# Sierra Series 640 FM

## Factory Mutual Approved
## Steel-Trak™ Insertion Mass Flow Meters

March 1996

REV. D
Part Number: IM-64-FM

SIERRA INSTRUMENTS, INC.

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## CUSTOMER CAUTION
## RE: OXYGEN SERVICE

Sierra Instruments, Inc., is not liable for any damage or personal injury, whatsoever, resulting from the use of Sierra Instruments mass flow meters or controllers for oxygen gas. Although Sierra cleans its mass flow meters and controllers prior to shipment, we make no claim or warranty that their cleanliness renders them safe for oxygen service. The customer must clean Sierra Instruments mass flow meters or controllers to the degree required for the customer's oxygen flow applications.

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# CAUTIONS AND WARNINGS

**WARNING! Sierra Instruments, Inc. has obtained approval for the Series 640 FM Flow Meter from Factory Mutual Research Corporation. You (the customer) must properly install solid metal conduit and fittings for all wiring, both power and signal, with the desired safety rating.**

**WARNING! All installation procedures must be performed with the power off.**

**WARNING! The T-3 rating allows for a maximum temperature of 200°C in the sensor's "fault" or failure mode. Refer to this code to assure that 200°C will not "auto ignite" the gas being measured or present any other hazards by encountering a maximum "fault" temperature of 200°C.**

**CAUTION! The flow meter is not a 24V, 4-20 mA loop powered transmitter. The meter requires four wiring connections, two for power and two for signal.**

**CAUTION! Refer to Appendix C for wiring instructions. You must use solid metal conduit and NFPA-approved wiring methods.**

**CAUTION! Before initial power up, check all wiring, both power and signal, to ensure it is in compliance with the wiring guide supplied with your flow meter.**

**WARNING! Before attempting any maintenance make sure there is no pressure in the line.**

**WARNING! Gas leaks are possible during probe maintenance. If there is toxic or combustible gas in the line use a Sierra flow meter with hot tap option or be sure the lines are completely purged before removing the probe.**

**WARNING! To prevent ignition of hazardous atmospheres, do not remove cover while circuits are live.**

**WARNING! Calibration must only be performed by qualified personnel using non-hazardous, safe gases. Sierra Instruments, Inc. strongly recommends that you return your Series 640 FM flow meter to the factory for calibration. Refer to Section 6.1, CUSTOMER SERVICE, for shipping instructions.**

**CAUTION! The electronics, sensor and any cable supplied by Sierra Instruments, Inc. is calibrated as a single precision mass flow meter. Interchanging sensors will impair the accuracy of the flow meter.**

# QUICK INSTRUCTIONS

(Refer to Section 2, INSTALLATION, for detailed instructions)

Factory Mutual Approval Requirement

This device has a Factory Mutual rating of EXP/I/1/BCD; DI/II/1/EF-T3 and must be used in accordance with the guidelines provided by the National Electrical Code for a device with this rating. It is of paramount importance that the user provide the appropriate metal conduit and conduit connectors to the Sierra electronics enclosures.

## Installation

1. Check label on flow meter for system pressure, temperature, gas composition, power input, and signal output.

2. Check the installation. Install the flow meter four-fifths of the length along the longest straight section of pipe available. Proper operation dictates using twenty pipe diameters straight run upstream minimum, five pipe diameters straight run downstream. These inlet and outlet conditions provide reasonable accuracy. NOTE: Performance will decay if fewer diameters are provided and/or if pipe sizes change.

3. Check for correct insertion depth (normally centered in pipeline).

4. When installing the flow meter, reference the flow direction label attached to the flow body. Install the meter with the label pointing in the same direction as gas flow. This ensures the sensors are correctly aligned 90-degrees to the gas flow.

5. Check system for anomalies: leaks, valves which might drastically change flow rate unexpectedly or cause turbulence, or heaters which might cause rapid excursions in temperature.

6. Hook up the system per the wiring guide (in this manual) and double check that the wiring for the power and signal connections are correct.

7. Observe that all plumbing and electrical hook-ups are in accordance with OSHA, NFPA, and all other safety requirements.

# 1 INTRODUCTION

This manual contains information on the Sierra Series 640 FM insertion mass flow meters. Within the text we shall use the terms mass flow meter or flow meter interchangeably.

Caution messages (Preceded by **"CAUTION!"** in the text) appear before procedures which, if not observed, could result in damage to equipment.

Warning messages (preceded by **"WARNING!"** in the text) indicate that when a specific procedure or practice is not followed correctly, personal injury could result.

This manual contains eight sections plus appendices. Section 1, this section, gives a general introduction to the flow meter and describes the important flow meter parts. Sections 2 and 3 comprise the main informational sections of the manual for actual operation of the flow meter. Sections 4, 5 and 6 cover maintenance, calibration and trouble shooting. Sections 7 and 8 cover general aspects of flow monitoring. The appendices contain reference drawings and tables.

Service Number

The Sierra Instruments, Inc. Applications and Service Engineers may be reached at (800) 866-0200 or Fax (408) 373-4402. In Europe you can reach our Applications and Service Engineers at Sierra Instruments b.v., 31(0)20-614580 or Fax 31(0)20-6145815.

## 1.1 Receipt of Your Mass Flow Meter

When your Sierra flow meter is received, carefully check the outside packing carton for damage incurred during shipment. If the packing carton is damaged, notify the local carrier. Submit a report to: Customer Service, Sierra Instruments, Inc., 5 Harris Court, Building L, Monterey, CA 93940 or Customer Service, Sierra Instruments b.v., Bolstoen 30A, 1046 AV Amsterdam, The Netherlands. Remove the packing slip from its envelope and check that the carton contains all parts listed. Make sure any spare parts or accessories are not discarded with the packing material. In case of shortages, contact Customer Service at one of the addresses below, or call (800) 866-0200 or 31(0)20-6145810 and ask for Customer Service.

Return Material Authorization

Do not return any equipment without a Return Material Authorization obtainable from the Customer Service Department. Please include information describing the problem, corrective action or work to be accomplished at the factory, the purchase order number under which the equipment was purchased, and the name and phone number of the person at your company to contact. Return shipping address:

USA HEADQUARTERS
Sierra Instruments, Inc.
5 Harris Court, Building L
Monterey, CA 93940
ATTN: SERVICE DEPT.

EUROPEAN HEADQUARTERS
Sierra Instruments b.v.
Bolstoen 30A
1046 AV Amsterdam
The Netherlands
ATTN: SERVICE DEPT.

**NOTE:** Equipment returned for repair that is found to be completely operational will be subject to the current "no problem found" billing rate.

## 1.2 Product Coverage

This instruction manual covers the installation and operation of all standard Series 640 FM mass flow meters.

### 1.2.1 General Description

Sierra's Series 640 FM insertion mass flow meters monitor the mass flow rate of air and process gases in any full scale range from 0-100 to 0-15,000 SFPM* or 0-0.5 to 0-75 SMPS†. The mass flow probe inserts into the gas flow and delivers a 0-1 VDC, 0-5 VDC, 0-10 VDC, or 4-20 mA analog output signal proportional to total gas mass flow rate, without requiring the temperature and pressure corrections necessary in Pitot-tube, orifice-plate, or turbine devices. An RS 485 serialized output signal is optionally available. Instrument performance is 2% of full scale velocity; 0.2% of full scale repeatability; 3 second velocity response time and 60 second temperature response time.

### 1.2.2 Options

Many options are available: input power choices of 15-18 VDC, 24 VDC, 100 VAC, 115 VAC, and 230 VAC; digital LCD readout of flow rate; high and low flow rate alarms; probe electronics mounted directly on the probe or remotely mounted up to 50 feet away; and a wide selection of probe mounting options, including compression fittings, flanges, brackets, in-line bodies, and "hot-tap" models.

**SFPM = Standard Feet Per Minute*
*†SMPS = Standard Meters Per Second*

## 1.3 Principle of Operation

Sierra's Steel-Trak probes are responsible for the accuracy, ruggedness, and reliability of Sierra flow meters. Each probe has two sensors: a velocity sensor and a temperature sensor that automatically corrects for temperature changes. Both sensors are reference-grade platinum resistance temperature detectors (RTD's). The platinum RTD wire is wound on a rugged ceramic mandrel for strength and stability. Steel-Trak sensors are clad in a rugged, sealed 316 stainless steel encasement, or thermowell.

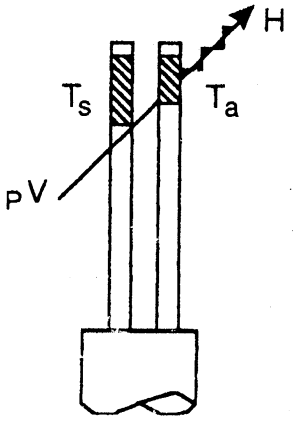



*Figure 1.3*
*The Sierra Thermal Principle*

The circuit heats the velocity sensor at a constant temperature differential, $T_s$–$T_a$, above ambient and measures the cooling effect of the air flow. The resulting output provides unsurpassed low-speed sensitivity and a rangeability of 1000:1. Velocities as low as 10 SFPM and as high as 15,000 SFPM are easily resolved. Since the heat is carried away by the molecules in the air, the heated sensor directly measures gas mass velocity, $\rho V$ (SFPM), referenced to standard conditions of 70°F (21.1°C) and 1 atmosphere. In the case of duct flows, the Sierra flow meters monitor the mass velocity, which, when multiplied by the cross-sectional area, yields the total mass flow rate in SCFM.

Mass flow rate is the quantity of direct interest in heating, ventilation, and air conditioning (HVAC) because it is the molecules of the air that heat or cool the human body. Mass flow also is the quantity of interest in combustion, heat transfer, and any chemical process. If the actual velocity in FPM or the flow rate in CFM is desired, simply multiply the reading by the ratio of the standard air density to the actual air density, as shown in Section 5, CALIBRATION.

# 2 INSTALLATION

**WARNING! Sierra Instruments, Inc. has obtained approval for the Series 640 FM Flow Meter from Factory Mutual Research Corporation. You (the customer) must properly install solid metal conduit and fittings for all wiring, both power and signal, with the desired safety rating.**

**WARNING! All installation procedures must be performed with the power off.**

Refer to the QUICK INSTRUCTIONS at the beginning of this manual for a summary of the installation procedure.

The Sierra 640 FM/CSA Approved Linear Flow Transmitter has a NEC Code Class I, Division 1 and 2, Groups B, C & D with a T-3 rating and Class II, Divisions 1 and 2, Groups E & F with a T-3 rating. The customer is responsible for following NEC guidelines. Specifically, refer to article 500-503 and 510-517 of the National Electrical Code for use in hazardous areas.

**WARNING! The T-3 rating allows for a maximum temperature of 200°C in the sensor's "fault" or failure mode. Refer to this code to assure that 200°C will not "auto ignite" the gas being measured or present any other hazards by encountering a maximum "fault" temperature of 200°C.**

It is also important to assure that all mechanical connections for the electrical signals are in accordance with the National Electrical Code. Specifically, Sierra's approval is based upon the requirement that all conduit runs to and from our instrument are metal and less than 18 inches long.

Although the sensing elements are rugged, take care not to damage them upon installation.

Especially for measuring low flows it is important that the probe be mounted securely to assure accurate results.

Check label on flow meter for system pressure, temperature, gas composition, power input, and signal output.

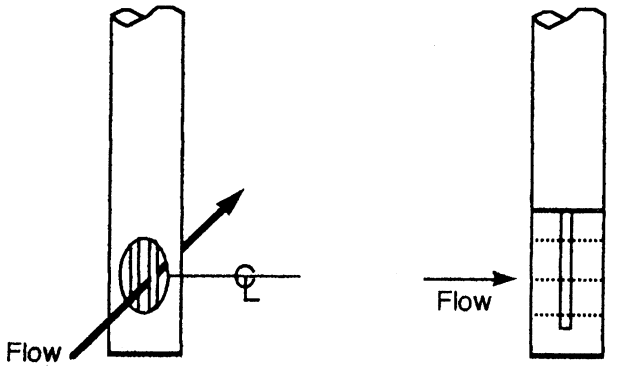
After all installation steps are completed for your flow meter, proceed to Section 3, OPERATING INSTRUCTIONS, particularly Section 3.1, GENERAL DESCRIPTION, and Section 3.2, POWER-UP.

## 2.1 Mounting of Probe and Electronics Enclosures

A common method of mounting the probe through a wall or duct is with a compression fitting. Flange mounting is optionally available. Contact Sierra Instruments directly to order the proper fitting for your flow meter. In-line bodies, with flanges or NPT threads, are optimally available.

For dimensional drawings of probe and electronics enclosure mountings, refer to Appendix B.

When installing the flow meter, reference the flow direction label attached to the flow body. Install the meter with the label pointing in the same direction as gas flow. This ensures that the sensors are correctly aligned 90-degrees to the gas flow.




*Probe Orientation*
*Figure 2-1*

Check the installation. Twenty pipe diameters straight run upstream and five pipe diameters straight run downstream minimum provides reasonable accuracy.

Check for correct insertion depth; usually the sensing point is located on the center line of the pipe or duct.

Check system for anomalies: leaks, valves which might drastically change flow rate unexpectedly or cause turbulence, heaters which might cause rapid excursions in temperature, etc. Excursions in temperature that exceed 3°F per minute will cause erroneous readings until the temperature stabilizes.

## 2.2 Access to Field Wiring

Field wiring to Series 640 FM flow meters is via terminal strips within an integral wiring compartment.

All Series 640 FM flow meters are supplied in an explosion proof enclosure and have an integral wiring compartment.

### 2.2.1 Explosion Proof Enclosure

Explosion proof enclosures have an integral wiring compartment which contains terminal strips for field wiring. To expose the wiring compartment, locate the two threaded dome lids, one on each side of the enclosure. The wiring compartment is inside the smaller dome lid.

Locate and loosen the small set screw which locks the dome lid in place. Carefully unthread the small dome lid by screwing it counterclockwise. Inside you will find terminal strips labeled TB1. Positions on these strips are labeled 1-15. See Appendix C for a description of these fifteen positions.

The explosion proof enclosure has two ¾" NPT conduit entries. To maintain separation between input power and signal wiring, it is recommended that separate conduit connections be utilized. This is especially important if 115V or 230V power is utilized.

Power supply to the meter will be either 115 V/230 VAC, 24 VDC or 15 VDC. Refer to the serial number label, the wiring label inside the wiring compartment, and the wiring hook-up guide.

Refer to Section 4, MAINTENANCE, for further information.

Refer to Appendix C for a pictorial of the terminal strips.

## 2.3 Power Supply Wiring

The following sections describe connecting power to a Series 640 FM flow meter. Power wiring at the flow meter is via a terminal strip within the short dome lid on the enclosure.

### 2.3.1 100/115/230 VAC, 50/60 Hz Input Power

All flow meters with 115 or 230 VAC power have an integral wiring compartment. Refer to Section 2.2, ACCESS TO FIELD WIRING, for instructions on access to the wiring compartment.

Two positions on TB1 are used for AC power hook-up. A copper lug is attached to the chassis for attachment of the AC power ground wire. Refer to Appendix C for wiring instructions.

The load represented by a flow meter is 15 VA max.

### 2.3.2 24 VDC Input Power

**CAUTION! The flow meter is not a 24V, 4-20 mA loop powered transmitter. The meter requires four wiring connections, two for power and two for signal.**

All Series 640 FM flow meters with 24 VDC power options have an integral wiring compartment which contain terminal strips for field wiring.

Refer to Section 2.2, ACCESS TO FIELD WIRING, for instructions on how to locate the field wiring terminals.

A fifteen position terminal strip is located within the wiring compartment. Refer to Appendix C for wiring instructions.

The load represented by a flow meter is about 500 mA max.

### 2.3.3 15 VDC Input Power

Series 640 FM flow meters with 15 VDC power options are supplied in an explosion proof enclosure with an integral wiring compartment. Refer to Appendix C for wiring connections.

### 2.4 Remote Electrical Enclosures

**CAUTION! Refer to Appendix C for wiring instructions. You must use solid metal conduit and NFPA-approved wiring methods.**

### 2.5 Signal Wiring

The following sections describes how to connect the signal wiring to a Series 640 FM flow meter. In general, signal wiring at the flow meter is via a terminal strip within the short dome lid of the enclosure. Refer to TABLE 2.5 for a general description of the signal wiring for the Series 640 FM flow meter.

For all flow meters, standard industrial wiring practices apply. The Sierra 640 FM Approved Linear Flow Transmitter has an NEC Code Class I, Division 1 and 2, Groups B, C & D with a T-3 rating and Class II, Divisions 1 and 2, Groups E & F with a T-3 rating. The customer is responsible for following NEC guidelines. Specifically, refer to article 500-503 and 510-517 of the National Electrical Code for use in hazardous areas.

The T3 rating allows for a maximum temperature of 200°C in the sensor's "fault" or failure mode. Refer to this code to assure that 200°C will not "auto ignite" the gas being measured or present any other hazards by encountering a maximum "fault" temperature of 200°C.

It is also important to assure that all mechanical connections for the electrical signals are in accordance with the National Electrical Code. Specifically, Sierra's approval is based upon the requirement that all conduit runs to and from our instrument are metal and less than 18 inches long.

### 2.5.1 0-5 VDC and 4-20 mA Output

All flow meters are equipped with either a 0-5 VDC or a 4-20 mA output signal. This signal represents 0-100% of full-scale and may or may not be linear. Check the serial number label on the outside of the flow meter for output signal, type of gas and full scale value.

The 0-5 VDC signal can drive a minimum load of 1,000 ohms and is output from "0-5V/4-40 mA Output" and "Signal Ground".

The meter will provide a 4-20 mA signal through a load resistance of 50 to 400 ohms to ground. The meter is not a loop powered device. 4-20 mA output signal must be referenced to ground. Refer to Appendix C for wiring instructions.

If the meter utilizes 115 or 230 VAC power, the 4-20 mA output signal will be electrically isolated. NOTE: however, that connecting any of the output terminals to earth ground will violate the isolation.

Whichever analog output signal the flow meter has, be sure to use "Signal Ground" for the signal return. Refer to the enclosed Wiring Guide and Appendix C for a pictorial of the connector and terminal strip.

*Table 2.5 Signal Wiring Series 600/640*

| Signal Name | Description |
|---|---|
| Relay 1<br>Relay 2 | Form C Contact Closure |
| Signal Ground | Analog Ground of 0-5 VDC or 4-20 mA |
| 0-5 V/4-20 mA Output | Analog Output of 0-5 VDC or 4-20 mA |
| Sensor Black<br>Sensor White<br>Sensor Orange<br>Shield<br>Sensor Red<br>Sensor Green | Remote Sensor Wiring |

**NOTE:** The model of your flow meter will determine the signals listed.

### 2.5.2 RS 485 Option

Included with flow meters equipped with microprocessor electronics is an EIA standard RS 485 serial bi-directional interface. This interface allows up to thirty flow meters to be daisy chained on a single twisted pair plus shield. Maximum distance is 4,000 feet (1,200 meters) using twenty-four gauge wire.

If you have a system which includes a Collector-Box, the interface is transparent and all the details of interface protocol are handled by the Collector-Box.

# 3 OPERATING INSTRUCTIONS

## 3.1 General Description

There are two main configurations for Sierra Series 640 FM flow meters:

• **Flow Meter Alone.** You will be reading an analog output signal, either 0-5 VDC or 4-20 mA which represents the flow value. Refer to Sections 3.2, 3.3, and 3.5.

• **Flow Meter with PC compatible computer running Sierra Net Software.** This configuration uses the RS 485 interface to interconnect the flow meters with the computer. The computer must have a Sierra Instruments, Inc. supplied RS 485 interface card installed as COM1: or COM2:. Refer to Section 3.4, RS 485 OPTION.

## 3.2 Power Up

**CAUTION! Before initial power up, check all wiring, both power and signal, to ensure it is in compliance with the wiring guide supplied with your flow meter.**

For all flow meters standard industrial wiring practices apply. The Sierra 640 FM Approved Linear Flow Transmitter has NEC Code Class I, Division 1 and 2, Groups B, C & D with a T-3 rating and Class II, Divisions 1 and 2, Groups E & F with a T-3 rating. The customer is responsible for following NEC guidelines. Specifically, refer to article 500-503 and 510-517 of the National Electrical Code for use in hazardous areas.

The T3 rating allows for a maximum temperature of 200°C in the sensor's "fault" or failure mode. Refer to this code to assure that 200°C will not "auto ignite" the gas being measured or present any other hazards by encountering a maximum "fault" temperature of 200°C.

It is also important to assure that all mechanical connections for the electrical signals are in accordance with the National Electrical Code. Specifically, Sierra's approval is based upon the requirement that all conduit runs to and from our instrument are metal and less than 18 inches long.

Upon applying power to a flow meter, the flow indication will momentarily go to a high value. It is normal for this condition to persist for a few seconds during which time the heated velocity sensor is warming up. After completion of warm up, the flow indication will rapidly approach a zero value (or the value of flow, if present). Within minutes, the flow meter is operational.

The flow meter may be turned on or off with flow present or absent, without damage to the meter.

## 3.3 0-5 VDC and 4-20 mA Output Signals

All flow meters are equipped with either a 0-5 VDC or a 4-20 mA output signal. This signal represents 0-100% of full-scale.

Check the serial number label on the outside of the flow meter for full-scale value and calibration gas for your flow meter.

For linear models, the output signal represents a linear proportional analog of flow ranging from zero (0 VDC or 4 mA) to the full-scale value (5 VDC or 20 mA), as indicated on the serial number label.

For non-linear models, a graph, table, or mathematical equation (polynomial) is supplied to convert the electrical signal to the flow value. Zero flow is always represented by either 0 VDC or 4 mA and full-scale flow by either 5 VDC or 20 mA. Between zero and full-scale the signal is not proportional to flow and a conversion using the supplied data must be performed.

## 3.4 RS 485 Option

The following description of the Sierra RS 485 protocol is provided mainly for reference and provides details of the RS 485 interface.

There is one "master" transceiver (Collector-Box™ or PC-compatible computer) and up to 30 "slave" transceivers (flow meters). The data format is 11 bits: 1 start bit, 8 data bits (MSB first), a tenth programmable bit (not parity), and a stop bit. The data rate is 9600 baud.

There are two types of bytes: address bytes and data bytes. The tenth bit would normally be the parity bit; however, in this application it is not used for parity. It signals which type of byte is being sent. When the tenth bit is one, the byte is an address byte. When it is zero, it is a data byte. Normally, the master sends address bytes and the slaves respond with an address byte echo followed by data bytes.

The following code is written from the point of view of the master (PC type computer) wishing to read a flow meter. Included are code examples written in C using Turbo-C and Greenleaf ComLib software.

```
/* Enable RS 485 transmitter, disable receiver. Set for "parity"
equal to space, i.e., bit 8=1. Transmit address byte. */
if      (comport ==0)
        outportb ( 0 x 3ff, 2);          /* COM1: enable xmitter  */
else
        outportb (0x2ff, 2);             /* COM2: enable xmitter */
/* Wait for transmission done before turning around interface to
receive. Enable RS 485 receiver, disable transmitter. */
do  {   /* check UART directly */
```

```
        rxbyte = bioscom (3, address, comport);
        } while (! (rxbyte>=0);
/* enable RS 485 receiver, disable xmitter */
if      (comport ==0)
        outportb (0x3ff,1);
else
        outportb (0x2ff, 1);
delay (150);    /* wait 150 milliseconds for returned characters. */
```

Wait 150 milliseconds for returned characters. All characters sent in a stream during this time interval correspond to the RS 485 description in Table 3.4.

To initiate a date exchange, the master transmits *an address byte composed of* an address (1-30) with the tenth bit equal to 1. At all other times, the tenth bit is zero. This generates a real time interrupt in all flow meters. They then inspect the received address to see if it matches their own address. If it doesn't, no action is taken and normal processing is resumed. If a match is detected, then the flow meter responds with a transmission which occurs within the next 150 milliseconds.

*Sierra Net Protocol Table 3.4 Rev. 1.01*

| Number | Description |
|---|---|
| 1 | Flow Meter Address Echo; Value: 1-30 |
| 2 | Flow Meter Type; Value: 1 Single Point, 2 Multi-Point |
| 3 | Flow Meter Software Version; Value: 0-65,535<br>100 Version 1.00, 250 Version 2.50, etc. |
| 4 | Number of Points; Value: 1-1 Point, 2-2 Points, etc. |
| 5 | Units English/Metric; Value: 0 MPS/°C, 1 SFPM/°F |
| 6, 7 | Full Scale Value; Value: 0-65,535; 0-65,535 MPS or SFPM depending on units above |
| 8, 9 | Low Alarm Setpoint; Local (Flow Meter Only) Low Alarm; Value: 0-65,535 |
| 10, 11 | High Alarm Setpoint; Local (Flow Meter Only) High Alarm, Value: 0-64,535 |
| 12 | Flow Meter Supply Voltage; Value: 0-255 equals 0-25.5 volts |
| 13 | Speed of Response; Proportional to response speed of output signal from Flow Meter; Value: 1-255; 1 = fast, 255 = slow |
| 14, 15 | Alarm Status Flags; Value: Alarms ON/OFF Flags |
| 16, 17 | Fault Status Flags; Value: Faults ON/OFF Flags |
| 18, 19 | Temperature Value; Value: 0-65,535 |
| 20, 21 | Average Flow Value; Value: 0-65,535 |
| 22 – 37 | Individual Point Flow Value Point 1-8, each reading; Value: 0-65,535; Unused points value: 0 |
| 38 – 47 | Spare; All bytes Value: 0 |
| 48, 49 | Check sum; Binary sum of all transmitted bytes including address, module 16 bits; Value: 0-65,535 |

**NOTE:** All numbers transmitted represent unsigned binary numbers unless noted. For 2-byte numbers, transmission is MSB first, then LSB. Call or write to Sierra Instruments, Inc., Applications Engineers, for latest release version.

Totalizer Readout Option

The following section answers some of the questions frequently asked by our customers:

**Q: What baud rate should I use?**
A: The flow meter is programmed internally to work with 9600 baud.

**Q: Why doesn't the program I wrote work, if all of my wires are hooked up correctly?**
A: It is mandatory to use an interrupt driven com library rather than a polled mode. The polled mode may not "stay on the line" long enough to receive all of the data. Remember, also, that you must enable the RS 485 transmitter and disable the receiver when you send information from the Series 640; and vice versa to receive information (refer to the computer code example in Section 3.4). It is easy to forget that the RS 485 is bidirectional.

**Q: Why doesn't Sierra require termination resistors to balance the lines?**
A: Since the RS 485 has the capability to run at one mega baud and we are only using it at 9600 baud, the "reflections" in the line at 9600 baud are virtually non-existent. Therefore, there is no need to balance the lines.

**Q: Why does Sierra send all the data on each query? Why doesn't Sierra only send the flow value?**
A: We do this because all of our systems operate the same way. You, the user, are given the option to discard any data you choose. Note that the entire "stream" is sent in 150 milliseconds, so that time is virtually inconsequential.

**Q: How do I calculate the flow?**
A: Obtain full scale flow from bytes 7, 8 and flow value from bytes 21, 22. Flow = $\frac{\text{(flow value)} \bullet \text{full scale}}{1020}$

**3.4.1 RS 485 Option Response Time Adjustment**

The microprocessor equipped flow meters have a "response" potentiometer which determines the speed of response of the meter. In the fast setting, the response is primarily governed by the speed of the sensor itself on the order of one second. Flow meters are shipped from Sierra Instruments, Inc. with fast response.

At the slowest setting, the time response of the flow meter is several seconds.

**3.5 Display Options**

Display options include flow rate readout, totalized (mass) flow readout, and front panel LED status indicators.

### 3.5.1 Front Panel Status LEDs Option

The front panel status LEDs include power, high alarm, low alarm, sensor fault, and RS 485 fault.

**Power:** This LED glows when power is applied to the flow meter.

**High and Low Alarms:** These LEDs glow when the measured flow is above/below the preset alarm setpoints, respectively. Refer to Section 3.6, ALARMS, for adjusting the alarm set points.

**Sensor Fault:** This LED glows when a problem is detected in the flow measuring circuit. The flow meter is not functioning properly. Refer to Section 4, MAINTENANCE. The flow meter may have to be returned to Sierra Instruments for repair. Sensor fault detection is only available on meters with the microprocessor option.

**RS 485 Fault:** The RS 485 Fault LED indicates the RS 485 interface bus is not functioning properly. If you are using the interface bus, you probably will not be able to read the flow meter. The flow meter may have to be returned to Sierra Instruments for repair.

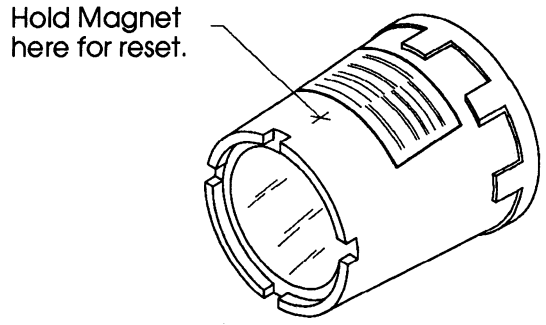
### 3.5.2 Flow Rate Readout Option

The flow rate readout is a 3½ digit LCD display which normally reads out engineering units directly (i.e. $FT^3$/MIN, $NM^3$/HR, LBS/HR) or engineering units divided by 10 (i.e. SFPM/10). Check the serial number label and front panel for information concerning the readout units.

### 3.5.3 Totalizer Readout Option

The totalizer readout shows accumulated (total) mass flow and is displayed on its own 6-digit LCD readout. The totalizer normally reads out directly in engineering units (i.e. cubic feet, grams, pounds, etc.). Check the serial number label and front panel for information concerning the totalizer units.

The totalizer will be reset to a reading of 000000 by holding the Sierra Instruments, Inc. supplied magnet (or any suitable magnet) to the spot indicated in the sketch below. The magnet must be held in this location for several seconds. This activates a magnetic sensing reset circuit within the enclosure. NOTE: the power must be on to allow resetting of the totalizer.



## 3.6 Alarm Options

All Series 640 flow meters feature Form C contact relay outputs. The LED indicators provided on the terminal board inside the wiring dome make setting the alarms easy. There is also an optional sensor fault alarm.

ALARM SETPOINT

The 52-0092 has dual alarm outputs (optional) configured as HIGH and LOW alarm. Each alarm setpoint is user adjustable by a multi-turn potentiometer. Refer to Appendix D, exploded view, and placement diagrams for critical electrical components for the location of the circuit board, test points and adjustment potentiometers. Each alarm has a built in hysteresis of 2% to avoid "chattering". The Sensor Fault Alarm is nonadjustable.

### 3.6.1 Adjusting Alarm Setpoint for Non-Microprocessor Electronics

Locate potentiometer VR4 (High alarm set) or VR5 (Low Alarm set) and the associated Test Points on the 52-0092 printed circuit assembly. To adjust the alarm setpoint, use one of the following two methods.

Table 1
Test Points

| | |
|---|---|
| TP1 | Bvv |
| TP2 | Bridge Amp – input |
| TP3 | Bridge Amp + input |
| TP4 | Sub. Cal Volts |
| TP5 | 0-5 VDC Non-Linear |
| TP6 | High alarm set |
| TP7 | Low alarm set |
| TP8 | Sensor fault |
| TP9 | VGND |
| TP10 | Ground |

DYNAMIC ADJUSTMENT

Set the flow rate to the point where the alarm must activate. Monitor the alarm output while adjusting VR4 (High) or VR5 (Low) to find the alarm actuation point. When the alarm activates, rotate the adjustment screw back and forth a few times to ensure that the setting is correct.

Table 2
Adjustment Potentiometers

| | |
|---|---|
| VR1 | Zero (0-5 VDC Output) |
| VR2 | Span (0-5 VDC Output) |
| VR3 | Cal Pot |
| VR4 | High Alarm Set |
| VR5 | Low Alarm Set |
| VR6 | 4 mA Adjust |
| VR7 | 20 mA Adjust |
| VR8 | Bridge Offset (Factory adjustment) |

STATIC ADJUSTMENT

Locate the alarm adjustment test points (see Table 1) on the 52-0092 PCB. Connect a voltmeter's positive lead to the TP6 (High) or TP7 (Low) and the negative lead to TP10 (Ground). As you rotate VR4 (High) or VR5 (Low), the voltmeter will sweep between 0 and 5 volts which represents an alarm setpoint between zero and full scale flow. Adjust VR4 or VR5 to the desired value. Linear Output Models may be adjusted by using a simple multiplier to convert Volts to the desired engineering units.

Example:
Linear Output Models:
Full scale = 4000 SCFM, alarm point = 1200 SCFM, find the voltage required to trigger the alarm at 1200 SCFM.

(1200/4000) x 5 = 1.50 VDC

Following the access procedure in reverse, install the enclosure over the electronics PCBs. This completes the alarm setpoint adjustment procedures.

*CAL POT:*
Moving J1 from the NORM position to the CAL position disconnects the flow sensor bridge circuit from the signal conditioning circuitry and enables the static calibration pot VR3. The static calibration pot provides a substitute Bridge Voltage signal. This allows you to check the operation of all of the output circuits, including the 0-5 VDC output, 4-20 mA Output, High Alarm, Low Alarm and Sensor Fault Monitor without actually running flow past the sensor.

To use the Cal Pot, you need to refer to the current calibration sheet that came with your flow meter. Find the table listing Bridge Voltage versus Flow. (Note: Some sheets may list non-linear 0-5 VDC data versus flow. Alternate methods for this will be listed in parentheses.)

Connect the Voltmeter's negative lead to TP10 (Gnd) and the positive lead to TP4 (TP5 for non-linear 0-5 VDC). Adjust VR3, Cal Pot, for the flow reading of interest. This could be Zero Flow, Full Scale Flow, an Alarm Point, etc. Once VR3 is set, move the positive lead of the Voltmeter to the output being tested to read.

**NOTE: Adjustments to VR1, VR2, VR6 and VR7 affect the calibration of your flow meter and should only be attempted by qualified personnel with the proper flow standards.**

**IMPORTANT: Replace jumper J1 in the NORM position when you are finished checking outputs or adjusting alarms.**

# 4 MAINTENANCE

**WARNING! Before attempting any maintenance make sure there is no pressure in the line.**

**WARNING! Gas leaks are possible during probe maintenance. If there is toxic or combustible gas in the line use a Sierra flow meter with hot tap option or be sure the lines are completely purged before removing the probe.**

Refer to Section 6, TROUBLESHOOTING, if you need to return your Series 640 FM flow meter to Sierra Instruments, Inc. for repair.

**WARNING! To prevent ignition of hazardous atmospheres, do not remove cover while circuits are live.**

## 4.1 Access to Electronics PCAs

The explosion proof enclosure contains electronics PCAs within the larger round dome lid. To gain access to the electronics PCAs, including adjustment potentiometers, locate and loosen the small set screw which locks the dome lid in place, then carefully unthread the large round dome lid and slide it away from the flow meter.

## 4.2 Totalizer Back-Up Battery

The totalizer back-up battery normally lasts six years. To replace the battery the flow meter must be returned to Sierra Instruments, Inc. Refer to Section 6.1, CUSTOMER SERVICE, for instructions on returning the flow meter.

## 4.3 Steel-Trak Probe Cleaning

Steel-Trak probes are insensitive to small amounts of contamination or dirt; minor contamination or discoloration will not cause accuracy errors. To inspect the sensor elements, retract the probe from the pipe or duct, exposing the sensor elements (Two stainless steel encasements, or thermowells). If they are visibly dirty, clean them with water or alcohol (ethanol) and an artist's brush until they appear clean again. Even though the sensor elements are rugged and breakage resistant, avoid touching them with any solid object and use a light touch while cleaning them.

## 4.4 Breakage or Damage of Probe

If the sensors are broken or damaged, the probe and electronics should be returned to the factory. A new sensor will be installed and calibrated. Refer to Section 6.1, CUSTOMER SERVICE, for further information.

# 5 CALIBRATION

## 5.1 Calibration at Sierra Instruments, Inc.

To ensure the continuing high accuracy of your Series 640 FM flow meter, Sierra Instruments, Inc. maintains a fully equipped, quality controlled Flow Calibration Metrology Laboratory for recalibration. If the probe or electronics have been damaged, or you want to recalibrate, please refer to Section 6.1, CUSTOMER SERVICE, for information in order to contact customer service and obtaining shipping instructions. The raw calibration data is sent with every order. The data is non-linear. If you have a linear unit, the calibration sheet shows the mathematical formula which the linearizer uses to produce the linear output. All accuracy specifications are per the system specifications unless other wise specified.

## 5.2 How to Calibrate the Series 640 FM Yourself

**WARNING! Calibration must only be performed by qualified personnel using non-hazardous, safe gases. Sierra Instruments, Inc. strongly recommends that you return your Series 640 FM flow meter to the factory for calibration. Refer to Section 6.1, CUSTOMER SERVICE, for shipping instructions.**

To calibrate the mass flow meter you must generate a precisely known velocity, preferably with a low-noise wind tunnel with a flat velocity profile. You must use the original calibration gas. Insert the probe into the wind tunnel with its axis either vertical or oriented as it is located in your installation. Sierra Instruments uses an in-house NIST-traceable laser doppler anemometer as a primary standard for calibration of our transfer standards and for calibration at high pressures or temperatures. It is also used to velocities below 500 FPM. An NIST-traceable Pitot-tube can be used for higher velocities. The sensor must be at or near the same location as the Pitot-tube. Mutual flow disturbances should be avoided. For lower velocities, less than approximately 1000 FPM, a high-accuracy flow meter, such as a laminar flow element, may be put in the line to measure the total flow rate. If the velocity profile at the measurement point is perfectly flat, the calibration velocity is the flow rate divided by the effective cross-sectional area.

To set the calibration refer to Appendix D for the location of the calibration-adjustment potentiometers. Insert the probe in the wind tunnel. Allow several minutes for the probe to stabilize. Adjust the zero potentiometer until the readout shows zero. The flow meter is now zeroed.

Next, select a suitable calibration point for the range, either nearest to full scale or the typical operating point for your application. Generate this velocity in the wind tunnel. Allow one minute for stabilization, and adjust the "span" potentiometer until the readout shows the correct value. The velocity range is now properly spanned.

Next, take data for multiple, equally spaced values to create a data chart that gives you indicated versus actual flows.

For linear mass flow meters, Sierra uses an EPROM look-up table for linearization. You will not be able to modify this table. If you need to change your gas or full scale flow range you will need to return the flow meter to Sierra Instruments for recalibration. Alternatively, you may elect to obtain the non-linear data and supply this data to Sierra Instruments to burn an EPROM with the proper transfer function matching your calibration data. Sierra would then return the EPROM. You would install the new EPROM and then perform the final span calibration. The new EPROM table will be as accurate as the data you took. Call our Customer Service Department for assistance at (800) 866-0200. In Europe call our Customer Service Department at 31(0)20-6145810.

# 6 TROUBLE-SHOOTING

**CAUTION! The electronics, sensor and any cable supplied by Sierra Instruments, Inc. is calibrated as a single precision mass flow meter. Interchanging sensors will impair the accuracy of the flow meter.**

If you experience any problem with your Series 640 FM flow meter, the solution is usually simple. This section helps you find that simple solution. If you cannot solve the problem yourself, please call Sierra's Customer Service Department, Technical Assistance, at the phone number listed below.

## 6.1 Customer Service and Shipping Instructions

The Sierra Instruments, Inc. Customer Service Department can be reached at (800) 866-0200. The European Customer Service Department can be reached at 31(0)21-6145810. Please have your model number and serial number available when you call.

If you find it necessary to return a Series 600 FM mass flow meter to Sierra Instruments, Inc., obtain a Return Material Authorization from the Customer Service Department.

Unless specifically instructed to do otherwise, you must return the entire flow meter, including *all* electronics.

Please include information describing the difficulties experienced, purchase order number under which the equipment was purchased, and a contact name and phone number.

Be sure to include **complete** return shipping instructions. **We cannot deliver to post office boxes.** Ship to one of the following addresses:

USA HEADQUARTERS

Sierra Instruments, Inc.
5 Harris Court, Building L
Monterey, CA 93940
ATTN: SERVICE DEPT.

EUROPEAN HEADQUARTERS

Sierra Instruments b.v.
Bolstoen 30A
1046 AV Amsterdam
The Netherlands
ATTN: SERVICE DEPT.

*Table 6-1*
*Troubleshooting*

| Problem | Possible Cause | Action |
|---|---|---|
| Velocity Measurement Seems Low | a) Probe not oriented properly | a) Orient probe with respect to flow |
| | b) Probe dirty | b) Refer to Section 4, Maintenance, for information on cleaning the probe |
| Velocity Measurement is erratic or fluctuating | a) Very turbulent flow | a) Try to find less turbulent area to measure velocity |
| | b) Sensor dirty | b) Refer to Section 4, Maintenance, for information on cleaning sensor |
| | c) Sensor broken | c) Refer to Shipping Instructions, to return flow meter to Sierra for repair |
| | d) Probe not mounted securely | d) Probe must be mounted securely without vibration |
| | e) Malfunction in flow meter | e) Refer to Shipping Instructions, to return flow meter to Sierra for repair |
| Reading Won't Zero | a) Out of calibration | a) Refer to Section 5, |
| | b) Sensor broken | b) Refer to Shipping Instructions, to return flow meter to Sierra for repair |
| 4-20 mA Output Not Indicating 4 mA at Zero Flow | a) Excessive current loop resistance. Loop resistance must be between 50 and 500 ohms | a) Use larger gauge wire or change load resistance |

# 7 MONITORING FLOW RATE

## 7.1 General Relationships

Measuring Free Air Velocity

Measuring Total Flow

The Sierra Series 640 FM flow meter has two major applications:

- Measuring free air velocity in open spaces
- Monitoring the total flow rate of gases in pipes, ducts, and stacks.

The first application is relatively easy because the flow meter directly monitors the parameter of interest – velocity, or flow within a nozzle of infinite diameter.

In the latter case, however, the total standard volumetric flow rate $Q_S$ (SCFM or $Sm^3/hr$), in the pipe or duct, is the quantity of direct interest. The total standard volumetric flow rate is determined by the following relationship:

$$Q_S = V_S \; A \qquad (1)$$

where:

$V_S$ = the average standard mass velocity over the cross-sectional area of the pipe or duct (SFPM or SMPS) and

A = the cross-sectional area of the pipe or duct ($ft^2$ or $m^2$). See Section 5 for an explanation of Equation (1) and the relationship between standard and actual flow rates.

The Sierra flow meter monitors the standard mass velocity at a single point in the cross section. Usually, the mass flow sensor is located at the center line of the pipe or duct and measures the standard center line mass velocity $V_{S,C}$. The flow meter does not directly measure the average velocity, $\overline{V}_S$. The total standard volumetric flow rate is then determined by the following relationship:

$$Q_S = KV_{S,C} \; A$$

where: (2)

$$K = V_S / V_{S,C}$$

If the velocity profile in the pipe or duct is perfectly flat, or uniform, then K = 1, and the flow meter directly monitors the average mass velocity. Unfortunately, in most applications, the velocity profile is not uniform. The flow in pipes, ducts and stacks is almost always turbulent and has a non-uniform profile because the velocity decreases as the gas approaches the pipe's wall (gas velocity is zero at the wall's surface). In a straight run of pipe or duct twenty to thirty diameters in length, the velocity profile is a fully developed turbulent velocity profile. This is a desirable place to locate the flow meter because the profile is predictable and the flow is unidirectional down the pipe's axis. In some cases, due to extreme mounting constraints, the flow meter must be located downstream of an elbow in which case the velocity profile is greatly skewed because the gases momentum speeds up the flow along the outer radius of the elbow. Secondary vortex flows also are created in elbows.

Due to the flow distribution, K generally does not equal one. Fortunately, K usually is essentially constant over a flow range, or Reynold's number range, of 4:1 to 10:1. This means the normalized shape of velocity profiles is essentially constant over a wide turn-down ratio. Because this is true, we can determine K by the traversal method. In this method, we divide the cross-sectional area at the monitoring location into equal areas, maintain a constant flow rate in the middle of the range of interest, and insert or traverse the flow meter into the pipe so that the mass flow sensor measures the local mass velocity at the geometric center of each equal area.

Let's say we divide the cross section into four equal areas, and via traversing, measure each area's velocity as $V_{s,1}$, $V_{s,2}$, $V_{s,3}$, and $V_{s,4}$ and the center-line velocity as $V_{s,c}$. Then the average velocity and K are:

$$V_s = 1/4\ (V_{s,1} + V_{s,2} + V_{s,3} + V_{s,4})$$

$$K = 1/4V_{s,c}\ \ (V_{s,1} + V_{s,2} + V_{s,3} + V_{s,4})$$

If we divide the cross-section into n equal areas, then K is expressed as:

$$V_s = (1/n) \sum_{i=1}^{n} V_{s,i} \qquad (5)$$

$$K = V_s/V_{s,c} \qquad (6)$$

For fully developed turbulent flows, K varies from (0.8 to 0.95).

For large ducts or monitoring applications where the velocity is highly non-uniform and where safety considerations allow, we recommend Sierra's Series 650 Flow Averaging Arrays for accurate flow averaging.

The remainder of this section describes methods for equal-area traversing of pipes, ducts, and stacks to obtain $\overline{V}_s$ using Equation (5).

## 7.2 Equal Area Traversal Method

The "Equal Area Method" is recommended for most flow measurement applications. Traversing in round ducts with diameters of 6 inches, or less, should be made as shown in Figure 7-1. The traverse should consist of a total of twelve readings taken along two diameters at 90° to each other and at centers of equal areas. Traversing in round ducts with a diameter larger than 6 inches should be made as shown in Figure 7-2. In this case, the traverse should consist of a total of twenty readings along two diameters at 90° to each other, at centers of equal areas.

*Figure 7-1*
*Equal Area Traverse for Round Ducts, 6-Inch Diameter or Less*

| | Tube Markings From Wall |
|---|---|
| 1 | " Dia. x 0.043 = " |
| 2 | " Dia. x 0.146 = " |
| 3 | " Dia. x 0.296 = " |
| 4 | " Dia. x 0.704 = " |
| 5 | " Dia. x 0.854 = " |
| 6 | " Dia. x 0.957 = " |

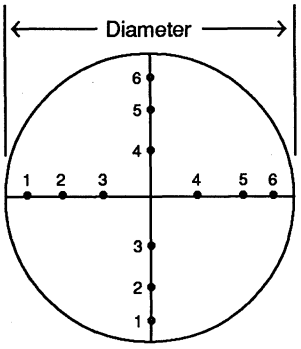
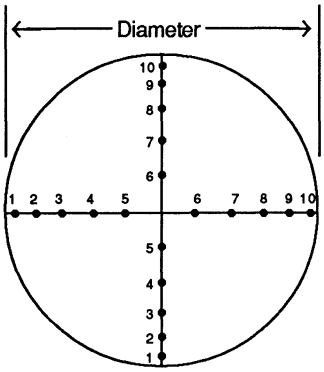



*Figure 7-2*
*Equal Area Traverse for Round Ducts Larger than 6-Inch Diameter*

| | Tube Markings From Wall |
|---|---|
| 1 | " Dia. x 0.026 = " |
| 2 | " Dia. x 0.082 = " |
| 3 | " Dia. x 0.146 = " |
| 4 | " Dia. x 0.226 = " |
| 5 | " Dia. x 0.342 = " |
| 6 | " Dia. x 0.658 = " |
| 7 | " Dia. x 0.774 = " |
| 8 | " Dia. x 0.854 = " |
| 9 | " Dia. x 0.918 = " |
| 10 | " Dia. x 0.974 = " |



For rectangular ducts, the following procedure should be followed:

1. At least sixteen, but not more than sixty-four, readings should be taken at centers of equal area.
2. If less than sixty-four readings are teaken, the traverse points should not be over 6 inches center-to-center.
3. If sixty-four readings are taken, the traverse points may be over 6 inches center-to-center .

The Duct Traversal Data Sheet presented in Appendix E facilitates taking the data.

## 7.3 Stack and Flue Monitoring

For stack monitoring, the U.S. EPA Method 1 is usually specified. This method requires that: (1) the stack flow is not cyclonic or swirling; (2) the stack is at least 12 inches in diameter or 113 square inches in cross-sectional area; and (3) the measurement location is at least eight diameters downstream and at least two diameters upstream from the nearest flow disturbance. EPA allows for relaxation of these requirements.

The number of monitoring points specified by EPA Method 1 is given in Table 7-1, as follows:

*Table 7-1 Minimum Number of EPA Method 1 Monitoring Points*

| Stack Diameter (or Equivalent Diameter) | Number of Monitoring Points |
|---|---|
| 12–24 inches | 8 (Circular stacks) |
| 12–24 inches | 9 (Rectangular stacks) |
| Over 24 inches | 12 (Circular or rectangular) |

After the number of monitoring points is determined, divide the stack's cross-section into equal areas. The flow meter's probe tip should be located in the center of each equal area. Table 7-2 gives EPA's recommendation for the size of each equal area for square or rectangular cross sections. The dimensions of each area can be modified provided the cross-sectional area is the same.

*Table 7-2 Size of Equal Areas for Square and Rectancular Stacks*

| Number of Monitoring Points | Size of each Individual Equal Area |
|---|---|
| 9 | 3 x 3 |
| 12 | 4 x 3 |
| 16 | 4 x 4 |
| 20 | 5 x 4 |
| 25 | 5 x 5 |
| 30 | 6 x 5 |
| 36 | 6 x 6 |
| 42 | 7 x 6 |
| 49 | 7 x 7 |

# 8 CALCULATING ACTUAL FLOW RATE

The mass flow meter measures the "standard" volumetric flow rate, $Q_s$, referenced to 70°F (21.1°C) and 1 atmosphere (760 mm of mercury). The units of measurement are standard cubic feet per minute (SCFM) or standard cubic meters per hour ($Sm^3/hr$).

In most monitoring applications the mass flow ($Q_s$) is the quantity of direct interest. However, in some cases the actual volumetric flow rate Q is desired. This is obtained by applying a correction factor given by the following equation:
where:

$$Q = Q_S\left(\frac{\rho_s}{\rho}\right) = Q_S\left(\frac{P_s}{P}\right)\left(\frac{T}{T_s}\right) \qquad (1)$$

where:

- $Q$ = "actual" volumetric flow rate at conditions of P and T ($m^3/h$, ACFM),
- $Q_S$ = "standard" volumetric flow rate referenced to standard conditions of $P_S$ and $T_S$, ($Sm^3/hr$, SCFM),
- $\rho$ = gas mass density at actual conditions, $lb/ft^3$,
- $\rho_S$ = gas mass density at standard conditions (0.0748 $lb/ft^3$ for air at 70°F)
- $T$ = gas temperature at actual conditions, °R,
- $T_S$ = standard gas temperature = 70°F = 529.69°R,
- $P$ = gas pressure at actual conditions, mm of mercury (psig),
- $P_S$ = standard gas pressure = 760 mm of mercury (14.7 psig).

Example Calculation:

Your flow meter shows a reading of 800 SCFM. The gas temperature is 150°F. The gas pressure is 200 psig. From Equation 1, the actual volumetric flow rate Q is calculated as:

$$Q = 800\left(\frac{14.7}{14.7 + 200}\right)\left(\frac{150 + 459.69}{529.67}\right) = 63.0 \text{ ACFM}$$

# APPENDIX A. Specifications

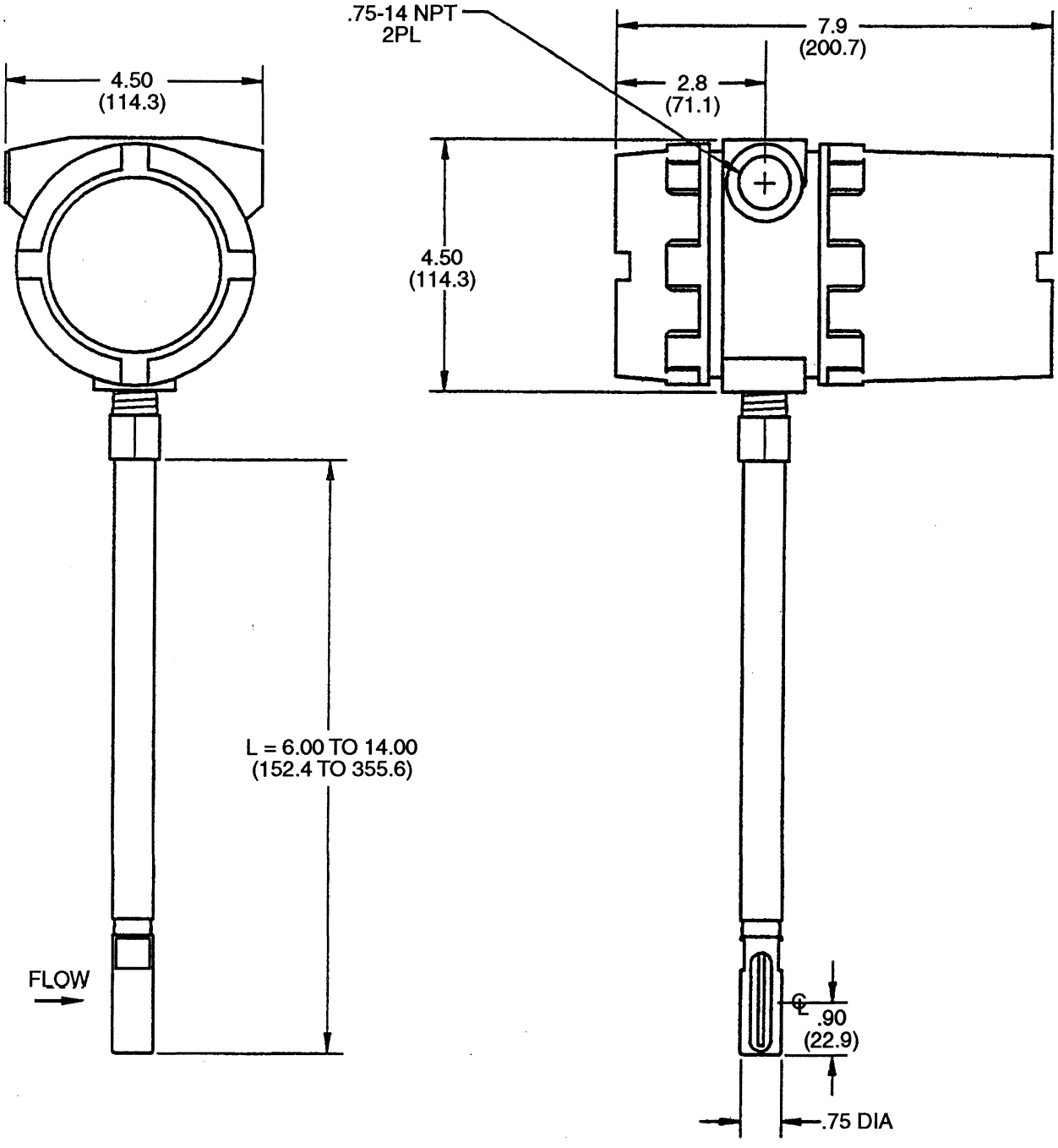
| Specifications | Series 640 FM Steel-Trak™ Meters |
|---|---|
| FLOW RANGE[1] | CODE / VELOCITY (SFPM): 01 0–100; 02 0–200; 03 0–500; 04 0–1,000; 05 0–2,000; 06 0–5,000; 07 0–10,000; 08 0–12,000; 09 0–15,000<br>CODE / VELOCITY (SMPS): 11 0–0.5; 12 0–1; 13 0–2.5; 14 0–5; 15 0–10; 16 0–25; 17 0–50; 18 0–60; 19 0–75 |
| GASES | Air, nitrogen; methane/natural gas, carbon dioxide, argon, helium (low pressure), digestor gas, hydrogen, flare gas; consult factory for others |
| FLOW OUTPUT SIGNALS | Choice of one of four analog output signals linearly proportional to mass flow rate or velocity: 0–5 VDC standard, 1000 ohms min. load resistance; 4–20mA optional. 250 ohms max. loop resistance: 0–1 VDC optional, 200 ohms min. load resistance; or 10 VDC optional, 2000 ohms min. load resistance<br>RS 485 serialized output standard for microprocessor electronics: 2-wire cable, 4,000 feet (1,200 m) max. length<br>Other output signals possibly available on special order |
| TOTALIZER | Separate 6-digit LCD displlay |
| ALARMS | Standard electronics: high or low alarms; microprocessor electronics; high, low, or "window" alarms; Form C relay outputs; specify levels |
| DIGITAL READOUT | Available for mass flow or velocity in any engineering units; 3-1/2 digit LCD display |
| LED INDICATORS | For microprocessor electronics only; power-on, RS 485 transmission fault, and sensor fault |
| INPUT POWER REQUIRED | 15-18 VDC, 350 mA max.; 20-25 VDC, 350 mA max.; 100 ± 10% VAC, 50 Hz, 10 watts; 115 ± 10% VAC, 60 Hz, 10 watts; or 230 ± 10% VAC, 50 Hz, 10 watts |
| ACCURACY IN POINT VELOCITY[3] | 1% FS + 0.5% RDG over 32 to 122°F (0 to 50°C) and 5 to 30 psia (0.35 to 2 kg/cm²) |
| REPEATABILITY | 0.2% FS |
| TIME RESPONSE | 3 seconds to 63% of final velocity value; 60 seconds to 63% of final temperature value; for microprocessor electronics; analog output signal and display time response variable from 0.5 to 5 seconds |
| GAS PRESSURE | 1000 psig (70 kg/cm² gauge) max. |
| GAS TEMPERATURE | Standard: –40 to 250°F (–40 to 125°C) |
| ELECTRONICS OPERATING TEMPERATURE | 32 to 122°F (0 to 50°C) |

| Specifications | Series 640 FM Steel-Trak™ Meters |
|---|---|
| ELECTRONICS STORAGE TEMPERATURE | 32 to 158°F (0 to 70°C) |
| WETTED MATERIALS | 316 stainless steel |
| PROBE MOUNTING OPTIONS | 316 SS 3/4-inch tube x 1-inch Male NPT compression fitting (1-inch Female NPT weldolet optional); flat duct mounting bracket; curved duct mounting bracket (specify O.D.); 150 lb. 1-inch NPT ASA raised flange; or low (100 psig max.) pressure "hot-tap" models, 1-1/4-inch Male NPT. For in-line mounting, 3", 4", 6" and 8" flanged or male NPT bodies are also available. |
| ELECTRONICS ENCLOSURES | Electronics Enclosure: aluminum explosion proof enclosure, complies with NEC Code: Class I, Groups B, C & D, Divisions 1 & 2, T3 rating; and Class II, Groups E, F, & G, Divisions 1 & 2, T3 rating; viewing window optional |
| PROBE DIMENSIONS | 0.750 in. (19.05 mm) O.D.: lengths; 6,13 (standard), 18, 24, 36, 48, or 72 in. (15, 33, 46, 61, 91, 122 or 183 cm); other lengths optional (72 in. max); distance from tip of probe to mass flow sensing point: 0.90 in. (22.9 mm). NOTE: Killark Seal Kit required beyond 14" probe length. |
| PROBE CABLE | Standard: vinyl; optional; Teflon™; 50 ft. (15 m) max. |
| NET WEIGHTS | Probe: 0.6 lb. (0.3 kg) per ft. (per 30 cm): explosion proof enclosure; 3 lb. (1.4 kg) |

Specifications subject to change without notice.
NOTES:
(1) Other ranges on special order (Code 10). SFPM = standard feet per minute (SCFM/ft²); 70°F (21.1°C) and 1 atmosphere.
(2) FS = Full Scale; R = Reading
(3) Add 1% FS for velocities less than 200 SFPM (1.0 SMPS). Add 1% R(2) for gas temperatures in the ranges –40 to 0C. Add 2% R for pressures in the range of 1-5 psia (0.07 = 0.35 kg/cm²) or 30-150 psia (2-10 kg/cm²). Add 1% FS + 4% R for pressures from 150-1000 psia (10-70 kg/cm²).

# APPENDIX B1

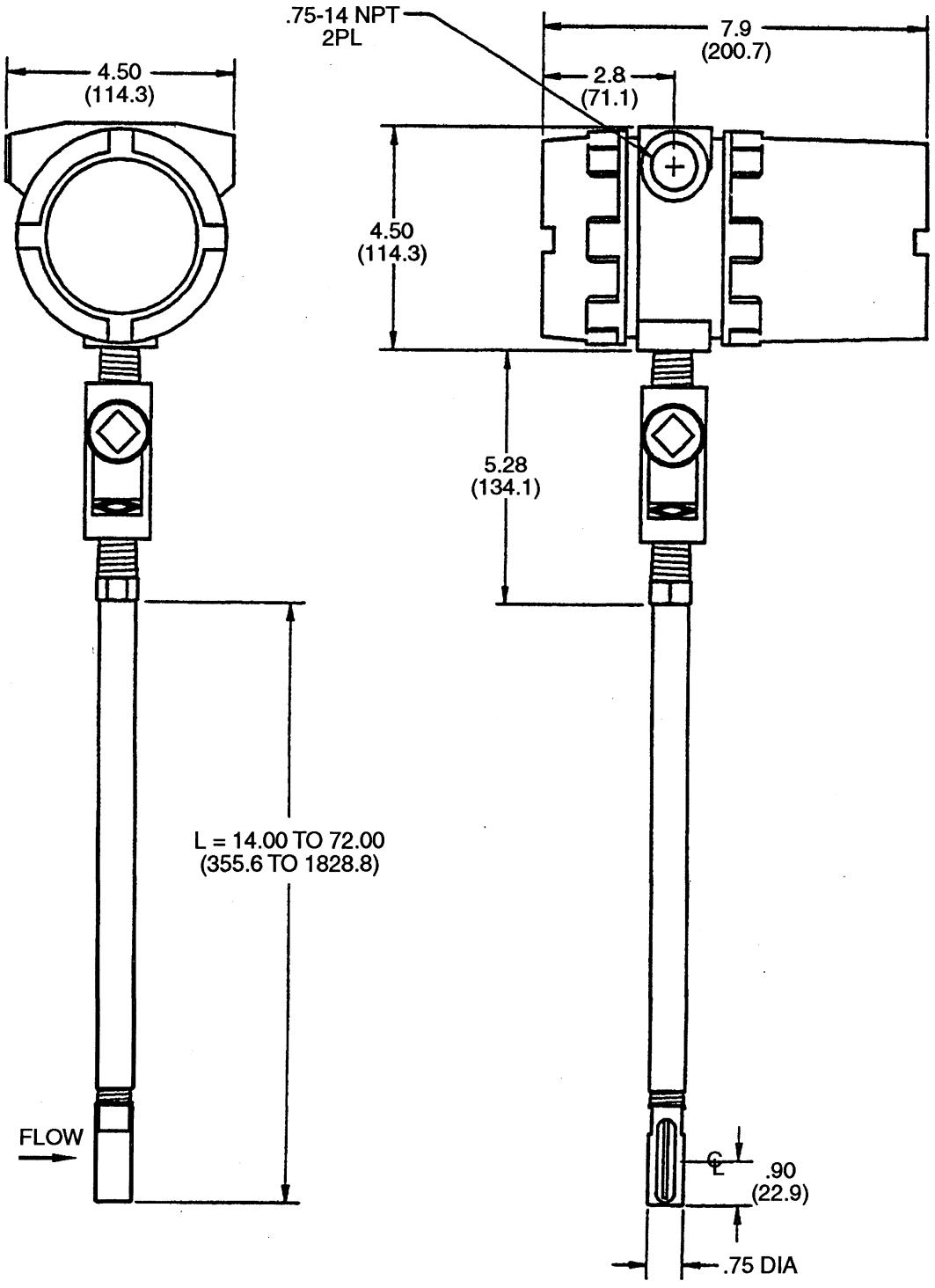
## Explosion Proof Enclosure with 6" (152.4) to 14" (355.6) Long Probes




DIMENSIONS IN INCHES
(DIMENSIONS IN MILLIMETERS IN PARENTHESES)

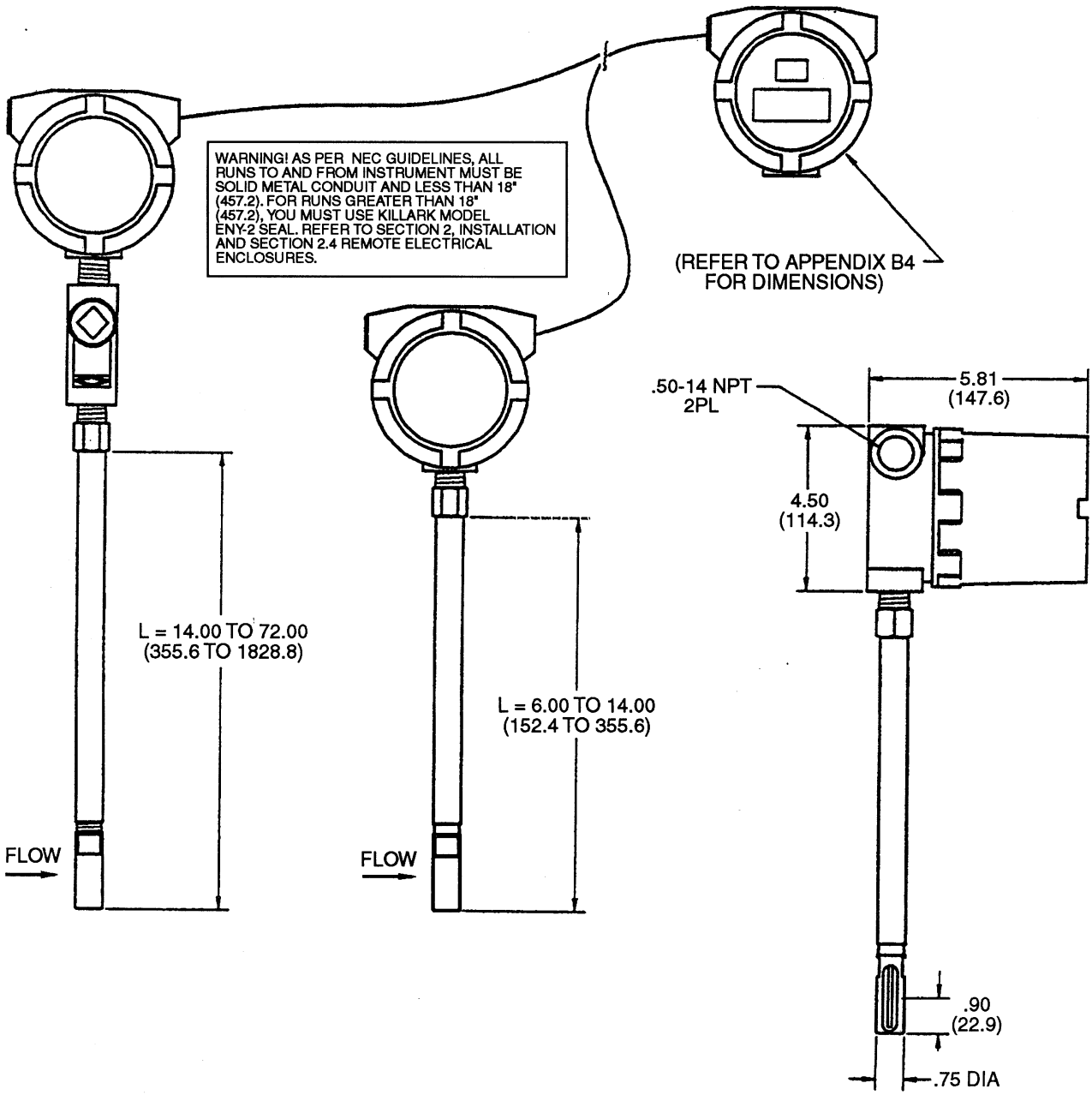
# APPENDIX B2

## Explosion Proof Enclosure with 14" (355.6) to 72" (1828.8) Long Probes and Killark Seal




DIMENSIONS IN INCHES
(DIMENSIONS IN MILLIMETERS IN PARENTHESES)

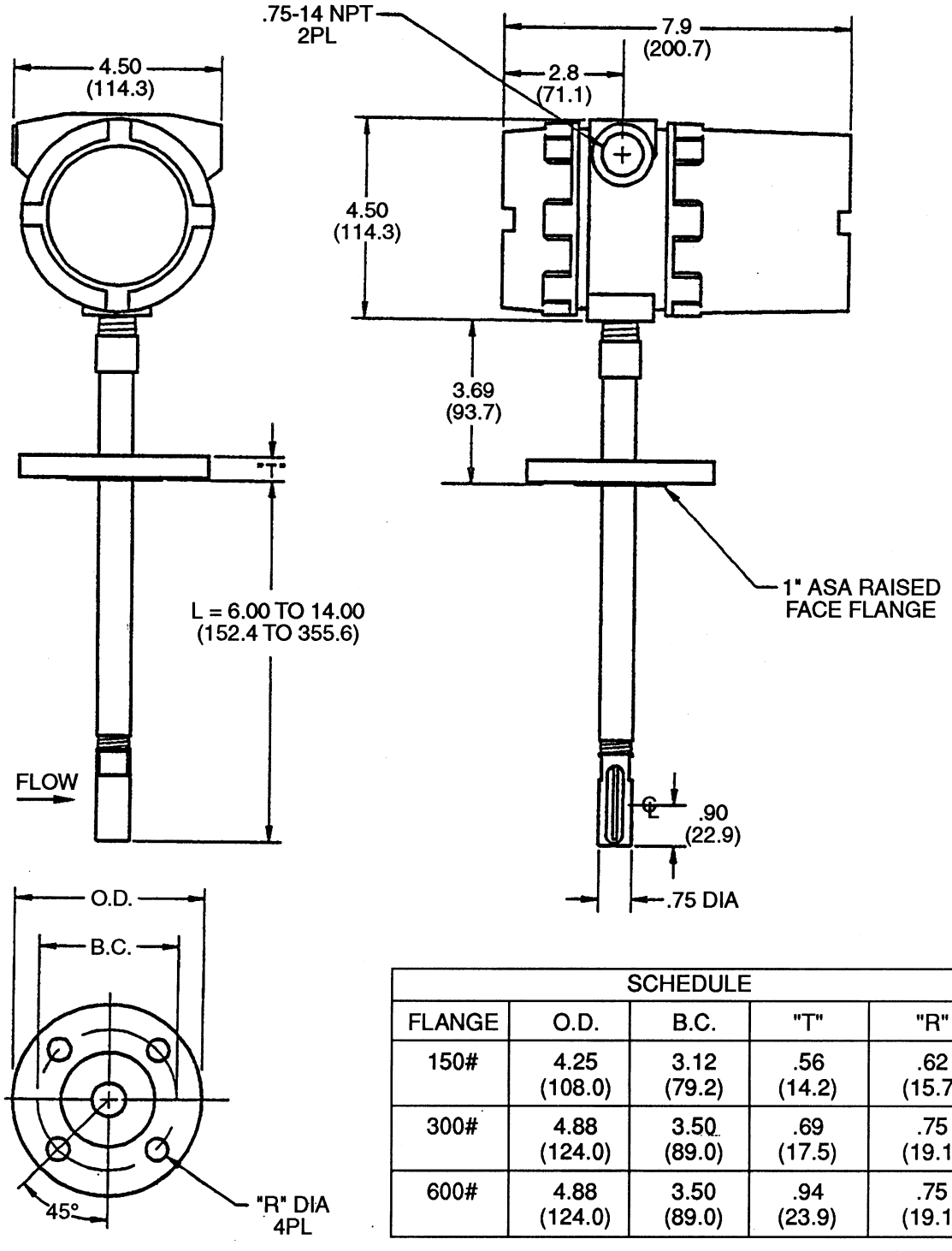
# APPENDIX B3
## Explosion Proof Enclosure Showing Option E4




DIMENSIONS IN INCHES
(DIMENSIONS IN MILLIMETERS IN PARENTHESES)

# APPENDIX B4

## Explosion Proof Enclosure Mounting Option h); Raised Face Flange with 6" (152.4) to 14" (355.6) Long Probes

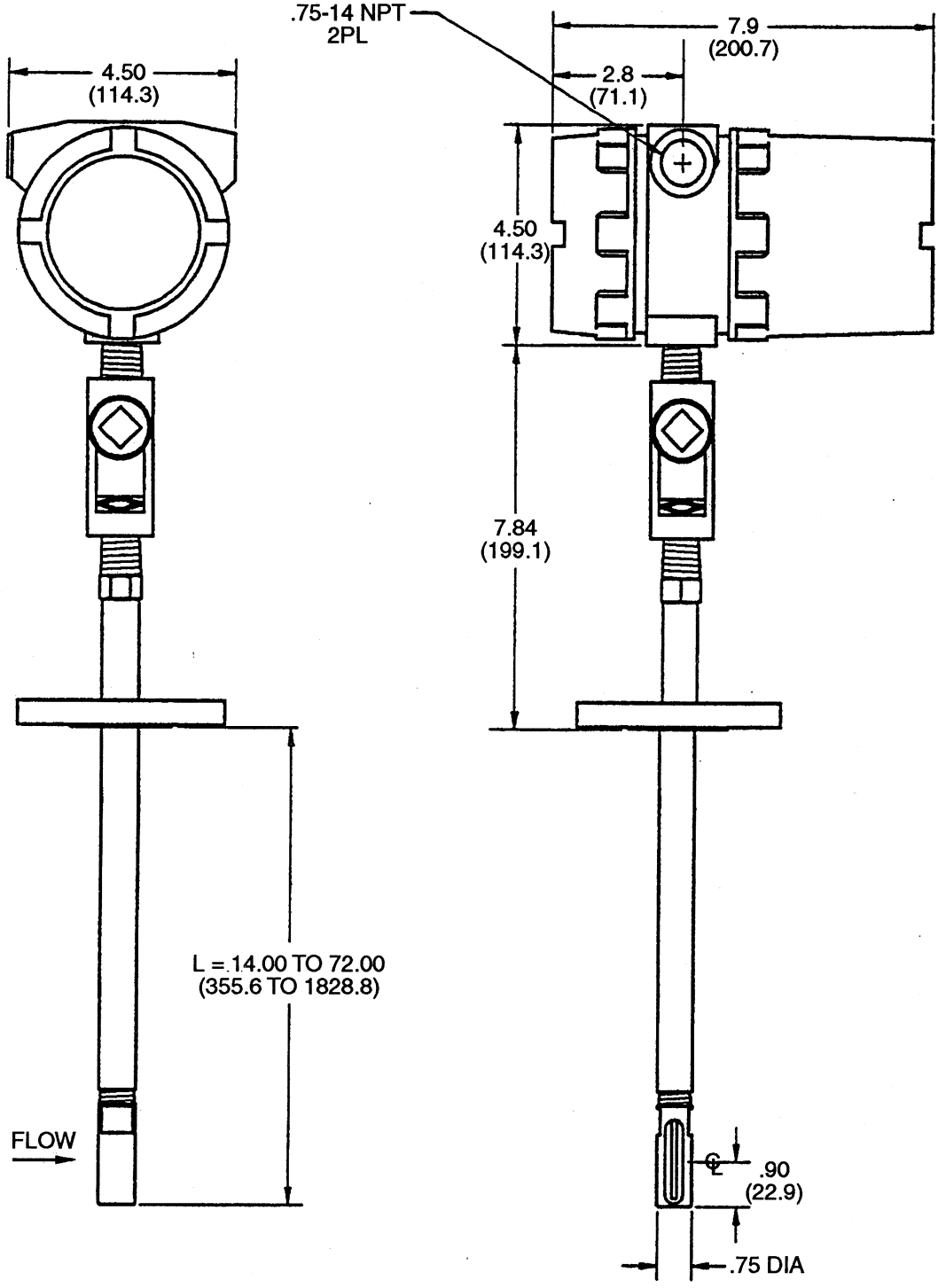



| SCHEDULE | | | | |
|---|---|---|---|---|
| FLANGE | O.D. | B.C. | "T" | "R" |
| 150# | 4.25 (108.0) | 3.12 (79.2) | .56 (14.2) | .62 (15.7) |
| 300# | 4.88 (124.0) | 3.50 (89.0) | .69 (17.5) | .75 (19.1) |
| 600# | 4.88 (124.0) | 3.50 (89.0) | .94 (23.9) | .75 (19.1) |

DIMENSIONS IN INCHES
(DIMENSIONS IN MILLIMETERS IN PARENTHESES)

# APPENDIX B5

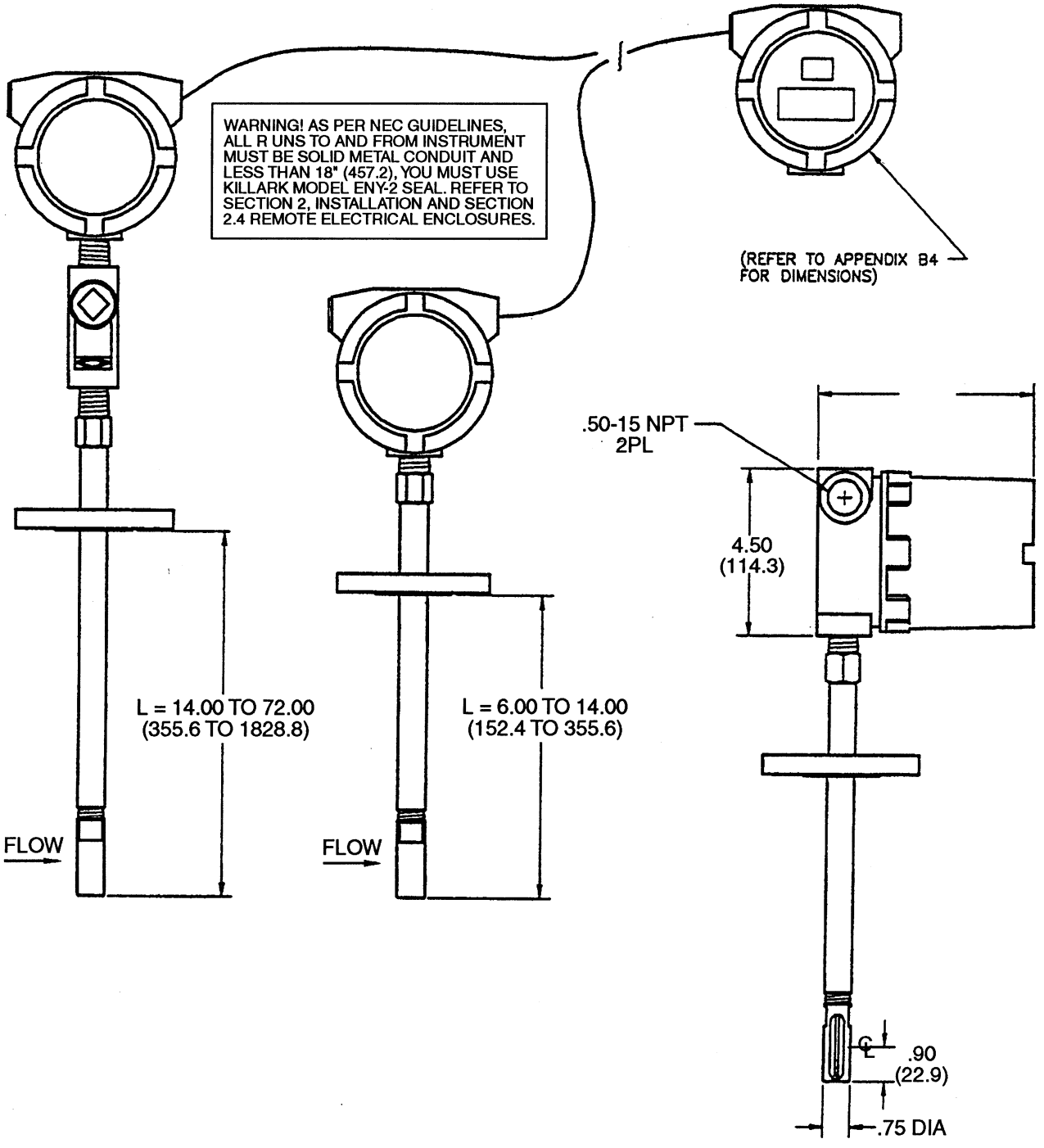
## Explosion Proof Enclosure Mounting Option h); Raised Face Flange with 14" (355.6) to 72" (1828.8) Long Probes and Killark Seal




DIMENSIONS IN INCHES
(DIMENSIONS IN MILLIMETERS IN PARENTHESES)

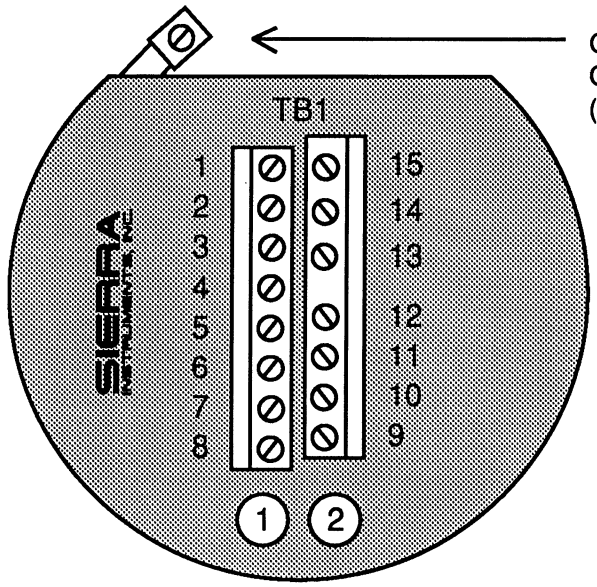
# APPENDIX B6

## Explosion Proof Enclosure Showing Option E4 and Option h); Raised Face Flange




DIMENSIONS IN INCHES
(DIMENSIONS IN MILLIMETERS IN PARENTHESES)

# APPENDIX C1
## Power Input Wiring



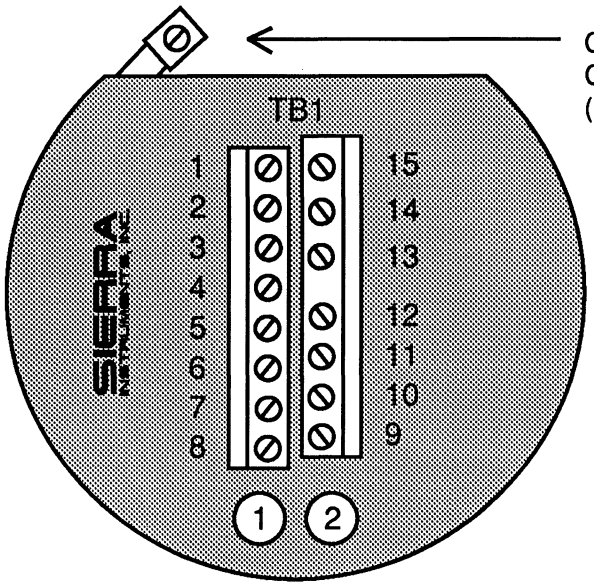

## AC POWER WIRING (PS/PE/PJ)

| TERMINAL BOARD CONNECTION | FUNCTION |
|---|---|
| TB1-14 | VAC NEUTRAL (WHITE) |
| TB1-15 | VAC HOT (BLACK) |
| CHASSIS SCREW (LOCATED UNDER PCB) | EARTH GROUND |

## DC POWER WIRING (PV1/PV2)

| TERMINAL BOARD CONNECTION | FUNCTION |
|---|---|
| TB1-14 | DC POWER COMMON |
| TB1-15 | +15VDC / +24VDC |

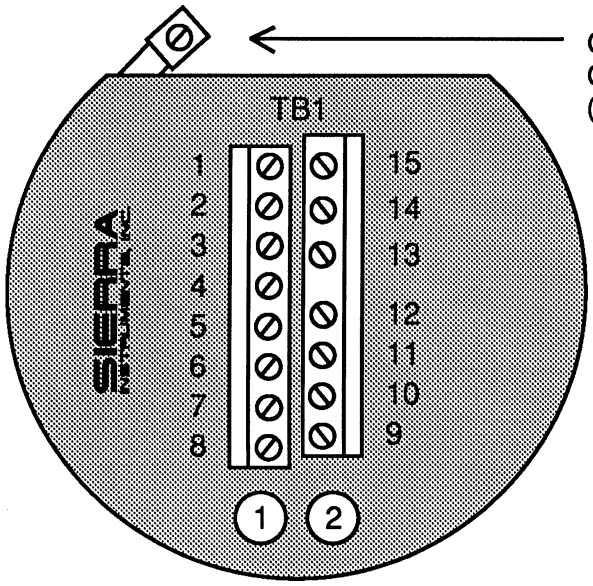
# APPENDIX C2
## Output Signal Wiring




## OUTPUT SIGNAL WIRING (V1/V4)

| TERMINAL BOARD CONNECTION | FUNCTION |
|---|---|
| TB1-1 | SIGNAL GROUND |
| TB1-2 | 0-5 VDC / 4-20 MA OUTPUT SIGNAL |

# APPENDIX C3
## Alarm Wiring

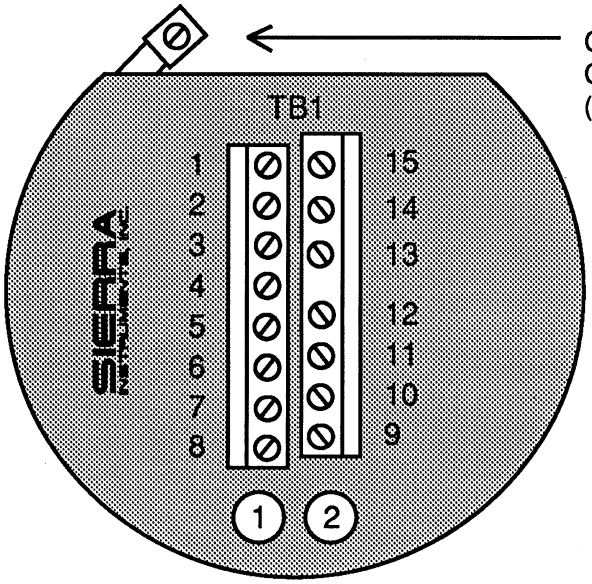



## ALARM WIRING (AL)

| TERMINAL BOARD CONNECTION | FUNCTION |
|---|---|
| TB1-7 | RELAY C (LOW ALARM) |
| TB1-8 | RELAY NC (LOW ALARM) |
| TB1-9 | RELAY NO (LOW ALARM) |
| TB1-10 | RELAY 2 C (HIGH ALARM) |
| TB1-11 | RELAY 2 NC (HIGH ALARM) |
| TB1-12 | RELAY 2 C (HIGH ALARM) |

*See also Appendix D for relay options.

# APPENDIX C4
## Series 900 to 640 Interface Wiring



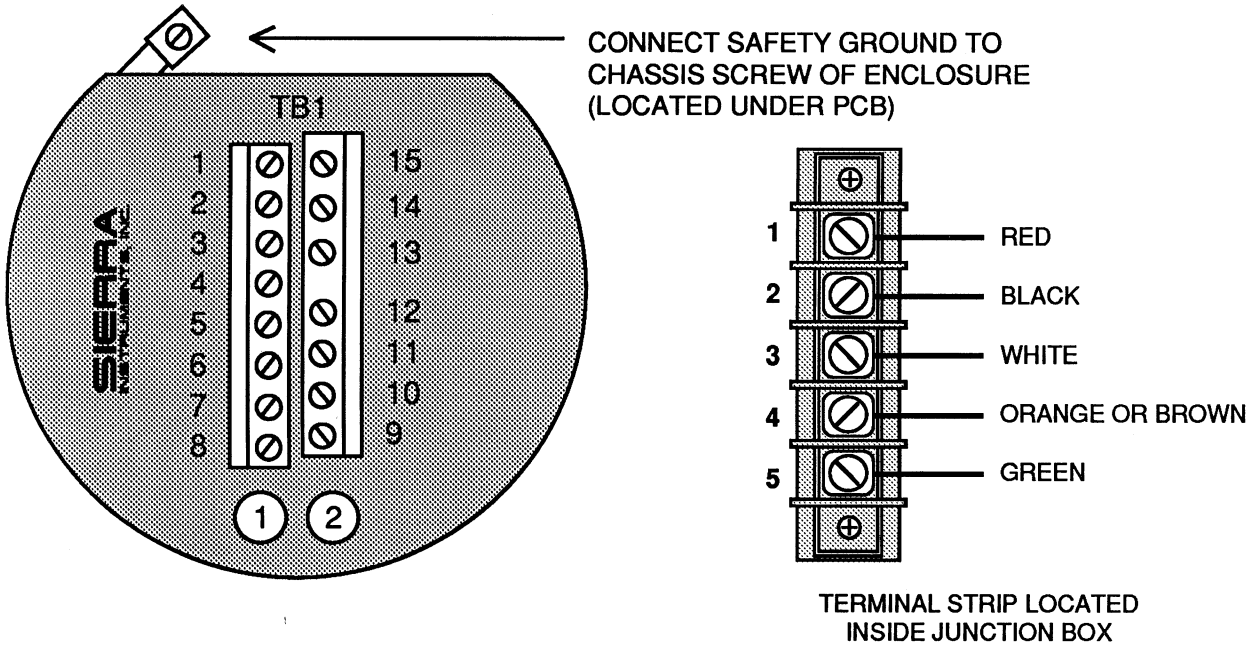

CONNECT SAFETY GROUND TO CHASSIS SCREW OF ENCLOSURE (LOCATED UNDER PCB)

CONNECT SHIELD OF CABLE TO CHASSIS SCREW AS SHOWN IN APPENDIX C6

## 900 SERIES INTERFACE WIRING

| TERMINAL BOARD CONNECTION | FUNCTION | 20-PIN BOX CONNECTOR |
|---|---|---|
| TB1-1 | SIGNAL GROUND | PIN 2 |
| TB1-2 | OUTPUT SIGNAL | PIN 3 |
| TB1-14 | DC POWER COMMON | PIN B |
| TB1-15 | +15 VDC | PIN 4 |

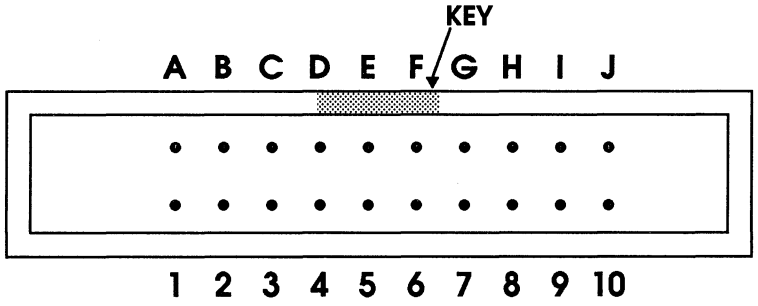
# APPENDIX C5
## Remote Sensor Wiring for E4 Enclosure Options




## REMOTE SENSOR WIRING

| TERMINAL BOARD CONNECTION | FUNCTION | SENSOR WIRE COLOR (INTERNAL) | CABLE WIRE COLOR (EXTERNAL) |
|---|---|---|---|
| TB1-3 | REMOTE TEMPERATURE SENSOR | BLACK | ORANGE OR BROWN |
| TB1-4 | REMOTE TEMPERATURE SENSOR | BLACK | GREEN |
| TB1-5 | REMOTE VELOCITY SENSOR | RED | RED |
| TB1-6 | REMOTE VELOCITY SENSOR | BLACK | BLACK |
| TB1-11 | REMOTE VELOCITY SENSOR | WHITE | WHITE |
| TB1-13 | SHIELD | SHIELD | SHIELD |

# APPENDIX C6
## Wiring Guide
## Series 900 Box



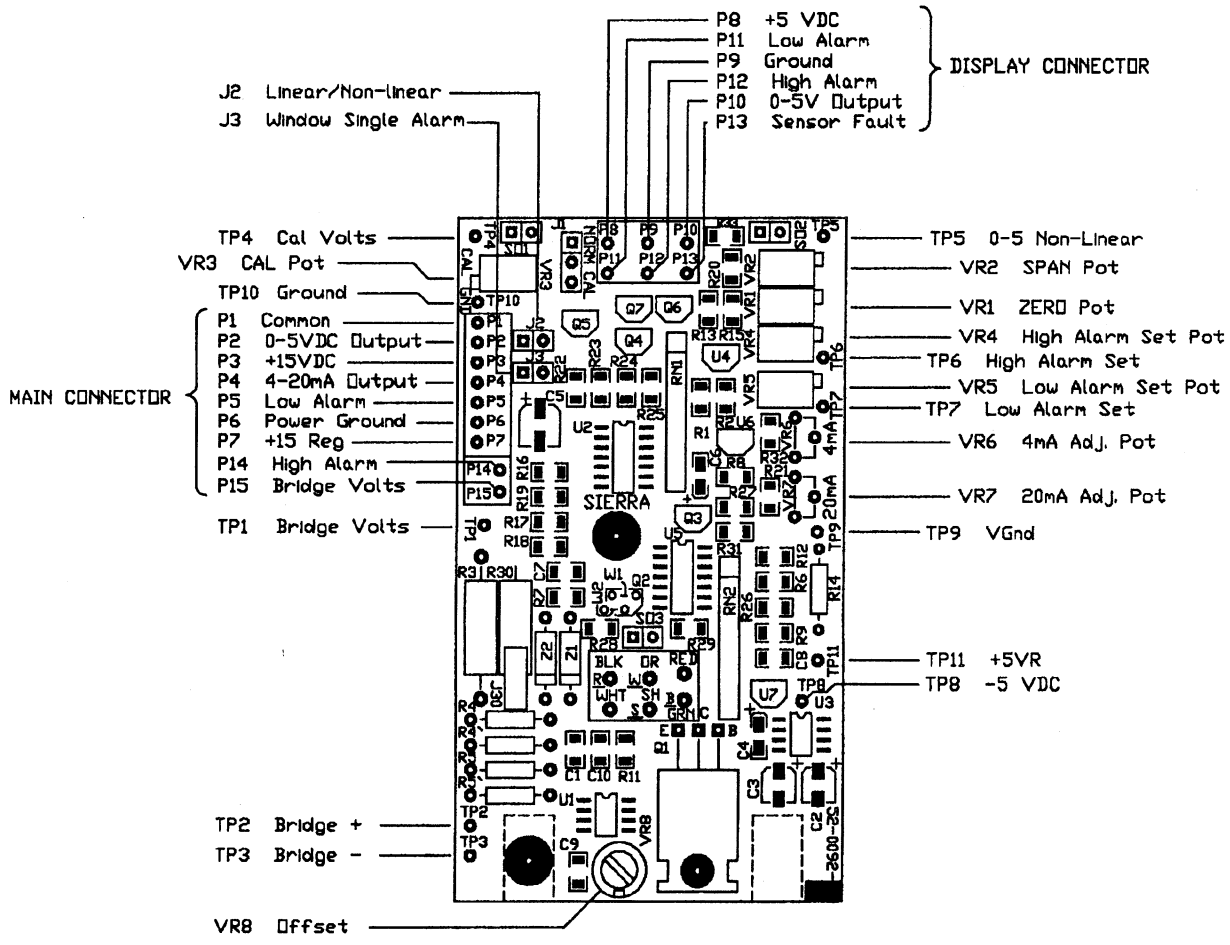

(View of connector from back of enclosure)

| PIN NO. | FUNCTION | PIN NO. | FUNCTION |
|---|---|---|---|
| A | Setpoint Output to Controllers | 1 | Chassis Ground |
| B | Common | 2 | Common |
| C | Common | 3 | 0-5 Volt Signal from Transducer |
| D | Valve Test Point (Avail. I/O Connector) | 4 | +15 VDC Supply from System Electronics to Transducers |
| E | RED Connection (Factory Use Only) | 5 | BLACK Connection (Factory Use Only) |
| F | –15 VDC supply from System Electronics to Transducers | 6 | No Connection |
| G | No Connection | 7 | No Connection |
| H | High Alarm Output (Avail. I/O Connector) | 8 | +15 VDC Supply from System Electronics to Transducers |
| I | Low Alarm Output (Avail. I/O Connector) | 9 | 4-20 mA Signal from Transducer |
| J | Valve Off (Avail. I/O Connector) | 10 | Common |

# APPENDIX D

## 737 PCB (0-5 V and 4-20 mA)

## Sierra Part Number: M52-0092




CRITICAL COMPONENT PLACEMENT

737LX REV A

M52-0092 10-3-94 44-0093

# APPENDIX E
## Duct Traversal Data Sheet

Date _____

Page _____ of _____

Project _____

System No. _____ Traverse Location _____

Area Served _____

## DUCT TRAVERSE READINGS

| POINT NO. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | | | | | | |
| B | | | | | | | | | | |
| C | | | | | | | | | | |
| D | | | | | | | | | | |
| E | | | | | | | | | | |
| F | | | | | | | | | | |
| G | | | | | | | | | | |
| H | | | | | | | | | | |
| I | | | | | | | | | | |
| J | | | | | | | | | | |
| SUB TOTAL | | | | | | | | | | |

TOTAL FPM ÷ NO. READINGS = AVERAGE FPM × AREA = TOTAL CFM

_____ ÷ _____ = _____ × _____ = _____

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| A | + | + | + | + | + | + |
| B | + | + | + | + | + | + |
| C | + | + | + | + | + | + |
| D | + | + | + | + | + | + |

READING POINTS FOR PITOT MEASUREMENTS

Remarks _____

| | | |
|---|---|---|
| DESIGN | DUCT SIZE | |
| | AREA | |
| | FPM | |
| | CFM | |

| | | |
|---|---|---|
| TEST DATA | DUCT SIZE O.D. | |
| | DUCT SIZE I.D. | |
| | AREA | |
| | CENTER LINE S.P. | |
| | AVERAGE FPM | |
| | CFM MEASURED | |
| | TEMP CORRECTION | |
| | ALT CORRECTION | |
| | CFM STD. COND. | |