examine each of the parameters. The [ENTER] key allows scrolling one message at a time. Use Table 5-2 to verify parameters with the Delta R Data sheet ST98 Parameters.

Table 5-2. Diagnostic Test Sequence on Display

Serial No.		eu:	
Cust. No.		curvefit:	
scale:		outmode:	
*c1:		*maxflow:	
*c2:		*minflow:	
*c3:		*Max A/D:	
*c4:		tot:	
*c5:		tflow:	
*c6:		*Min A/D:	
*c7:		*Density:	
*c8:		K-Factor:	
*c9:		zero:	
*c10		*sensor:	
*caltemp:		*tslp:	
*balance:		*tcslp0:	
*outz:		*tcslp:	
*outf:		*tcslp2:	
*heater i:		line size0	
*toff:		line size1:	
factor:		F.S.:	

If parameters that have an asterisk (*) have changed, this may indicate a problem. Customer Service should be contacted. If the parameters have not changed, continue with the next section.

Check the Hardware

Equipment Required

FC88 Communicator or Computer with Interface Kit - Contact a Field Representative or Customer Service to purchase an FC88 or computer interface kit.
Digital Multimeter (DMM)
Allen Wrench 1/16 Inch (for aluminum, circular enclosure)
Flat blade Screwdriver (for steel, square enclosure)

Troubleshooting the Flow Element

Use Table 5-3 to determine if the flow element is wired correctly or has failed. Table 5-3 is for resistances at a process temperature of about 70 degrees. To determine the exact resistance at another process temperature use the temperature versus resistance table in Appendix A.

Turn off the input power to the instrument. Unplug TS2 from the circuit board assembly and measure the resistances as shown in Table 5-3.

See Figure 5-1 for component placement and Figure 5-2 for a view of the plug. If the instrument is set up in a remote configuration (flow element enclosure separate from the control circuit enclosure), and the ohm readings are incorrect disconnect the flow element cable at the local (flow element) enclosure. Measure the resistance as shown in Table 5-3. Figure 5-3 shows the terminal block configuration.
If the resistance is correct then the cable between the enclosures is probably bad or not connected properly (loose, corroded, or connected to the wrong terminal).

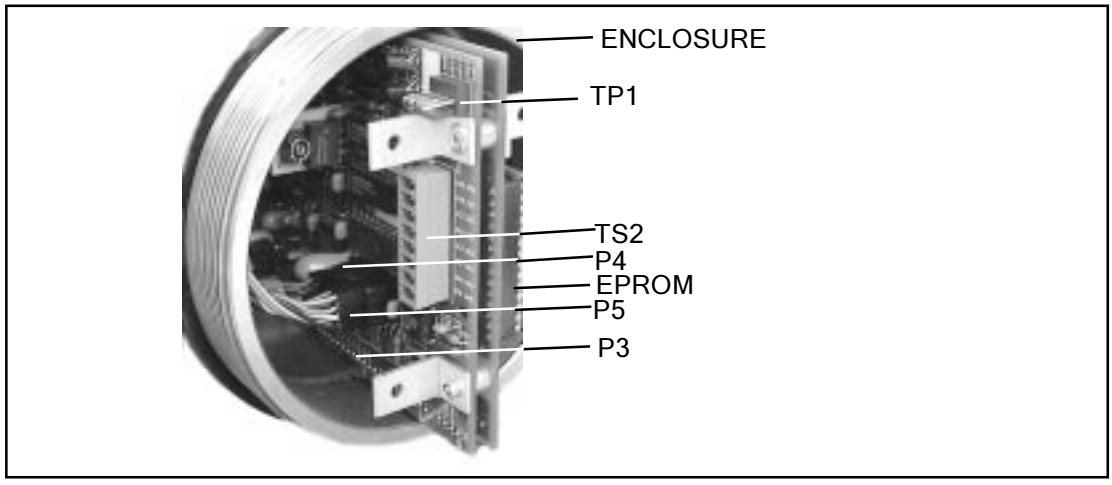


Figure 5-1. Component Identification

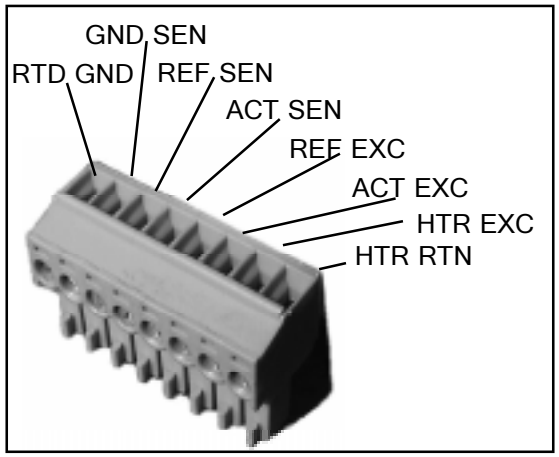


Figure 5-2. TS2 Connector Plug

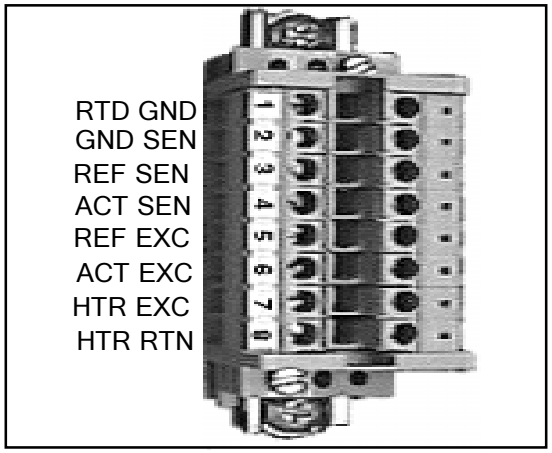


Figure 5-3. Terminal Block In Local Enclosure

Table 5-3. Flow Element Resistance at TS2 or Local Terminal Block

LUG OR PIN NUMBER	RESISTANCE
(7) HTR EXC TO (8) HTR RTN	110 - 118 OHMS
(4) ACT SEN TO (2) GND SEN	1.1K OHM
(3) REF SEN TO (2) GND SEN	1.1K OHM
(3) REF SEN TO (4) ACT SEN	2.2K OHMS
(1) RTD GND TO (2) GND SEN	0 OHMS
(4) ACT SEN TO (6) ACT EXC	0 OHMS
(3) REF SEN TO (5) REF EXC	0 OHMS
SHIELD TO HTR RTN (8) (REMOTE INSTALLATIONS)	

The resistance of the Active and Reference sensor will depend on the temperature of the sensing element. Refer to the "Temperature Versus Resistance" Table in Appendix A.

When measuring the resistance of the flow element through a long remote cable, the cable resistance must be subtracted from the measurement. The residual resistance of the DVM and its leads should also be considered. See Table 5-4 to calculate the resistance for copper wire. Each wire gauge size number increase represents a factor of 1.26 resistance increase over the previous size. Moving three gauge sizes higher doubles the resistance. To convert the table values to ohms per meter, multiply the value by 0.0394.

Table 5-4. Resistance Versus Wire Size (AWG)

AWG Size	Ohms Per 1000 Feet
14	2.52
15	3.18
16	4.02
17	5.05
18	6.39
19	8.05
20	10.1
21	12.8
22	16.2
23	20.3
24	25.7

Check the Flow Element Voltages

Use the following voltage measurements if power cannot be easily removed from the instrument or if resistance measurement fail to resolve the problem. Be sure the sensor heater current is set to 75 mA LO by pressing [O] on the FC88 and selecting the heater current. Be sure to set the heater current back to where it was before beginning this procedure. Make the voltage measurements found in Table 5-5 at terminal strip TS2 on the flow transmitter, or on the Local Terminal Block.

Table 5-5. Approximate Flow Element Voltages AT 70° F

LUG OR PIN NUMBER	VOLTAGE*
(7) HTR EXC TO (8) HTR RTN	Approximately 6.79 VDC
(4) ACT SEN TO (6) ACT EXC	Approximately 0.00 VDC
(3) REF SEN TO (5) REF EXC	Approximately 0.00 VDC
(5) REF EXC TO (1) RTD GND	Approximately 2.20 VDC
(6) ACT EXC TO (1) RTD GND	Approximately 2.21 - 2.82 VDC**
(4) ACT SEN TO (3) REF SEN	Approximately 0.24 VDC**

Cable resistance of the remote flow element will affect the TS2 voltage readings at the electronics enclosure.

*Voltages varies with Temperature and Flow and the Sensor Heater Current Selection.

**Voltage will vary with the process flow rate.

Verification Of The Electronics

Check the Flow Transmitter Voltages

Check the voltages in Table 5-6 being sure the volt meter is in the volt mode. Using the DVM in the current mode will damage the flow transmitter.

Table 5-6. Instrument Voltages

PIN NUMBER	VOLTAGE
P3-1 TO P3-5	-9 TO -5 VDC
P3-1 TO P3-6	+5 ± 0.2 VDC
P3-1 TO P3-11	+2 ± 0.01 VDC
TP1 +15 TO TP1 GND	+15 ± 0.5 VDC
TP1 +20 TO TP1 GND	+20 ± 0.5 VDC
TP1 +10 TO TP1 GND	+10 ± 0.01 VDC

If the voltage checks correspond to Table 5-6, the electronics are functioning properly.

Transmitter Circuit Calibration Check (Delta R Verification)

Equipment Needed

FC88 Communicator or equivalent
DVM
Original Delta R Data Sheet - Match By Serial Numbers
2 Precision Decade Resistance Boxes, 0.1% (Largest Steps: 1K Ohm, Smallest Steps 0.01 Ohms)
10 feet of wire, 22 to 18 AWG
Small Flat Blade Screwdrivers, 3/32 and 1/8 inches wide blades.
Small Wire Cutters
Small Wire Strippers

Procedure

1. Turn power off.
2. Mark all wires connected to terminal strip TS2 (or the terminal block for remote instruments) so they may be reconnected to the proper terminals. Disconnect the wires.
3. Connect the resistance decade boxes to terminal strip TS2 (or the terminal block for remote instruments) as shown in Figure 5-4. Check the Delta R Data sheet for the nominal resistance value. Set the decade boxes for the nominal resistance value ±0.01%.
4. Turn the power on and allow the instrument 5 minutes to stabilize.
5. Press [T] [ENTER] to view the normal operating mode. Adjust the active and reference decade boxes. Verify the parameters on the FC88 change.

If the display changes, proceed to the next section. If the display is frozen the instrument is malfunctioning. Contact Customer Service.

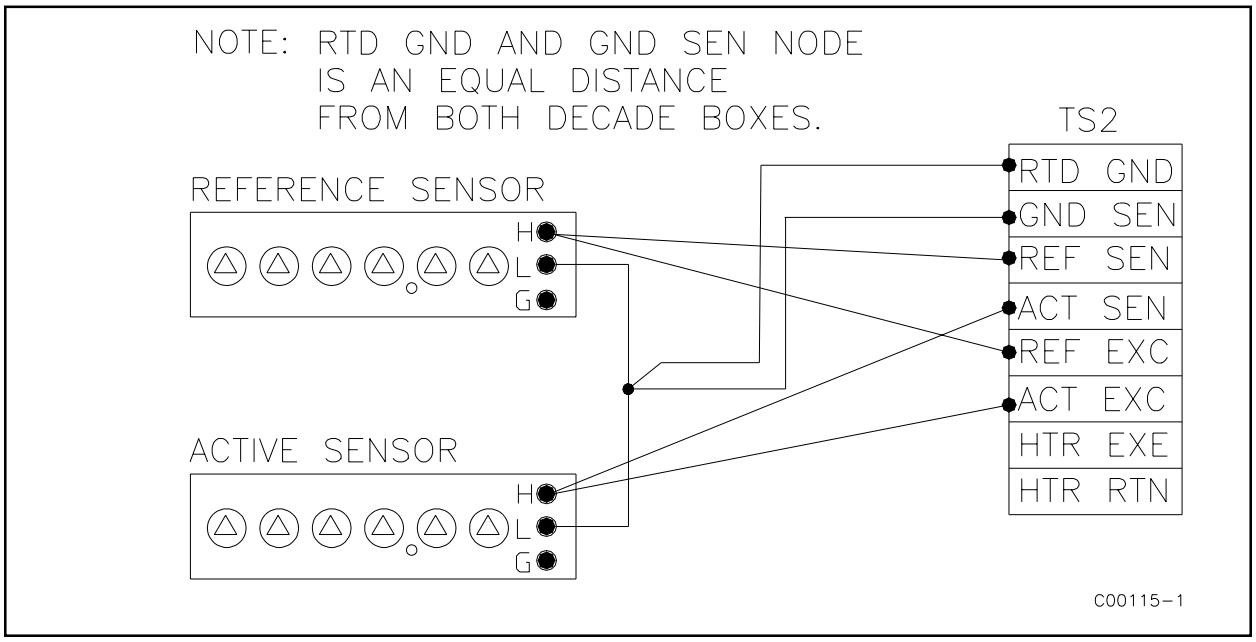


Figure 5-4. Decade Box Connections

Instrument Output Check

Alert: If the mA output is being used on the flow transmitter, the receiver must have a resistance range of 0 to 700 ohms, including the cable resistance.

To vary the output, follow the procedure below:

1. Press [I] then [ENTER] on the FC88. "Enter #(0 01000)" will be displayed on the FC88. Press [0] for minimum output or [500] for an output that is in the center of the range or [1000] for a maximum output.
2. Check the receiver and verify that it agrees with what is being sent.
3. When the above step is verified press [ENTER].

If the receiver is not responding to the signal being sent, remove the power from the instrument. Disconnect the output cable (TS3) and connect a current meter to "mA OUT". Apply power to the instrument and go through the [I] routine to check the output locally. If the mA output responds correctly then there is a problem with the cable or receiver. If there is no response form the mA output, there may be a configuration error or the output circuit is inoperative.

The voltage output option can also be checked with the [I] menu and can help solve problems with the 4-20 mA output

Alert: When finished with troubleshooting be sure that environmental seals are intact and properly installed when securing enclosure lids. Damage resulting from moisture penetration of the Local or Remote Enclosure is NOT covered by product warranty.

Spares

FCI recommends one of each of the following should be kept as a spare: One identically set up ST98 Flow meter. Contact FCI for specific recommendations.

Defective Parts

Before returning any equipment to FCI, please obtain an RA number for authorization, tracking, and repair/ replacement instructions. If a return is required, remove defective instrument, replace with spare, calibrate, then return defective instrument to FCI freight prepaid for disposition.

Customer Service

1. In the event of problems or inquiries regarding the flowmeter, please contact the regional or country authorized FCI Field Agent. There is an extensive list of these representatives at the front of this manual.
2. Before contacting the FCI representative, please be sure that all the applicable information is near so that a more effective, efficient and timely response may be provided.
3. Refer to Appendix C for specific Customer Service policy provisions.

4. Maintenance

Caution: To avoid hazards to personnel, ensure that all environmental isolation seals are properly maintained.

Alert: The flow transmitter contains electrostatic discharge (ESD) sensitive devices. Use standard ESD precautions when handling the flow transmitter. See Chapter 2, Installation for ESD details.

The FCI instrument requires little maintenance. There are no moving parts or mechanical parts subject to wear in the instrument. The sensor assembly which is exposed to the process media is all stainless steel construction.

Maintenance

Without detailed knowledge of the environmental parameters of the application surroundings and process media, FCI cannot make specific recommendations for periodic inspection, cleaning, or testing procedures. However, some suggested general guidelines for maintenance steps are offered below. Use operating experience to establish the frequency of each type of maintenance.

Calibration

Periodically verify the calibration of the output and recalibrate if necessary. See Chapter 5 - Troubleshooting. FCI recommends every 18 months at a minimum.

Electrical Connections

Periodically inspect cable connections on terminal strips and terminal blocks. Verify that terminal connections are tight and physically sound with no sign of corrosion.

Remote Enclosure

Verify that the moisture barriers and seals protecting the electronics in the local and remote enclosures are adequate and that no moisture is entering those enclosures.

Electrical Wiring

FCI recommends occasional inspection of the system's interconnecting cable, power wiring and flow element wiring on a "common sense" basis related to the application environment. Periodically the conductors should be inspected for corrosion and the cable insulation checked for signs of deterioration.

Flow Element Connections

Verify that all seals are performing properly and that there is no leakage of the process media. Check for deterioration of the gaskets and environmental seals used.

Flow Element Assembly

Periodically remove the flow element for inspection based on historical evidence of debris, foreign matter, or scale build-up and appropriate plant shutdown schedules and procedures. Check for corrosion, stress cracking, and/or build-up of oxides, salts, or foreign substances. The thermowells must be free of excessive contaminants and be physically intact. Any debris or residue build-up could cause inaccurate switching. Clean the flow element, as necessary, with a soft brush and available solvents (compatible with Stainless Steel).

Appendix A. Drawings

All dimensions are shown in inches. Brackets [ ] indicate dimensions in millimeters.

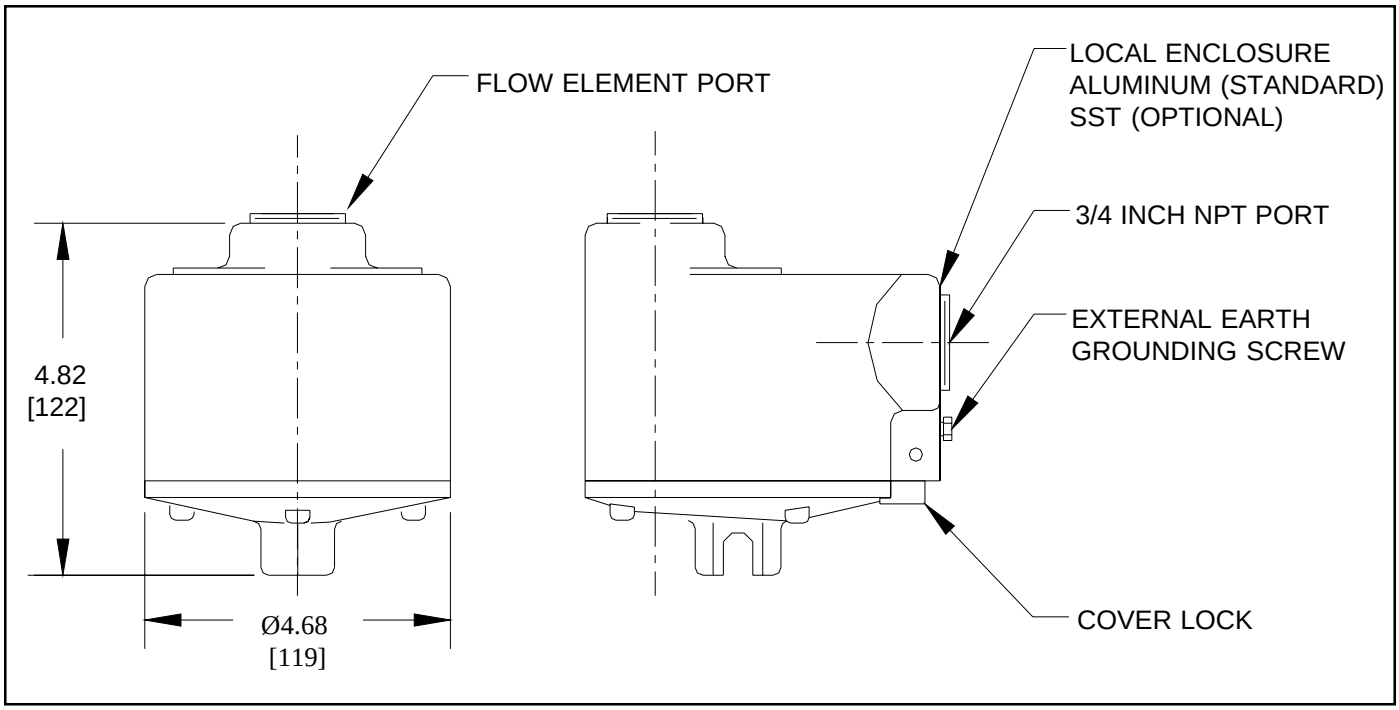


Figure A-1. Local Enclosure, NEMA Type 4X and Hazardous Location (Aluminum Enclosure Shown)

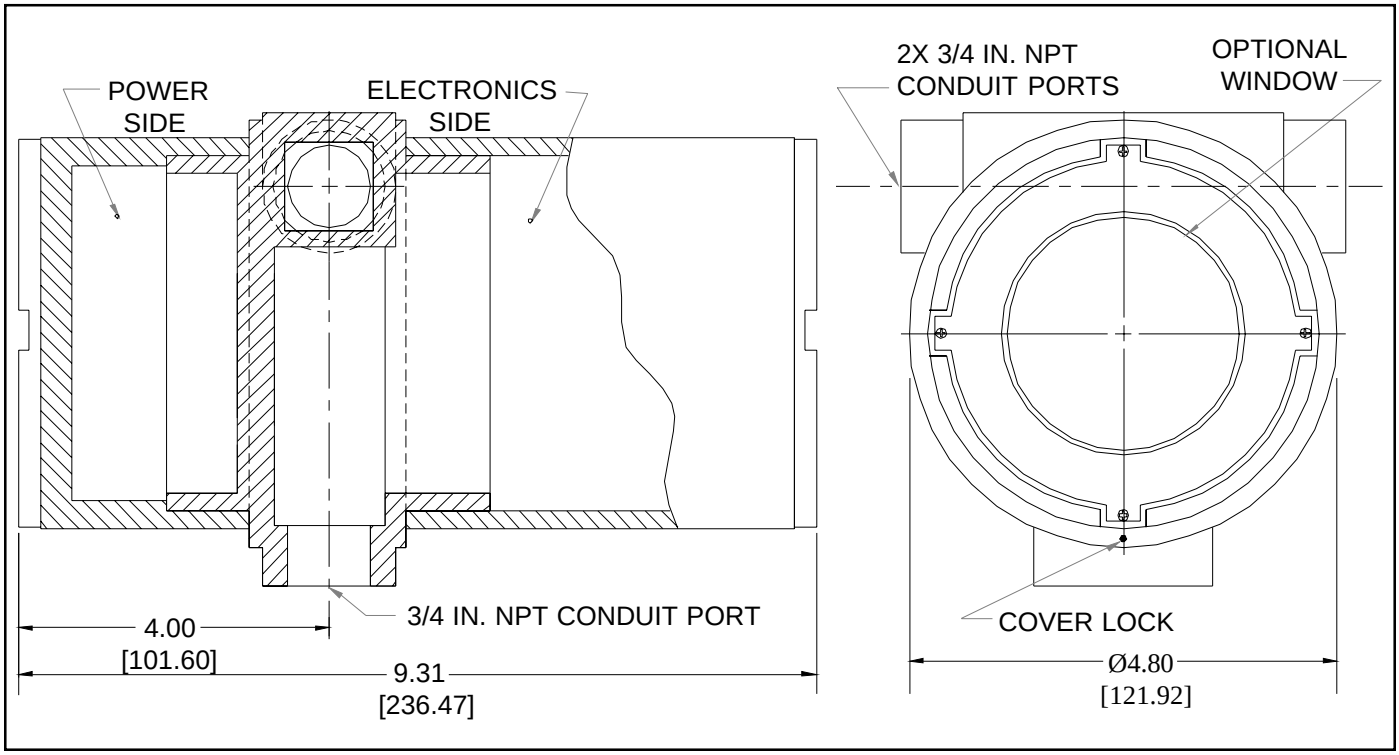


Figure A-2. Remote Aluminum Double Ended Enclosure NEMA 4X and Hazardous Location

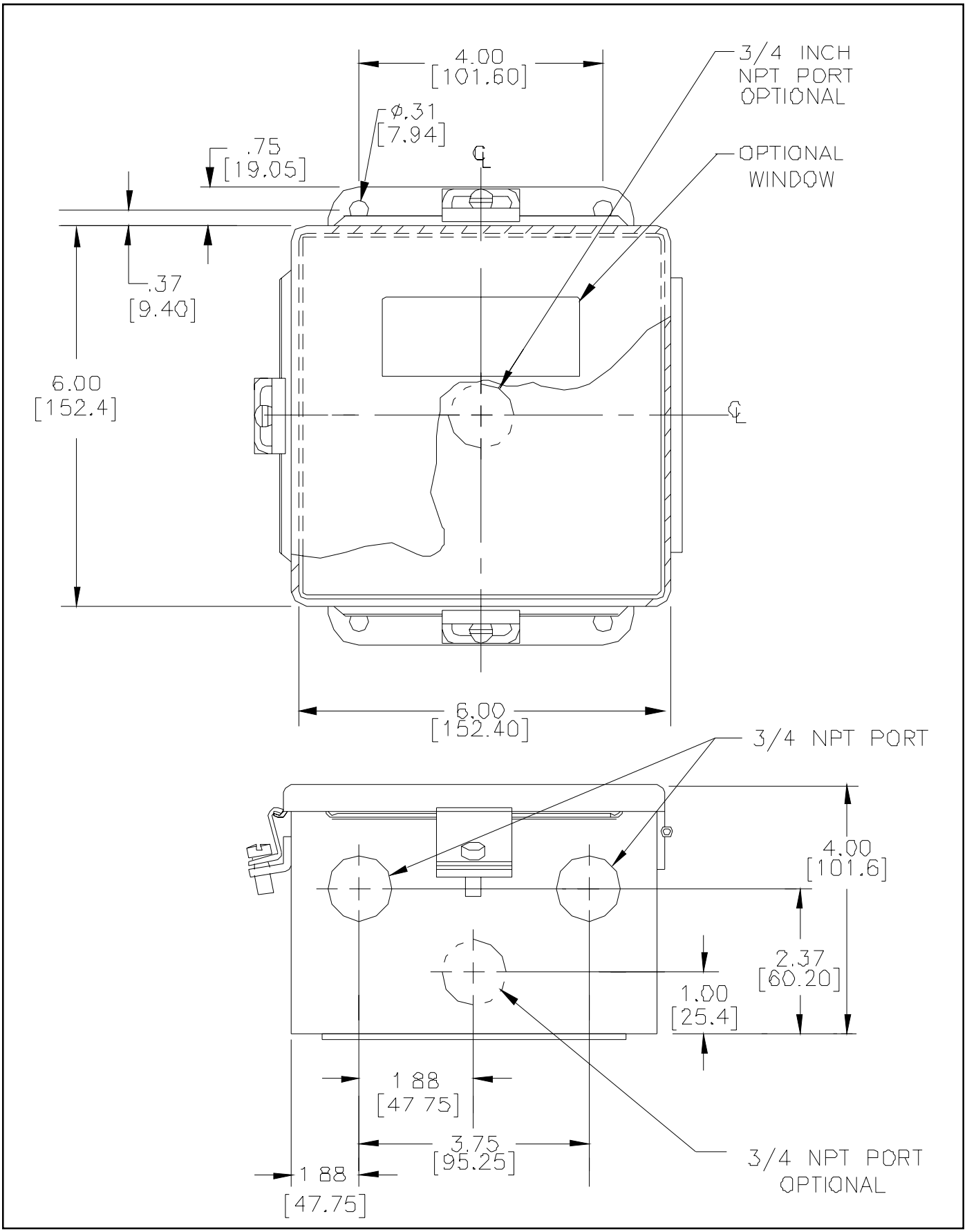


Figure A-3. Remote or Local Enclosure, Carbon Steel

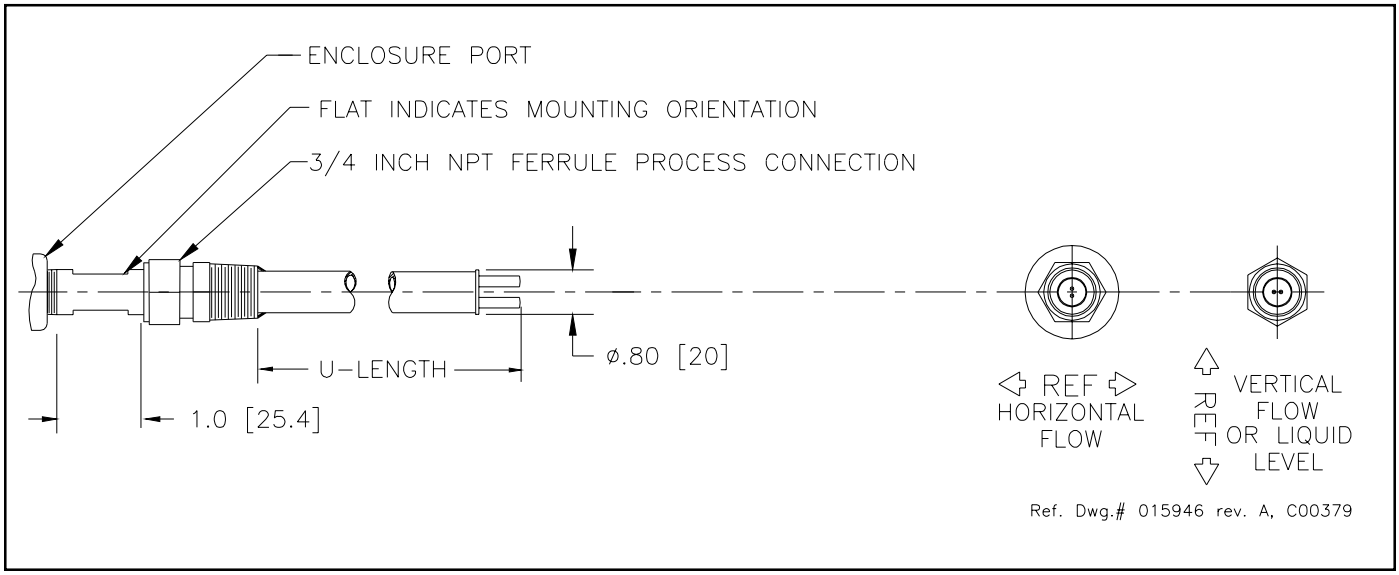


Figure A-4. 3/4 Inch Ferrule NPT Process Connection

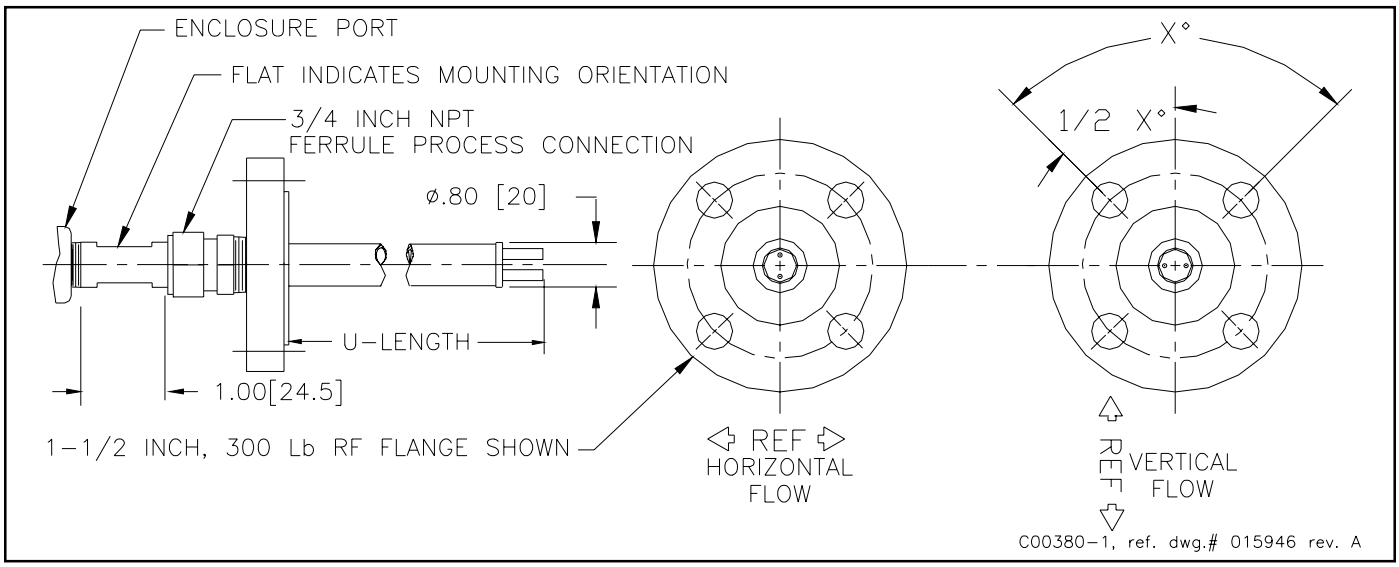


Figure A-5. 3/4 Inch Ferrule NPT With Flange Process Connection

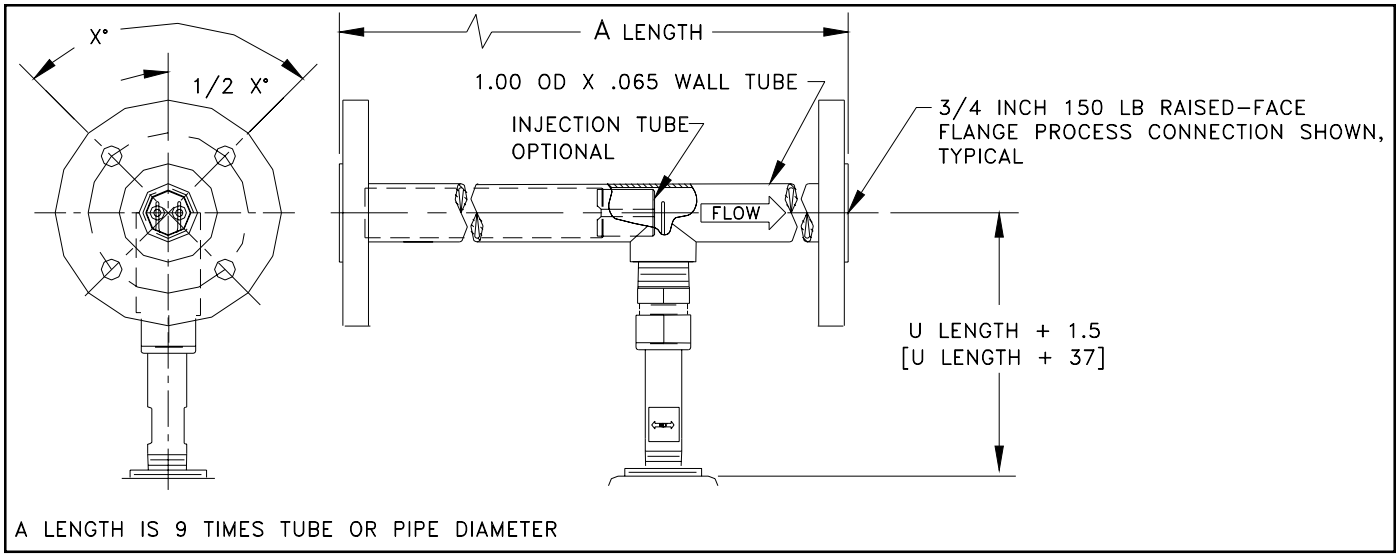


Figure A-6. In-Line Flanged Process Connection

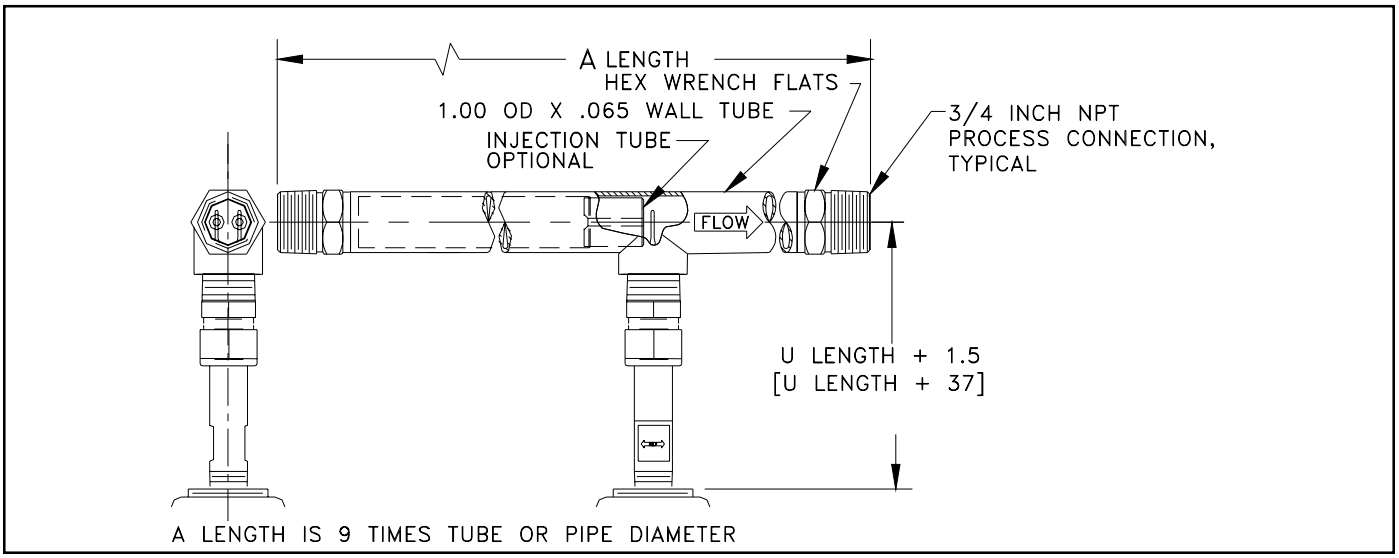


Figure A-7. In-Line NPT Process Connection

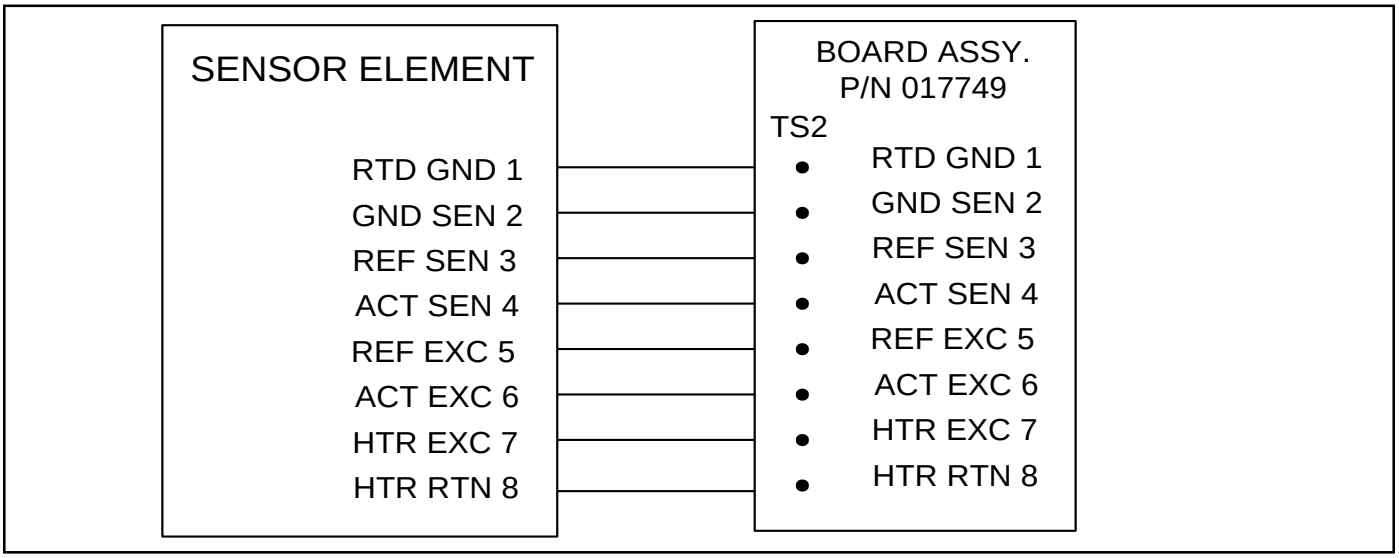


Figure A-8. Integral Option Wiring Diagram

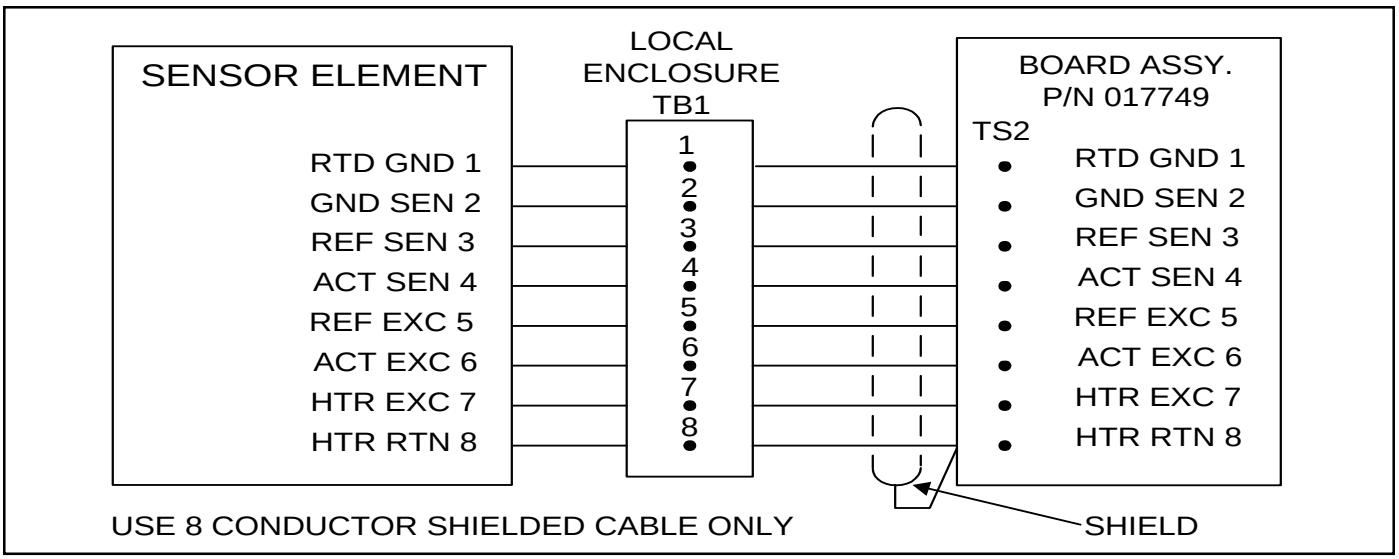


Figure A-9. Remote Wiring Diagram

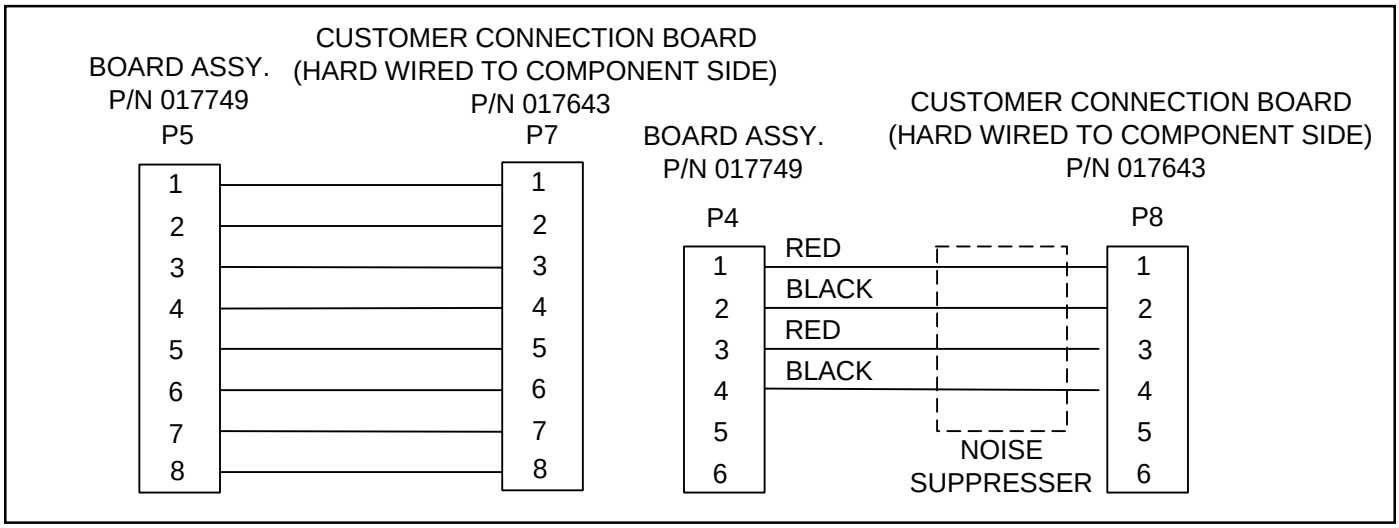


Figure A-10. Wiring Diagram Between Circuit Boards

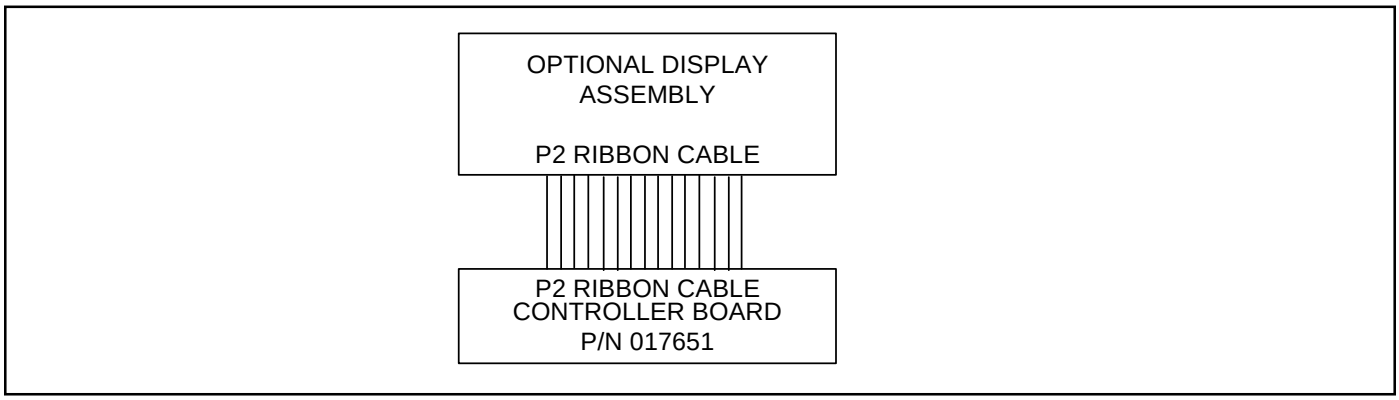


Figure A-11. Optional Display Ribbon Cable Connection

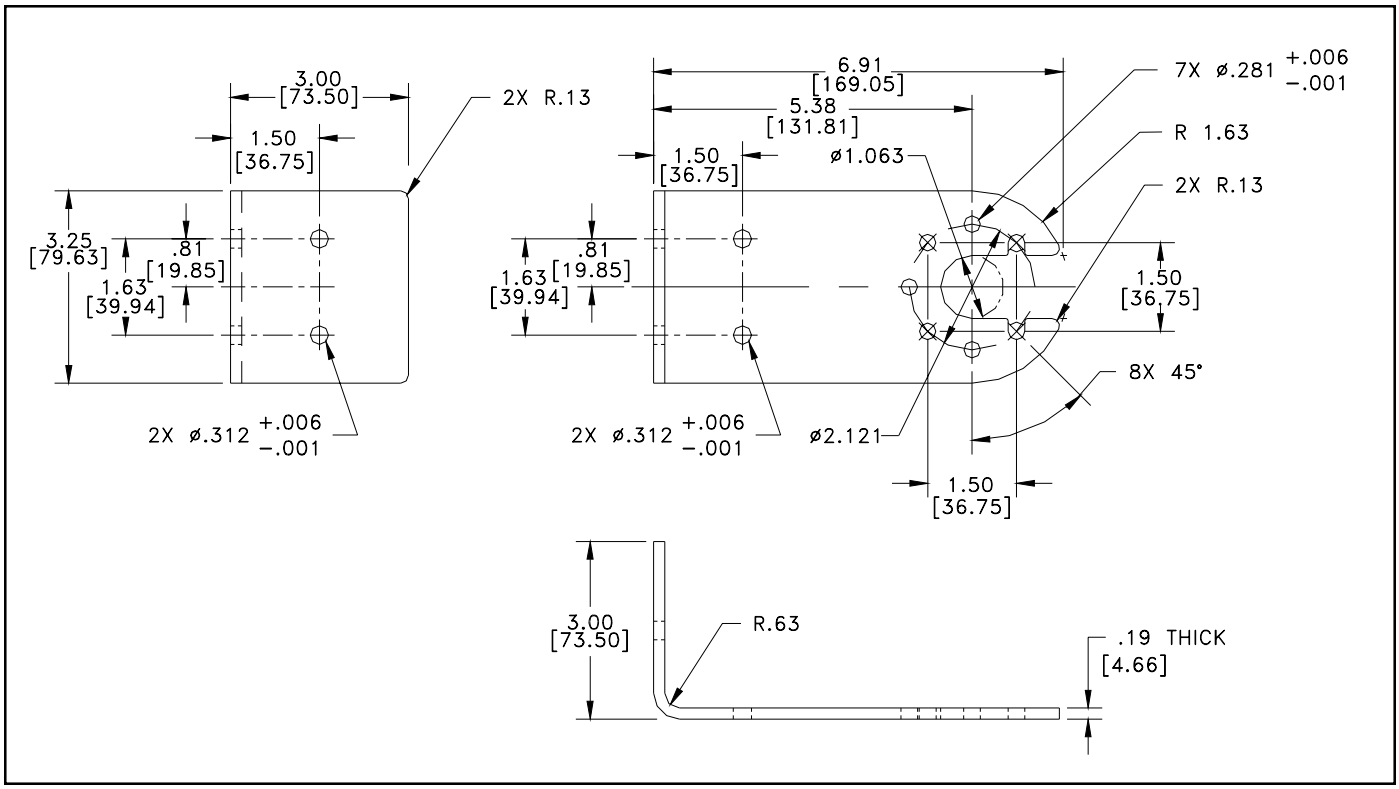


Figure A-12. Remote Mounting Bracket (Hazardous Location Enclosure Only)

0.00375 OHMS/OHMS/°C 1000 OHMS PLATINUM

TEMPERATURE VERSUS RESISTANCE

(Sheet 1 of 3)

T(°F)	OHMS	T(°F)	OHMS	T(°F)	OHMS	T(°F)	OHMS
-40	846.614	3	938.457	46	1029.598	89	1120.046
-39	848.758	4	940.584	47	1031.710	90	1122.141
-38	850.902	5	942.711	48	1033.821	91	1124.236
-37	853.045	6	944.838	49	1035.931	92	1126.330
-36	855.188	7	946.964	50	1038.042	93	1128.424
-35	857.331	8	949.090	51	1040.152	94	1130.517
-34	859.473	9	951.216	52	1042.261	95	1132.610
-33	861.615	10	953.341	53	1044.370	96	1134.703
-32	863.756	11	955.466	54	1046.479	97	1136.795
-31	865.897	12	957.590	55	1048.587	98	1138.887
-30	868.038	13	959.714	56	1050.695	99	1140.978
-29	870.178	14	961.838	57	1052.803	100	1143.069
-28	872.318	15	963.961	58	1054.910	101	1145.160
-27	874.457	16	966.084	59	1057.017	102	1147.250
-26	876.596	17	968.207	60	1059.124	103	1149.340
-25	878.734	18	970.329	61	1061.230	104	1151.429
-24	880.873	19	972.451	62	1063.335	105	1153.518
-23	883.010	20	974.572	63	1065.441	106	1155.607
-22	885.148	21	976.693	64	1067.546	107	1157.695
-21	887.285	22	978.814	65	1069.650	108	1159.783
-20	889.421	23	980.934	66	1071.755	109	1161.870
-19	891.558	24	983.054	67	1073.859	110	1163.957
-18	893.693	25	985.174	68	1075.962	111	1166.043
-17	895.829	26	987.293	69	1078.065	112	1168.129
-16	897.964	27	989.412	70	1080.168	113	1170.215
-15	900.099	28	991.530	71	1082.270	114	1172.300
-14	902.233	29	993.648	72	1084.372	115	1174.385
-13	904.367	30	995.766	73	1086.474	116	1176.470
-12	906.500	31	997.883	74	1088.575	117	1178.554
-11	908.633	32	1000.000	75	1090.676	118	1180.637
-10	910.766	33	1002.117	76	1092.776	119	1182.720
-9	912.899	34	1004.233	77	1094.876	120	1184.803
-8	915.030	35	1006.349	78	1096.976	121	1186.885
-7	917.162	36	1008.464	79	1099.075	122	1188.967
-6	919.293	37	1010.579	80	1101.174	123	1191.049
-5	921.424	38	1012.694	81	1103.272	124	1193.130
-4	923.555	39	1014.808	82	1105.371	125	1195.210
-3	925.685	40	1016.922	83	1107.468	126	1197.290
-2	927.814	41	1019.036	84	1109.566	127	1199.370
-1	929.944	42	1021.149	85	1111.663	128	1201.449
0	932.073	43	1023.262	86	1113.759	129	1203.528
1	934.201	44	1025.374	87	1115.855	130	1205.607

0.00375 OHMS/OHMS/°C 1000 OHMS PLATINUM

TEMPERATURE VERSUS RESISTANCE

(Sheet 2 of 3)

T(°F)	OHMS	T(°F)	OHMS	T(°F)	OHMS	T(°F)	OHMS
132	1209.762	175	1298.661	218	1386.609	261	1473.427
133	1211.839	176	1300.717	219	1388.641	262	1475.431
134	1213.916	177	1302.773	220	1390.673	263	1477.434
135	1215.992	178	1304.829	221	1392.705	264	1479.436
136	1218.068	179	1306.884	222	1394.736	265	1481.438
137	1220.143	180	1308.939	223	1396.766	266	1483.439
138	1222.218	181	1310.993	224	1398.795	267	1485.439
139	1224.293	182	1313.047	225	1400.824	268	1487.439
140	1226.367	183	1315.100	226	1402.853	269	1489.437
141	1228.440	184	1317.152	227	1404.880	270	1491.435
142	1230.513	185	1319.204	228	1406.907	271	1493.432
143	1232.586	186	1321.256	229	1408.934	272	1495.429
144	1234.658	187	1323.307	230	1410.959	273	1497.424
145	1236.730	188	1325.357	231	1412.985	274	1499.419
146	1238.801	189	1327.407	232	1415.009	275	1501.413
147	1240.872	190	1329.456	233	1417.033	276	1503.407
148	1242.942	191	1331.505	234	1419.056	277	1505.399
149	1245.012	192	1333.553	235	1421.079	278	1507.391
150	1247.082	193	1335.601	236	1423.101	279	1509.382
151	1249.151	194	1337.648	237	1425.122	280	1511.372
152	1251.219	195	1339.695	238	1427.142	281	1513.361
153	1253.287	196	1341.741	239	1429.162	282	1515.350
154	1255.355	197	1343.786	240	1431.182	283	1517.338
155	1257.422	198	1345.831	241	1433.200	284	1519.325
156	1259.488	199	1347.875	242	1435.218	285	1521.311
157	1261.554	200	1349.919	243	1437.235	286	1523.296
158	1263.620	201	1351.962	244	1439.252	287	1525.281
159	1265.685	202	1354.005	245	1441.268	288	1527.264
160	1267.750	203	1356.047	246	1443.283	289	1529.247
161	1269.814	204	1358.089	247	1445.298	290	1531.229
162	1271.878	205	1360.130	248	1447.311	291	1533.210
163	1273.941	206	1362.170	249	1449.324	292	1535.191
164	1276.003	207	1364.210	250	1451.337	293	1537.170
165	1278.066	208	1366.249	251	1453.349	294	1539.149
166	1280.127	209	1368.288	252	1455.360	295	1541.127
167	1282.189	210	1370.326	253	1457.370	296	1543.104
168	1284.249	211	1372.363	254	1459.380	297	1545.080
169	1286.310	212	1374.400	255	1461.389	298	1547.056
170	1288.369	213	1376.436	256	1463.397	299	1549.030
171	1290.429	214	1378.472	257	1465.404	300	1551.004
172	1292.487	215	1380.507	258	1467.411	301	1552.977
173	1294.546	216	1382.541	259	1469.417	302	1554.948
174	1296.603	217	1384.575	260	1471.422	303	1556.919

0.00375 OHMS/OHMS/°C 1000 OHMS PLATINUM

TEMPERATURE VERSUS RESISTANCE

(Sheet 3 of 3)

T(°F)	OHMS
304	1558.890
305	1560.859
306	1562.827
307	1564.795
308	1566.761
309	1568.727
310	1570.692
311	1572.656
312	1574.619
313	1576.581
314	1578.542
315	1580.502
316	1582.462
317	1584.420
318	1586.378
319	1588.334
320	1590.290
321	1592.245
322	1594.198
323	1596.151
324	1598.103
325	1600.054
326	1602.004
327	1603.953
328	1605.901
329	1607.848
330	1609.794
331	1611.739
332	1613.683
333	1615.626
334	1617.568
335	1619.509
336	1621.449
337	1623.388
338	1625.326
339	1627.263
340	1629.200
341	1631.135
342	1633.069
343	1635.002
344	1636.933
345	1638.864
346	1640.794
347	1642.723
348	1644.651
349	1646.577
350	1648.503

Appendix B. Glossary of Terms

A/D number Analog to Digital number.

Area Cross-sectional area for a process line.

$$\text{Area of a Circular duct} = \pi r^2 \text{ or } \pi\left(\frac{\text{I.D.}}{2}\right)^2$$

Area of rectangular duct = Length x Width

COM1
COM2 Serial ports located on a personal computer.

DelR The active RTD A/D number minus the reference RTD A/D number.

DVM Digital Voltmeter.

EPROM Erasable Programmable Read Only Memory.

Firmware Software plus hardware. The software is written and then stored in a hardware EPROM chip.

Flow Element The portion of the flow meter that is contains the thermowells, RTDs, and produces a signal with a defined relationship to the flow rate.

Flow Transmitter The portion of the flow meter that conditions, converts, and scales the flow element signal.

RefR The A/D number corresponding to the reference RTD resistance.

RTD A Resistance Temperature Detector operates on the principle of change in resistance as a function of temperature.

SFPS Standard Feet Per Second.

ΔR The difference between two resistance values.

ΔT The difference between two temperature values.

ST98 Parameter Definitions

A. ANALOG INPUT Menu Function.

Channel 0 - 7 Analog signals describing inputs to the electronics.

B. SENSOR BALANCE Menu Function.

Code A passcode (942) is required to continue into the menu selection.

Balance# A number found in the D portion of the menu. This number electronically matches the active and reference RTD's when the heater is off.

C. CALIBRATE DISPLAY Menu Function.

d=xxx The display of Delta-R in the Calibrate Display menu.

r=xxx The display or Ref-R in the Calibrate Display menu.

D. DIAGNOSTIC Menu Function.

Single Poly Fit The polynomial equation used by the electronics to interpret the signal from the flow element.

Two Poly Fit The equation used by the electronics to interpret the signal from the flow element.

Brkpt This is the break point (Delta-R) between the two poly fit equations.

Poly Segment 1 The first group of polynomial equations used to detect flow.

Poly Segment 2 The second group of polynomial equations used to detect flow.

C1 - C5 Calibration equation coefficients.

Balance A number used to balance or match the active and reference RTD's when the heater is off.

Outz An A/D number representing 4 mA. This is set during calibration.

Outf An A/D number representing 20 mA. This is set during calibration.

Heater I An A/D number representing heater current. This is set during calibration.

Factor This is a conversion factor that is multiplied by SFPS to convert to customer units.

Eu The ASCII code for engineering units are as follows:

English			Metric		
ASCII code	**Letter code**	**Engineering Units**	**ASCII code**	**Letter code**	**Engineering Units**
70	F	ft./sec.	77	M	SMPS
67	C	SCFM	78	N	NCMH
76	L	lbs./hr.	75	K	kg./hr.

Tot A 1 after the Tot indicates the Totalizer is turned on. A 0 after the Tot indicates the Totalizer is turned off.

Tottemp A 1 after the Tottemp indicates the Totalizer Temperature display is turned on. A 0 after Tottemp indicates the Totalizer Temperature display is turned off.

Tflow This is the totalized flow in volumetric or mass units, it will change as the instrument totalizes flow.

Rollover The place where the totalizer will roll over to zero. (1E9)

Roll cnt Counts the number of times the Totalizer has rolled over to zero.

Outmode The output mode is symbolized as follows:

Number that indicates output selection.		
0	**1**	**2**
4-20 mA	0-5 VDC	0-10 VDC

Max A/D High end cut-off A/D number. Prevents false low flow readings.

Min A/D Low end cut-off A/D number. Prevents false high flow readings.

Kfactor User programmable correction factor. The corrected output equals K times the output.

Zero An adjustment that establishes at what flow rate the flow transmitter's output is at its minimum (4 mA, 0 VDC). 0.00 is for zero based

applications. Minimum flow is for non-zero based applications.

Sensor This lets the user know what resistance is being used for the RTD's. A 2 indicates a 1K ohm resistance.

Tslp Slope coefficient for the temperature equation. *Caltemp = (Ref R)(tslp + Toff)*

Refr Abbreviation for Reference Resistance.

Caltemp Temperature at calibration. *Caltemp = (Ref R)(tslp) + toff*

Toff Temperature offset.

Tcslp The second slope coefficient for the temperature compensation equation.

Tcslp0 The third slope coefficient for the temperature compensation equation.

Tcslp2 The first slope coefficient for the temperature compensation equation.

Maxflow Maximum calibrated flow in Standard Feet Per Second (SFPS).

Minflow Minimum calibrated flow in Standard Feet Per Second (SFPS).

Density The molecular weight of media is entered here. The software back calculates to the standard density of the media which is used when converting from mass to volumetric units.

$M' = r \bullet Q.$ M' = *Mass Flow Rate*
r = *Density*
Q = *Volumetric Flow Rate.*

Line size0 This field indicates the diameter of a round duct or the length of a rectangular duct. The shape of the duct is dependent on the next field.

Line size1 This field indicates the width of a rectangular duct if it contains a value greater than zero. If the value is zero, then it indicates a round duct.

F.S. This is the full scale value, in customer units, which gives the maximum output signal (20mA, 5 VDC, or 10 VDC).

E. SENSOR CURRENT SELECT Menu Function.

Sensor Current Select 2.0 ma - 1k ohm is always displayed.

F. K-FACTOR Menu Function.

K.F. An abbreviation for K-Factor. A factor the user can input to modify the final flow reading from the calibrated flow rate.

G. EEPROM Menu Function.

EEPROM Only the factory has access to this area.

H. HEATER Menu Function.

Heater Off The user can turn the heater off.

Heater On The user can turn the heater on.

I. OUTPUT CURRENT ADJUST Menu Function.

Enter # Entering a number (0-1000) will force the output to a corresponding level.

DAC Digital to Analog Converter number corresponds to output level.

J. SERIAL NUMBER, CUSTOMER ORDER

NUMBER	Menu Function.
S/N and CO No.	Only the factory has access to this area.
K. CONSTANTS SETUP	Menu Function.
Parameter Definitions	See the parameters in Menu Function D.
L. CALIBRATE OUTPUTS	Menu Function.
(U)p (P)down	Increases or decreases the DAC count.
(F)fast/slow	This controls the speed of the DAC counting.
M. MIN/MAX A/D LIMITS	Menu Function.
Max A/D	High end cut-off A/D number. Prevents false low flow readings.
Min A/D	Low end cut-off A/D number. Prevents false high flow readings.
N. SOFTWARE RESET	Menu Function.
Software Reset	Resets instrument without removing power.
O. SELECT SENSOR HEATER CURRENT	Menu Function.
xxxLO **xxxMD**	Choosing xxxLO sets software flags to show user if flow values are out of range. Choosing xxxMD does not set any software flags.
P. RECONFIGURE THE FC88 UNIT	Menu Function.
FC88 Reset	Re-configures the FC88 so it will function properly in conjunction with the ST98.
R. A/D CALIBRATE RESISTANCE	Menu Function.
A/D Delta-R	The difference between the RTD resistances as used by the A/D converter.
A/D Ref-R	The reference RTD resistance as used by the A/D converter.
r = xxx	A/D Delta-R resistance
R = xxx	A/D Ref-R resistance.
S. AUTO SCALE	Menu Function.
Auto Scale ON	Always on.
T. NORMAL OPERATING MODE	Menu Function.
U. DISPLAY TOTAL FLOW TIME	Menu Function.
Time	Time in minutes since the last reset
Reset	Resets time to zero.
V. OUTPUT MODE SELECT	Menu Function.
Output	Displays the selected instrument output (4-20 mA, 0-5 VDC, 0-10 VDC, 1-5 VDC).
W. TOTALIZER MODE	Menu Function.
Totalizer is	The Totalizer can be toggled on or off. If it is on, the results are displayed on the second line of the normal operating mode window.
Reset Totalizer	The Totalizer can be reset to 0 with this command.
During Powerup	The Totalizer can be automatically reset each time power is applied to the instrument.

Appendix C. Customer Service

Point of Contact

Your point of contact for service, or return of equipment to FCI is your authorized FCI service representative.

Reference Documents

- Return Authorization Request/Certificate of Non-Contamination (Document 1)
- Warranties (Document 2)

Documents 1 and 2 are included in this appendix.

Hardware Return Procedure

Complete a Return Authorization (RA) Request/Certificate of Non-Contamination form (Document 1). Mail or fax it to FCI Customer Service Department. After FCI issues an RA number, complete the following steps.

1. Thoroughly clean the hardware.
2. Package each instrument with protective packing material similar to the original FCI shipment cartons indicated below. **All damage occurring in transit is the customer's responsibility.**
   a. Instruments weighing less than 25 pounds each are to be covered with protective wrap, i.e. bubble wrap or surrounded with "popcorn". Instruments weighing greater than 60 pounds or extending more than four feet should be secured in wooden crates by bolting the sensing element assembly in place.
   b. Protect the sensing element with a cardboard tube or other sturdy wrapping as shown below.
   c. Protect the electronics with an Anti-Static bag like the one shown below.
   d. Do not pack more than four small instruments in each carton.
   e. Packages weighing in excess of 70 pounds or with a combined length and girth of more than 138 inches cannot be shipped by United Parcel Service. Larger packages or crates should be shipped by carriers who specialize in the transport of industrialized instrumentation.
   f. The RA number should be noted on the packing list and marked clearly on the outside of the box.
3. Prepay freight to the FCI receiving door.

Shipping/Handling Charges

All Shipping (Warranty and Nonwarranty Repairs or Returns)

The customer prepays all shipping, freight, duty/entry and handling charges from the customer site to the FCI door. If the customer does not prepay, FCI will invoice the customer for the charges that appear on the freight bill. Address the return equipment to:

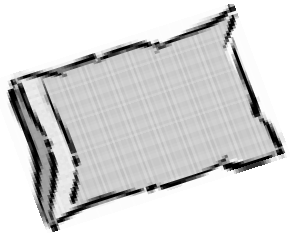
FLUID COMPONENTS INTL

1755 LA COSTA MEADOWS DRIVE

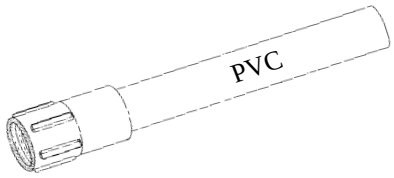
SAN MARCOS, CA. 92069

ATTN: REPAIR DEPT.

RA NUMBER: _____



Anti-Static Bag



Probe protector

Warranty Repairs or Returns

FCI prepays ground transportation charges for return of freight to the customer's door. FCI reserves the right to return equipment by the carrier of our choice.

International freight, handling charges, duty/entry fees for return of equipment are paid by the customer.

Nonwarranty Repairs or Returns

FCI returns repaired equipment to the customer either collect or prepaid and adds freight charges to the customer invoice.

Return to Stock Equipment

The customer is responsible for all shipping and freight charges for equipment that is returned to FCI stock from the customer site. These items will not be credited to customer's account until either all freight charges are cleared or until the customer agrees to have any freight costs incurred by FCI deducted, along with applicable return to stock charges, from the credit invoice. (Exceptions are made for duplicate shipments made by FCI.)

If any repair or return equipment is received at FCI, freight collect, without prior factory consent, FCI bills the sender for these charges.

Field Service Procedures

Field Service Requests

Contact your FCI field representative to request field service.

A field service technician is dispatched to the site from either the FCI factory or one of the FCI representative offices. After the work is complete, the technician completes a preliminary field service report at the customer site and leaves a copy with the customer.

Following the service call, the technician completes a formal, detailed service report. The formal report is mailed to the customer within five days of the technician's return to the factory or office.

Rates

All field service calls are billed at the prevailing rates as listed in the FCI Price Book unless specifically excepted by the FCI Customer Service Manager. FCI reserves the right to bill for travel times at our discretion.

Customers are charged for shipping costs related to the transfer of equipment to and from the job site. They are also invoiced for field service work and travel expenses by FCI's Accounting Department.

Document 1.
FCI RETURN AUTHORIZATION REQUEST

Customer Information R.A. Number:

Name of Company Returning Hardware _____

Contact Name: _____ Phone # _____ Fax # _____

Customer Bill to Address: _____ Ship to: _____

_____ _____

_____ _____

_____ _____

Purchase Agent Contact: _____ Phone # _____ Fax # _____

Product Information

Model Number(s) _____ Serial Number(s) _____

Sending: Electronics only ☐ Sensor only ☐ Complete unit ☐ Number of units ____

Failure Symptoms _____

_____

Troubleshooting done in the field by: FCI representative ☐ or by Customer ☐ _____

_____

Action to be taken by FCI: Recalibrate ☐ Electronics Repair ☐ Sensor Element Repair ☐ Upgrade ☐ Other ☐

(Note: Re-calibration/Re-certification requires the completion of a new Application Data Sheet)

Authorization to repair, if under: $500 ☐ $1000 ☐ Purchase Order Reference: _____

Probe Protector Requested ☐ Antistatic Bag Requested ☐

Process Flow Media: _____

Who is your FCI factory technical contact: _____

Note: FCI will charge a handling fee on all non-warranty evaluations.

Have you contacted your local FCI representative for assistance? _____ yes _____ no

Decontamination Information

Exposure to hazardous materials is regulated by Federal, state (California), County and City laws and regulations. These laws provide FCI's employees with the right to know the hazardous materials with which they come in contact while handling our products. Consequently, our employees must have access to data regarding the hazardous materials which the equipment has been exposed to in your process(es). Accordingly, prior to returning your instrument for repair, please sign the certification below and thoroughly comply with the instructions, if applicable.

I certify that the item(s) has (have) been thoroughly and completely cleaned and if the item(s) has (have) been exposed to or contacted by a hazardous material, hazardous substance or toxic materials or substances that the undersigned can assure the returned item(s) has (have) been thoroughly and completely decontaminated and neutralized of such substances and contamination. I have also attached a Material Safety Data Sheet (MSDS) which covers all hazardous material, hazardous substance or toxic materials or substances exposed to or contacted by the instrument. Furthermore, I understand that this Certificate, or providing a MSDS, shall not waive our responsibility to provide a neutralized, decontaminated, and clean product for repair to FCI.

Authorized Signature _____ Date _____

Cleanliness of a returned item or the acceptability of the MSDS shall be at the sole discretion of FCI.
Any returned item which does not comply with these instructions shall be returned to you at your expense.

Document 2. Warranties

Warranties

Goods furnished by the Seller are to be within the limits and of the sizes published by the Seller and subject to the Seller's standard tolerances for variations. All items made by the Seller are inspected before shipment, and should any of said items prove defective due to faults in manufacture or performance under Seller approved applications, or fail to meet the written specifications accepted by the Seller, they will be replaced or repaired by Seller at no charge to Buyer provided return or notice of rejection of such material is made within a reasonable period but in no event longer than one (1) year for non-calibration defects and one (1) year for calibration defects from date of shipment to Buyer, and provided further, that an examination by Seller discloses to Seller's reasonable satisfaction that the defect is covered by this warranty and that the Buyer has not returned the equipment in a damaged condition due to Buyer's or Buyer's employees', agents', or representatives' negligence and Buyer has not tampered, modified, redesigned, misapplied, abused, or misused the goods as to cause the goods to fail. In addition, this warranty shall not cover damage caused by Buyer's exposure of the goods to corrosive or abrasive environments. Moreover, Seller shall in no event be responsible for (1) the cost or repair of any work done by Buyer on material furnished hereunder (unless specifically authorized in writing in each instance by Seller), (2) the cost or repair of any modifications added by a Distributor or a third party, (3) any consequential or incidental damages, losses, or expenses in connection with or by reason of the use of or inability to use goods purchased for any purpose, and Seller's liability shall be specifically limited to free replacement, or refund of the purchase price, at Seller's option, provided return or rejection of the goods is made consistent with this paragraph, and the Seller shall in no event be liable for transportation, installation, adjustment, loss of good will or profits, or other expenses which may arise in connection with such returned goods, or (4) the design of products or their suitability for the purpose for which they are intended or used. Should the Buyer receive defective goods as defined by this paragraph, the Buyer shall notify the Seller immediately, stating full particulars in support of his claim, and should the Seller agree to a return of the goods, the Buyer shall follow Seller's packaging and transportation directions explicitly. In no case are the goods to be returned without first obtaining a return authorization from the Seller. Any repair or replacement shall be at Seller's factory, unless otherwise directed, and shall be returned to Seller transportation prepaid by Buyer. If the returned goods shall prove defective under this clause they will be replaced or repaired by Seller at no charge to Buyer provided the return or rejection of such material is made within a reasonable period, but in no event longer than (1) year from the date of shipment of the returned goods or the unexpired terms of the original warranty period whichever is later. If the goods prove to be defective under this paragraph, the Buyer shall remove the goods immediately from the process and prepare the goods for shipment to Seller. Continued use or operation of defective goods is not warranted by Seller and damage occurring due to continued use or operation shall be for Buyer's account. Any description of the goods contained in this offer is for the sole purpose of identifying them, and any such description is not part of the basis of the bargain, and does not constitute a warranty that the goods will conform to that description. The use of any sample or model in connection with this offer is for illustrative purposes only, is not part of the basis of the bargain, and is not to be construed as a warranty that the goods will conform to the sample or model. No affirmation of that fact or promise made by the Seller, whether or not in this offer, will constitute a warranty that the goods will conform to the affirmation or promise. THIS WARRANTY IS EXPRESSLY IN LIEU OF ANY AND ALL OTHER EXPRESS OR IMPLIED WARRANTIES WITH RESPECT TO THE GOODS OR THEIR INSTALLATION, USE, OPERATION, REPLACEMENT OR REPAIR, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS OF PURPOSE; AND THE GOODS ARE BEING PURCHASED BY BUYER "AS IS". SELLER WILL NOT BE LIABLE BY VIRTUE OF THIS WARRANTY OR OTHERWISE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL LOSS OR DAMAGE RESULTING FROM THE USE OR LOSS OF USE OF THE GOODS.

Temp Display is The temperature display can be toggled on or off. If it is on, the results are displayed on the second line of the normal operating mode window. If the Totalizer is also on the totalized value and the temperature value will be alternately displayed.

X. NAMUR OUTPUT FAULT INDICATOR Menu Function.

NAMUR Flag is This function can be toggled on or off at this command.

Z. FLOW UNITS SELECT Menu Function.

Flow Units Are:

	Velocity	Volume	Mass
English	SFPS	SCFM	LLB/HR
Metric	SMPS	NCMH	KG/HR

Max = This is the maximum value, in the customer's units, that the instrument can display.

F.S. This is the full scale value, in customer units, which gives the maximum output signal. This value can be input as anything less than the max value from above.

Zero This establishes at what flow rate the flow transmitter's output is at its minimum output. It is 0.00 for zero based applications. For non-zero based applications the zero is at minimum flow.