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User's Guide

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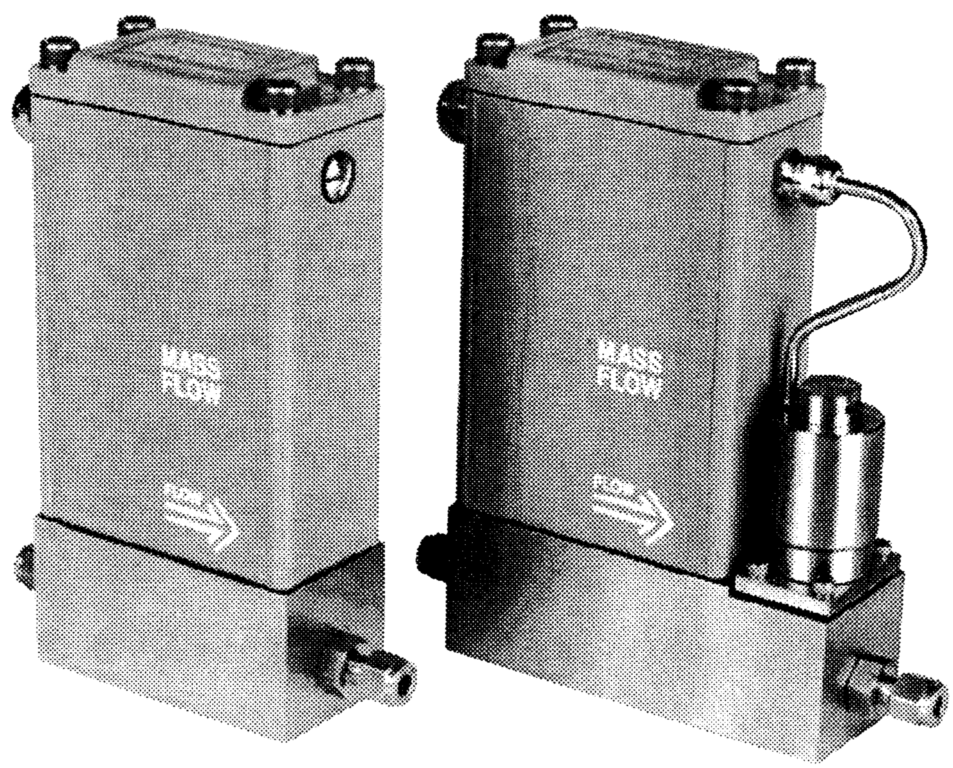

FMA-8200/8300
NEMA 4X, IP65 Mass Flow Controllers and Meters

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It is the policy of OMEGA to comply with all worldwide safety and EMC/EMI regulations that apply. OMEGA is constantly pursuing certification of its products to the European New Approach Directives. OMEGA will add the CE mark to every appropriate device upon certification.

WARNING: These products are not designed for use in, and should not be used for, patient-connected applications.

Essential Instructions

Read this page before proceeding!

OMEGA Engineering Inc., designs, manufactures and tests its products to meet many national and international standards. Because these instruments are sophisticated technical products, you must properly install, use and maintain them to ensure they continue to operate within their normal specifications. The following instructions must be adhered to and integrated into your safety program when installing, using and maintaining OMEGA products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, telephone 800-826-6342 and the requested manual will be provided. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact OMEGA for clarification.
- Follow all warnings, cautions and instructions marked on and supplied with the product.
- Inform and educate your personnel in the proper installation, operation and maintenance of the product.
- Install your equipment as specified in the installation instructions of the appropriate instruction manual and per applicable local and national codes. Connect all products to the proper electrical and pressure sources.
- To ensure proper performance, use qualified personnel to install, operate, update, program and maintain the product.
- When replacement parts are required, ensure that qualified people use replacement parts specified by OMEGA. Unauthorized parts and procedures can affect the product's performance and place the safe operation of your process at risk. Look-alike substitutions may result in fire, electrical hazards or improper operation.
- Ensure that all equipment doors are closed and protective covers are in place, except when maintenance is being performed by qualified persons, to prevent electrical shock and personal injury.

WARNING: Do not operate this instrument in excess of the specifications listed below. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

CAUTION:

This instrument contains electronic components that are susceptible to damage by static electricity. Proper handling procedures must be observed during the removal, installation or other handling of internal circuit boards or devices.

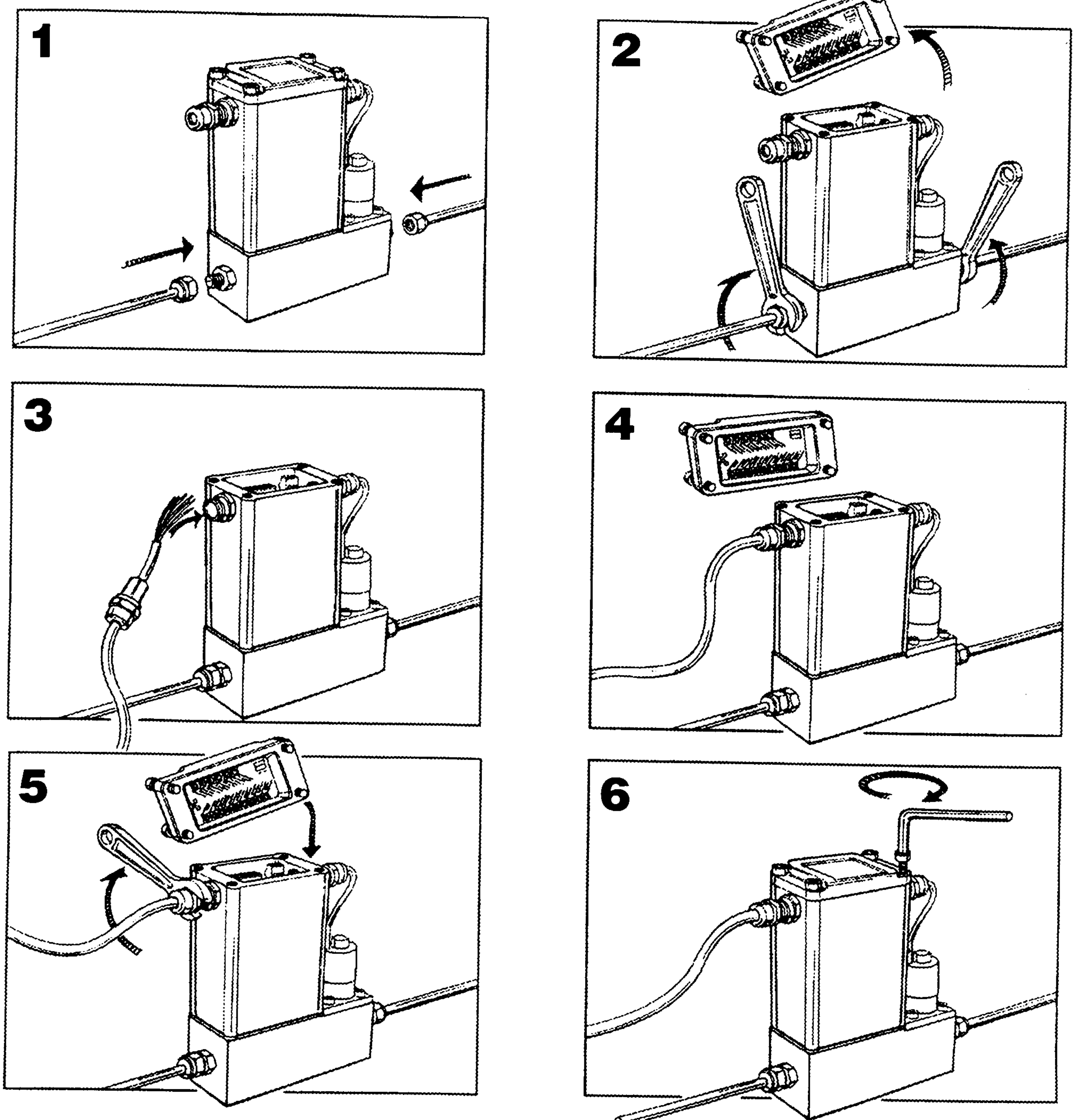
Handling Procedure:

1. Power to unit must be removed.
2. Personnel must be grounded, via a wrist strap or other safe, suitable means before any printed circuit card or other internal device is installed, removed or adjusted.
3. Printed circuit cards must be transported in a conductive container. Boards must not be removed from protective enclosure until immediately before installation. Removed boards must immediately be placed in protective container for transport, storage or return to factory.

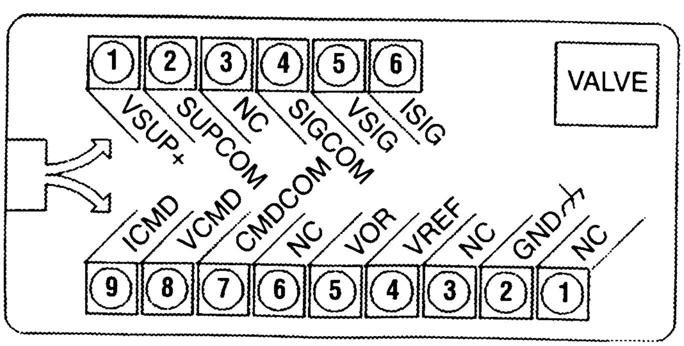
Comments

This instrument is not unique in its content of ESD (electrostatic discharge) sensitive components. Most modern electronic designs contain components that utilize metal oxide technology (NMOS, SMOS, etc.). Experience has proven that even small amounts of static electricity can damage or destroy these devices. Damaged components, even though they appear to function properly, exhibit early failure.

Quick Start Instructions



Terminal Strip Label:



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Tables

Section 1 - Introduction

1.1 Description

The OMEGA® FMA-8200/8300 Series mass flow controllers and flowmeters are specifically designed to be used in an industrial environment. These controllers and meters offer high accuracy, control and measurement of industrial gases with the added integrity of NEMA 4X, IP65 industrial packaging. The heart of the controller and meter is the removable flow sensor which produces an electrical output signal linear with mass flow rate. This output can be used for indicating, recording and/or control purposes. The OMEGA® FMA-8200/8300 Series Mass Flow Controller has an integral valve and accepts a remote setpoint which makes it a simple and easy to install flow control system. Many options are offered to provide a versatile system of mass flow control and measurement.

1.2 Design Features

- NEMA 4X, IP65 watertight construction
- Robust industrial construction
- Easy access screw terminal strips
- Wide range of flows:
  Flow control to 1000 slpm N_2
  Flow metering to 36000 slpm N_2
- Dual analog signal outputs 4-20 mA and 0-5 Vdc
- Easy Maintenance
- Removable sensor
- Insensitive to mounting attitude
- Selectable response time
- Electrically activated valve override
- Low command flow cutoff
- Corrosion resistant valve
- EMI and RFI immunity
- User configurable set point command

1.3 Principle of Operation

The operating principle of the OMEGA® mass flow controller and meter is thermodynamic. A wire wound heating element directs heat to the midpoint of the bypass sensor tube. A predetermined portion of the total flow, flows through the bypass sensor tube. On the same tube, equidistant upstream and downstream of the heat input, are resistance temperature measuring elements. With no flow, the heat reaching each temperature element is equal. With increasing flow the flow stream carries heat away from the upstream element, T1, and an increasing amount towards the downstream element, T2. An increasing temperature difference develops between the two elements and this difference is proportional to the amount of gas flowing or the mass flow rate. A bridge circuit interprets the temperature difference and an amplifier provides a 0-5 Vdc, 4-20 mA or 0-20 mA linear output signal.

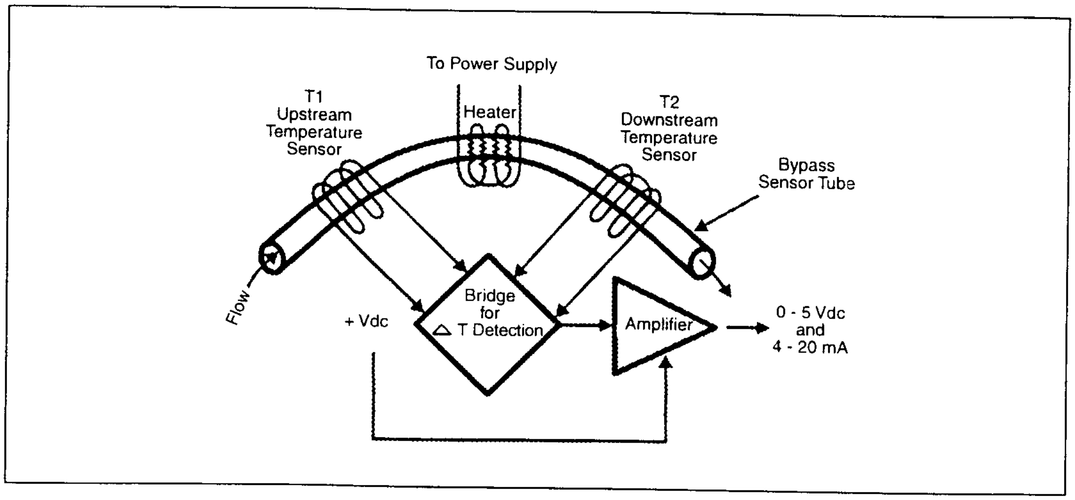


Figure 1-1. Principal of Operation

The control circuitry compares the command setpoint to the flow signal and positions the precision solenoid control valve. When the command signal is below 1% of full scale, the control valve is positioned to fully closed. The control valve can be latched fully open or closed by activating the valve override circuit.

1.4 Specifications

WARNING:

Do not operate this instrument in excess of the specifications listed below. Failure to heed this warning can result in serious personal injury and/or damage to the equipment.

Performance:

Mass Flow Controller	Mass Flow Meter	Flow Ranges Nitrogen*		
Model	Model	Min. F.S.	Max. F.S.	Units
FMA-8200	FMA-8300	0.003	30	slpm

* Standard temperature and pressure equals 0°C and 101kPa (760 Torr). These mass flow controllers and meters can be calibrated to other conditions. Specify at time of ordering.

Table 1-1. Flow Ranges

Control/Usable Range

50 to 1

Accuracy

±1% full scale including linearity at calibrated conditions
±1.5% full scale including linearity for flow ranges greater than 20 slpm

Repeatability

0.25% of rate

Sensitivity to Mounting Attitude

±0.5% full scale maximum deviation from specified accuracy after rezeroing under 200 psig. Specify mounting attitude at time of order to insure optimum performance.

Temperature Sensitivity

Zero: Less than ±0.075% F.S. per degree C
Span: Less than ±1.0% F.S. shift from original calibration over 50°F to 122°F range (10°C to 50°C)

Pressure Sensitivity

±0.03% per psi up to 200 psi (N_2)

Ratings:
Operating Pressure

1500 psig (100 bar) maximum

Differential Pressure (Controllers)

FMA-8200: 5 to 50 psid pressure drop
Optional: Low differential valve 7.5 to 30 psid (<500 slpm)
11.8 to 30 psid (<500 slpm)

Response Time

Less than 6 seconds to within 2% of full scale of final value for a 0 to 100% command change. Refer to figure 1-2, typically performance curve.

Temperature Ambient/Gas

41°F to 149°F (5°C to 65°C)

Leak Integrity, Outboard

1 x 10^{-9} atm cc/sec. He (excluding permeation)

Materials of Construction

Standard wetted parts: Stainless steel with Viton® or Buna-N
Optional: Kalrez®

Dimensions:

Controllers: Refer to Figures 1-6
Meters: Refer to Figures 1-10

Process Connections:

Refer to the table at the bottom of each dimensional drawing for process connection sizes and options specific to each size controller and meter.

1.5 Electrical Specifications

Set Point Command Requirements (Controllers)

4-20 mA (75 ohms input resistance) or 0 to 5 Vdc (220 K ohms input resistance)

Output Signals

0/4-20 mA, loop resistance is power supply dependent, refer to Figure 1-3, or 0 to 5 Vdc into 200 K ohms, or greater load. Maximum ripple 3 mV.

Power Requirements

Refer to Table 1-2

Electrical Connections

Wire hookup is through a Pg11 water tight cable gland suitable for cable diameters of .20 to .39 inches. Wiring terminations are pluggable moving vise clamp with screw type terminators. Refer to Figure 1-4 for termination points and Table 1-4 for terminal identification and functions.

Mass Flow Controllers			Mass Flow Meters		
Model	Voltage	Current	Model	Voltage	Current
FMA-8200	15 to 28 Vdc	240 mA @ 15 Vdc 370 mA @ 28 Vdc	FMA-8300	15 to 28 Vdc	90 mA

Table 1-2. Power Requirements.

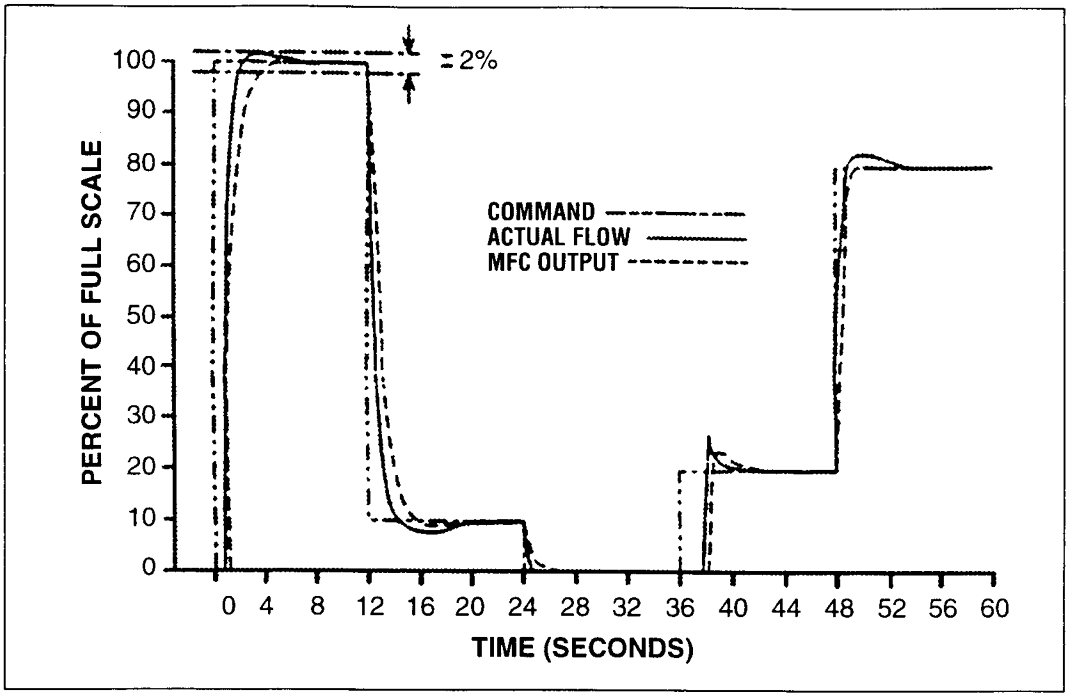


Figure 1-2. Typical Performance Curve.

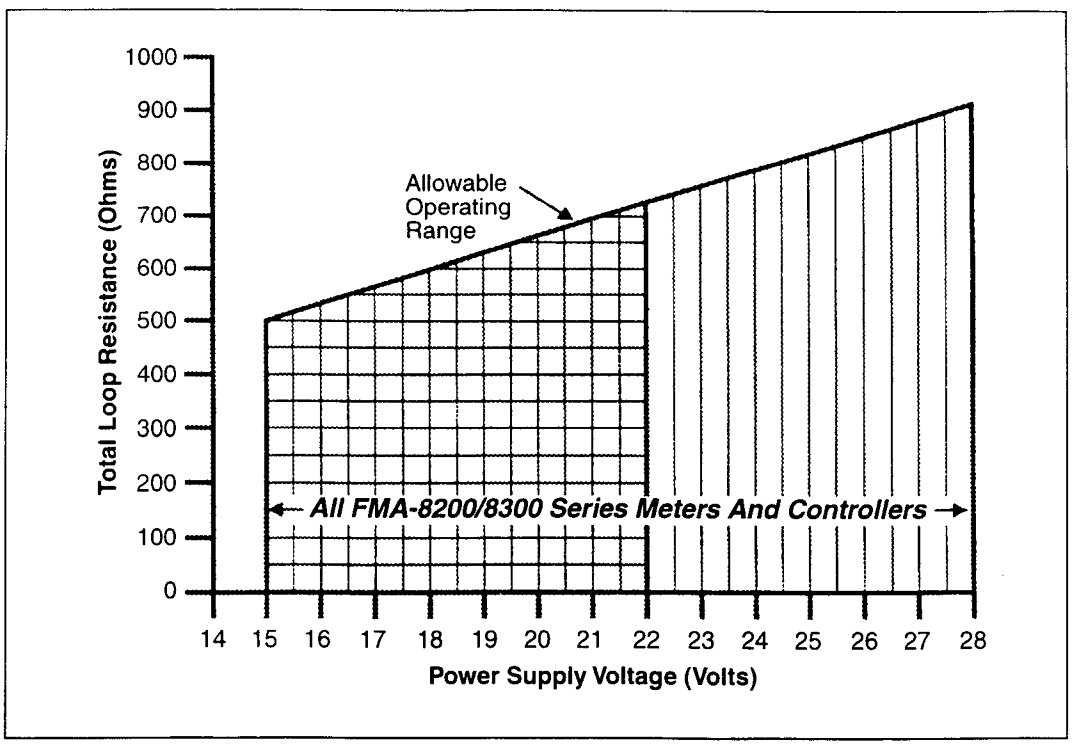


Figure 1-3. Maximum Allowable Output Loop Resistance.

TB-1 Terminal 1-6	Label Identification	Function	Color Code**
1	VSUP	Supply Voltage Plus (+) See Table 3	Orange
2	SUPCOM	Supply Voltage Common	Grn/Blk
3	NC	Not Used	Blue
4	SIGCOM	Signal Common	Org/Blk
5	VSIG	Voltage Signal Output	White
6	ISIG	Current Signal Output	Green
TB-2 Terminal 1-9	**Label Identification**	**Function**	**Color Code**
1	NC	Not Used	Blu/Wht
2	GND	Chassis Ground	Grn/Wht
3	NC	Not Used	Red
4	VREF	Reference Output +5 Vdc	Blu/Blk
5	VOR	Valve Override Input	Blk/Wht*
6	NC	Not Used	Red/Wht
7	CMDCOM	Command Common	Black*
8	VCMD	Voltage Command Input (Setpoint)	Red/ Blk*
9	ICMD	Current Command Input (Setpoint)	Wht/Blk*
TB-3 Terminal 1& 2	**Label Identification**	**Function**	**Color Code**
1	None	Valve Hookup	Orange*
2	None	Valve Hookup	Orange*

* These connections used only for controller, FMA-8200.
** OMEGA Reference

Table 1-4. OMEGA® FMA-8200/8300 Series Controllers and Meters Terminal Strip Hookup.

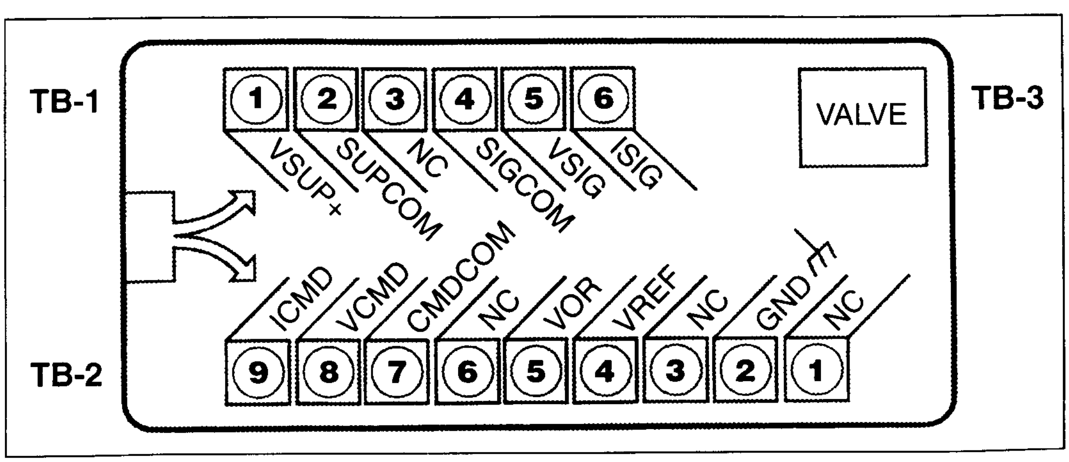
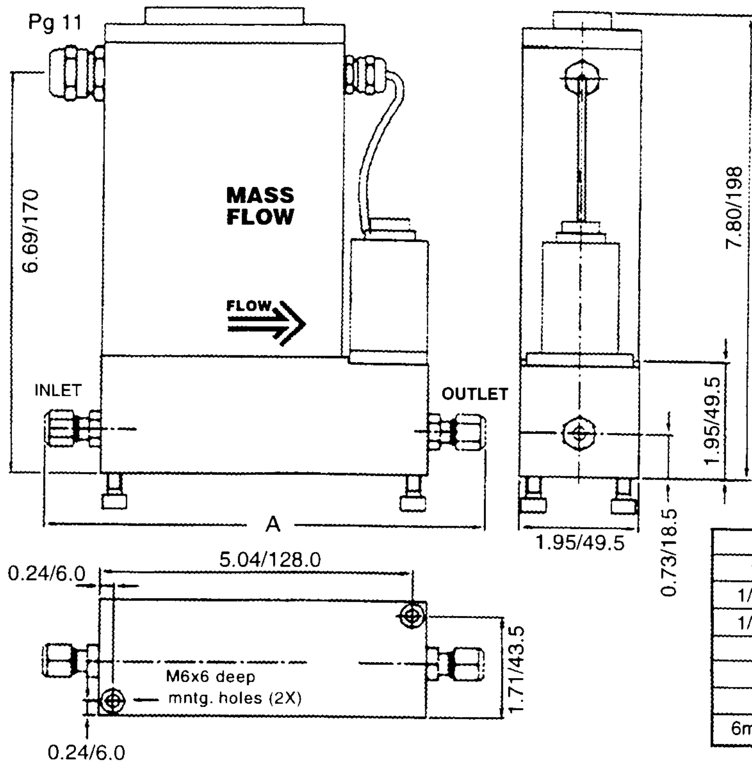


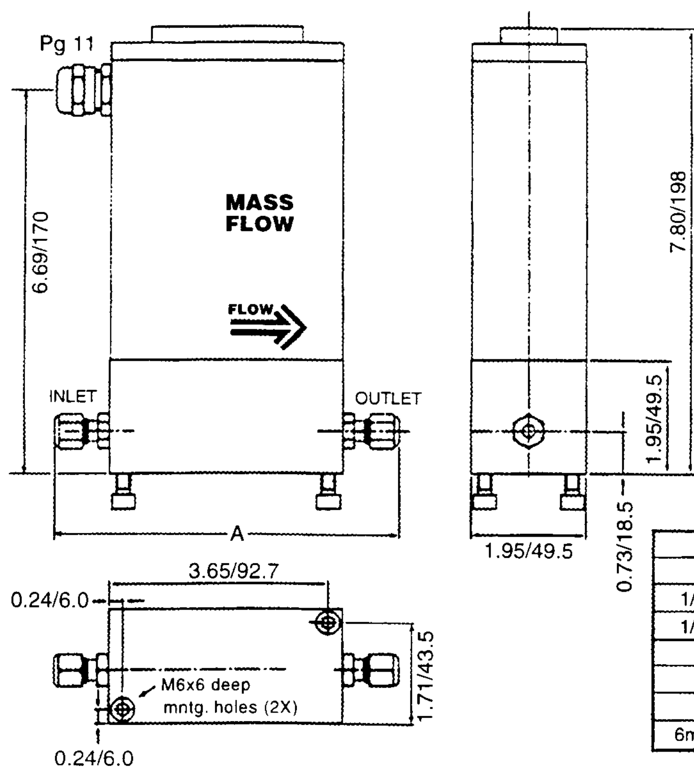
Figure 1-4. Terminal Strip Labeling.Table 1-4.



Connections	"A" Dim.
9/16 - 18 UNF	5.25/134
1/4" Tube Compr.	7.30/185
1/8" Tube Compr.	7.13/181
1/4" VCR	7.17/182
1/4" VCO	6.85/174
1/4" NPT	6.89/175
6mm Tube Compr.	7.32/186

Dimensions in inches/mm

Figure 1-5. FMA-8200 Controller Dimensions.



Connections	"A" Dim.
9/16 - 18 UNF	3.89/98.7
1/4" Tube Compr.	5.93/150.7
1/8" Tube Compr.	5.74/145.7
1/4" VCR	5.78/146.7
1/4" VCO	5.46/138.7
1/4" NPT	5.50/139.7
6mm Tube Compr.	5.93/150.7

Dimensions in inches/mm

Figure 1-6. FMA-8300 Meter Dimensions.

NOTES:

Section 2 - Installation

2.1 Receipt of Equipment

When the equipment is received, the outside packing case should be checked for damage incurred during shipment. If the packing case is damaged, the local carrier should immediately be notified regarding his liability. Then call OMEGA Customer Service for further instructions 1-800-622-2378.

Remove the envelope containing the packing list. Outside of your clean area, carefully remove the equipment from the packing case. Make sure spare parts are not discarded with the packing material. Inspect for damaged or missing parts.

This device has been assembled, calibrated and vacuum bagged in a Class 100 clean room. Remove the vacuum bag only when the instrument is ready to be tested and/or installed.

2.2 Recommended Storage Practice

If intermediate or long-term storage is required for equipment, as supplied by OMEGA, it is recommended that said equipment be stored in accordance with the following:

a. In the original vacuum bag and shipping container.

b. In a sheltered area with the following conditions:

1. Ambient temperature 21°C (70°F) nominal, 32°C (90°F) maximum and 7°C (45°F) minimum.
2. Relative humidity 45% nominal, 60% maximum and 25% minimum.

2.3 Return Shipment

Prior to returning any OMEGA equipment to the factory, contact the factory for a Authorized Return Number (AR#). This can be obtained from OMEGA Customer Service or call toll free 1-800-622-2378.

2.4 Gas Connections

Refer to Tables 5-1 through 5-2 for the available process connection types and sizes. It is recommended that good tubing and piping practice be followed. It is also recommended that for very low flows in meter size FMA-8200 that tubing 1/4 or less be used and foe flows over 10 slpm 3/8 tubing be applied. Prior to installation, make certain all piping is clean and free of obstructions. Install the piping in such a manner that permits easy removal if the instrument is to be removed for cleaning or test bench troubleshooting.

2.5 Installation (Refer to Table 1-4, Figure 1-4, 2-1 and Quick Start Instructions)

CAUTION:

When installing the controller, care should be taken that no foreign materials enter the inlet or outlet of the instrument. Do not remove the protective end caps until time of installation.

Recommended installation procedures:

a. The FMA-8200/8300 Series instrument should be located in a clean, dry atmosphere relatively free from shock and vibration.

b. Leave sufficient room for access to the electrical components.

c. Install in such a manner that permits easy removal if the instrument requires cleaning.

CAUTION:

When used with reactive (sometimes toxic) gas, contamination or corrosion may occur as a result of plumbing leaks or improper purging. Plumbing should be checked carefully for leaks and the controller purged with dry Nitrogen before use.

d. The FMA-8200/8300 Series controllers and meters can be installed in any position. However, mounting orientations other than the original factory calibration will result in a ±0.5% maximum full scale shift after rezeroing.

e. When installing controllers with full scale flow rates of 10 slpm or greater, be aware that sharp abrupt angles in the system piping directly upstream of the controller may cause a small shift in accuracy. If possible, have at least 10 pipe diameters of straight tubing upstream of the FMA8200/8300 devices.

NOTE:

The control valve in the FMA-8200/8300 Series controller provides precision controls and is not designed for positive shut-off. If positive shut-off is required, it is recommended that a separate shut-off valve be installed in-line.

CAUTION:

Since the FMA-8200/8300 Series control valve is not a positive shut-off, a separate shut-off valve may have been installed foe that purpose. It should be noted that a small amount of gas may be trapped between the downstream side of the mass flow controller and the shut-off resulting in a surge upon actuation of the controller. This surge can be reduced in magnitude by locating the controller and the shut-off valve upstream of the controller.

2.6 In-Line Filter

It is recommended that an OMEGA in-line filter be installed upstream from the instrument to prevent the possibility of any foreign material entering the flow sensor or control valve. The filtering element should be periodically replaced or ultrasonically cleaned.

Maximum Flow Rate	Recommended Filter Size
100 sccm	1 micron
500 sccm	2 micron
1 to 5 slpm	7 micron
10 to 30 slpm	15 micron

Table 2-1. Recommended Filter Size.

NOTE:

The above lists the max. recommended porosity for each flow range. It is recommended that the minimum micron porosity that does not limit the full scale flow rate used.

2.7 Electrical Interfacing

To insure proper operation, the FMA-8200/8300 Series device must be connected per Figures Figure 1-3 (Maximum Allowable Loop Resistance); Figure 1-4 and Table 1-4 (Terminal Strip Hookup); and 1-6 (Dimension drawing). Configure in accordance to Section 2-7 and Figure 3-5. As a minimum, the following connections must be made for new installations:

Chassis Ground
Signal Output Common
Voltage or Current Signal Output
Plus (+) Vdc Supply
Supply Common
Voltage or Current Setpoint Input
Setpoint Common

Electrical Hookup:
Setpoint (Common) Input

The FMA-8200/8300 Series Mass Flow Controller can be used with a current (4-20 mAdc) or voltage (0-5 Vdc) setpoint. To use the current setpoint, connect the setpoint (+) signal to TB-2, Terminal 9, and the setpoint return (–) signal to TB-2, Terminal 7, and configure the PC board per section 2-7. To use the voltage setpoint, connect the setpoint signal to TB-2, Terminal 8, and the voltage setpoint return to TB-2, Terminal 7, and configure the PC board per Section 2-7 and Figure 3-5.

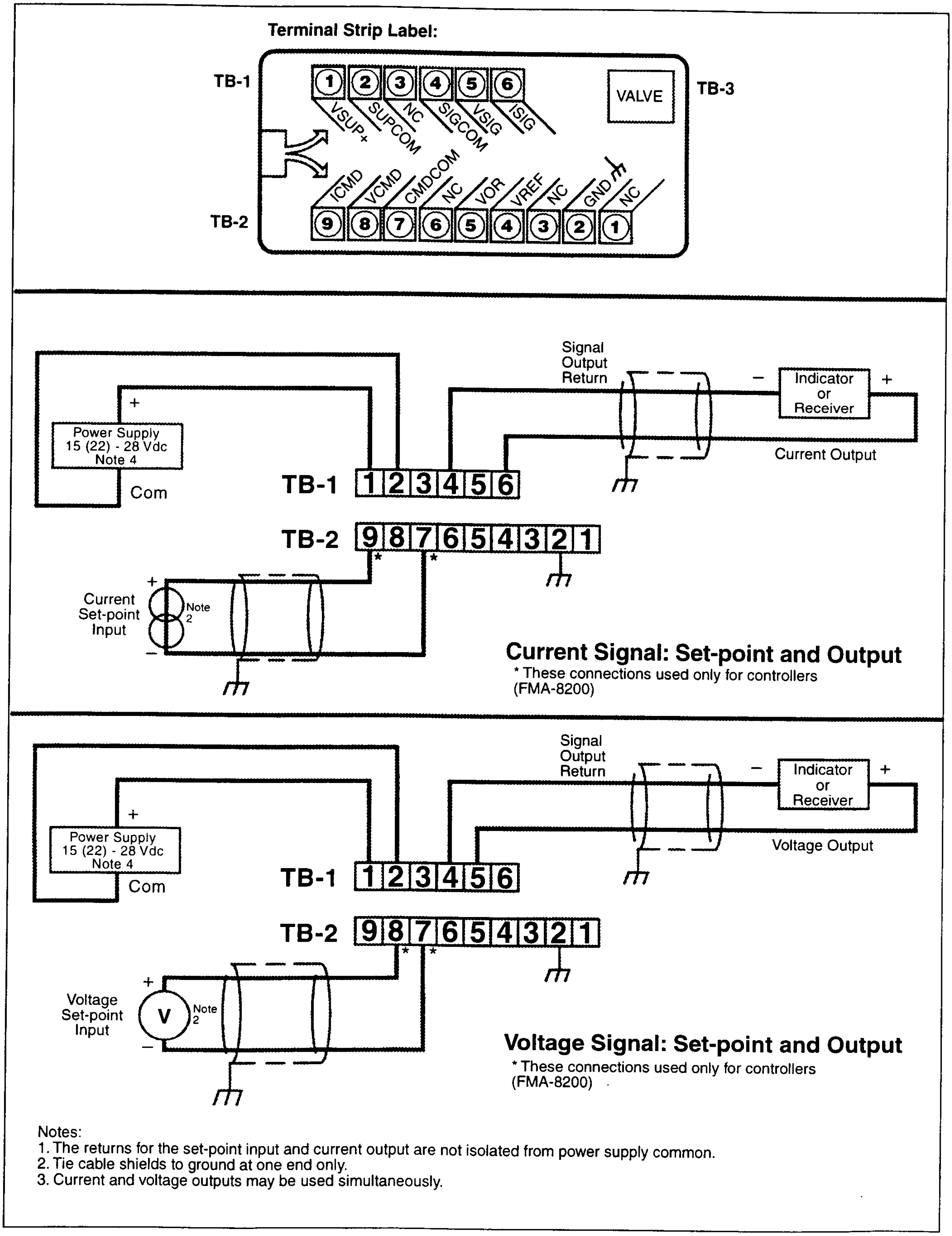


Figure 2-1. Common Electrical Hookups.

Signal Output

The flow signal output can be measured as a voltage or a current simultaneously on two different positions of the Terminal Strip, TB-1, Terminal 5 indicates the flowrate with a 0-5 Vdc signal proportional to the mass flow rate. TB-1, Terminal 6 indicates the flowrate with either a 0-20 mAdc or 4-20 mAdc current signal as determined by jumpers on the PC board (refer to Section 2-7 and Figure 3-5 for jumper positions). Both the current and voltage signals are returned on TB-1, Terminal 4.

Supply

The power for the mass flow controller is connected to TB-1, Terminal 1 (+ Supply Voltage, Table 1-4) and TB-1, Terminal 2 (supply common) of the terminal strip connector. Refer to Section 1-3 for power requirements. Note: The length of wire for the power supply connections (TB-1, Terminals 1 and 2) must be kept as short as possible to insure the minimum required voltage is available at the mass flow controller.

Chassis Ground

Connect earth ground to TB-2, Terminal 2.

Valve Override - Controller Only (connection optional)

The valve override function allows full opening and closing of the valve independent of the setpoint:

- To open the valve, apply voltage (15-24) Vdc to TB-2, Terminal 5.
- To close the valve, connection TB-2, Terminal 5 to power supply common.
- Isolating TB-2, Terminal 5 (no connection) returns the controller to normal operation.

NOTE:

For normal operation, TB-2, Terminal 5 should be left open (floating).

2.8 Configuring the PC Board

NOTE:

To obtain access to the jumpers, the electronics housing must be removed. Remove the cover from the electronics housing by loosening the four (4) self -retained screws in the corner of the top cover. Disconnect power to the mass flow controller/meter, unplug Terminal Strips TB-1 and TB-2, and disconnect valve coil wire TB-3. Loosen the four (4) screws in the corner of the housing body using a long (6 inch) 3 mm hex wrench. Lift the housing off the circuit board. The can must be replaced before returning the unit to service.

Refer to Section 2-6 for the proper electrical hookup. Refer to Figure 3-5 for PC board jumper locations and functions.

Setpoint (Command) Input

The mass flow controller can be configured for voltage or current setpoint (command) input. Jumper J7 must be in the right-hand position for 0-5 Vdc setpoint and in the left -hand position for a 4-20 mAdc setpoint input.

Signal Output

A 0-5 Vdc flow signal output is always available. The current signal output is jumper selectable for either 0-20 mAdc or 4-20 mAdc. Jumpers J3 and J4 must be in the upper position for 0-20 mAdc output and in the lower position for 4-20 mAdc output.

Note: Both J3 and J4 must be in the same position. Jumpers J3 and J4 do not affect voltage output.

Soft Start

To enable soft start, place Jumper J2 in the right hand position (SS). To disable soft start, place jumper J2 in the left hand position (N).

Section 3 - Operation

3.1 Theory of Operation

The thermal mass flow sensing technique used in the FMA-8200/8300 Series works as follows:

A precision power supply provides a constant power heat input (P) to the heater which is located at the midpoint of the sensor tube. Refer to Figure 3-1. At zero or no flow conditions, the heat reaching each temperature sensor is equal. Therefore, the temperatures T1 and T2 are equal. When gas flows through the tube, the upstream sensor is cooled and the downstream sensor is heated, producing a temperature difference.The temperature difference T2-T1 is directly proportional to the gas mass flow.

The equation is: $\Delta T = A * P * C_P * m$
Where,
ΔT = temperature difference T2 - T1 (°k)
C_P = specific heat of the gas at constant pressure (kJ/kg-°K)
P = heater power (kJ/s)
m = mass flow (kg/s)
A = constant of proportionality (S^2-K^2/kJ^2)

A bridge circuit interprets the temperature difference and a differential amplifier generates a linear 0-5 Vdc signal directly proportional to the gas mass flow rate. The flow restrictor shown in Figure 3-1 performs a ranging function similar to a shunt resistor in an electrical ammeter. The restrictor provides a pressure drop that is linear with flow rate. The sensor tube has the same linear pressure drop/flow relationship. The ratio of the restrictor flow to the sensor tube flow remains constant over the range of the meter. Different restrictors have different pressure drops and produce controllers with different full scale flow rates. The span adjustment in the electronics affects the fine adjustment of the controllers full scale flow.

In addition to the mass flow sensor, FMA-8200/8300 Series mass flow controllers have an integral control valve and control circuit, as shown in Figure 3-2.The control circuit senses any difference between setpoint and flow sensor signal and adjusts the current in the modulating solenoid valve to increase or decrease flow. The FMA-800/8300 Series has the following features incorporated in the integral control circuit:

- Fast Response adjusted by the anticipate potentiometer. This circuit, when properly adjusted, allows the high frequency information contained in the sensor signal to be amplified to provide a faster responding flow signal for remote indication and use by the control valve.
- Soft Start enabled by moving a jumper on the PC Board. This circuit provides a slow injection of the gas as a projection to the process, particularly those using a volatile or reactive gas. Full gas flow is achieved in approximately 20 seconds. Refer to Section 2-7.
- Precision 5 Volt Reference allows the direct connection of a setpoint potentiometer to produce a 0-5 Volt command signal to the controller. A precision ten-turn 2 K ohm potentiometer with an integral turns counter is recommended. This will permit repeatable adjustments of setpoint to 1 part in 1,000.
- Valve Override allows full opening and closing of the control valve independent of the command setting. Refer to Section 2-6.

3.2 Operating Procedure

a. Apply power and allow approximately 45 minutes for the instrument to warm-up and stabilize its temperature.

b. Turn on the gas supply.

c. Command 0% flow to the controller/shut-off flow to the meter and observe the instrument's output signal. If the output is not zero mVdc ±.05 mAdc, check for leaks and if none are found, refer to rezeroing procedure in Section 3-3.

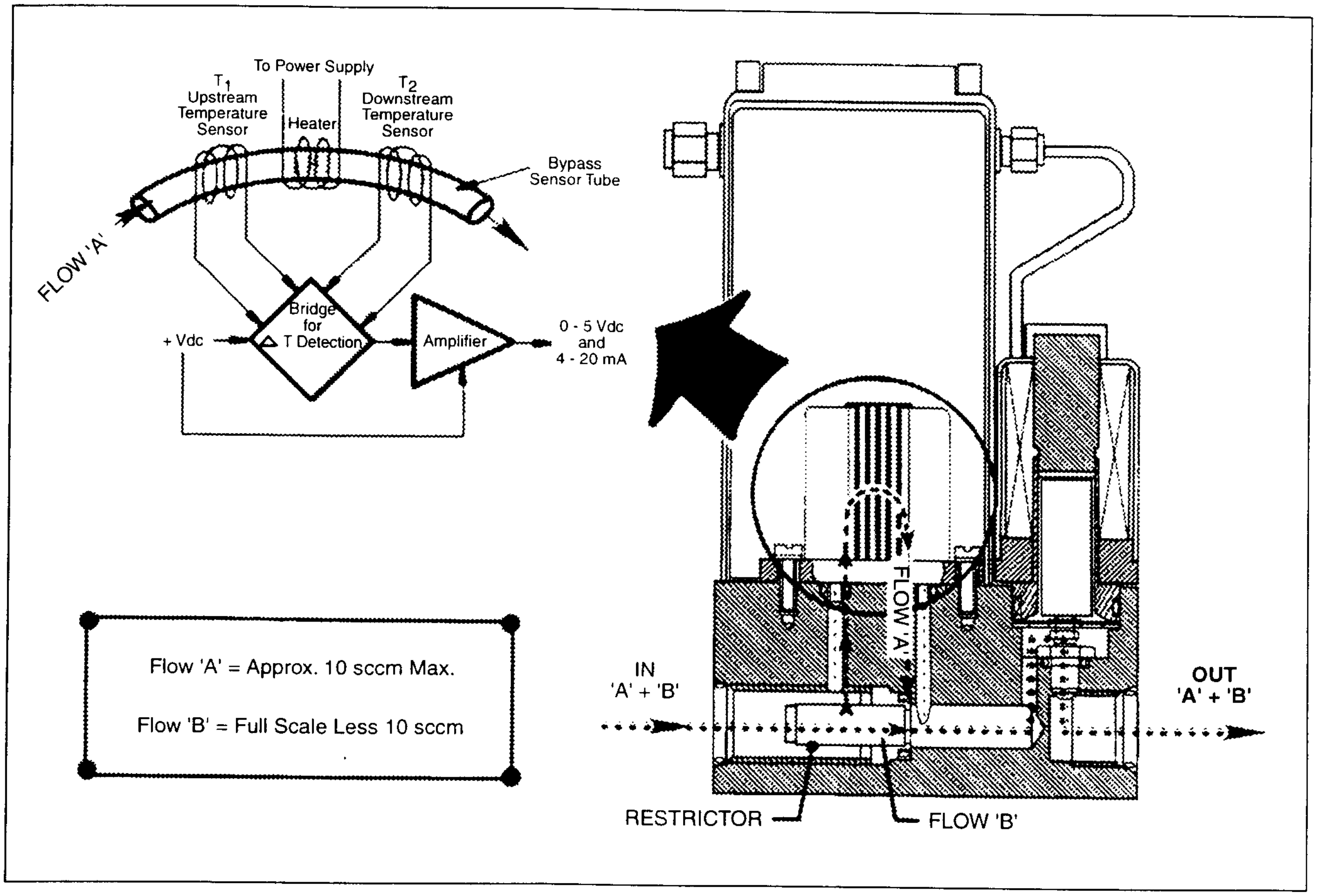


Figure 3-1. Flow Sensor Operational Diagram.

d. Set the command for the desired flow rate to assume normal controller operation. Open valve to allow flow to pass through the meter. Monitor the flow signal output.

3.3 Zero Adjustment

Each FMA-8200/8300 Series controller and meter is factory adjusted to provide a zero ±10 mVdc signal or a 4 mAdc ±.05 mAdc signal at zero flow. The adjustment is made in our calibration laboratory which is temperature controlled to 21.1°C (70°F ±2°F). After initial installation and warm-up of the gas system, the zero flow indicator may be other than the factory setting. This is primarily caused by changes in temperature between our calibration laboratory and the final installation. The zero flow reading can also be affected, to a small degree, by changes in line pressure and mounting attitude.

To check zero, always mount the instrument in its final configuration and allow a minimum of twenty minutes for the temperature of the instrument and its environment to stabilize. Using a suitable voltmeter or current meter, check the instrument output signal. If it differs from the factory setting, adjust it by removing the lower pot hole plug which is located closest to the instrument body. Adjust the zero potentiometer (refer to Figure 3-4) until the desired output signal is obtained.

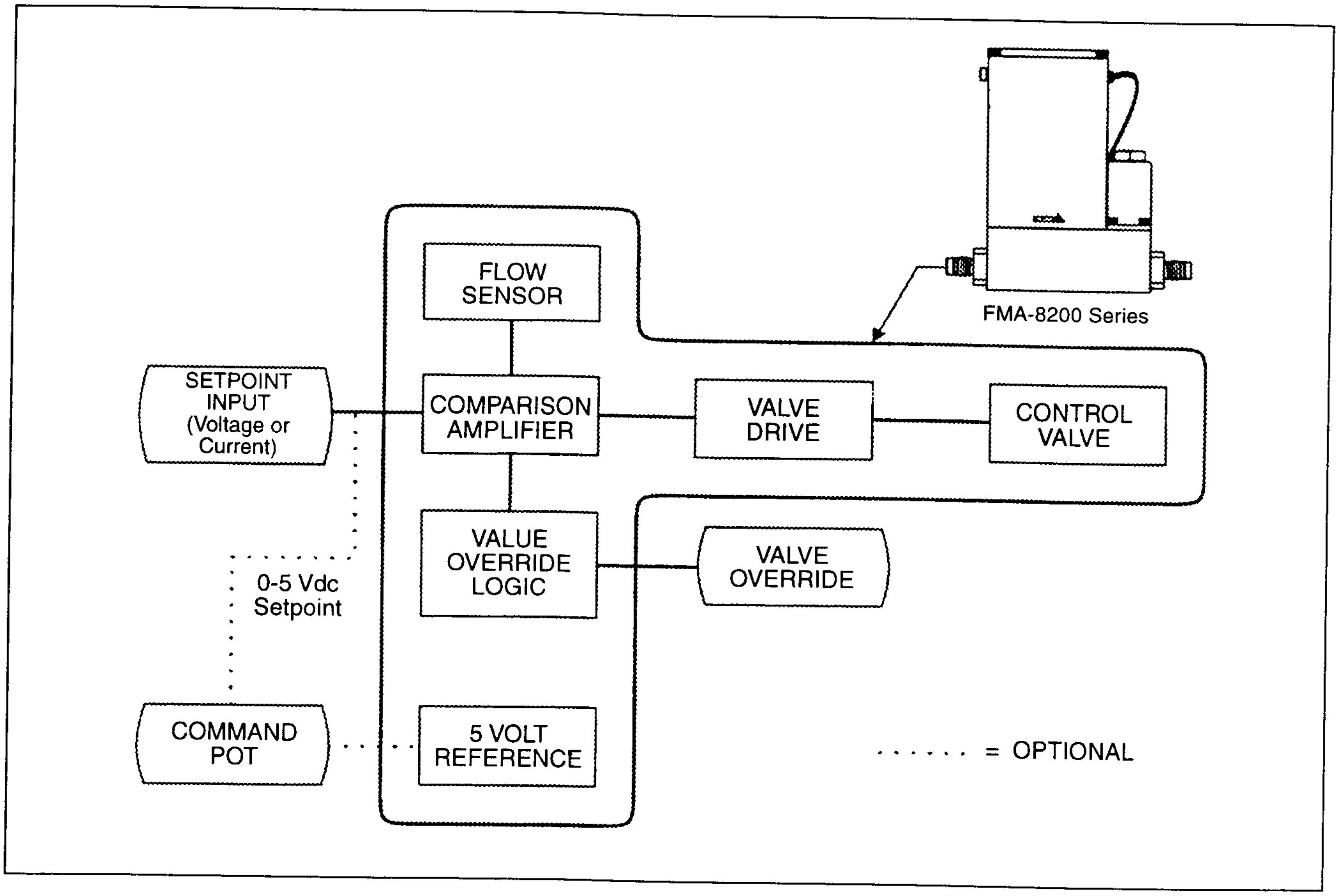


Figure 3-2. Flow Control System Block Diagram.

NOTE:

If the 0-20 mA output is used, adjust zero by monitoring the voltage output signal. This is required because the current output cannot go negative.

3.4 Calibration Procedure

NOTE:

1: If the valve has been disassembled and any of the following parts have been replaced, the control valve adjustment procedure in Section 4-4c must be performed before the FMA-8200/8300 instrument is calibrated.
orifice
valve stem
plunger

lower guide spring
valve

NOTE:

2: Calibration of the FMA-8200/8300 Series Controller/Meter requires the use of a digital voltmeter (DVM) and is a precision flow standard calibrator. It is recommended that the calibration be performed only by trained and qualified service personnel.

NOTE:

3: If the mass flow controller/meter is to be used on a gas other than the calibration gas, apply the appropriate sensor conversion factor. For controllers, size the orifice for actual operating conditions, refer to Section 4-6.

a. With the controller installed in an unpressurized gas line, apply power and allow approximately 45 minutes for warm-up. During the warm-up, adjustment and calibration check procedures, do not allow the control valve to open when gas flow is not present. This situation is not a normal operating mode; it will cause the control valve to abnormally heat up. A controller with an abnormally warm valve will be difficult to calibrate. This situation can be prevented by the valve override "closed" when there is no gas flow, or setting the setpoint to less than 1%. Also avoid unnecessary periods with the valve override "open".

b. Adjust the anticipate potentiometer fully clockwise (twenty turns). Then adjust the anticipate potentiometer ten turns counterclockwise to center the potentiometer. This will provide a rough adjustment of this circuit and make the flow more stable for calibration.

c. Connect the DVM positive lead to the 0-5 V signal output TB-1, Terminal 5, and the negative lead to signal common (Terminal 4). Adjust the zero potentiometer for an output of 0 mV ±2mV (refer to Figures 3-4 and 3-5 for test point and potentiometer locations.

d. Apply pressure to the system and insure that the zero signal repeats within 2 mV of the voltage set in step c above. If the zero does not repeat, check for leakage.

NOTE:

Controllers supplied with all metal valve seats do not provide tight shut-off. A 0-8% leak-through is typical. For metal seat controllers, close a downstream shut-off valve and observe the zero signal.

e. Adjust the setpoint for 100% flow (5.000 V or 20.00 mAdc). Connect the DVM positive lead to TP2 (linearity voltage) and the negative lead to TP4 (circuit common). Adjust the linearity potentiometer for an output of 0.00 V (zero Volts).

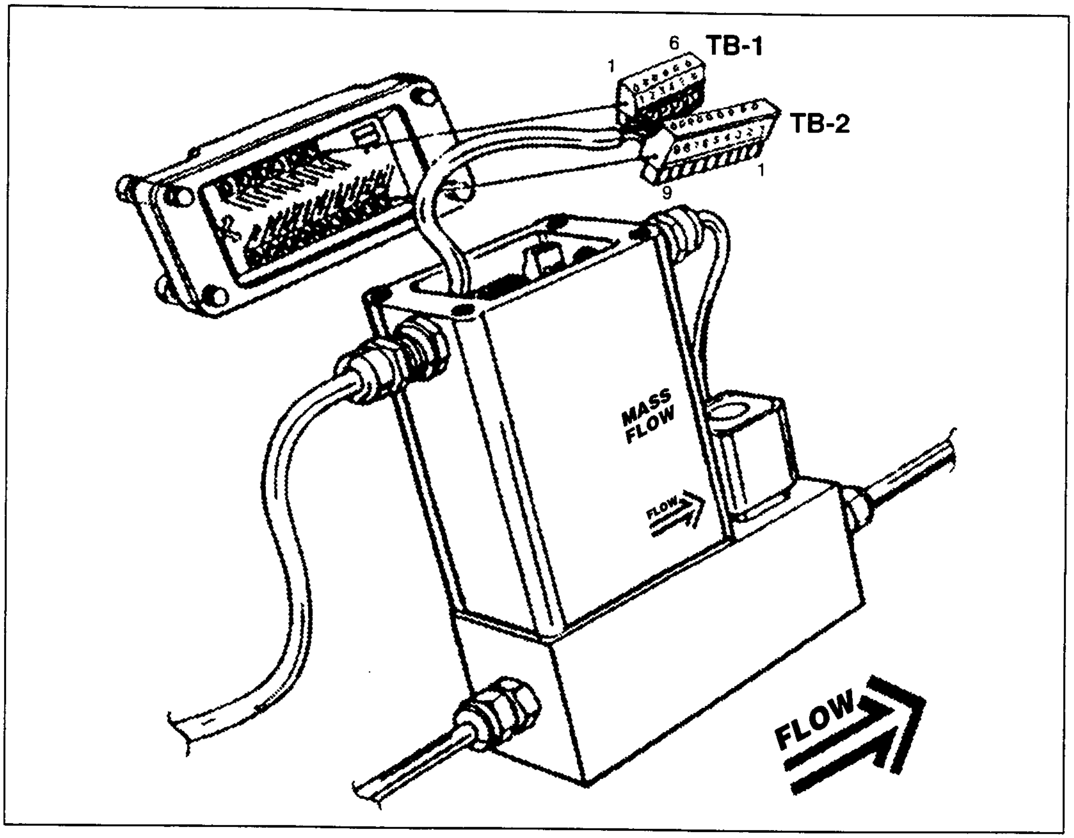


Figure 3-3. Calibration Connections.

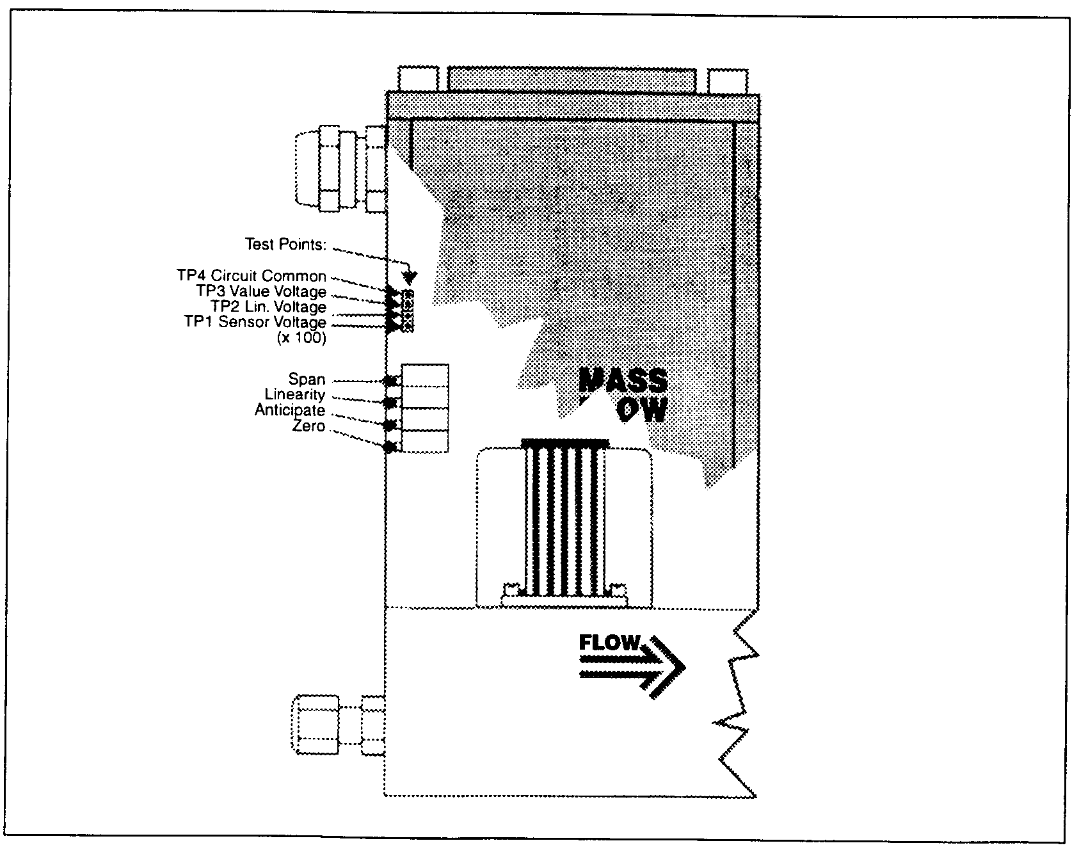


Figure 3-4. Adjustment Potentiometer Location.

f. Connect the DVM positive lead to TP1 (100x sensor voltage) and the negative lead to TP4 (circuit common). The setpoint should still be set at 100% flow (5.000 V). Measure the flow rate using a suitable volumetric calibration equipment. To adjust the controller to the proper full scale flow, calculate a new TP1 voltage using the following equation:

$$\text{New TP1 Voltage} = \frac{\text{measured TP1 voltage}}{\text{measured flow rate}} \times \text{desired flow rate}$$

Adjust the span potentiometer until the voltage at TP1 is equal to the value calculated above. Recheck the flow rate after the flow has stabilized for at least two minutes. Repeat this check and adjustment procedure until the measured flow rate is within 1% of the desired flow rate.

NOTE:

The voltage at TP1 is 100 times the output voltage of the sensor. This voltage can range from 1.2 to 12 Volts, however, it is recommended that this voltage stays between 2.0 and 9.0 Volts for proper operation. If the recommended voltage range exceeds that desired, accuracy and /or signal stability may not be achieved. If one of the limits is reached, check the orifice and restrictor sizing procedures. Refer to Sections 4-5 and 4-6 respectively.

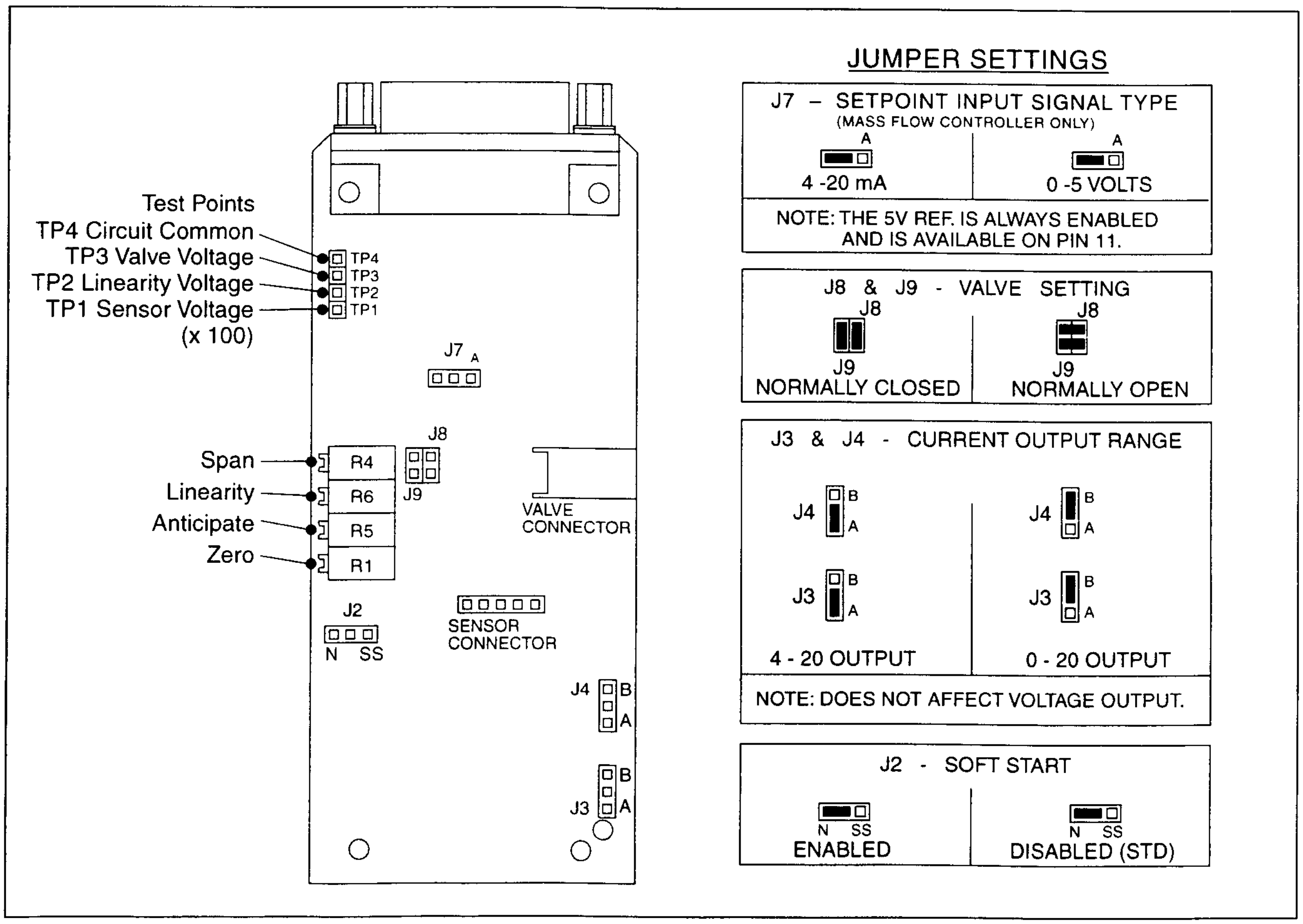


Figure 3-5. PC Board Jumper Location & Function.

g. Adjust the controller setpoint for 0% flow/shut-off the flow to the meter. Connect the DVM positive lead to 0-5 V signal output (TB-1, Terminal 5) and the negative lead to TP4. Readjust the zero potentiometer for an output of 0 mV ±2 mV as necessary.

h. Adjust the controller setpoint/adjust flow rate to the meter for 50% flow, and measure the flow rate. Calculate the error as a percentage of full scale.

$$\text{Full Scale Error} = 100\% \; \frac{\text{Measured Flow Rate} - \text{Desired Flow Rate}}{\text{Full Scale Flow Rate}}$$

Example: What is the percent of full scale error when full scale is equal to 100 sccm?
Measure flow rate = 48.5 sccm
Desired flow rate = 50.0 sccm

$$\text{Full Scale Error} = 100 \; \frac{(48.5 - 50)}{100} = -1.5\%$$

i. Calculate the TP2 correction voltage:
(error recorded in Step h) x 0.450 Volts

Example:
Error = -1.5%
TP2 correction voltage = -1.5 x 0.450 = -0.675 Volts
New TP2 voltage = 0 Volts + (-0.675) = -0.675 Volts

j. Adjust the setpoint for 100% flow. Connect the DVM positive lead to TP2 and the negative lead to TP4.

k. Adjust the linearity potentiometer for an output equal to the new calculated TP2 voltage.

l. Repeat Steps f, g and h.
1. If the error recorded in Step h is less than 0.5%, then the calibration procedure is complete.
2. If the error is greater than 0.5% adjust the setpoint for 100% (5.000V). Connect the DVM positive lead to TP2 (linearity voltage) and the negative lead to TP4 (circuit common).

Calculate a new TP2 voltage as follows:

$$\text{New TP2 voltage} = \text{error recorded in Step i} \times 0.450\text{ V} + \text{Measured TP2 voltage}$$

Example:
Controller error = 0.7%
Measured TP2 voltage = -0.567 Volts
TP2 correction = 0.7 x 0.450 = 0.315 Volts
New TP2 correction = 0.315 Volts + (-0.567) = -0.252 Volts

Adjust the linearity potentiometer for an output equal to the new TP2 voltage and then repeat Steps f, g and h.

NOTE:

The voltage at TP2 can range from -10 to +3 Volts, however, it is recommended that this voltage stays between -2.5 and +2.5 Volts for proper operation. If the recommended voltage range is exceeded, the desired accuracy and/or signal stability may not be achieved. If one of the limits is reached, check the restrictor sizing. Refer to Section 4-5.

3.5 Response

Fast Response Adjustment (Controller)

Two methods of adjusting the step response of the FMA-8200/8300 mass flow controllers can be used. Number 1 below, describes a method that will get the step response close to optimum quickly and without any flow measuring equipment. This method should be used when the response time of the flow controller is not critical to overall system performance.

Method Number 2 describes a procedure that will allow adjustment of your FMA-8200/8300 Series mass flow controller to optimum step response performance. This method is the preferred way to adjust the step response. Adjustment of the fast response circuit will not affect the accuracy of the flow controller as adjusted in Section 3-4.

1. Fast response adjustment (six seconds response specification not guaranteed)

NOTE:

This procedure requires an oscilloscope, chart recorder (the OMEGA® RD101A) or a DVM (the OMEGA® HHM29) with a sample speed of three sample per second or greater to monitor the rate of change of the output signal.

a. Adjust the setpoint for 100% flow and wait about 45 seconds for the flow output signal to stabilize.

b. Step the setpoint to 0% or activate valve override closed to stop the flow. Observe the flow signal output as it decays.

c. The behavior of the flow signal during this transition between 100% and 0% flow indicates the adjustment required of the anticipate potentiometer. Refer to Figure 3-6.

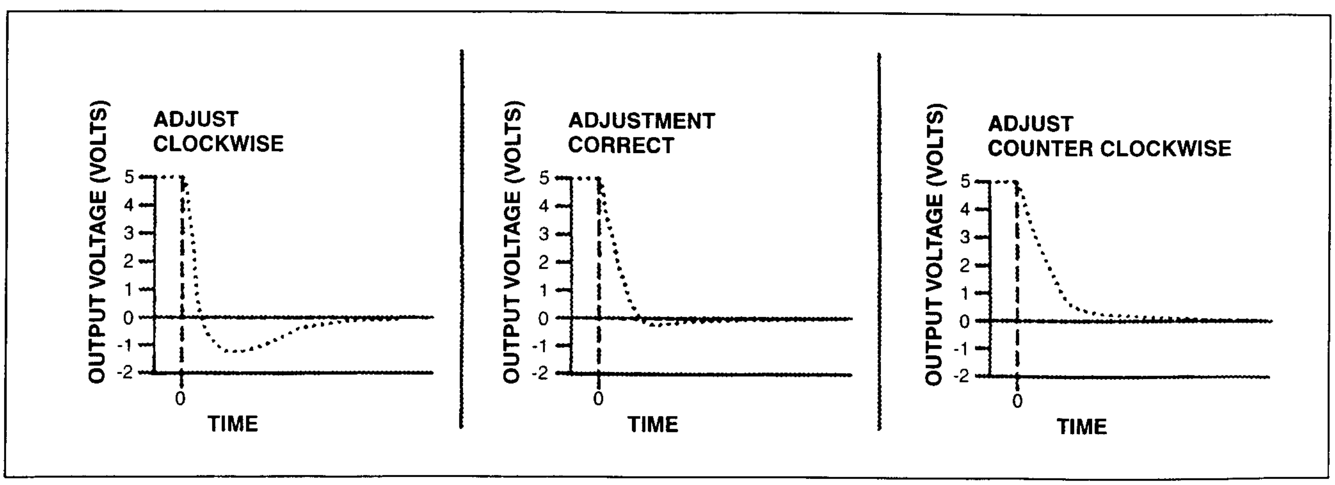


Figure 3-6. Fast Response Adjustment.

1. If the flow signal measured on TB-1, Terminal 5, decays to -.05 to -.5 V, then rises to 0 V, the anticipate potentiometer is properly adjusted.
2. If the flow signal decays rapidly and goes below -.5 V before rising to 0 V, the anticipate potentiometer must be adjusted clockwise and Steps a and b repeated.
3. If the flow signal decays slowly and does not go below -.05 V, the anticipate potentiometer must be adjusted counterclockwise and Steps a and b repeated.

2. Fast response adjustment (six second response specification guaranteed)
Adjustment of the anticipate potentiometer to obtain a flow rate performance to be within 2% of flow rate commanded in less than six seconds after setpoint change requires the use of a fast response flowmeter (500 millisecond response to be within 0.2% of final value or better) in series with the FMA-8200/8300 and a storage oscilloscope or recorder.

a. Allow the flow controller to stabilize at 0% setpoint for at least thirty seconds. Make a step in setpoint to the controller from 0-100% of full scale flow and record the output signal of the fast response flowmeter.

b. If this signal shows more than 4% overshoot, adjust the anticipate potentiometer one-half to one turn counterclockwise. If the signal does not show overshoot but is not within 2% full scale of final value after three seconds, adjust the anticipate potentiometer one-half to one turn clockwise. Set command potentiometer for 0% of flow.

c. Repeat Steps a and b until the fast response flowmeter output signal meets the specified response requirements.

NOTE:

With the above equipment, the anticipate potentiometer can be adjusted to give optimum response characteristics for any process.

Response (Flow Output Signal for Meter)

To achieve the proper response characteristics the response compensation circuit must be adjusted. This adjustment is performed by observing the output signal of the meter when the flow is suddenly stopped. Place a metering valve upstream of the FMA-8200/8300 Series Meter to control the flow rate. A precision metering valve is well suited for this application. Also place a fast acting shut-off valve immediately downstream of the flowmeter. A solenoid valve is ideal for this, but a manual toggle valve will do. Keep the length of interconnecting tubing as short as possible between the valves and the FMA-8200/8300 Series Meter since the tubing can have a dampening effect on the flow and the gas may not stop flowing the instant the downstream valve is closed. Adjustment of the fast response circuit will not alter the steady state accuracy of the flowmeter as adjusted in Section 3-4.

NOTE:

This procedure requires an oscilloscope chart recorder, or a DVM with a sampling speed of three samples per second or greater to monitor the rate of change of the output signal during the test. Monitor the output signal at TB1-5 TP1-4 may be used for circuit common.

a. With the shut-off valve open adjust the metering valve so that the output voltage of the FMA-8200/8300 Series Meter is 4.0505 to 5.000 Vdc. Allow the output to stabilize at this setting.

b. Close the shut-off valve to stop the flow. Observe the output signal as it decays.

c. The behavior of the output signal during the transition between 100% and 0% flow indicates the adjustment required of the anticipate potentiometer. Refer to Figure 3-6.

1. If the flow signal decays to -0.05 to -0.5 V then arises to 0.0 V, the anticipate potentiometer is properly adjusted.
2. If the flow signal decays rapidly and goes below -0.5 V before rising to 0.0 V, the anticipate potentiometer must be adjusted clockwise and Steps a and b repeated.
3. If the flow signal decays slowly and does not go below -0.05 V, the anticipate potentiometer must be adjusted counterclockwise and Steps a and b repeated.

Section 4 - Maintenance

4.1 General

No routine maintenance is required on the FMA-8200/8300 Series other than an occasional cleaning. If an in-line filter is used, the filtering element should periodically be replaced or ultrasonically cleaned.

4.2 Troubleshooting

CAUTION:

It is important that this Instrument be serviced only by properly trained and qualified personnel.

A. System Checks

The FMA-8200/8300 Series instrument is generally used as a component in gas handling systems which can be quite complex. This can make the task of isolating a malfunction in the system a difficult one. An incorrectly diagnosed malfunction can cause many hours of unnecessary downtime. If possible, make the following system checks before removing a suspected defective mass flow controller for bench troubleshooting or return, especially if the system is new:

1 . Verify low resistance common connections and that the correct power supply voltage and signals are reaching and leaving the controller.

2. Verify that the process gas connections have been correctly terminated and leak checked.

3. If the mass flow controller appears to be functioning but cannot achieve setpoint, verify that sufficient inlet pressure and pressure drop are available at the controller to provide the required flow.

4. Verify that all user selectable jumpers are in their desired positions. Refer to Figure 3-5.

WARNING:

It becomes necessary to remove the instrument from the system after exposure to toxic, pyrophoric, flammable or corrosive gas, purge the controller thoroughly with a dry inert gas such as nitrogen before disconnecting the gas connections. Failure to correctly purge the controller could result in fire, explosion or death. Corrosion or contamination of the mass flow controller upon exposure to air may also occur.

B. Bench Troubleshooting

1. Properly connect the mass flow instrument to a correct Vdc power supply, refer to Table 1-3, power requirements and setpoint source (controller). Connect an output signal readout device (4-1/2 digit voltmeter recommended) to TB-1, Terminals 5 and 4 (refer to Figure 1-4 and Table 1-4). Apply power, set the setpoint to zero (controller). Allow the instrument to warm-up for 45 minutes. Do not connect to a gas source at this time.

Trouble	Possible Cause	Check/Corrective Action
Actual flow overshoots controller setpoint by more than 5% full scale.*	Anticipate potentiometer out of adjustment.	Adjust anticipate potentiometer. Refer to Section 3-5.
Output stays at zero and there is flow through instrument.	Clogged Sensor	Clean sensor. Refer to cleaning, Section 4-2d.
Output stays at zero regardless of setpoint/flow and there is no flow through the controller.	Clogged Control Valve*	Check TP3 with the setpoint at 100%. If the voltage is greater than 11V, disassemble and repair the control valve. Refer to Section 4-4c.
(TB2, Terminal 5).	Valve override input is	Check valve override input grounded.*
	Defective PC board.	Replace PC board. Refer to Section 4-4.
Output signal stays at +6.8 V or 26 mA regardless of setpoint and there is flow through the instrument.	Valve stuck open or leaky.*	Clean and/or adjust control valve. Refer to cleaning procedure and/or Section 4-4c.
	+15 V -28 Vdc applied to the valve override input.*	Check the valve override terminal (TB-2, Terminal 5).
	Defective PC board.	Replace PC board. Refer to Section 4-4.
Controller output signal follows setpoint at higher setpoints but will not go below 2% (8% for all-metal seat).*	Leaky control valve.	Disassemble and repair valve. Refer to Section 4-4c.
Controller output signal follows setpoint at lower setpoints but does not reach full scale.*	Insufficient inlet pressure or pressure drop.	Adjust pressures, inspect in-line filters and clean/ replace as necessary.
	Partially clogged sensor.	Check calibration. Refer to Section 3-4.
	Partially clogged valve.	Disassemble and repair control valve. Refer to Section 4-4.
	Valve out of adjustment.	Adjust valve. Refer to Section 4-4.
	Valve guide spring failure.	Controller oscillates (see below).
Instrument grossly out of calibration. Flow is higher than desired.	Partially clogged sensor.	Clean sensor, refer to the cleaning procedure, Section 4-2d.
Instrument grossly out of calibration. Flow is lower than desired.	Partially clogged restrictor.	Replace restrictor. Refer to Section 4-4.
Instrument oscillates.	Pressure drop or inlet pressure excessive.	Adjust pressures.
	Oversized orifice.*	Check orifice size. Refer to Section 4-5.
	Valve out of adjustment.*	Adjust valve. Refer to Section 4-4c.
	Anticipate potentiometer out of adjustment.	Adjust anticipate potentiometer. Refer to Section 3-4.
	Faulty pressure regulator.	Check regular capacity.
	Defective PC board.	Replace PC board. Refer to Section 4-4.

* For controller only (FMA8200)

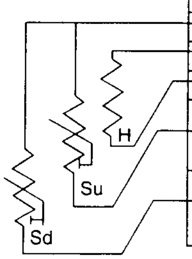
Table 4-1. Bench Troubleshooting

Observe the output signal and, if necessary, perform the zero adjustment procedure (Section 3-3). If the output signal will not zero properly, refer to the sensor troubleshooting section and check the sensor. If the sensor is electrically functional, the printed circuit board is defective and will require replacement

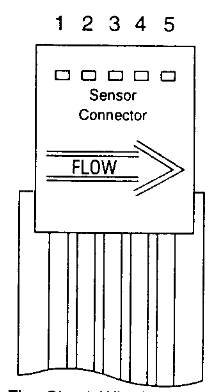
2. Connect the instrument to a source of gas on which it was originally calibrated. Adjust the setpoint for 100% flow. Adjust flow to 100% indication (5.00 V) and adjust the inlet and outlet pressures to the calibration conditions. Verify that the output signal reaches and stabilizes at 5.00 Volts or 20 mA. Vary the setpoint/flow rate over the 2 to-100% range and verify that the output signal follows the setpoint/flow rate. For controller apply the correct voltage to the valve override input (TB-2, Terminal 5) and verify that the output exceeds 100%. Connect the valve override pin to power supply common and verify that the output signal falls below 2%. If possible, connect a flow measurement device in series with the mass flow instrument to observe actual flow behavior and verify accuracy of the mass flow instrument. If the mass flow instrument functions as described above, it is functioning properly and the problem may lie elsewhere.

Table 4-1 lists possible malfunctions which may be encountered during bench troubleshooting.

SENSOR SCHEMATIC



WIRE COLOR	PIN NO.	FUNCTION
White	4	Sensor common
Yellow	1	Heater
Blue	5	Heater common
Red	2	Upstream temperature sensor (Su)
Black	3	Downstream temperature sensor (Sd)



OHMMETER CONNECTION	RESULT IF ELECTRICALLY FUNCTIONAL
Yellow and white to body (ground) (Pin 1 or 4 to body)	Open circuit on ohmmeter. If either heater (yellow) or sensor common (white) are shorted, an ohmmeter reading will be obtained.
White to red (Pin 4 to Pin 2)	Nominal 1100 ohms reading.
White to black (Pin 4 to Pin 3)	(Depending on temperature and ohmmeter current.)
Blue to yellow (Pin 5 to Pin 1)	Nominal 1200 ohms reading.

Note: Remove the sensor connector from the PC Board for this procedure.

Table 4-2. Sensor Troubleshooting

C. Sensor Troubleshooting

If it is believed the sensor coils are either open or shorted, troubleshoot using Table 4-2. If any of the steps do not produce the expected results, the sensor assembly is defective and must be replaced. Refer to Section 4-4 for the disassembly and assembly procedures to use when replacing the sensor.

NOTE:

Do not attempt to disassemble the sensor.

D. Cleaning

No routine external cleaning is required for OMEGA thermal mass flow controllers/meters. Should the FMA-8200/8300 Series mass flow controller/meter require cleaning due to deposition, use the following procedures:

1. Remove the unit from the system.
2. Refer to Section 4-4 to disassemble the controller.

CAUTION:

Do not soak the sensor assembly in a cleaning solution. If solvent seeps into the sensor assembly, it will probably damage the sensor or significantly alter its operating characteristics.

3. Use a hemostat or tweezers to push a 0.007" diameter piano wire through the flow sensor tube to remove any contamination. For best results, push the wire into the downstream opening of the sensor tube (end closest to the control valve). The sensor tube can be flushed with a non-residuous solvent (Freon TF recommended). A hypodermic needle filled with solvent is a convenient means to accomplish this.

   An alternate method for flushing out the sensor is to replace the restrictor element with a low flow plug restrictor. This plug forces all the flow through the sensor and may dislodge any obstructions. With the valve orifice removed, subject the flow controller to a high differential pressure. Pressurizing the outlet of the MFC higher than the inlet may help force the obstruction upstream and out of the sensor tube.

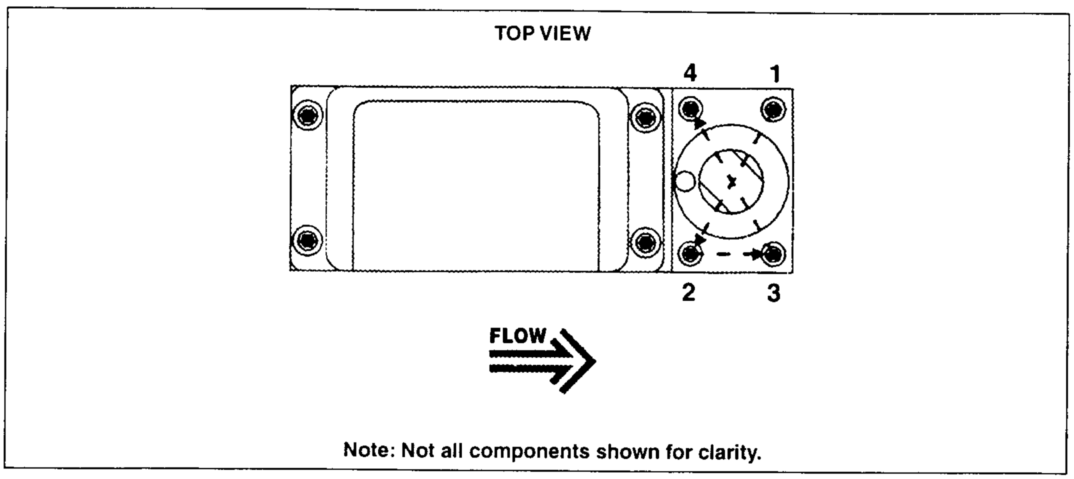


Figure 4-1 Torque Sequence for the Valve Retainer Plate (Controller)

4. Inspect the orifice for clogging by holding it in front of a light source and looking for light through the bore. Clean by soaking in a suitable non residuous solvent and directing a stream of compressed dry nitrogen through the bore.
5. Deposits of silicon dioxide may be removed by soaking the internal parts in a solution of 5 parts hydrofluoric acid (HF) and 95 parts water (H_2O) followed by Freon TF.
6. Restrictor elements can be cleaned in an ultrasonic bath. Refer to Section 4-5 for the correct restrictor to use.
7. Blow all parts dry with dry nitrogen and reassemble. Refer to Section 4-4B, assembly.
8. Purge the assembled instrument with dry nitrogen.
9. Perform the calibration procedure in Section 3-4.
10. When the instrument is reinstalled in the system, the connections should be leak-tested and the system should be purged with dry nitrogen for 30 minutes prior to start-up to prevent the formation of deposits.

4.3 Sensor Tube

The sensor tube is part of a calibrated flow divider that is designed to operate within a preset gas flow range. The sensor assembly may be removed or replaced by referring to Section 4-4, disassembly and assembly. If the sensor assembly is cleaned and reinstalled, a calibration check should be performed. Refer to Section 3-4.

4.4 Disassembly and Assembly

The FMA-8200/8300 Series mass flow controller and meter may be disassembled in the field by the user for cleaning, re-ranging or servicing. Disassemble and assemble the controller as follows:

NOTE:

The FMA8200/8300 Series mass flow controller and meter should be disassembled and assembled in a clean environment to prevent particulate contamination.

A. Disassembly

The numbers in parentheses refer to the spare parts exploded view in Figures 5-1.

WARNING:

Do not attempt to disassemble the mass flow controller until pressure has been removed and purging has been performed. Hazardous gas may be trapped in the valve assembly which could result in explosion, fire or serious injury.

1. Remove the cap nut (20) on top of the valve assembly. Loosen dome nut on PG7 fitting (19) two turns counterclockwise. Remove PG7 fitting from housing assembly and slide it onto the tubing until it contacts the radius.

2. Disconnect the valve wires from the terminal (TB-3) and remove the coil assembly (21).
3. Remove the hex socket screws (22) securing the valve retaining plate (23) attaching the valve stem assembly (24).

CAUTION:

When performing the following procedure, the valve stem must be removed without cocking It to prevent damage to the valve spring.

4. Carefully remove the valve stem assembly (24).
5. Remove the plunger assembly (26, 29, 28B and 32).
6. Remove and note the position of the valve spring spacers (28A) which may be located above and/or below the lower valve springs (29).
7. Unscrew the orifice (33) from the flow controller body
8. Carefully unscrew the valve seat (32) from the plunger (26). Note the position and number of spacers (25A) and springs (29) that are stacked on the threaded end of the valve seat.
9. Remove the cover from the electronics housing by loosening the four (2) self retained screws in the corner of the cover.
10. Unplug signal wire terminal strip connectors TB-1 and TB-2.

11 Loosen the four screws (4) in the corner of the housing using a long (6 inch) 3 mm hex wrench. Lift the housing off the circuit board. Note: Signal wire assembly is still installed through housing gland (5).

CAUTION:

Be careful not to stress the sensor flex circuit cable when removing the sensor connector from the PC Board. If the sensor cable is stressed, an opening in the sensor wire could result.

12. Unplug the sensor connector from the PC Board. Remove the screw and washer (42 and 43) securing the PC Board ground lug. Remove the two screws (17) and washers (16) securing the PC board (14). Remove the PC board.
13. Remove the two screws (37) and washers (38) securing the sensor assembly (18). Remove the sensor assembly.

NOTE:

Do not attempt to disassemble the sensor assembly.

CAUTION:

Do not scratch the O-ring sealing surface.

14. Remove the sensor assembly O-rings (25B) from the flow controller body. Using an O-ring removal tool will help prevent scratching the sealing surface (Refer to Section 5, Table 5-3).

15. Remove the adapter fittings from the flow controller body.
16. Remove the restrictor assembly (40) from the inlet side of the flow controller body using the restrictor tool (part of service tool kit listed in Section 5, Table 5-3).

B. Assembly

CAUTION:

Do not get Fomblin lubricant on the restrictor element or hands. This is a special inert lubricant which is not easily removed.

NOTE:

It is recommended that all service O-rings be replaced during instrument assembly. All service O-rings should be lightly lubricated with Fomblin lubricant (part of service O-ring kit, Section 5) prior to their installation.

NOTE:

Torque valves for all critical fasteners are listed in Table 4-3.

1. Examine all parts for signs of wear or damage, replace as necessary.
2. Place the restrictor O-ring on the restrictor assembly. Screw the restrictor assembly into the inlet side of the flow controller body using the restrictor tool, tighten hand tight.

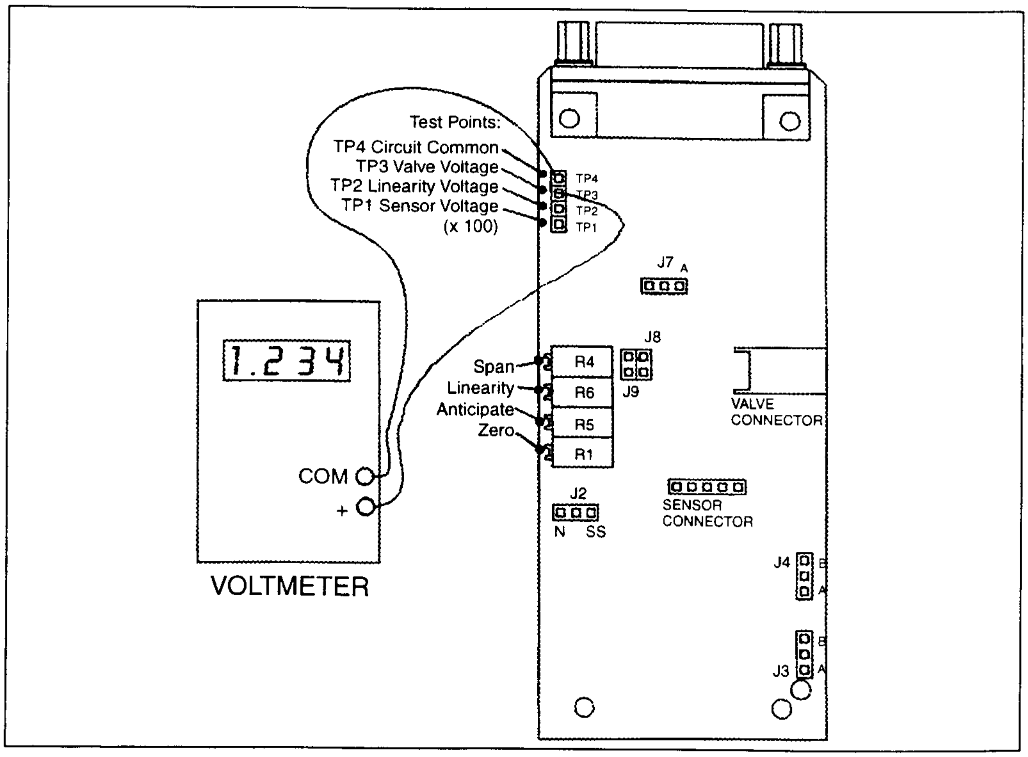


Figure 4-2. Voltmeter Connections for Valve Adjustment.

CAUTION:

The following steps must be performed as written. Placing the O-rings on the sensor before it is installed will result in damage to the O-rings causing a leak.

3. Press the lubricated sensor O-rings (25B) into the flow controller body. Install the sensor assembly and secure with two screws (37) and washers (38) and tighten.
4. Install the orifice (33) and its O-ring (25A) using a 3/8 nut driver. Insure that the orifice is fully seated but do not overtighten.
5. Insert the valve preload spacers (28A), if used, into the valve cavity in the flow controller body. Use care to preserve the correct order.
6. Place the spacers (28B) and springs (29) on the valve seat (32) in the same order as noted in Step 8 of the disassembly. Screw the valve seat (32) into the plunger (26). Tighten the assembly until there is no looseness but do not overtighten.
7. Install the valve plunger assembly (26, 29, 28B and 32) on the preload spacers (28A). Install air gap spacers (28A), if used, on top of the valve springs.
8. Install the valve stem assembly (24), secure with the valve retaining plate (23) and four hex socket screws (22). Install O-ring (1) onto valve stem (24). When installing the screws they should first make light contact with the plate which should be checked to insure that it makes full contact around the stem assembly. Torque the screws securing the valve retaining plate in a diagonal pattern (refer to Figure 4-1) to 17 in/lbs.

Model No.	End Block Screws	Valve Retaining Plate Screws	Sensor Screws	Electronics Housing Screws (M4)	Dome Nuts**	Electronics Housing Cover Screws
FMA-8200	N/A	17	15	25	1 1/2 Turns past finger tight	Tighten until cover contacts housing
FMA-8300	N/A	N/A	17	25		

Table 4-3. FMA-8200/8300 Torque Requirements.

* The torque values listed should be used as a guide for assembly The actual torque may need to be adjusted depending on the lubrication of the mating threads. It is recommended that the fasteners are used only one time. New fasteners can be obtained as spare parts from the factory (refer to Section 5).

** This should be used only as a guide. It is recommended that the actual number of turns, or torque, be determined empirically, using the actual cable.

9. Install the coil assembly (21) over the valve stem assembly (24) and secure with jam nut (20). Make sure O-rings (1) are installed on retaining plate (23) and jam nut (20).
10. Install the PC board (20) and two screws. Plug the connector from the sensor assembly onto the PC board. The flow arrow on the connector should be pointing toward the valve assembly. Attach PC board ground lug to body with screw and washer (41, 42). Install the grounding spring (43) in the flat bottom hole on the body.
11. Install the electronics housing (6) on the controller, secure with four screws (4).
12. Connect the valve wires to terminal (TB-3). Tighten P67 fitting into electronics housing and tighten dome nut. Plug in signal wire terminal. Strip connectors TB-1 and TB-2.
13. Install cover (3) and tighten four screws until cover touches electronics housing.
14. Prior to installation, leak and pressure test to any applicable pressure vessel codes.

C. Adjusting the Control Valve

The FMA8200/8300 Series control valve has been factory adjusted to insure proper operation. Readjustment is only required if any of the following parts have been replaced:

orifice (33)
valve stem (24)
plunger (26)
lower guide springs (29)
valve seat (32)

The valve is adjusted in OMEGA® FMA-8200 Series Controllers by adding spacers (28A and 28B) to the control valve assembly to vary the air gap and initial preload. Spacers are used to affect the proper adjustment because they provide a reliable and repeatable means for adjustment. Screw type adjustment mechanisms can change with pressure or vibration and introduce an additional dynamic seal that is a potential leak site and source for contamination. Refer to Figure 4-3 for spacer locations.

The preload determines the initial force that is required to raise the valve seat off the orifice and start gas flow. If the preload is insufficient, the valve will not fully close and gas will leak through. If the preload is excessive, the magnetic force generated between the plunger and stem will be insufficient to raise the plunger and the valve will not open.

The air gap is the space between the top of the plunger and stem. The air gap determines the force between the plunger and stem at a given voltage and the total travel of the valve. If the air gap is too small, the plunger travel may be insufficient to fully open the valve. Also, the magnetic force may be too high for a given valve coil voltage. If the air gap is too large, the magnetic force will be insufficient to raise the plunger and the valve will not open.

NOTE:

Prior to starting the valve adjustment procedure, check to insure that the orifice is properly seated and that the valve parts are not bent or damaged.

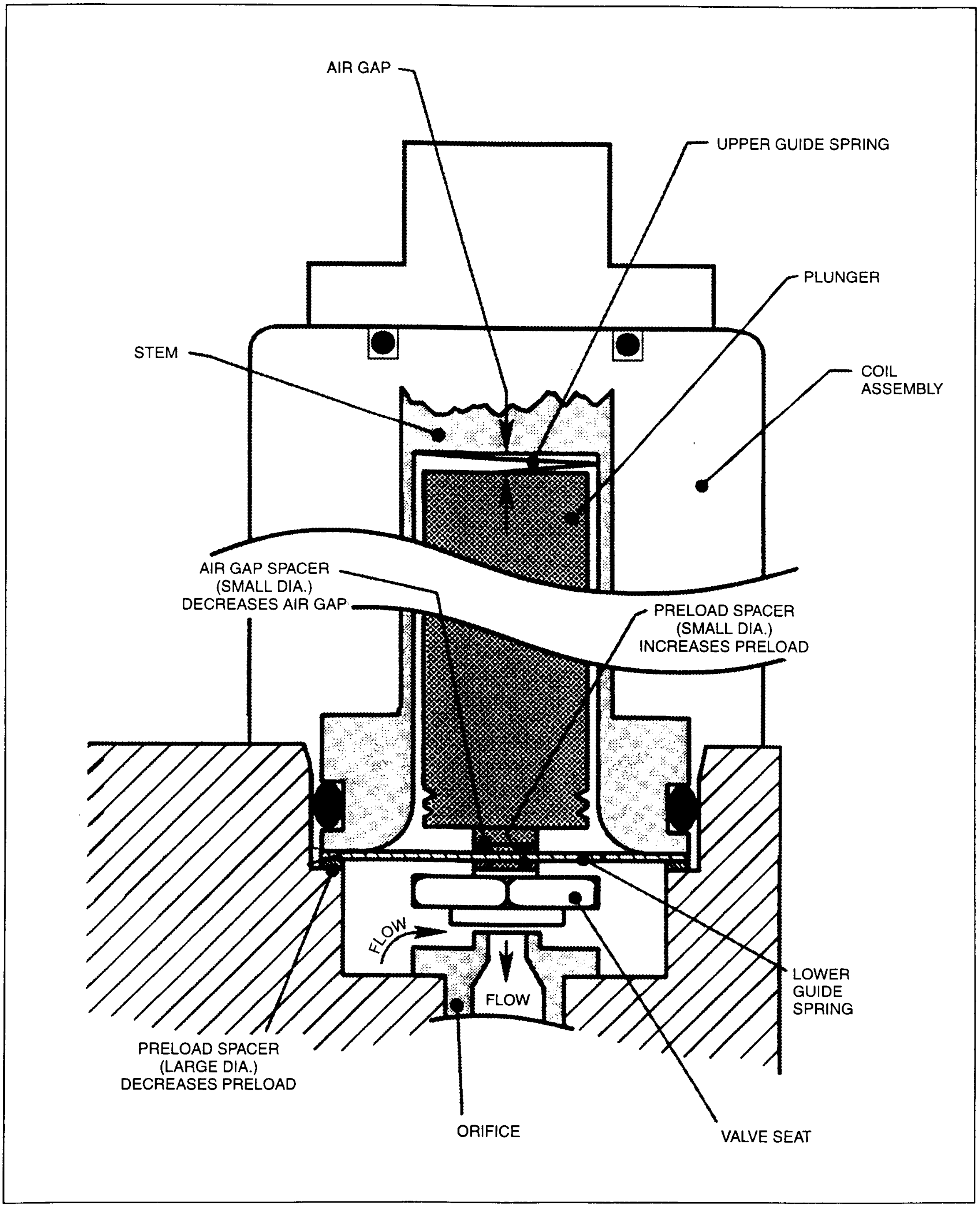


Figure 4-3. Valve Adjusting Spacer Locations

Adjustment Procedure (Controller)
(Refer to Section 5, Spare Parts for Spacer/Shim Kit)

a. Remove the electronics housing (6) from the controller. Insure that the connector from the coil assembly (15) is properly reconnected to the PC board after the electronics cover is removed.

b. Perform the electrical and gas connections to the controller following the instructions in Section 2 of this manual. Use a clean dry inert gas, such as nitrogen, for this procedure. Do not apply gas pressure to the controller at this time.

c. Disassemble the control valve following the procedure given in Section 4-4B above. Note the number, locations and thicknesses of all spacers (28A and 28B).

d. Decrease the preload of the valve by 0.005 inches by either removing a 0.005-inch small preload spacer or by adding a 0.005-inch large preload spacer. Refer to Figure 4-3.

e. Reassemble the valve following the assembly procedure in Section 4-4B.

f. Adjust setpoint for zero percent flow, apply normal operating pressure and check for valve leak through by observing the output signal.

g. If the valve leaks through, increase the preload by 0.005" and go to Step h. If the valve does not leak through, repeat Steps d, e, f and g.

h. Apply normal operating gas pressure and adjust setpoint for 100% flow.

NOTE:

Due to possible heat capacity and density differences between the test gas and actual process gas for which the MFC was sized, it may be necessary to increase the inlet pressure to obtain proper control at 100% flow.

i. Measure the valve voltage by connecting a voltmeter between Test Point 3 (TP3) and Test Point 4 (TP4). Refer to Figure 4-3.

j1. If the flow controller output signal is 100% and the valve voltage is less than 11.5 V, the valve adjustment is complete.

j2. If the flow controller output signal is 100% and the valve voltage is greater than 11.5 V, decrease the air gap with a small 0.005 inch air gap spacer. Refer to Figure 4-2. Repeat Steps h and i.

j3. If the flow controller output signal is less than 100% and the valve voltage is greater than 11.5 V, this condition indicates that the inlet pressure is too small.

k. Refer to Section 3-4, Calibration Procedure, if required.

Conversion Tables, Orifice and Restrictor Selection

Your thermal mass flow controller or meter has been sized for the specified flow rate and process conditions at the factory prior to sale. If your meter or controller is operated on a gas other than the gas it was calibrated with, a scale shift will occur in the relationship between the output signal and the mass flow rate. This is due to the difference in the heat capacities between the two gases. This shift can be approximated by using the molar specific heat of the two gases or by using a sensor conversion factor. The sensor conversion factor can be supplied by OMEGA's Flow Engineering Department.

4.5 Restrictor Sizing

The restrictor assembly is a ranging device for the sensor portion of the controller/meter. It creates a pressure drop which is linear with flow rate. This diverts a sample quantity of the process gas flow through the sensor. Each restrictor maintains the rate of sensor flow to restrictor flow, however, the total flow through each restrictor is different. Different restrictors (micron porosity and active area) have different pressure drops and produce instruments with different full scale flow rates. For a discussion of the interaction of the various parts of the instruments, you are urged to review Section 3-1, Theory of Operation.

If the restrictor assembly has been contaminated with foreign matter, the pressure drop vs. flow characteristics will be altered and it must be cleaned or replaced. It may also be necessary to replace the restrictor assembly when the mass flow instrument is to be calibrated to a new flow rate.

	Range sccm Air Equivalent Flow		Part Number	
Size	Low	High	ACLFE	Wire Mesh
D	8.022	11.36	S110Z275BMT	
E	11.23	15.90	S110Z276BMT	
F	15.72	22.26	S110Z277BMT	
G	22.01	31.17	S110Z278BMT	
H	30.82	43.64	S110Z279BMT	
J	43.14	61.09	S110Z280BMT	
K	60.40	85.53	S110Z281BMT	
L	84.56	119.7	S110Z282BMT	
M	118.4	167.6	S110Z283BMT	
N	165.7	234.7	S110Z284BMT	
P	232.0	328.6	S110Z285BMT	
Q	324.8	460.0	S110Z286BMT	
R	454.8	644.0	S110Z287BMT	
S	636.7	901.6	S110Z288BMT	
T	891.4	1262	S110Z289BMT	
U	1248	1767	S110Z290BMT	
V	1747	2474	S110Z291BMT	
W	2446	3464	S110Z292BMT	
X	3424	4849		S110Z319BMA
Y	4794	6789		S110Z321BMA
1	6711	9504		S110Z317BMA
2	9396	13310		S110Z228BMA
3	13150	18630		S110Z226BMA
4	18420	30000		S110Z224BMA

Materials: BMT = 316 stainless steel (ACLFE only)
BMA = Sintered 316 stainless steel (wire mesh only)

Table 4-4. FMA-8200/8300 Series Standard Restrictors.

NOTE:

For flow rates less than 8 sccm, use the low flow plug P/N 618K0l 9BMT in place of a restrictor assembly and install a low flow filler ring P/N 724Z363BMT in the valve cavity after the orifice is installed.

Restrictor assembly replacement should be performed only by trained personnel. The tools required for the removal/replacement procedure as follows:

1. Appropriate size wrench for the removal of the inlet process connection
2. Restrictor removal tool (contained in service tool kit P/N S778D017AAA)
3. Restrictor O-ring, refer to the Section 5, Spare Parts, for the correct kit part number

FMA-8200/8300 Series Restrictors

The FMA-8200/8300 Series mass flow controller and meter use two types of restrictor assemblies depending upon full scale flowrate.

1. Anti-Clog Laminar Flow Element (ACLFE). This type of restrictor assembly is used for air equivalent flow rates less than 3.4 slps.
2. Sintered wire mesh for air equivalent flow rates above 3.5 slps. These restrictor assemblies are made from a cylinder of sintered wire mesh and are easily cleaned if they become contaminated in service.

Assembly Procedures

1. Select the proper restrictor element combination.
2. When handling restrictor elements, use care to insure that they are not contaminated with dirt, grease, oil, etc. The use of rubber gloves is recommended.
3. Put a lightly lubricated O-ring onto the header plate. The restrictor assembly can then be installed in the mass flow controller body (restrictor element(s) go in first). It is important that the restrictor assembly is put into the body in the correct orientation (Refer to Figure 4-5). Push this assembly in with your fingers. Do not use an arbor press or hammer to install the restrictor assembly. The restrictor assembly should be pushed in until it bottoms out. Do not force it beyond this point.
4. Place the end block O-ring in position and install the end block with the four hex socket screws. Tighten these screws to 30 in./lbs. Do not overtighten.

CAUTION:

The end block screws and the valve screws (22) are not interchangeable. The end block screws are stronger and are needed for the pressure rating. The end block screws are darker in color and can be attracted by a magnet.

5. Install the inlet adapter fitting and O-ring.
6. Recalibration of the controller or meter should be considered in order to maintain correct accuracy.

NOTES:

Section 5 - Parts List

5.1 General

When ordering parts, please specify:

OMEGA Serial Number
Model Number
Part Description
Quantity

Refer to Figures 5-1 for exploded parts drawing and Tables 5-1 through 5-2 for parts lists.

Trademarks

Kalrez® and Viton® are registered trademarks of DuPont Dow Elastomers.
Teflon® is a registered trademark of Dupont.

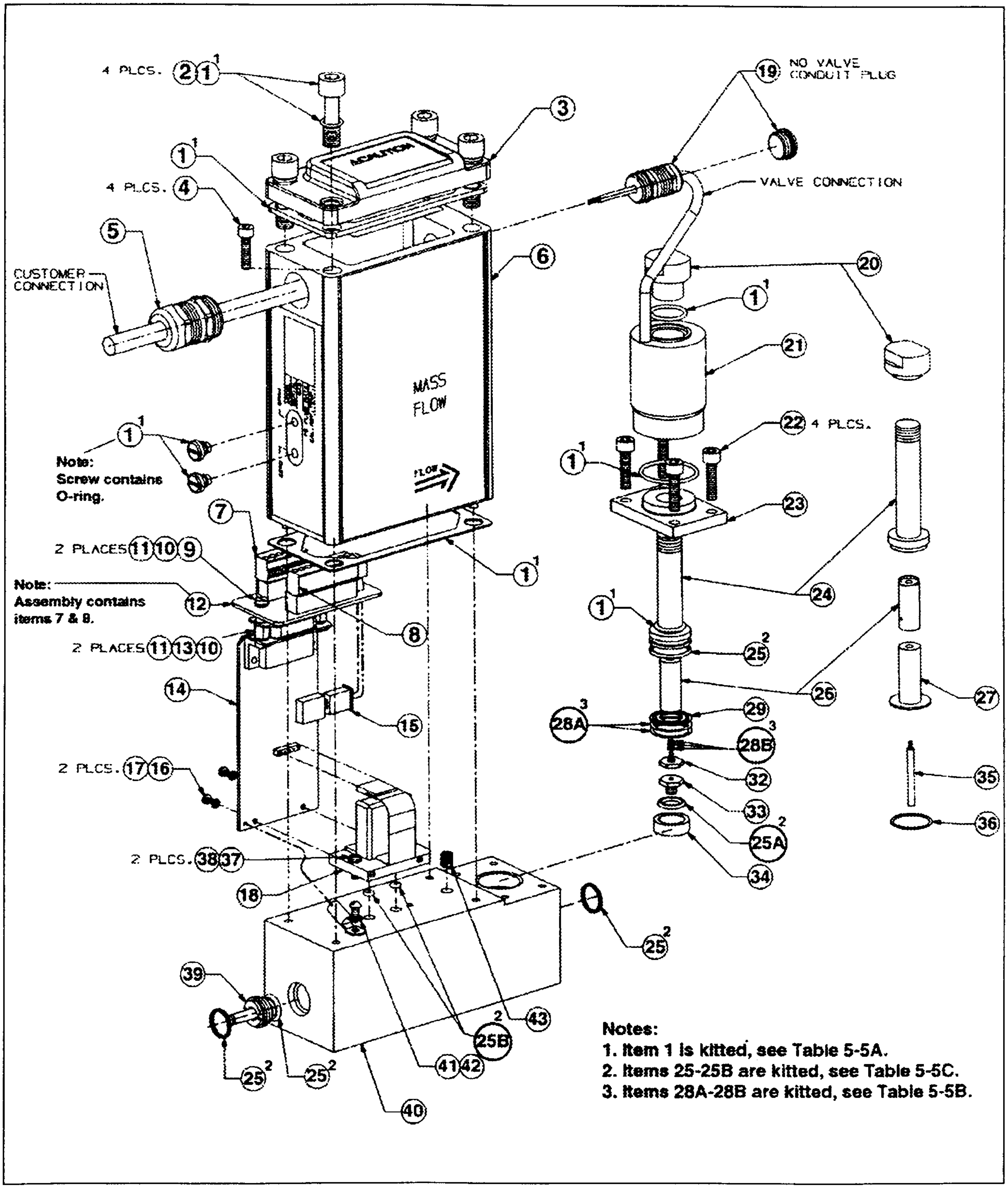


Figure 5-1. Parts Drawing.

Item No.	Description	Qty.	Part Number
2	Screw Cap Socket Head 5/16 x 1.25"	4	753Z197AWA
3	Top Cover	1	442C043EA%
4	Screw, Housing M4 x 12mm	4	758Z018AWA
5	Fitting PG11 Straight	1	326Z017GGJ
6	Housing Assembly	1	S441 Z479AAA
7	Terminal Strip Connector 6-position	1	883F053QRZ
8	Terminal Strip Connector 9-position	1	883J020QRZ
9	Screw Binding Head	2	753A166AWA
10	Flat Washer (for D-Connector)	4	962A004AWA
11	Lockwasher (for D-Connector)	4	962D004AWA
12	PCA Terminal Board	1	097X224AAA
13	Standoff (for D-Connector)	2	830D332GGA
14	PC Board Assembly: 4-20mA D-Connector	1	S097220AAA
15*	Cable Assembly Valve Connector	1	S124Z977AAA
	No Valve		N.P.
16	Lockwasher Flat # 2	2	962C002BYA
17	Screw Round Head	2	753G056AWA
18	Removable Sensor Assembly	1	S774Z508BMA
19	Fitting Conduit-PG7 Plug with Buna No Valve	1	326Z018GGJ
	Fitting Conduit-PG7 Straight	1	326Z016GGJ
20*	Nut Normally Open	1	573Z290QOT
	Nut Normally Closed		573Z289QOT
21*	Coil Assembly (includes Coil)	1	S185Z290AAA
22*	Cap Screws	4	751C322AWA
23*	Valve Mounting Plate	1	715Z304QOT
24*	Valve Plug: No Valve Unit	1	953Z068BMT
	Valve Stem: Normally Closed Valve		949Z194QOT
	Valve Stem: Normally Open Valve		949Z215BMT
26*	Back-Up Ring - NO VALVE unit	1	763Z064QTA
	Plunger Assembly: Normally Open Valve		S622Z203QOT
	Plunger Assembly: Normally Closed Valve		S622Z165AAA
27*	Insert: Norm. Closed	-	N.P
	Insert: Norm. Open Valve	1	456Z071QOG
29*	Lower Guide Spring	1	
	unit with NO ORIFICE		820Z109DR%
	N.C. Valve: .001 - .014 orifice		820Z109DR%
	.020 -.120 orifice		820Z110DR%
	N.O. Valve - all orifice sizes		820Z110DR%
32*	Valve Seat: Viton	1	S715Z051AAG
	Buna		S715Z050AAG
	Kalrez (< or = 200 psig)		S715Z297AAG
	Kalrez (> 200 psig)		S715Z163AAA
	Teflon®		S715Z049AAA
	316L SS		715Z181BNT
34*	Low Flow Filler Ring	1	
	for 'Plug' Type Restrictor		724Z363BMT
	other restrictors		N.P.
35*	Plunger Extension: Norm. Closed	-	N.P
	Plunger Extension: Norm. Open Valve	1	622Z200BMG
36*	Preload Spacer: Norm. Closed Valve	-	N. P.
	Preload Spacer: Norm. Open Valve	1	810A388BMT

*These parts are used only for controllers FMA-8200 Series

Table 5-1. Replacement Parts

Item No.	Description	ID	Qty.	Part Number Stainless
		0.001		577Z375BMT
		0.002		577Z376BMT
		0.003		577Z377BMT
		0.004		577Z378BMT
		0.005		577Z379BMT
		0.007		577Z381BMT
		0.010		577Z383BMT
		0.014		577Z385BMT
		0.020		577Z387BMT
33*	Orifice	0.032	1	577Z391BMT
		0.048		577Z393BMT
		0.052		577Z394BMT
		0.062		577Z395BMT
		0.078		577Z397BMT
	Refer to Section	0.093		577Z398BMT
	4-5 for Sizing	0.116		577Z399BMT
		0.120		577Z400BMT
37	Fillister Head Screw: Sensor/Body		2	753B269AWA
38	Spring Lockwasher: Sensor/Body		2	963D006AWA
39	Restrictor Assembly and Components (Refer to Section 4-5 for sizing)		1	
40	Body FMA8200 FMA8300		1	092B183BMT 092B184BMT
41	Screw Round Head 6-32 X 3/16LG		1	753G263AWA
42	Lockwasher Internal #6		1	962C006BYA
43	Spring Compression .250 OD		1	820B417BBT
NS	M6 Mounting Screw		2	Customer Supplied
	Fittings:			
NS	1/8" Compression		2	320B182BMA
NS	1/4" Compression		2	320B136BMA
NS	3/8" Compression		2	320B150BMA
NS	1/4" VCR		2	315Z036BMA
NS	3/8" VCR (3/8" or 1/2" Tube)		2	315Z034BMA
NS	1/4" VCO		2	315Z035BMA
NS	3/8" VCO (3/8" or 1/2" Tube)		2	315Z033BMA

*These parts are used only for controllers FMA-8200 Series

Table 5-2. Replacement Parts

FMA-8200/8300 Tool Kit
P/N S778D017AAA

Permits the complete disassembly of the FMA-8200/8300 Series for servicing

Contains:

1 - O-ring Removal Tool
1 - Potentiometer Adjustment Tool
2 - Allen Wrench
1 - Phillips Screw Driver
2 - Hex Wrench
1 - Nut Driver for Orifice
1 - Restrictor Removal Tool
2 - Common Screw Driver

A. FMA-8200/8300 NEMA 4 Gasket Kit
P/N S375Z383AAA

Contains:

1 - Cover Gasket
1 - Electronics Housing Gasket
1 - Valve Nut O-ring
1 - Coil Housing O-ring
1 - Coil Base O-ring
4 - Cover Screw O-ring
2 - Calibration Screws with O-ring

FMA-8200/8300 Header Removal Tool
P/N S-817-Z-036-AAA

FMA-8200/8300 Orifice Removal Tool
P/N S-9D08-Z-049-AAA

B. FMA-8200/8300 Valve Shim Kit
P/N S810A372BMA

Contains:

1 - .010" Large Spacer
2 - .005" Large Spacers
1 - .010" Small Spacer
2 - .005" Small Spacers

C. O-ring Service Kit
P/N S375Z278***

Contains:

1 - Orifice O-ring
1 - Restrictor O-ring
1 - Valve O-ring
2 - Sensor O-rings
2 - Adapter O-rings
1 - Syringe with Fumblin Grease
1 - Information Sheet

D. FMA-8200/8300 O-ring Service Kit
P/N S375Z339***

Contains:

1 - Orifice O-ring
1 - Restrictor O-ring
1 - Valve O-ring
2 - Sensor O-rings
2 - Adapter O-rings
1 - Endblock O-ring
1 - Syringe with Fumblin Grease
1 - Information Sheet

E. FMA-8200/8300 O-ring Service Kit
P/N S375Z395***

Contains:

1 - Orifice O-ring
1 - Restrictor O-ring
1 - Valve O-ring
2 - Sensor O-rings
2 - Adapter O-rings
3 - Endblock O-ring
1 - Filter O-ring
1 - Valve Plate O-ring
1 - Seal O-ring
1 - Syringe with Fumblin Grease
1 - Information Sheet

***OTA = Viton, SUA = Buna, TTA = Kalrez, NS = Not Shown, AR = As Required

Table 5-3-FMA-8300 Tool and Spare Parts Kit.

NOTES:

MADE IN USA

WARRANTY/DISCLAIMER

OMEGA ENGINEERING, INC. warrants this unit to be free of defects in materials and workmanship for a period of **37 months** from date of purchase. OMEGA's WARRANTY adds an additional one (1) month grace period to the normal **three (3) year product warranty** to cover handling and shipping time. This ensures that OMEGA's customers receive maximum coverage on each product.

If the unit malfunctions, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective, it will be repaired or replaced at no charge. OMEGA's WARRANTY does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside of design limits, improper repair, or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of having been damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear are not warranted, including but not limited to contact points, fuses, and triacs.

OMEGA is pleased to offer suggestions on the use of its various products. However, OMEGA neither assumes responsibility for any omissions or errors nor assumes liability for any damages that result from the use of its products in accordance with information provided by OMEGA, either verbal or written. OMEGA warrants only that the parts manufactured by it will be as specified and free of defects. OMEGA MAKES NO OTHER WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER, EXPRESS OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED. LIMITATION OF LIABILITY: The remedies of purchaser set forth herein are exclusive, and the total liability of OMEGA with respect to this order, whether based on contract, warranty, negligence, indemnification, strict liability or otherwise, shall not exceed the purchase price of the component upon which liability is based. In no event shall OMEGA be liable for consequential, incidental or special damages.

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RETURN REQUESTS/INQUIRIES

Direct all warranty and repair requests/inquiries to the OMEGA Customer Service Department. BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, PURCHASER MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OMEGA'S CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

The purchaser is responsible for shipping charges, freight, insurance and proper packaging to prevent breakage in transit.

FOR **WARRANTY** RETURNS, please have the following information available BEFORE contacting OMEGA:

1. Purchase Order number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems relative to the product.

FOR **NON-WARRANTY** REPAIRS, consult OMEGA for current repair charges. Have the following information available BEFORE contacting OMEGA:

1. Purchase Order number to cover the COST of the repair,
2. Model and serial number of the product, and
3. Repair instructions and/or specific problems relative to the product.

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