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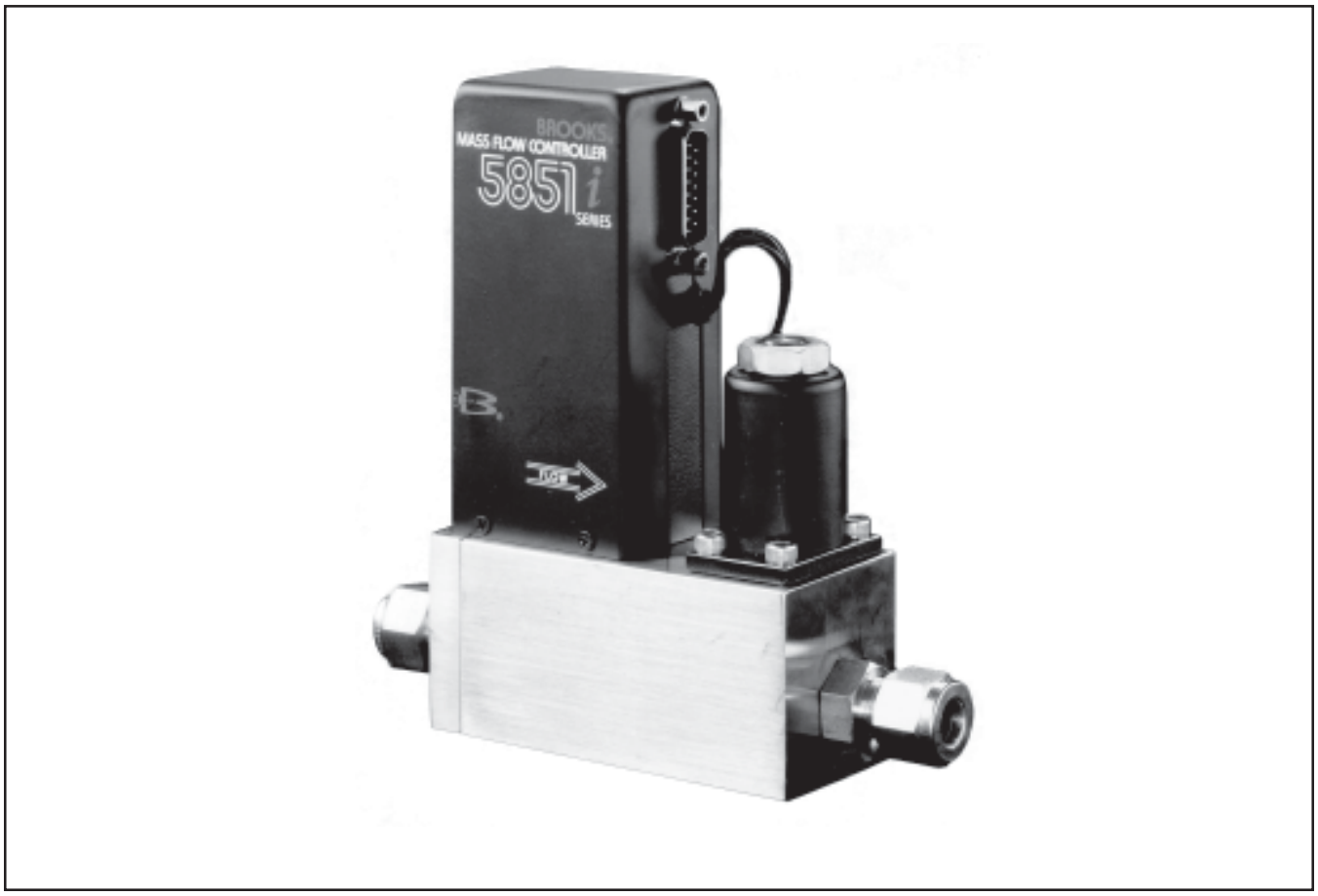
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Find the *Brooks Instrument 5851i* at our website: ***Click HERE***

Installation and Operation Manual
X-TMF-5851i-MFC-eng
Part Number: 541B109AAG
September, 2009

Model 5851*i*
Mass Flow Controller



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Essential Instructions

Read this page before proceeding!

Brooks Instrument 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 Brooks Products.

- Read all instructions prior to installing, operating and servicing the product. If this instruction manual is not the correct manual, please see back cover for local sales office contact information. Save this instruction manual for future reference.
- If you do not understand any of the instructions, contact your Brooks Instrument representative 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 Brooks Instrument. 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.

Pressure Equipment Directive (PED)

All pressure equipment with an internal pressure greater than 0.5 bar (g) and a size larger than 25mm or 1" (inch) falls under the Pressure Equipment Directive (PED). The Directive is applicable within the European Economic Area (EU plus Norway, Iceland and Liechtenstein). Pressure equipment can be traded freely within this area once the PED has been complied with.

- Section 1 of this manual contains important safety and operating instructions related to the PED directive.
- Meters described in this manual are in compliance with EN directive 97/23/EC module H *Conformity Assessment.*
- All Brooks Instrument Flowmeters fall under fluid group 1.
- Meters larger than 25mm or 1" (inch) are in compliance with category I, II, III of PED.
- Meters of 25mm or 1" (inch) or smaller are Sound Engineering Practice (SEP).

ESD (Electrostatic Discharge)

⚠ 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 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.

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Dear Customer,

We appreciate this opportunity to service your flow measurement and control requirements with a Brooks Instrument device. Every day, flow customers all over the world turn to Brooks Instrument for solutions to their gas and liquid low-flow applications. Brooks provides an array of flow measurement and control products for various industries from biopharmaceuticals, oil and gas, fuel cell research and chemicals, to medical devices, analytical instrumentation, semiconductor manufacturing, and more.

The Brooks product you have just received is of the highest quality available, offering superior performance, reliability and value to the user. It is designed with the ever changing process conditions, accuracy requirements and hostile process environments in mind to provide you with a lifetime of dependable service.

We recommend that you read this manual in its entirety. Should you require any additional information concerning Brooks products and services, please contact your local Brooks Sales and Service Office listed on the back cover of this manual or visit www.BrooksInstrument.com

Yours sincerely,

Brooks Instrument

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1-1 Purpose

The Brooks® Model 5851*i* Flow Controller is a mass flow measurement device designed for accurately measuring and rapidly controlling flows of gases. This instruction manual is intended to provide the user with all the information necessary to install, operate and maintain the Brooks 5851*i* Mass Flow Controller. This manual is organized into five sections:

Section 1	Introduction
Section 2	Installation
Section 3	Operation
Section 4	Maintenance and Troubleshooting
Section 5	Replacement Parts

It is recommended that this manual be read in its entirety before attempting to operate or repair the Model 5851*i*.

1-2 Description

The Brooks Model 5851*i* Mass Flow Controller is used where manual, electronic or computer controlled gas handling occurs. The Model 5851*i* consists of three basic units: a flow sensor, a control valve and an integral electronic control system. This combination produces a stable gas flow, which eliminates the need to continuously monitor and re-adjust gas pressures. Standard features include:

Fast Response Control permits rapid gas settling times with little or no over/undershoot. Refer to Figure 1-1.

Soft Start provides a flow ramping function which slows down the introduction of the process gas for those processes which cannot tolerate rapid flow transition. Refer to Section 2-7 and Figure 1-2.

Valve Override permits the user to fully open and close the control valve independent of the setpoint (command) setting. Refer to Section 2-6.

Setpoint (Command) permits the user to program the mass flow controller with an external 0-5 Vdc or 4-20 mAdc signal. Refer to Section 2-6.

Low Command Valve Inhibit (Auto Shutoff) prevents the valve from opening whenever the set-point is less than 2% of full scale.

Removable Cleanable Sensor permits the user to clean or replace the sensor. Refer to Sections 4-2 & 4-4.

Output Limiting prevents possible damage to delicate data acquisition devices by limiting the output to -0.7 Vdc and +6.8 Vdc on the voltage signal output and 0 to 26 mA on the current output.

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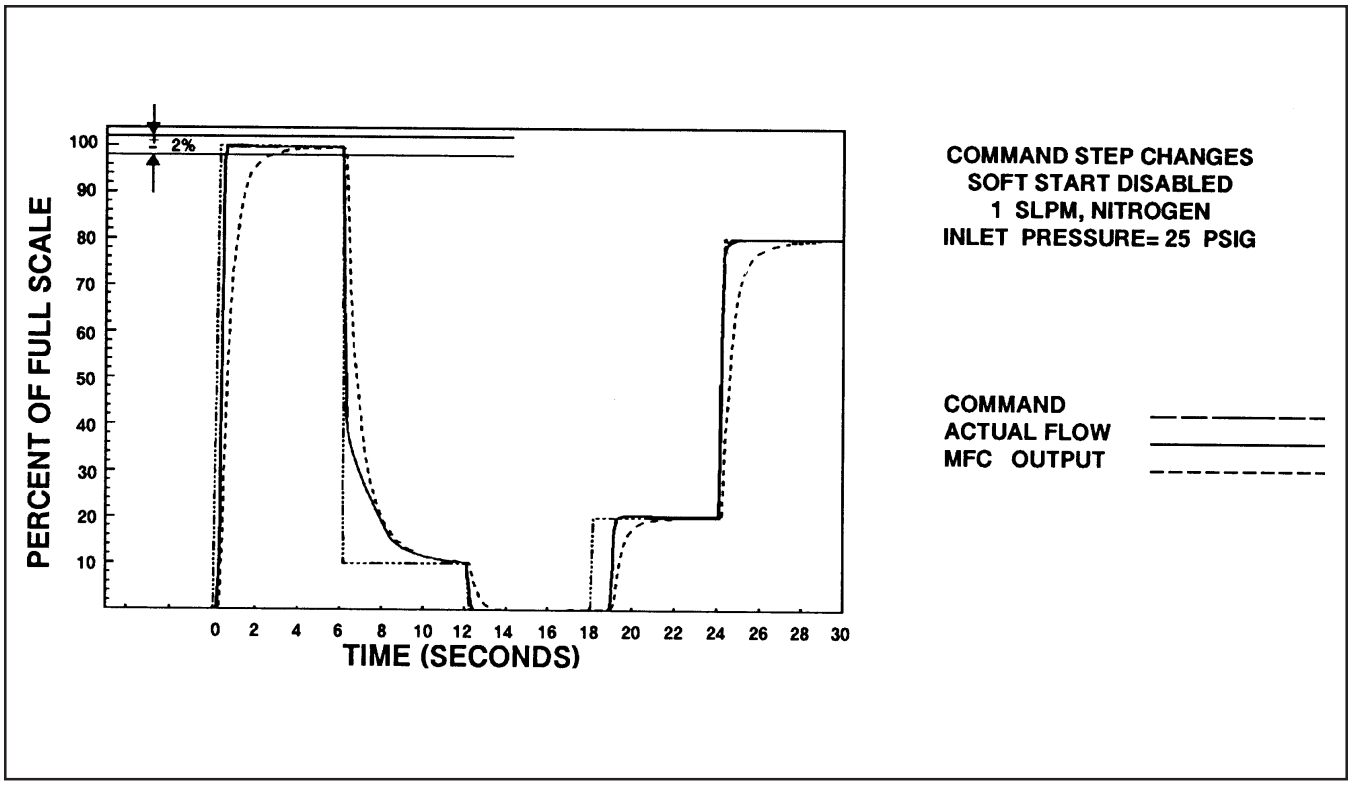


Figure 1-1 Command Steps, Soft Start Disabled

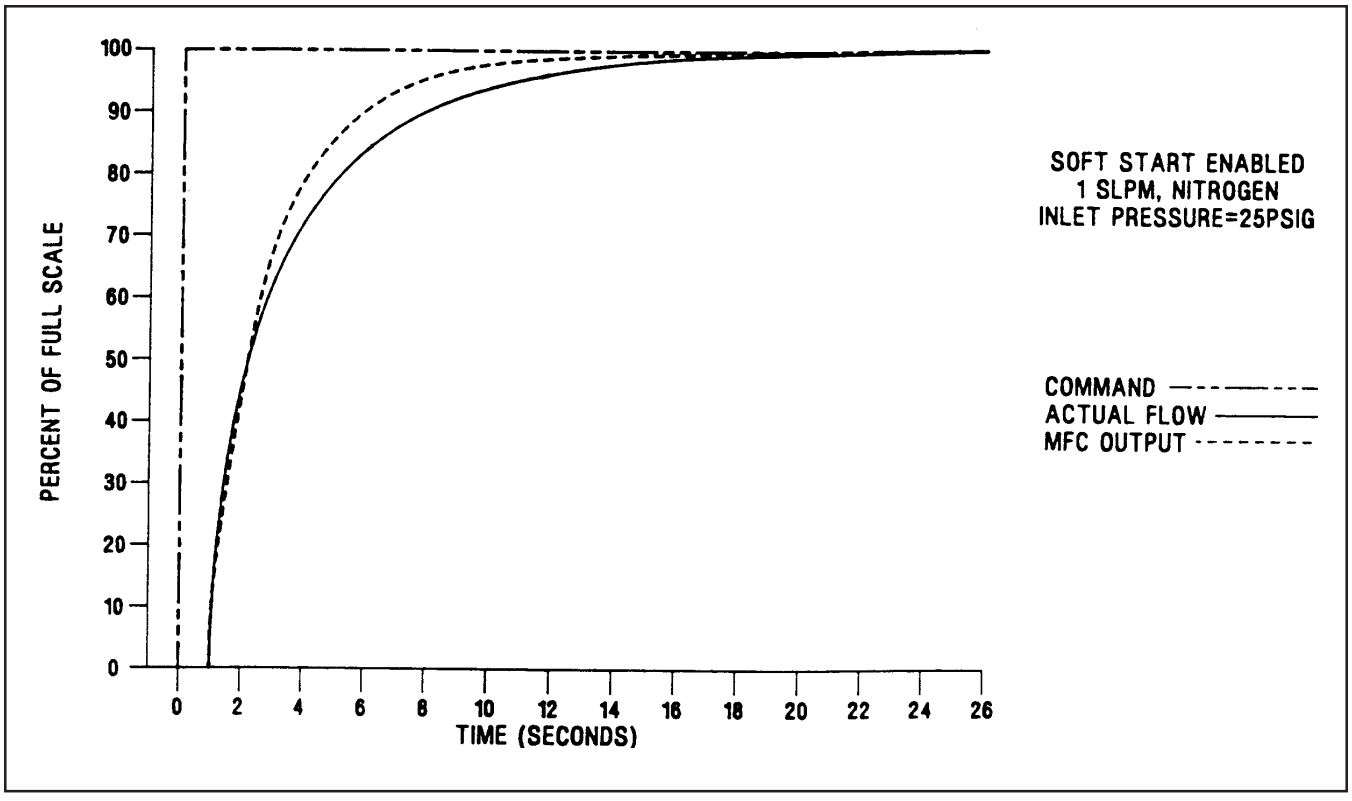


Figure 1-2 0 - 100% Command Step, Soft Start Enabled

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1-3 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.

Standard Ranges
Any full scale flow rate from 10 slpm to 100 slpm (nitrogen equivalent); up to 200 slpm hydrogen.

Accuracy
±1% full scale including linearity at calibration conditions

Repeatability
0.25% of rate

Response Time
Less than 6 seconds response to within 2% of full scale final value with a 0 to 100% command step.

Power Requirements
+22.5 to 28 Vdc — 370 mA @ +28 Vdc

Ambient Temperature Limits
Operating: 5 to 65°C (40 to 150°F)
Non-Operating: -25 to 100°C (-13 to +212°F)

Working Pressure
1500 psi (10.342 MPa) maximum

Differential Pressure
10 to 50 psi. Higher differential pressures are allowable depending on gas and range. Consult factory for details.

Output Signal
0-5 Vdc into 2,000 ohms or greater. Maximum ripple 3 mV. Jumper selectable 4-20 mAdc or 0-20 mAdc. Refer to Fig. 2-3 for maximum total loop resistance.

5 Volt Reference Output
5 Volts ±0.2%. Maximum load 1k ohms.

Temperature Sensitivity
Zero: less than ±0.075% full scale per degree C.
Span: less than ±1.0% full scale shift over 10-50°C range

Mounting Attitude Sensitivity
±0.5% maximum full scale deviation after re-zeroing

Command Input
Jumper Selectable: 0-5 Vdc, Input resistance 200k ohm or 4-20 mAdc, Input resistance 75 ohm

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Leak Integrity
1 x 10^{-9} Atm. scc/sec Helium

Control Range
50 to 1

Mechanical Connection
Interchangeable with most popular mass flow controllers.
Refer to Figure 2-1.

Electrical Connection
D-Type, 15-pin connector (DA-15P). Mating connector supplied.

*Standard temperature and pressure in accordance with SEMI (Semiconductor Equipment and Materials International) standard: 0°C and 101.3 kPa (760 Torr). The mass flow controller can be calibrated to other reference standard conditions. Specify at time of ordering.

⚠ CAUTION

It is the user's responsibility to select and approve all materials of construction. Careful attention to metallurgy, engineered materials and elastomeric materials is critical to safe operation.

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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 be notified at once regarding his liability. A report should be submitted to the Product Service Department, Brooks Instrument, Hatfield, Pennsylvania 19440-0903.

Remove the envelope containing the packing list. Carefully remove the equipment from the packing case. Make sure spare parts are not discarded with the packing materials. Inspect for damaged or missing parts.

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Email: BrooksAs@BrooksInstrument.com

2-2 Recommended Storage Practice

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

a. Within the original shipping container.

b. Store in a sheltered area with the following conditions:

1. Ambient temperature 21°C (70°F) nominal.
2. Relative humidity 45% nominal, 60% maximum/25% minimum. Upon removal from storage, a visual inspection should be conducted to verify its condition is “as received.” If the equipment has been in storage for an excess of ten (10) months or in conditions in excess of those recommended, all pressure boundary seals should be replaced and the device subjected to a pneumatic pressure test in accordance with applicable vessel codes.

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2-3 Return Shipment

Prior to returning any Brooks equipment to the factory, contact the factory - for a Return Materials Authorization Number (RMA#). This can be obtained at Brooks Instrument, Product Service Department, 407 West Vine Street, Hatfield, PA 19440-0903, or call toll free 1-888-554-FLOW (3569).

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Email: BrooksAs@BrooksInstrument.com

Also, completion of Form RPR003-1, Brooks Instrument Decontamination Statement, as well as, a Material Safety Data Sheet (MSDS) for the fluid(s) used in the meter, is required before any Brooks Personnel can begin processing the equipment. Copies of the form can be obtained at one of the locations above.

2-4 Gas Connections

Standard inlet and outlet connections supplied on the Model 5851*i* are 3/8" compression fittings.

Optional VCO™ and VCR™ connections are available upon request. 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 Figures 2-1 through 2-4)

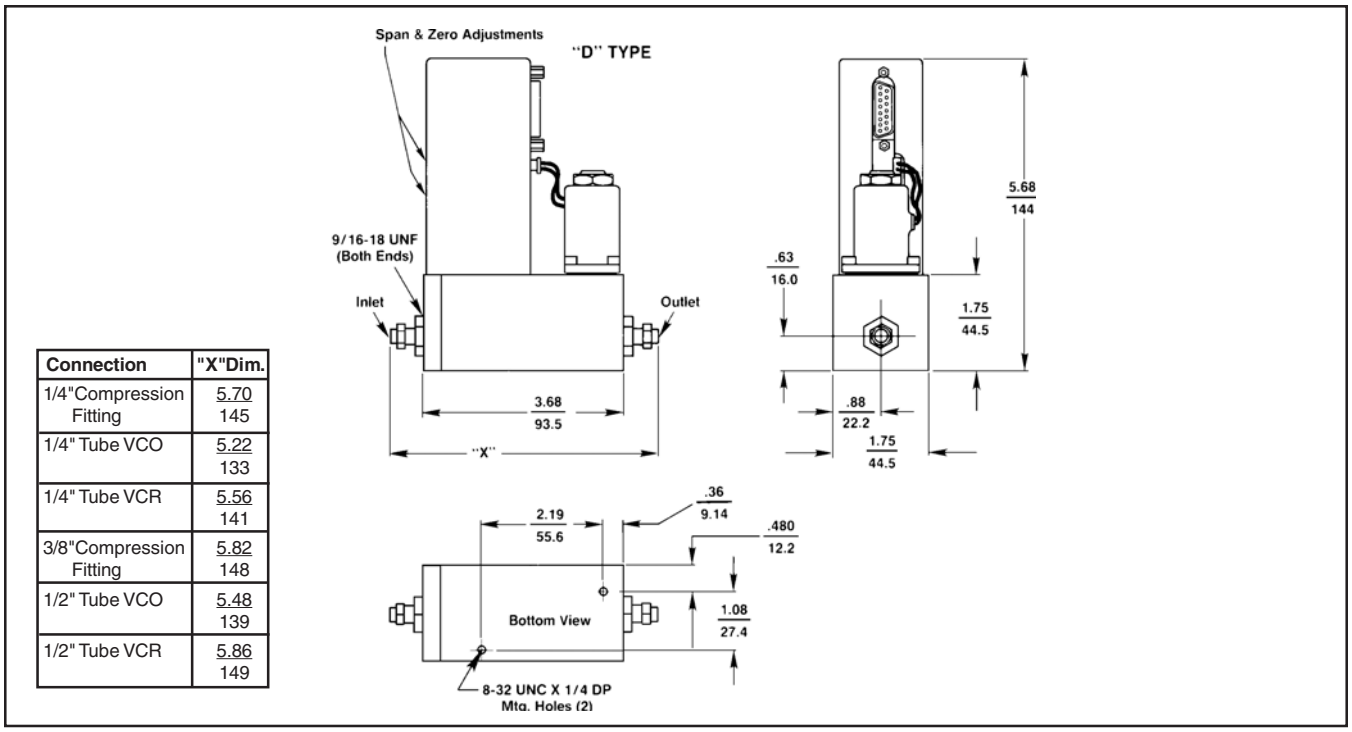
⚠ CAUTION

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.

⚠ CAUTION

Any sudden change in system pressure may cause mechanical damage to elastomer materials. Damage can occur when there is a rapid expansion of fluid that has permeated elastomer materials. The user must take the necessary precautions to avoid such conditions.

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Connection	"X"Dim.
1/4"Compression Fitting	5.70 145
1/4" Tube VCO	5.22 133
1/4" Tube VCR	5.56 141
3/8"Compression Fitting	5.82 148
1/2" Tube VCO	5.48 139
1/2" Tube VCR	5.86 149

Figure 2-1 Model 5851i Dimensions

Recommended installation procedures:

a. The Model 5851*i* 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

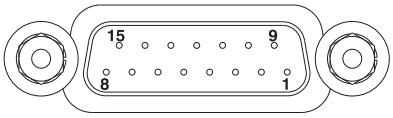
Do not soak the sensor assembly in a cleaning solution. If solvent seeps into the sensor assembly, it will probably damage the sensor, or, at least, significantly alter its operating characteristics.

d. The Model 5851*i* Mass Flow Controller can be installed in any position. However, mounting orientations other than the original factory calibration (see data sheet) will result in a ±0.5% maximum full scale shift after re-zeroing.
e. When installing controllers, 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 ten pipe diameters of straight tubing upstream of the 5851*i* mass flow controller.

NOTE: The control valve in the Model 5851*i* provides precision control 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.

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15 PIN MALE D-CONNECTOR



*BROOKS READ OUT SIDE SUB D (15 PIN)	MFC / MFM PIN	FUNCTION	WIRE COLOR
6	1	**Setpoint**, Common Input (-)	BLACK
10	2	**Flow Signal**, 0(1)-5 volt, Output (+)	WHITE
9	3	**NA**	RED
2	4	**Flow Signal**, 0(4)-20 mA, Output (+)	GREEN
13	5	**Power Supply**, +15 Vdc to +28 Vdc	ORANGE
14	6	**NA**	BLUE
3	7	**Setpoint**, 0(4)-20 mA, Input (+)	WHT/BLK
5	8	**Setpoint**, 0(1)-5 volt, Input (+)	RED/BLK
12	9	**Power Supply**, Common (-)	GRN/BLK
8	10	**Flow Signal**, Common, Output (-)	ORG/BLK
4	11	**Reference**, +5 Vdc, Output (+)	BLU/BLK
7	12	**Valve Override**, Input	BLK/WHT
1	13	**NA**	RED/WHT
11	14	**Chassis Ground**	GRN/WHT
15	15	**NA**	BLU/WHT

* Brooks Read Out Models 0151, 0152, 0154, 0254

Figure 2-2 D Connector Shielded Cable Hookup Diagram

⚠ CAUTION

Since the Model 5851*i* control valve is not a positive shut-off, a separate solenoid valve may have been installed for 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 solenoid resulting in a surge upon actuation of the controller. This surge can be reduced in magnitude by locating the controller and solenoid valve close together or by moving the solenoid valve upstream of the controller.

2-6 In-Line Filter

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

Table 2-1 Recommended Filter Size

Maximum Flow Rate	Recommended Filter Size
10 to 30 slpm	15 micron
Above 30 slpm	30 micron

NOTE: The above lists the maximum recommended porosity for each flow range. It is recommended that the minimum micron porosity that does not limit the full scale flowrate be used.

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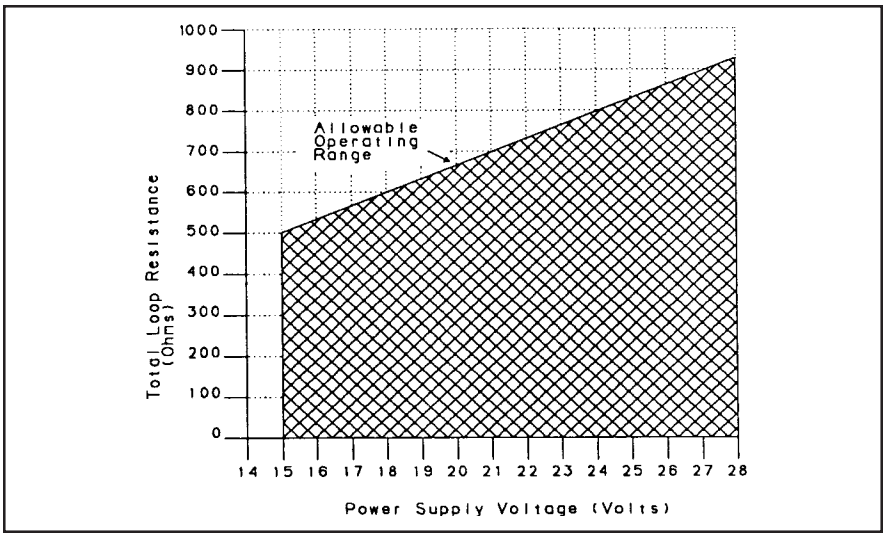


Figure 2-3 Maximum Allowable Loop Resistance

2-7 Electrical Interfacing

To insure proper operation, the 5851*i* must be connected per Figures 2-2, 2-3 and 2-4 and configured according to Section 2-7. As a minimum, the following connections must be made for new installations:

Function
Chassis Ground
Signal Output Return
Voltage or Current Signal Output
22.5-28 Vdc Supply
Supply Common
Voltage or Current Setpoint Input
Setpoint Return

Electrical Hook-up

Setpoint (Command) Input

The 5851*i* 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 pin 7 and the setpoint return (-) signal to pin 1 of the D-connector and configure the PC Board per Section 2-7. To use the voltage setpoint, connect the setpoint signal to pin 8 and the voltage setpoint return to pin 1 of the D-connector and configure the PC Board per Section 2-7.

(The Brook's MFC acts as a current sink to a setpoint input signal. The 0/4-20 mA setpoint signal should be "driven" into the MFC input by a controlled current source. Reference Brook's device specifications for the setpoint input impedance.)

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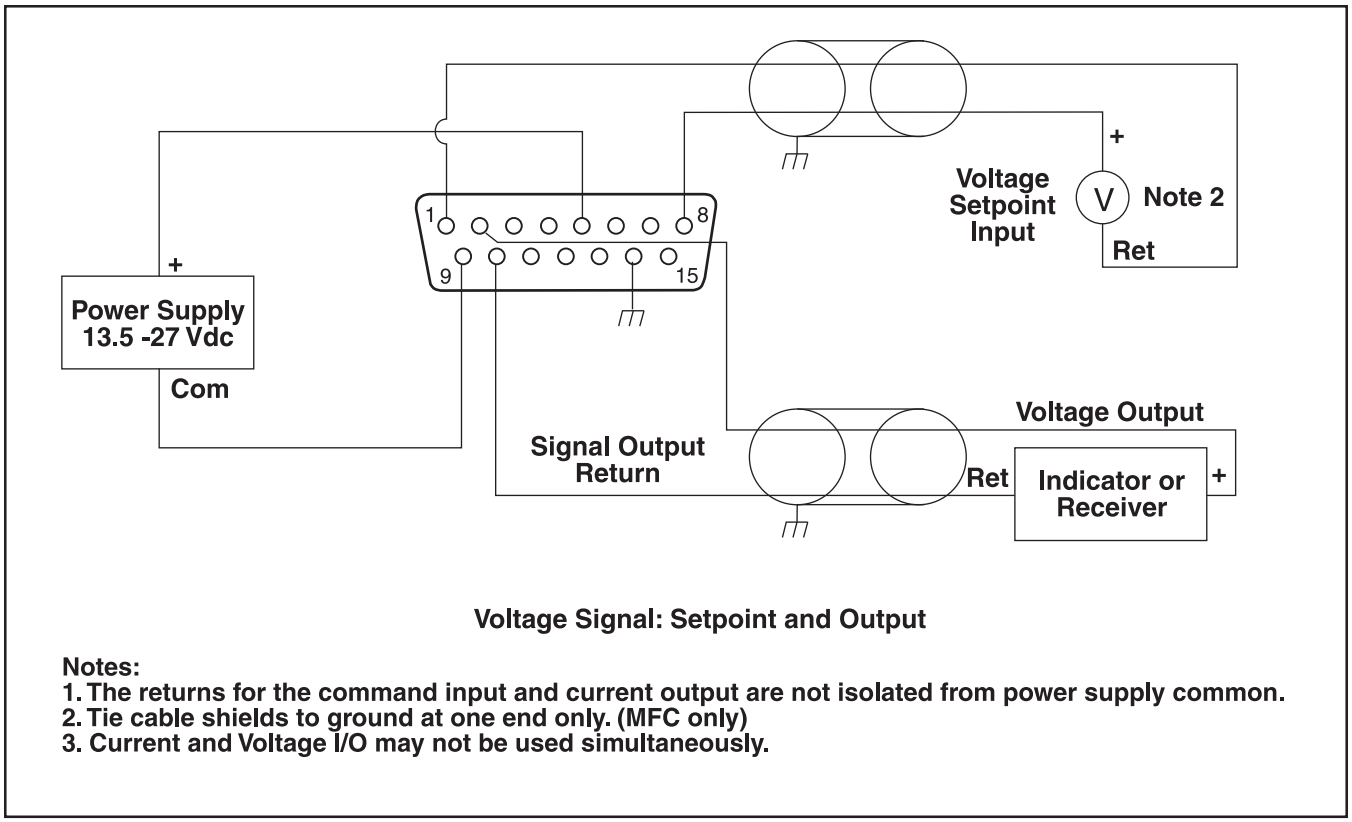


Figure 2-4 Common Electrical Hook-Ups, Voltage I/O Version

Signal Output

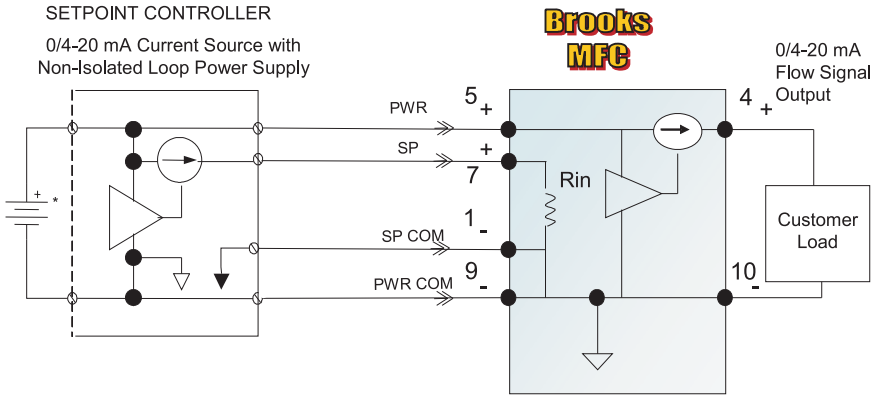
The flow signal output can be measured as a voltage and a current simultaneously on two different pins of the D-connector. Pin 2 indicates the flowrate with a 0-5 Vdc signal proportional to the mass flow rate. Pin 4 indicates the flowrate with either a 0-20 mAdc or 4-20 mAdc current signal as determined by jumpers on the PC Board (refer to Section 2-7 for jumper positions). Both the current and voltage signals are returned on pin 10 of the D-connector.

(The Brook's MFC acts as the current source when providing a 0/4-20 mA output signal to the load. The output signal is "driven" by the MFC into the customer load. Reference Brook's device specifications for maximum load capacity.)

Supply

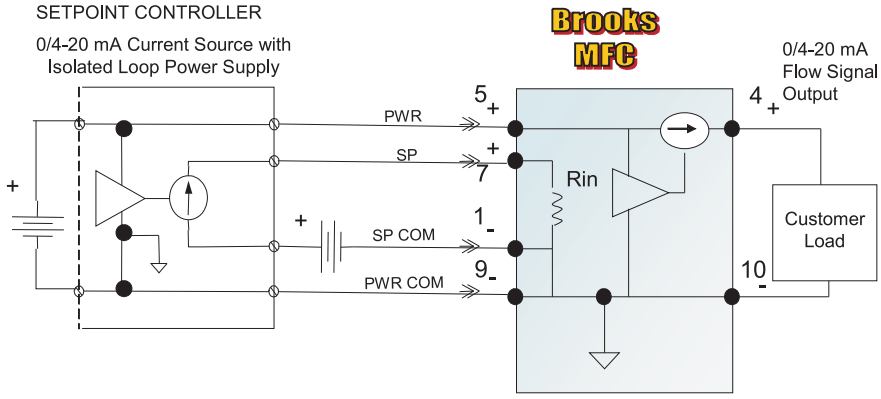
The power for the mass flow controller is connected to pin 5 (+22.5 to +28 Vdc) and pin 9 (supply common) of the D-connector. Refer to Section 1-3 for the power requirements.

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Note: Setpoint common, flow signal output common, and power supply common are connected internally in the MFC. Reference Brook's device specifications for power supply voltage and setpoint input impedance.
Input: The 4/20 mA setpoint signal is "driven" into the MFC input using a controlled source.
Output: The 4/20 mA output signal is "sourced" by the MFC into the customer load.

Figure 2-5 Recommended I/O Wiring Configuration for Current Signals (Non-Isolated Power Supply)



Note: Setpoint common, flow signal output common, and power supply common are connected internally in the MFC. Reference Brook's device specifications for power supply voltage and setpoint input impedance.
Input: The 4/20 mA setpoint signal is "driven" into the MFC input using a controlled source.
Output: The 4/20 mA output signal is "sourced" by the MFC into the customer load.

Figure 2-6 Recommended I/O Wiring Configuration for Current Signals (Isolated Power Supply)

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Chassis Ground

Connect earth ground to pin 14 of the D-connector.

Valve Override (connection optional)

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

To open the valve, apply +22.5 to +28 Vdc to pin 12
To close the valve, connect pin 12 to ground.
Isolating pin 12 (no connection) returns the controller to normal operation.

NOTE: For normal operation, pin 12 must be left open (floating)

2-8 Configuring the PC Board

NOTE: To obtain access to the jumpers, the electronics cover can must be removed. Disconnect the power to the mass flow controller and any cables to the D-connector and the valve coil connector. Remove the three screws at the base of the can and remove the top jack post of the D-connector. Remove the can. The can must be replaced before returning the unit to service. Refer to Section 2-6 for the proper electrical hook-up. Refer to Figure 3-3 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 (green) 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 (blue) 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 the voltage output.

Soft Start

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

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3-1 Theory of Operation

The thermal mass flow sensing technique used in the 5851*i* works as follows:

A precision power supply provides a constant power heat input (P) at 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 (one upstream and one downstream of the heater) 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 controller's full scale flow.

In addition to the mass flow sensor, the Model 5851*i* Mass Flow Controller has an integral control valve and control circuit, as shown in Figure 3-2. The control circuit senses any difference between setpoint and the flow sensor signal and adjusts the current in the modulating solenoid valve to increase or decrease the flow.

The Model 5851*i* 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.

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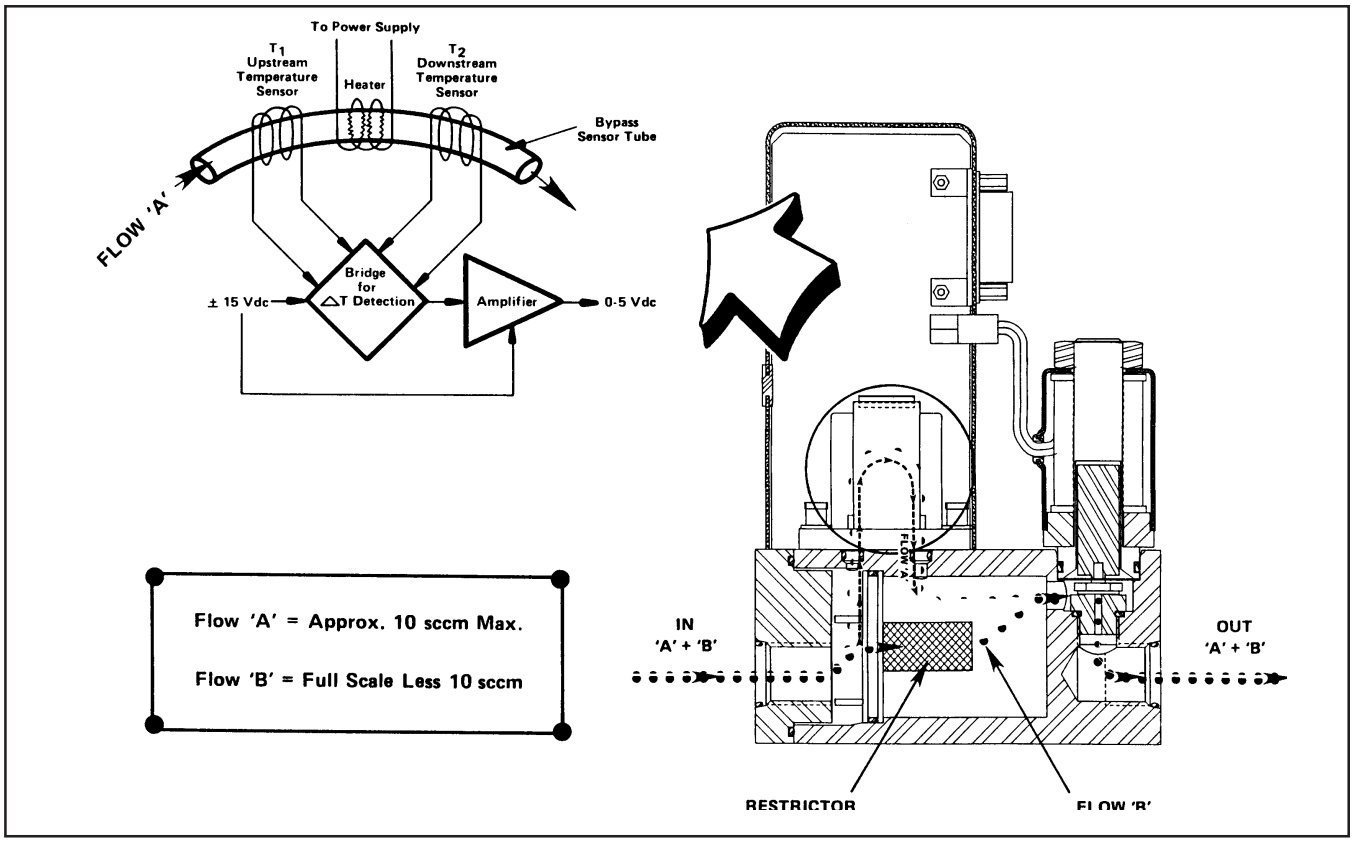


Figure 3-1 Flow Sensor Operational Diagram

Soft Start enabled by moving a jumper on the PC Board. This circuit provides a slow injection of the gas as a protection 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 2k 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 to the controller 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 and observe the controller's output signal. If the output is not zero mVdc ±10 mVdc or 4 mAdc ±0.05 mAdc, check for leaks and if none are found, refer to the re-zeroing procedure in Sect. 3-3.
d. Set the command for the desired flow rate to assume normal operation.

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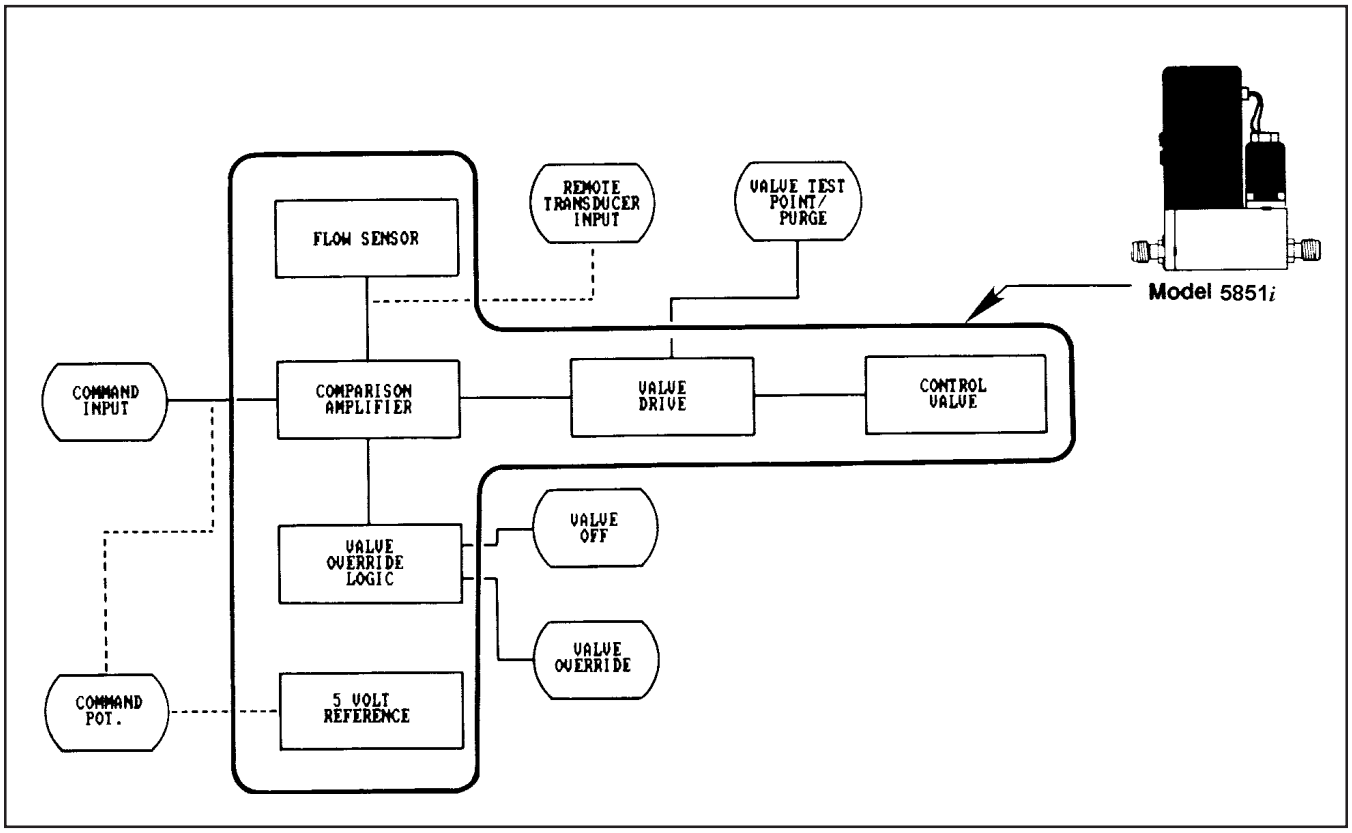


Figure 3-2 Flow Control System Block Diagram

3-3 Zero Adjustment

Each 5851*i* is factory adjusted to provide a zero ±10 mVdc signal or a 4 mAdc ±0.05 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 in the gas system, the zero flow indication 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 controller in its final configuration and allow a minimum of twenty minutes for the temperature of the controller and its environment to stabilize. Using a suitable voltmeter or current meter, check the controller output signal. If it differs from the factory setting, adjust it by removing the lower pot hole plug which is located closest to the controller body. Adjust the zero potentiometer (refer to Figure 3-5) until the desired output signal is obtained.

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.

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3-4 Calibration Procedure

NOTE 1: If the valve has been disassembled and any of the following parts have been replaced, the control valve adjusting procedure in Section 4-4c must be performed before the Model 5851*i* is calibrated.

orifice
valve stem
plunger
lower guide spring
valve seat

NOTE 2: Calibration of the 5851*i* mass flow controller requires the use of a digital voltmeter (DVM) and a precision flow standard calibrator such as the Brooks Vol-U-Meter. It is recommended that the calibration be performed only by trained and qualified service personnel.

NOTE 3: If the mass flow controller is to be used on a gas other than the calibration gas, apply the appropriate sensor conversion factor (refer to Section 4-5). 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 meter 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 0-5V signal output (pin 2) and the negative lead to signal common (TP4). Adjust the zero potentiometer for an output of 0mV ±2 mV.
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 (5.000V or 20 mAdc). Connect the DVM positive lead to TP2 (linearity voltage) and the negative lead to TP4 (signal common). Adjust the linearity potentiometer for an output of 0.0V (zero volts).

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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 (5.000V). Measure the flow rate using 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 is stable (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 4-6 and 4-7 respectively.

g. Adjust the command potentiometer for 0% flow. Connect the DVM positive lead to 0-5V signal output (Pin 2) and the negative lead to TP4. Readjust the zero potentiometer for an output of 0 mV ±2 mV as necessary.
h. Set the command potentiometer for 50% flow (2.500V) and measure the flow rate. Calculate the error as a percentage of full scale.

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

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

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

i. Calculate the TP2 correction voltage: (error recorded in step "h") x 0.450 volts.

Error = -1.5%

TP2 correction voltage	= -1.5 x 0.450	= -0.675 volts
New TP2 voltage	= 0 volts + (-0.675)	= -0.675 volts

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j. Set the command potentiometer for 100% flow (5.000V). 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% set the command potentiometer 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 + (-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 4-7.

3-5 Response

Fast Response Adjustment

Two methods of adjusting the step response of the 5851*i* mass flow controllers can be used.

Method Number 1 describes a procedure 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 5851*i* 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 or a DVM with a sample speed of three samples per second or greater to monitor the rate of change of the output signal.

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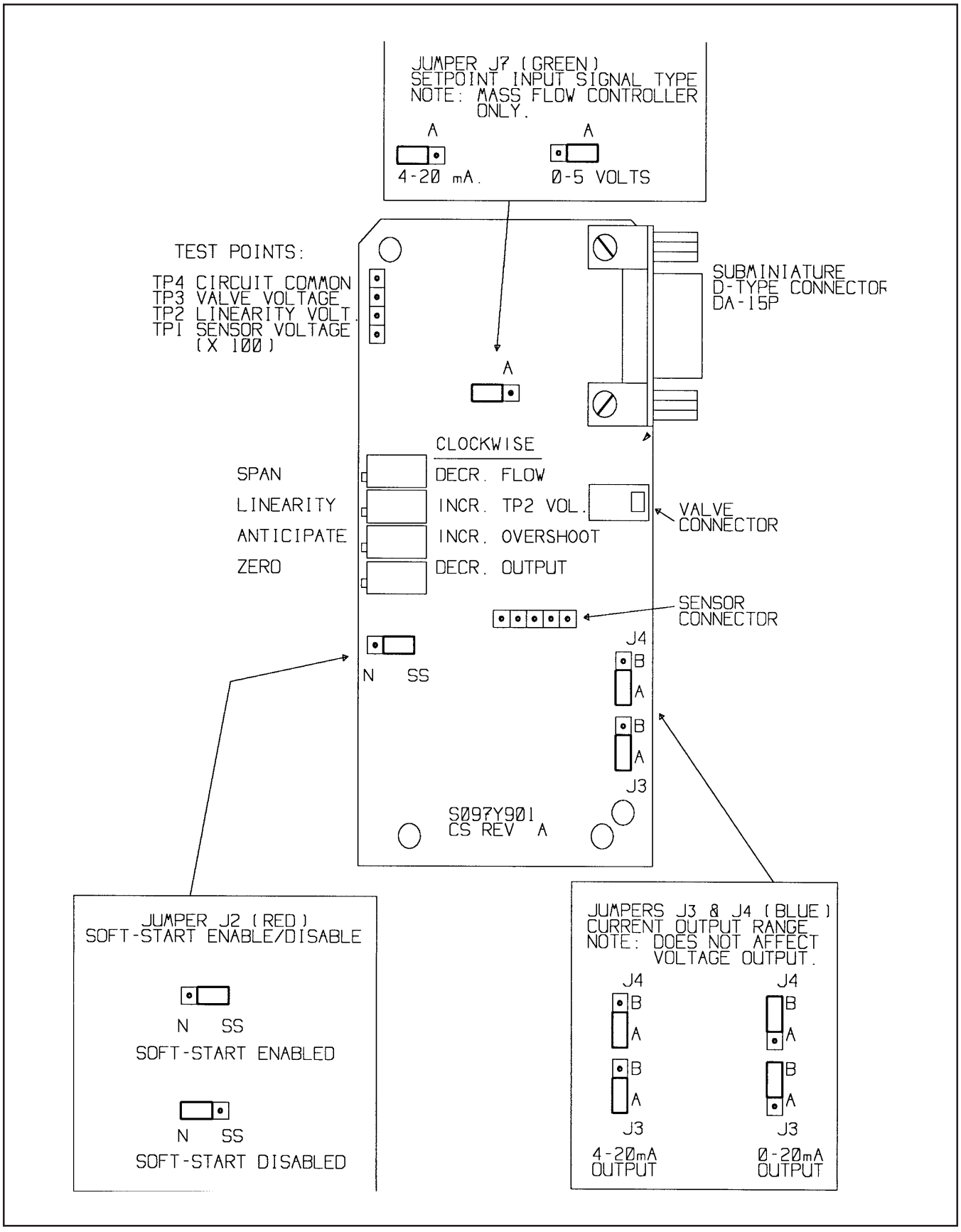


Figure 3-3 PC Board Jumper Location & Function

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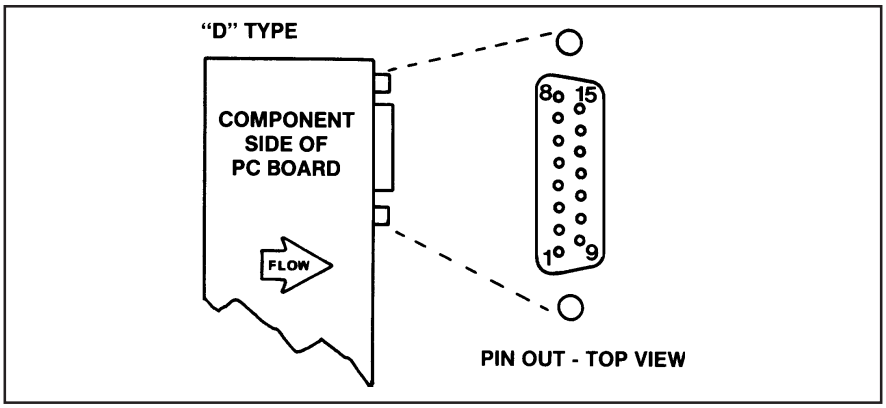


*Figure 3-4 Model 5851*i *Calibration Connections*

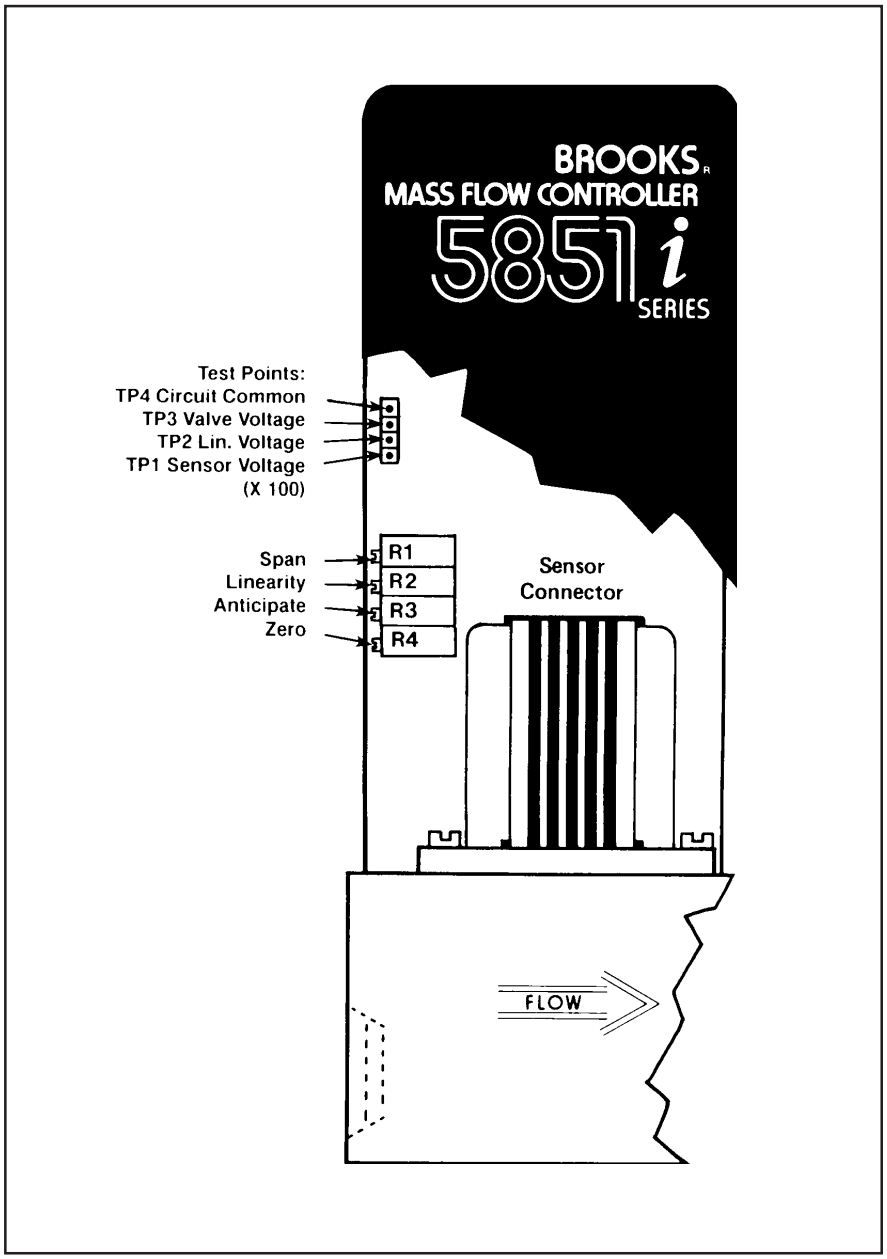


Figure 3-5 Adjustment Potentiometer Location

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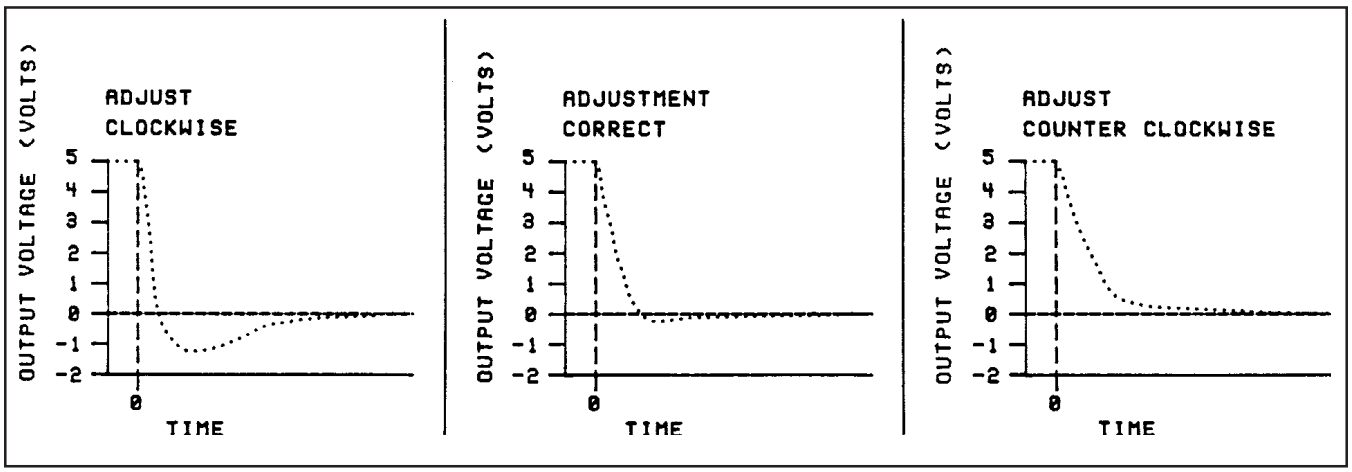


Figure 3-6 Fast Response Adjustment

a. Set the command potentiometer for 100% flow (5.00V) and wait about 45 seconds for the flow output signal to stabilize.
b. Step the command signal 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.
d. If the flow signal measured on pin 2 decays to -0.05 to -0.5V, then rises to 0V, the anticipate potentiometer is properly adjusted.
e. If the flow signal decays rapidly and goes below -0.5V before rising to 0 V, the anticipate potentiometer must be adjusted clockwise and steps a and b repeated.
f. 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.

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 5851*i* 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 six 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.

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4-1 General

No routine maintenance is required on the Model 5851*i* other than an occasional cleaning. If an in-line filter is used, the filtering element should periodically be replaced or ultrasonically cleaned.



⚠ WARNING

METER/CONTROLLER SEAL COMPATIBILITY

Products in this manual may contain metal or elastomeric seals, gaskets, O-rings or valve seats. It is the "user's" responsibility to select materials that are compatible with their process and process conditions. Using materials that are not compatible with the process or process conditions could result in the Meter or Controller leaking process fluid outside the pressure boundary of the device, resulting in personnel injury or death.

It is recommended that the user check the Meter or Controller on a regular schedule to ensure that it is leak free as both metal and elastomeric seals, gaskets, O-rings and valve seats may change with age, exposure to process fluid, temperature, and /or pressure.

4-2 Troubleshooting

⚠ CAUTION

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

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A. System Checks

The 5851*i* 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 power supply connections and that the correct power supply voltage and signals are reaching and leaving the controller. The breakout board (P/N S273Z668AAA) listed in Section 5 will make this job much easier.
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 3-3.

⚠ WARNING

If it becomes necessary to remove the instrument from the system, power to the device must be disconnected.

⚠ WARNING

If it becomes necessary to remove the controller 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 disconnection 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.

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Table 4-1 Bench Troubleshooting

Trouble	Possible Cause	Check/Corrective Action
Actual flow overshoots setpoint by more than 5% full scale.	Anticipate potentiometer out of adjustment.	Adjust anticipate potentiometer. Refer to Section 3-5 .
Output stays at zero regardless of setpoint and there is no flow through the controller.	Clogged Sensor. Refer to Section 4-4.	Clean sensor. Refer to cleaning.
	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 Sections 4-4c and 2-10.
	Valve override input is grounded.	Check valve override input (Pin 12)
	Defective PC Board.	Replace PC Board. Refer to Section 4-4.
Output signal stays at +6.8V or 26 mA regardless of command and there is flow through the controller.	Valve stuck open or leaky.	Clean and/or adjust control valve. Refer to cleaning procedure and/or Section 4-4C.
	+22.5V -28Vdc applied to the valve override input.	Check the valve override terminal. (Pin 12)
	Defective PC Board.	Replace PC Board. Refer to Section 4-4.
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.
Output signal follows setpoint at lower setpoints but does not reach full scale.	Insufficient inlet pressure or pressure drop.	Adjust pressure, inspect the 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).
Controller grossly out of calibration. Flow is higher than desired.	Partially clogged sensor.	Clean sensor, refer to the cleaning procedure.
Controller grossly out of calibration. Flow is lower than desired.	Partially clogged restrictor.	Replace restrictor. Refer to Section 4-4.
Controller oscillates.	Pressure drop or inlet pressure excessive.	Adjust pressures.
	Oversized orifice.	Check orifice size. Refer to Section 4-6.
	Valve out of adjustment.	Adjust valve. Refer to Section 4-4.
	Anticipate potentiometer out of adjustment.	Adjust anticipate potentiometer. Refer to Section 3-5.
	Faulty pressure regulator.	Check regulator output.
	Defective PC Board.	Replace PC Board. Refer to Section 4-4.

B. Bench Troubleshooting

1. Properly connect the mass flow controller to a +22.5-28 Vdc power supply, setpoint source and connect an output signal readout device (4-1/2 digit voltmeter recommended) to pins 2 and 10 of the D-connector (refer to Figure 2-2). Apply power, set the setpoint to zero and allow the controller to warm up for 45 minutes. Do not connect to a gas source at this time. 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 controller to a source of the gas on which it was originally calibrated. Command 100% flow and adjust the inlet and outlet pressures to the calibration conditions. Verify that the output signal reaches and stabilizes at 5.00 volts or 20mA. Vary the setpoint over the 2 to 100% range and verify that the output signal follows the setpoint. Apply +22.5-28 volts to the valve override input (pin 12) and verify that the output exceeds 100%. Connect the valve override pin to ground and verify that the output signal falls below 2%. If possible, connect a flow measurement device in series with the mass flow controller to observe the actual flow behavior and verify the accuracy of the mass flow controller. If the mass flow controller functions as described above, it is functioning properly and the problem may lie elsewhere.

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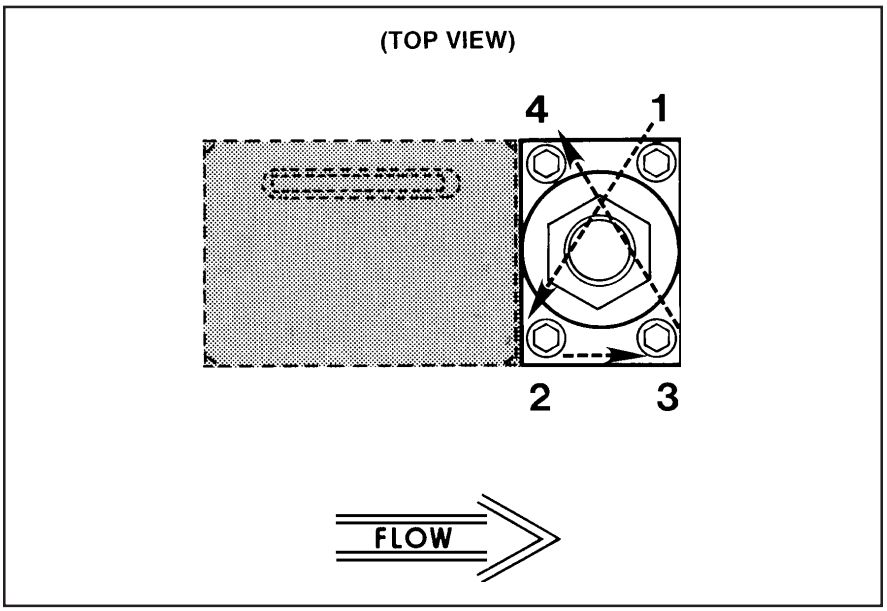


Figure 4-1 Torque Sequence for the Valve Retainer Plate

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

C. Sensor Troubleshooting

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.

NOTE: Do not attempt to disassemble the sensor.

D. Cleaning Procedures

Should the Model 5851*i* Mass Flow Controller 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

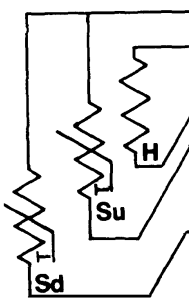
Do not soak the sensor assembly in a cleaning solution. If solvent seeps into the sensor assembly, it will probably damage the sensor, or, at least, significantly alter its operating characteristics.

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 or DI water. A hypodermic needle filled with solvent is a convenient means to accomplish this.

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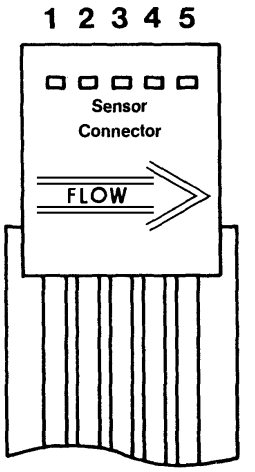
Table 4-2 Sensor Troubleshooting

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)

Note: Sensors manufactured before 9/88 used a wire harness interconnect, newer sensors use a "Flex" cable.



Flex Circuit Wire Numbers

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 ohm reading.

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

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.

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 a non-residuous solvent or DI water.
6. Restrictor elements can be cleaned in an ultrasonic bath or replaced. Refer to Section 4-7 for the correct restrictor to use.
7. Blow all parts dry with dry nitrogen and reassemble. Refer to Section 4-4b (assembly).

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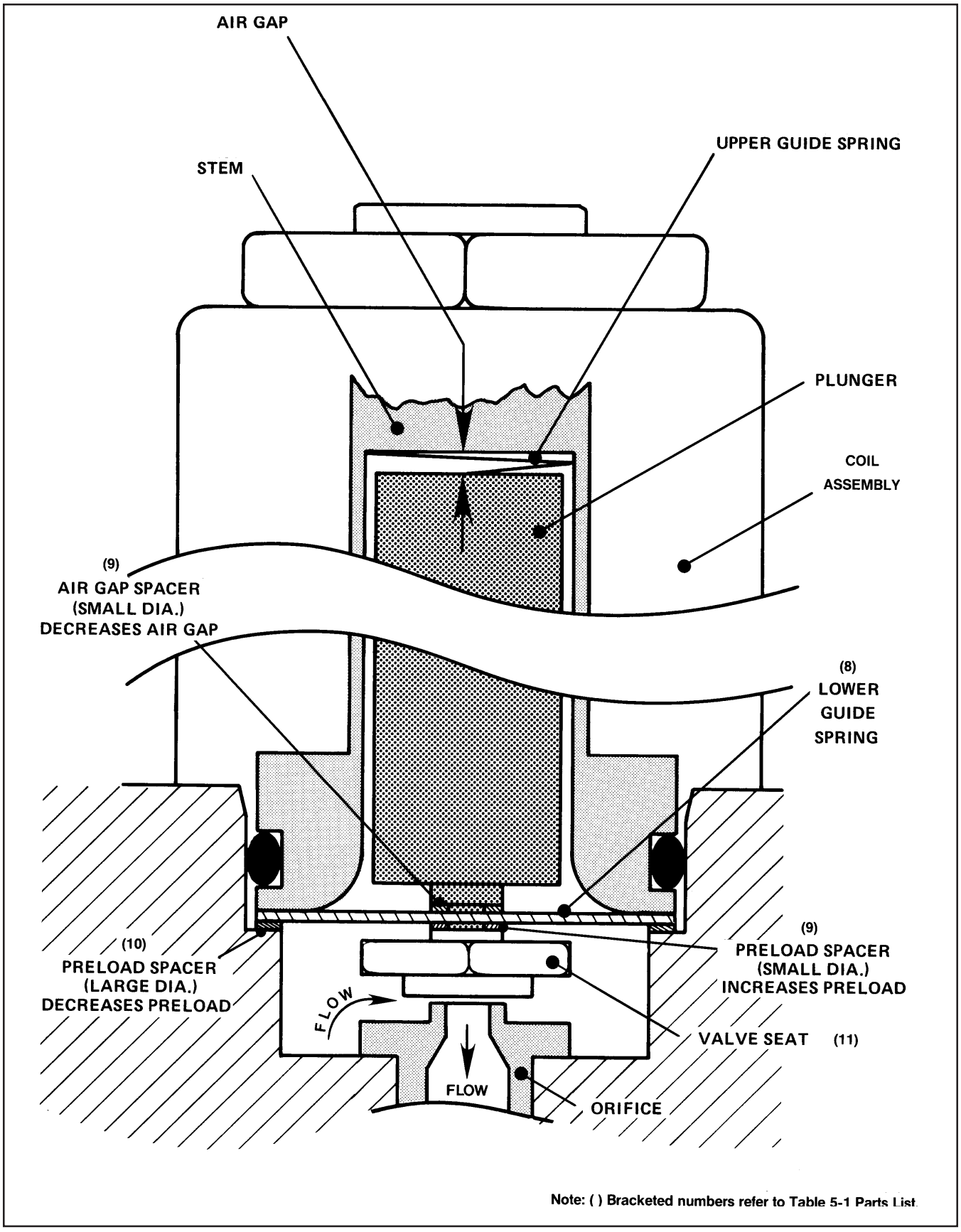


Figure 4-2 Valve Adjusting Spacer Locations

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8. Purge the assembled controller with dry nitrogen.
9. Perform the calibration procedure in Section 3-4.
10. When the controller is re-installed 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 Model 5851*i* Mass Flow Controller may be disassembled in the field by the user for cleaning, reranging or servicing. Disassemble and assemble the controller as follows:

NOTE: The 5851*i* Mass Flow Controller 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 Figure 5-1.

⚠ WARNING

If it becomes necessary to remove the controller 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. Do not attempt to disassemble the mass flow controller until pressure has been removed and purging has been performed. Failure to correctly purge the controller could result in hazardous gas being trapped in the valve assembly which could result in explosion, fire or serious injury/death. Corrosion or contamination of the mass flow controller upon exposure to air may also occur.

1. Remove the jam nut (1) on top of the valve assembly.
2. Unplug the valve connector from the electronics cover and remove the coil assembly (2).
3. Remove the hex socket screws (3) securing the valve retaining plate (4) attaching the valve stem assembly (6).

⚠ 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 (6).
5. Remove the plunger assembly (7, 8, 9 and 11).

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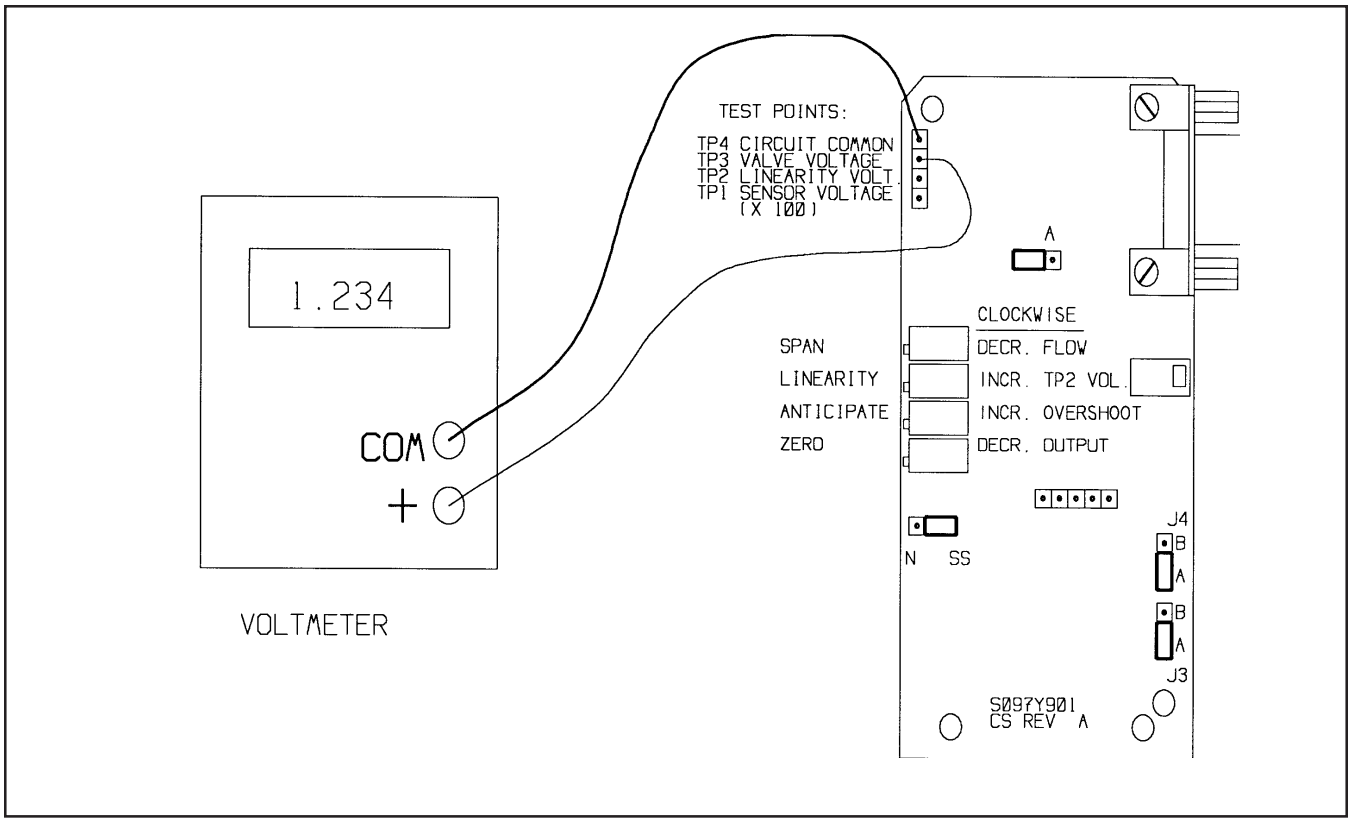


Figure 4-3 Voltmeter Connections for Valve Adjustment

6. Remove and note the position of the valve spring spacers (10) which may be located above and/or below the lower valve springs (8).
7. Unscrew the orifice (12) from the flow controller body (14) using the orifice removal tool. (See Section 5, Table 5-2.)
8. Remove the three screws (20) attaching the electronics cover. Remove the upper jack post on the D-connector. Remove the electronics cover (23).

⚠CAUTION

Be careful not to stress the sensor lead wire to sensor assembly junction when removing the sensor connector from the PC Board. If the sensor lead wires are stressed an opening in the sensor wiring could result.

9. Unplug the sensor connector from the PC Board. Remove the two screws (20) securing the bracket (24) and PC Board (15). Remove the bracket and PC Board.
10. Remove the two hex head screws (18) using a 1/8" hex wrench, and washers (19) securing the sensor assembly (16). Remove the sensor assembly.

NOTE: Do not attempt to disassemble the sensor assembly.

⚠CAUTION

Do not scratch the O-ring sealing service.

11. Remove the sensor assembly O-rings (17) from the flow controller body (14). Using the Brooks O-ring removal tool will help prevent scratching the sealing surface.

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12. Remove the adapter fittings and O-rings (27) from the flow controller body (14).
13. Remove the four screws (29) from the end block (28) and carefully remove the end block.
14. Remove the restrictor assembly (21) from the inlet side of the flow controller body (14) using the header removal tool (Section 5, Table 5-2). Note the rotational position of the restrictor assembly. (Refer to Section 4-7)

B. ASSEMBLY

⚠ CAUTION

Be careful not to stress the sensor lead wire to sensor assembly junction when removing the sensor connector from the PC Board. If the sensor lead wires are stressed an opening in the sensor wiring could result.

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

1. Examine all parts for signs of wear or damage, replace as necessary.
2. See Section 4-7 Restrictor Sizing, Assembly Procedures, Steps 1 through 3 on Page 22.

⚠ 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. Place the end block O-ring in position and install the end block with the four hex socket screws. Tighten these screws to 49 inch-lbs. Do not overtighten.

⚠ CAUTION

Do not scratch the O-ring sealing service.

4. Press the lubricated sensor O-rings (17) into the flow controller body (14). Install the sensor assembly and secure with two screws (18) and washers (19) and tighten to 15 in./lbs.
5. Install the orifice (12) and its O-ring (13) using a 3/8 nut driver. Insure that the orifice is fully seated but do not overtighten.
6. Insert the valve preload spacers (10), if used, into the valve cavity in the flow controller body (14). Use care to preserve the correct order.
7. Install the valve plunger assembly (7, 8, 9 and 11) on the preload spacers (10). Install air gap spacers (10), if used, on top of the valve springs.
8. Install the valve stem assembly (6), secure with the valve retaining plate (4) and four hex socket screws (3). 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 15 in./lbs.

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9. Install the coil assembly (2) over the valve stem assembly (6) and secure with a jam nut (1).
10. Install the PC Board (15), secure with the bracket (24) 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.
11. Install the electronics cover (23) on the controller, secure with three screws (20). Plug the connector from the valve coil into the PC Board through the hole in the electronics cover.
12. Prior to installation, leak and pressure test to any applicable pressure requirements.

C. Adjusting the Control Valve

The 5851*i* control valve has been factory adjusted to insure proper operation. Readjustment is only required if any of the following parts have been replaced:

orifice (12)
valve stem (6)
plunger (7)
lower guide springs (8)
valve seat (11)

The valve is adjusted in Brooks Mass Flow Controllers by adding spacers (9 and 10) 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 4-2 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.

Adjustment Procedure

(Refer to Section 5, Spare Parts for Spacer Kit)

a. Remove the electronics cover (23) from the controller. Insure that the connector from the coil assembly (2) 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.

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c. Disassemble the control valve following the procedure given in Section 4-4A above. Note the number, locations and thicknesses of all spacers (9 and 10).
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 4-2.
e. Reassemble the valve following the assembly procedure in Section 4-4a.
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 (5.000 Volts on terminal A, Pin 2).

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 low and/or the orifice size is too small. First check Section 4-6 to insure that the orifice size is correct.

k. Proceed to Section 3 and perform “3-4 Calibration Procedure,” if required.

4-5 Use of the Conversion Tables

If a mass flow controller is operated on a gas other than the gas it was calibrated with, a scale shift will occur in the relation between the output signal and the mass flow rate. This is due to the difference in heat capacities between the two gases. This scale shift can be approximated by using the ratio of the molar specific heat of the two gases or by sensor conversion factor. Table 4-3 has a list of sensor conversion factors. To change to a new gas, multiply the output reading by the ratio of the gas factor for the desired gas by the gas factor for the calibration gas used.

$$\text{Actual gas flow rate} = \text{Output reading} \times \frac{\text{factor of the new gas}}{\text{factor of the calibrated gas}}$$

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Example:
The controller is calibrated for Nitrogen.
The desired gas is Carbon Dioxide.
The output reading is 75 sccm when Carbon Dioxide is flowing.
Then 75 x 0.778 = 58.35 sccm

In order to calculate the conversion factor for a gas mixture, the following formula should be used:

$$\text{Sensor Conversion Factor}_{\text{Mixture}} = \frac{100}{\frac{P_1}{\text{Sensor Conversion Factor}_1} + \frac{P_2}{\text{Sensor Conversion Factor}_2} + \frac{P_3}{\text{Sensor Conversion Factor}_3}}$$

Where,
P1 = percentage (%) of gas 1 (by volume)
P2 = percentage (%) of gas 2 (by volume)
Pn = percentage (%) of gas n (by volume)
Example: The desired gas is 20% Helium (He) and 80% Chlorine (Cl) by volume. The desired full scale flow rate of the mixture is 20 slpm. Sensor conversion factor for the mixture is:

$$\text{Mixture Factor} = \frac{100}{\frac{20}{1.387} + \frac{80}{.828}} = .901$$

Nitrogen equivalent flow = 20/.901 = 22.20 slpm Nitrogen

It is generally accepted that the mass flow rate derived from this equation is only accurate to ±5%. The sensor conversion factors given in Table 4-3 are calculated based on a gas temperature of 21°C and a pressure of one atmosphere. The specific heat of most gases is not strongly pressure- and/or temperature-dependent. However, gas conditions that vary widely, from these reference conditions, may cause an additional error due to the change in specific heat caused by temperature and/or pressure.

4-6 Use of Orifice Sizing Nomograph

The Orifice Sizing Nomograph, Figure 4-5, is used to calculate the control valve's orifice size when changing any or all of the following factors from the original factory calibration:

gas
operating pressure (inlet and outlet)
flow range

The flow controller's orifice is factory-sized to a preselected gas, operating pressure and flow range. Note that the orifice is marked with its size in thousandths of an inch. When changing the aforementioned factors, calculate the new orifice size by following the procedure and example outlined in the following paragraphs.

Example: Determine the orifice size for the following conditions:

Gas: Hydrogen

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Table 4-3. Conversion Factors (Nitrogen Base).

GAS NAME	FORMULA	SENSOR FACTOR	ORIFICE FACTOR	DENSITY (kg/m³)
Acetylene	C_2H_2	0.615	0.970	1.173
Air	Mixture	0.998	1.018	1.293
Allene	C_3H_4	0.478	1.199	1.787
Ammonia	NH_3	0.786	0.781	0.771
Argon	Ar	1.395	1.195	1.784
Arsine	AsH_3	0.754	1.661	3.478
Boron Trichloride	BCL_3	0.443	2.044	5.227
Boron Trifluoride	BF_3	0.579	1.569	3.025
Bromine Pentafluoride	BrF_5	0.287	2.502	7.806
Bromine Trifluoride	BrF_3	0.439	2.214	6.108
Bromotrifluoroethylene	C_2BrF_3	0.326	2.397	7.165
Bromotrifluoromethane f-13B1	$CBrF_3$	0.412	2.303	6.615
1,3-Butadiene	C_4H_6	0.354	1.413	2.491
Butane	C_4H_{10}	0.257	1.467	2.593
1-Butene	C_4H_8	0.294	1.435	2.503
CIS-2-Butene	C_4H_8	0.320	1.435	2.503
Trans-2-Butene	C_4H_8	0.291	1.435	2.503
Carbon Dioxide	CO_2	0.740	1.255	1.977
Carbon Disulfide	CS_2	0.638	1.650	3.393
Carbon Monoxide	CO	0.995	1.000	1.250
Carbon Tetrachloride	CCL_4	0.344	2.345	6.860
Carbon Tetrafluoride f-14	CF_4	0.440	1.770	3.926
Carbonyl Fluoride	COF_2	0.567	1.555	2.045
Carbonyl Sulfide	COS	0.680	1.463	2.180
Chlorine	CL_2	0.876	1.598	3.214
Chlorine Dioxide	CLO_2	0.693	1.554	3.011
Chlorine Trifluoride	CLF_3	0.433	1.812	4.125
2-Chlorobutane	C_4H_9Cl	0.234	1.818	4.134
Chlorodifluoromethane f-22	$CHCLF_2$	0.505	1.770	3.906
Chloroform (Trichloromethane)	$CHCL_3$	0.442	2.066	5.340
Chloropentafluoroethane f-115	C_2CLF_5	0.243	2.397	7.165
Chlorotrifluoroethylene	C_2CLF_3	0.337	2.044	5.208
Chlorotrifluoromethane f-13	$CCLF_3$	0.430	1.985	4.912
Cyanogen	$(CN)_2$	0.498	1.366	2.322
Cyanogen Chloride	CLCN	0.618	1.480	2.730
Cyclobutane	C_4H_8	0.387	1.413	2.491
Cyclopropane	C_3H_6	0.505	1.224	1.877
Deuterium	D_2	0.995	0.379	0.177
Diborane	B_2H_6	0.448	1.000	1.235
Diboromodifluoromethane f-12B2	CBr_2F_2	0.363	2.652	8.768
1,2-Dibromotetrafluoroethane f-114B2	$C_2Br_2F_4$	0.215	2.905	10.53
Dichlorodifluoromethane f-12	CCL_2F_2	0.390	2.099	5.492
Dichlorofluoromethane f-21	$CHCL_2F$	0.456	1.985	4.912
Dichlorosilane	SiH_2CL_2	0.442	1.897	4.506
1,2-Dichloroethane	$C_2H_4Cl_2$	0.382	1.879	4.419
1,2-Dichlorotetrafluoroethane f-114	$C_2CL_2F_4$	0.231	2.449	7.479
2,2 Dichloro	$C_2HC_{12}F_3$	0.259	2.336	6.829
1,1-Difluoro-1-Chloroethane	$C_2H_3CLF_2$	0.341	1.957	4.776
1,1-Difluoroethane	CH_3CHF_2	0.415	1.536	2.940
1,1-Difluoroethylene	CH_2CF_2	0.458	1.512	2.860
Diethylsilane	$C_4H_{12}Si$	0.183	1.775	3.940
Difluoromethane f-32	CF_2H_2	0.627	1.360	2.411
Dimethylamine	$(CH_3)_2NH$	0.370	1.269	2.013
Dimethylether	$(CH_3)_2O$	0.392	1.281	2.055
2,2-Dimethylpropane	$C(CH_3)_4$	0.247	1.613	3.244
Disilane	Si_2H_6	0.332	1.493	2.779
Ethane	C_2H_6	0.490	1.038	1.357
Ethanol	C_2H_6O	0.394	1.282	2.057
Ethylacetylene	C_4H_6	0.365	1.384	2.388
Ethyl Chloride	C_2H_5CL	0.408	1.516	2.879
Ethylene	C_2H_4	0.619	1.000	1.261
Ethylene Oxide	C_2H_4O	0.589	1.254	1.965
Fluorine	F_2	0.924	1.163	1.695
Fluoroform f-23	CHF_3	0.529	1.584	3.127
Germane	GeH_4	0.649	1.653	3.418
Germanium Tetrachloride	$GeCl_4$	0.268	2.766	9.574
Halothane (R-123B1)	$C_2HBrClF_3$	0.257	2.654	8.814
Helium	He	1.386	0.378	0.178
Hexafluoroacetone	F_3CCOCF_3	0.219	2.434	7.414
Hexaflorobenzine	C_6F_6	0.632	2.577	8.309
Hexafluoroethane f-116	C_2F_6	0.255	2.219	6.139
Hexafuoropropylene (HFP)	C_3F_6	0.249	2.312	6.663
Hexamethyldisilane (HMDS)	$(CH_3)_6Si_2$	0.139	2.404	7.208
Hexane	C_6H_{14}	0.204	1.757	3.847

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Table 4-3. Conversion Factors (Nitrogen Base) Continued.

GAS NAME	FORMULA	SENSOR FACTOR	ORIFICE FACTOR	DENSITY (kg/m³)
Hydrogen	H_2	1.008	0.269	0.090
Hydrogen Bromide	HBr	0.987	1.695	3.645
Hydrogen Chloride	HCL	0.983	1.141	1.639
Hydrogen Cyanide	HCN	0.744	0.973	1.179
Hydrogen Fluoride	HF	0.998	0.845	0.893
Hydrogen Iodide	HI	0.953	2.144	5.789
Hydrogen Selenide	H_2Se	0.837	1.695	3.613
Hydrogen Sulfide	H_2S	0.850	1.108	1.539
Iodine Pentafluoride	IF_5	0.283	2.819	9.907
Isobutane	C_4H_{10}	0.260	1.440	2.593
Isobutene	C_4H_8	0.289	1.435	2.503
Isopentane	C_5H_{12}	0.211	1.605	3.222
Krypton	Kr	1.382	1.729	3.708
Methane	CH_4	0.763	0.763	0.717
Methylacetylene	C_3H_4	0.473	1.196	1.782
Methyl Bromide	CH_3Br	0.646	1.834	4.236
3-Methyl-1-butene	C_5H_{10}	0.252	1.584	3.127
Methyl Chloride	CH_3CL	0.687	1.347	2.308
Methyl Fluoride	CH_3F	0.761	1.102	1.518
Methyl Mercaptan	CH_4S	0.588	1.313	2.146
Methyl Silane	CH_6Si	0.393	1.283	2.061
Methyl Trichlorosilane (MTS)	CH_3Cl_3Si	0.267	2.310	6.675
Methyl Vinyl Ether	C_3H_6O	0.377	1.435	2.567
Monoethanolamine	C_2H_7NO	0.305	1.477	2.728
Monoethylamine	$C_2HH_5NH_2$	0.359	1.269	2.013
Monomethylamine	CH_3NH_2	0.565	1.067	1.420
Neon	Ne	1.398	0.847	0.902
Nickel Carbonyl	$Ni(CO)_4$	0.212	2.371	7.008
Nitric Oxide	NO	0.995	1.030	1.339
Nitrogen	N_2	1.000	1.000	1.251
Nitrogen Dioxide	NO_2	0.758	1.713	2.052
Nitrogen Trifluoride	NF_3	0.501	1.598	3.168
Nitrogen Trioxide	N_2O_3	0.443	1.649	3.389
Nitrosyl Chloride	NOCL	0.644	1.529	2.913
Nitrous Oxide	N_2O	0.752	1.259	1.964
Octofluorocyclobutane	C_4F_8	0.169	2.672	8.933
Oxygen	O_2	0.988	1.067	1.429
Oxygen Difluoride	OF_2	0.672	1.388	2.402
Ozone	O_3	0.738	1.310	2.138
Pentafluorethane f-125	C_2HF_5	0.287	2.070	5.360
Pentane (n-Pentane)	C_5H_{12}	0.212	1.605	3.222
Perchloryl Fluoride	CLO_3F	0.448	1.905	4.571
Perfluorobutane	C_4F_{10}	0.738	2.918	10.61
Perfluoro-2-Butene	C_4F_8	0.268	2.672	8.933
Perfluoromethyl-vinylether	PMVE	0.296	2.029	5.131
Perfluoropropane	C_3F_8	0.179	2.591	8.396
Pentane (n-Pentane)	C_5H_{12}	0.212	1.605	3.222
Phosgene	$COCL_2$	0.504	1.881	4.418
Phosphine	PH_3	0.783	1.100	1.517
Phosphorous Pentafluoride	PF_5	0.346	2.109	5.620
Phosphorous Trifluoride	PF_3	0.495	1.770	3.906
Propane (same as $CH_3CH_2CH_3$)	C_3H_8	0.343	1.274	2.008
Propylene (Propene)	C_3H_6	0.401	1.234	1.875
Rhenium Hexafluoride	ReF_6	0.230	3.279	13.41
Silane	SiH_4	0.625	1.070	1.440
Silicon Tetrachloride	$SiCL_4$	0.310	2.465	7.579
Silicon Tetrafluoride	SiF_4	0.395	1.931	4.648
Sulfur Dioxide	SO_2	0.728	1.529	2.858
Sulfur Hexafluoride	SF_6	0.270	2.348	6.516
Sulfur Tetrafluoride	SF_4	0.353	1.957	4.776
Sulfur Trioxide	SO_3	0.535	1.691	3.575
Sulfuryl Fluoride	SO_2F_2	0.423	1.931	4.648
Tetrachloromethane	CCL_4	0.344	2.345	6.858
Tetrafluoroethylene (TFE)	C_2F_4	0.361	1.905	4.526
Tetrafluorohydrazine	N_2F_4	0.367	1.926	4.624
Trichlorofluoromethane f-11	CCL_3F	0.374	2.244	6.281
Trichlorosilane	$SiHCL_3$	0.329	2.201	6.038
Trimethyloxyborane (TMB)	$B(OCH_3)_3$	0.300	1.929	4.638
1,1,2-Trichloro-1,1,2-Triflouroet f-113	$C_2CL_3F_3$	0.231	2.520	7.920
Trimethylamine	$(CH_3)_3N$	0.316	1.467	2.639
Tungsten Hexafluoride	WF_6	0.227	3.264	13.28
Uranimum Hexafluoride	UF_6	0.220	3.548	15.70
Vinyl Bromide	C_2H_3Br	0.524	1.985	4.772
Vinyl Chloride	C_2H_3CL	0.542	1.492	2.788
Vinyl Fluoride	C_2H_3F	0.576	1.281	2.046
Water Vapor	H_2O	0.861	0.802	0.804
Xenon	Xe	1.383	2.180	5.851

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Flow Rate: 100 slpm
Outlet Pressure: 30 psig
Inlet Pressure: 50 psig

1. Determine Nitrogen equivalent flow rate (refer to Table 4-3).

$$Q_{NITROGEN} = Q_{GAS} \times \sqrt{\frac{\rho_{GAS}}{\rho_{NITROGEN}}}$$

OR

$$Q_{NITROGEN} = Q_{GAS} \times \sqrt{\frac{SG_{GAS}}{SG_{NITROGEN}}}$$

$Q_{Nitrogen}$	=	Nitrogen equivalent flow rate (sccm)
Q_{gas}	=	Desired flow rate of the gas (sccm)
$D_{Nitrogen}$	=	Density of Nitrogen at 70°F
D_{gas}	=	Density of the gas (taken at customer temperature)
SG_{gas}	=	Specific gravity of the gas (taken at customer temperature)

Refer to Table 4-3 for specific gravities.
Example:

$$Q_{GAS} = 100 \text{ slpm}$$

$$\sqrt{\frac{SG_{GAS}}{SG_{NITROGEN}}} = .269$$

$$Q_{NITROGEN} = Q_{GAS} \times \sqrt{\frac{SG_{GAS}}{SG_{NITROGEN}}}$$

$$= 100 \times .269$$

$$= 26.9 \text{ slpm Nitrogen}$$

In order to calculate the orifice conversion factor when using a gas mixture, the following formula must be used:

$$\text{Orifice Conversion Factor Mixture} = \sqrt{\frac{P_1\left(\text{Orfice Conversion Factor 1}\right) + P_2\left(\text{Orfice Conversion Factor 2}\right) + P_n\left(\text{Orfice Conversion Factor n}\right)}{100}}$$

Where	P1	=	percentage by volume of gas 1
	P2	=	percentage by volume of gas 2
	Pn	=	percentage by volume of gas n

Example: Find the Nitrogen equivalent flow for 20 slpm of a 20% Helium and 80% Chlorine gas mixture.

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$$\text{Orifice Conversion Factor Mixture} = \sqrt{\frac{20(.378)^2 + 80(1.598)^2}{100}}$$

$$Q_{Nitrogen} = Q_{gas}\,(\text{orifice conversion factor})$$
$$= 20 \times 1.439$$
$$= 28.34 \text{ slpm Nitrogen}$$

2. If inlet and outlet pressures are given in gauge pressure (psig) add 14.7 to convert to absolute pressure (psia).

   Outlet Pressure — 30 psig + 14.7 = 44.7 psia
   Inlet Pressure — 50 psig + 14.7 = 64.7 psia

3. Determine Critical Pressure Drop
   Critical pressure drop occurs when the outlet pressure (psia) is less than half the inlet pressure (psia) or

$$P_{outlet} < \frac{P_{inlet}}{2}$$

If these conditions exist, the pressure drop (Δp) should be calculated as follows:

$$\Delta P = \frac{P_{in}}{2}$$

ΔP = Pressure Drop (psi)

P_{IN} = Inlet Pressure (psia)

If these conditions do not exist, pressure drop equals the inlet pressure minus the outlet pressure.

$$\text{Is } 44.7 \text{ psia} < \frac{64.7 \text{ psia}}{2} ? \quad — \quad \text{No.}$$

Then $\Delta p = 64.7 - 44.7 = 20$ psi

4. Using the nomograph, locate the pressure drop (psi) on the vertical line marked "Dp" (Point A).
5. Locate the Nitrogen equivalent flow rate (sccm Nitrogen) on the vertical line marked "$Q_{Nitrogen}$" (Point B).
6. Draw a line connecting Dp and $Q_{Nitrogen}$ and extend it to the baseline. Mark this point (Point C).
7. Locate inlet pressure (psia) on the vertical line marked "P_{in}" (Point D).
8. Draw a line connecting P_{in} (Point D) and baseline (Point C) and then extend this line to the vertical line marked D_o (orifice diameter, inches) (Point E).
9. This point on the line is the minimum orifice size for the given conditions. If this point is between two orifice sizes, select the next largest size orifice to ensure adequate flow. If the orifice selected falls below .0013, choose .0013 size orifice.

For the example in Figure 4-4, the .007 size orifice would be selected.

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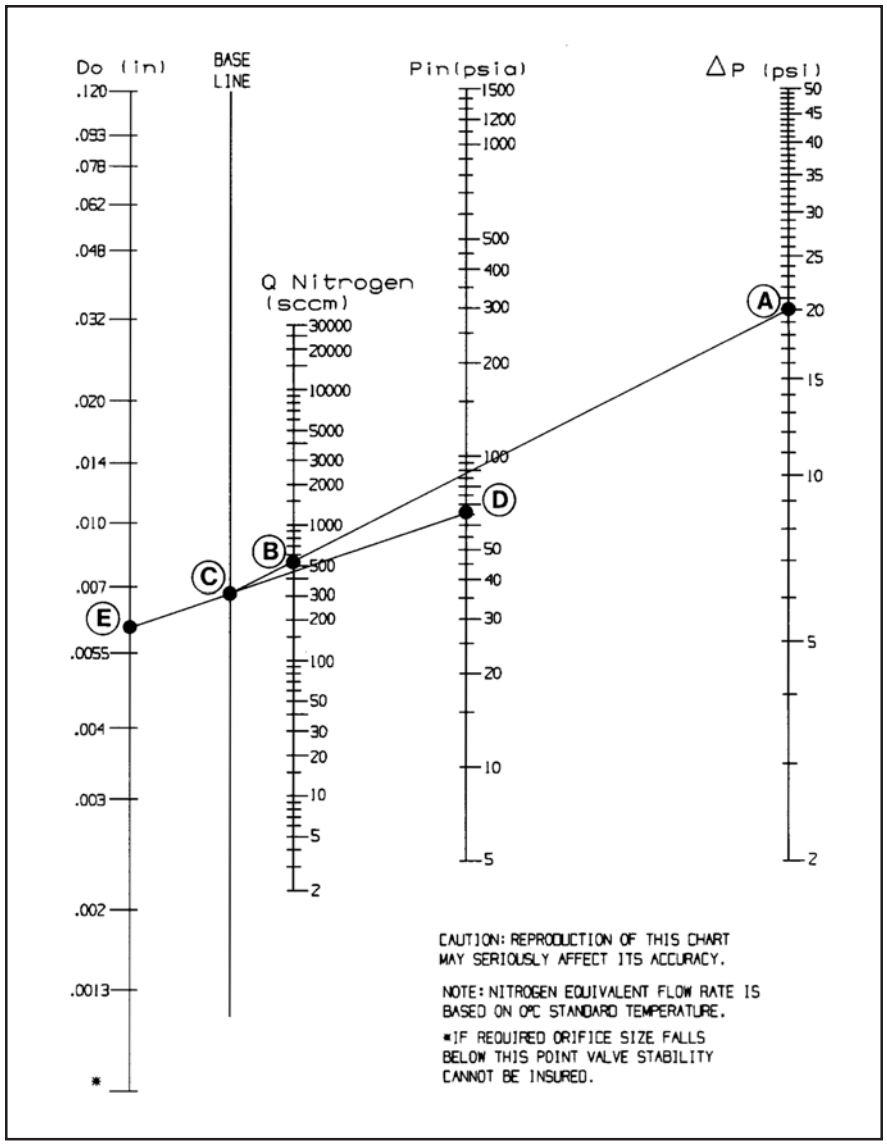


Figure 4-4 Example Nomograph

Table 4-4 5851i Restrictor Selection Guide.

Range slpm Nitrogen Equivalent Flow*	Restrictor Element Combination	Part Number
4.6 to 15	1-40 micron (1 inch)	S-613-E-604-BMT
15 to 26	1-40 micron	S-613-E-636-BMT
26 to 42	2-40 micron	S-613-E-523-BMT
42 to 60	3-40 micron	S-613-E-526-BMT
60 to 79	2-40 micron/1-60 micron	S-613-E-528-BMT
79 to 93	1-40 micron/2-60 micron	S-613-E-529-BMT
93 to 130**	3-60 micron	S-613-E-527-BMT

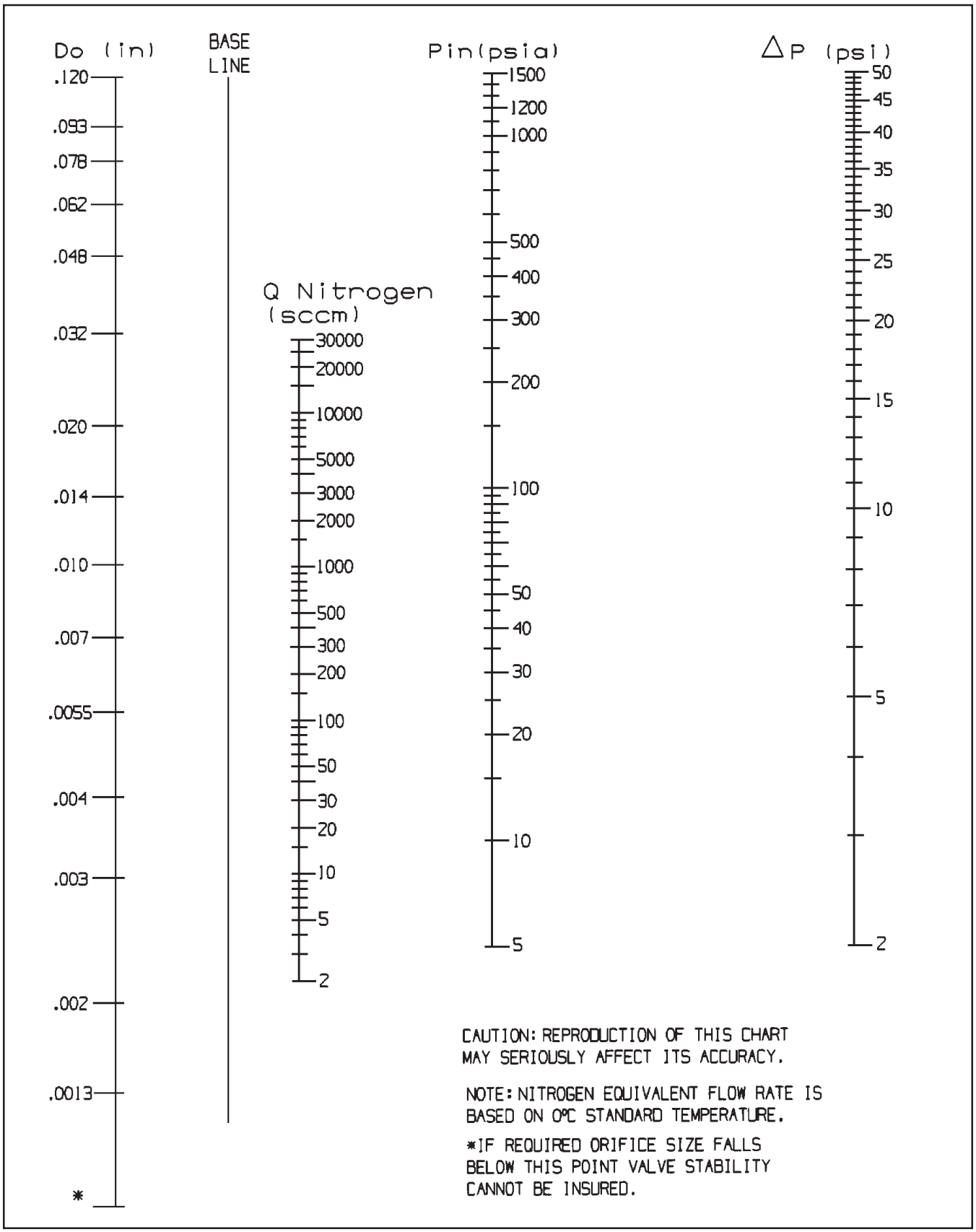
* Based on 0°C Standard Reference Temperature

** For Hydrogen from 130 slpm to 200 slpm use 3-60 micron restrictor elements.

NOTE: If the nitrogen equivalent flow is between two sizes, select the larger size.

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Table 4-5 Model 5851i Orifice Sizing Nomograph



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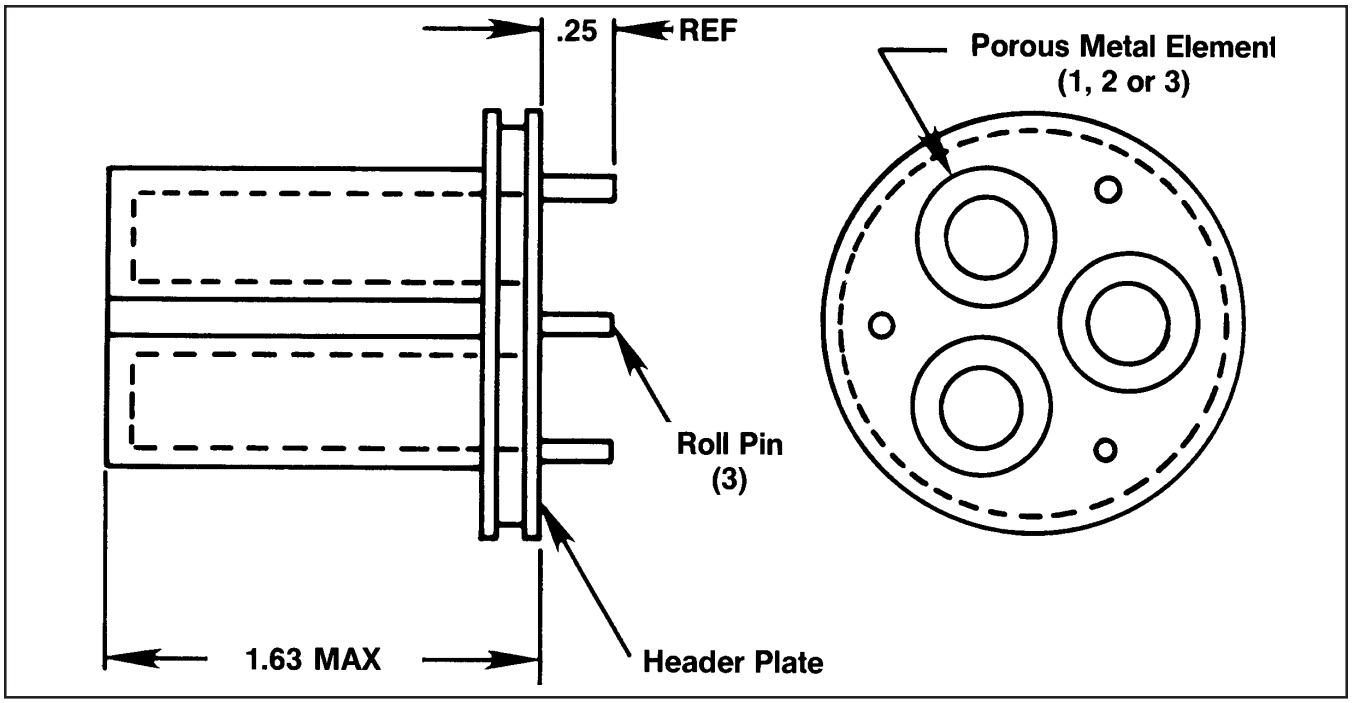


Figure 4-6 Model 5851*i* Restrictor Element Assembly

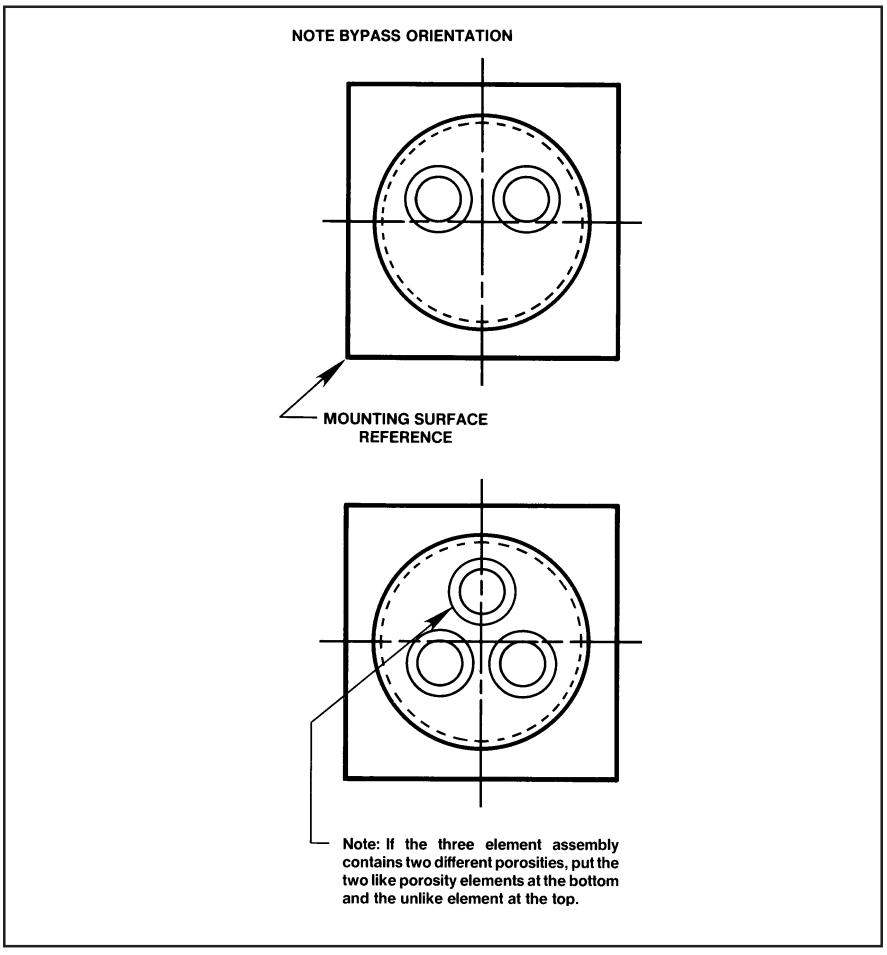


Figure 4-7 Model 5851i Restrictor Element Orientation in Controller Body

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4-7 Restrictor Sizing

The restrictor assembly is a ranging device for the sensor portion of the controller. 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 ratio of sensor flow to restrictor flow, however, the total flow through each restrictor is different. Different restrictors have different pressure drops and produce controllers with different full scale flow rates. For a discussion of the interaction of the various parts of the controller, you are urged to review Section 3-1 “Theory of Operation.”

If the restrictor assembly has been contaminated with foreign matter, the pressure drop versus 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 controller is to be calibrated to a new flow rate.

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

Appropriate size hex wrench for the removal of the inlet block.
Restrictor removal tool may be required (contained in Service Tool Kit P/N S778D017AAA)
Restrictor O-ring, refer to the spare parts Section 5 for the correct part number.

The 5851*i* Mass Flow Controller utilizes porous metal restrictor assemblies for all full scale flow rates. Restrictor elements with porosities of 40 and 60 microns are used in different combinations. Up to three restrictor elements can be placed in one assembly. These restrictors are assembled by pressing the porous metal elements into the header plate.

When sizing a restrictor assembly for gases other than nitrogen, the sensor conversion factor must be included as the restrictor is used to divert a portion of the process flow through the sensor. Use the following equation to obtain the desired output in nitrogen equivalent units. Refer to Table 4-3 for the conversion factor list.

Example:
The desired gas is cyanogen (C_2N_2).
The desired full scale flow rate is 30 slpm.
Sensor conversion factor is 0.499 from Table 4-3.
Nitrogen equivalent flow = 30/0.499 = 60.1 slpm Nitrogen.

In the example above, the restrictor should be sized for a 60.1 slpm flow rate (P/N S613E528BMT).

If a restrictor assembly is being replaced because the original has become contaminated, the original may be used as a guide to select the replacement assembly. The porosity of the original element or elements is marked on the calibration sheet which was shipped with the flow controller. The replacement assembly should be replaced in the same orientation as the original restrictor.

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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 4-7). 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 49 in./lbs. Do not over-tighten.

⚠ CAUTION

The end block screws (29) and the valve screws (3) are not interchangeable. The end block screws are stronger and are needed to achieve the pressure rating. The end block screws are darker in color and can be attracted by a magnet.

5. Install the inlet adaptor fitting and O-ring.
6. Calibrate the mass flow controller (Refer to Section 3-4). If the TP2 voltage as calculated in the calibration procedure, Section 3-4, step f, is below 1.2 volts, the flow rate will be greater than desired. If this occurs, the restrictor assembly should be replaced with the next lower flow rate assembly. If the TP1 procedure, Section 3-4 step f is greater than 4.5 volts, the flow through the controller will be less than desired. If this occurs, the restrictor assembly should be replaced with the next higher flow rate assembly.

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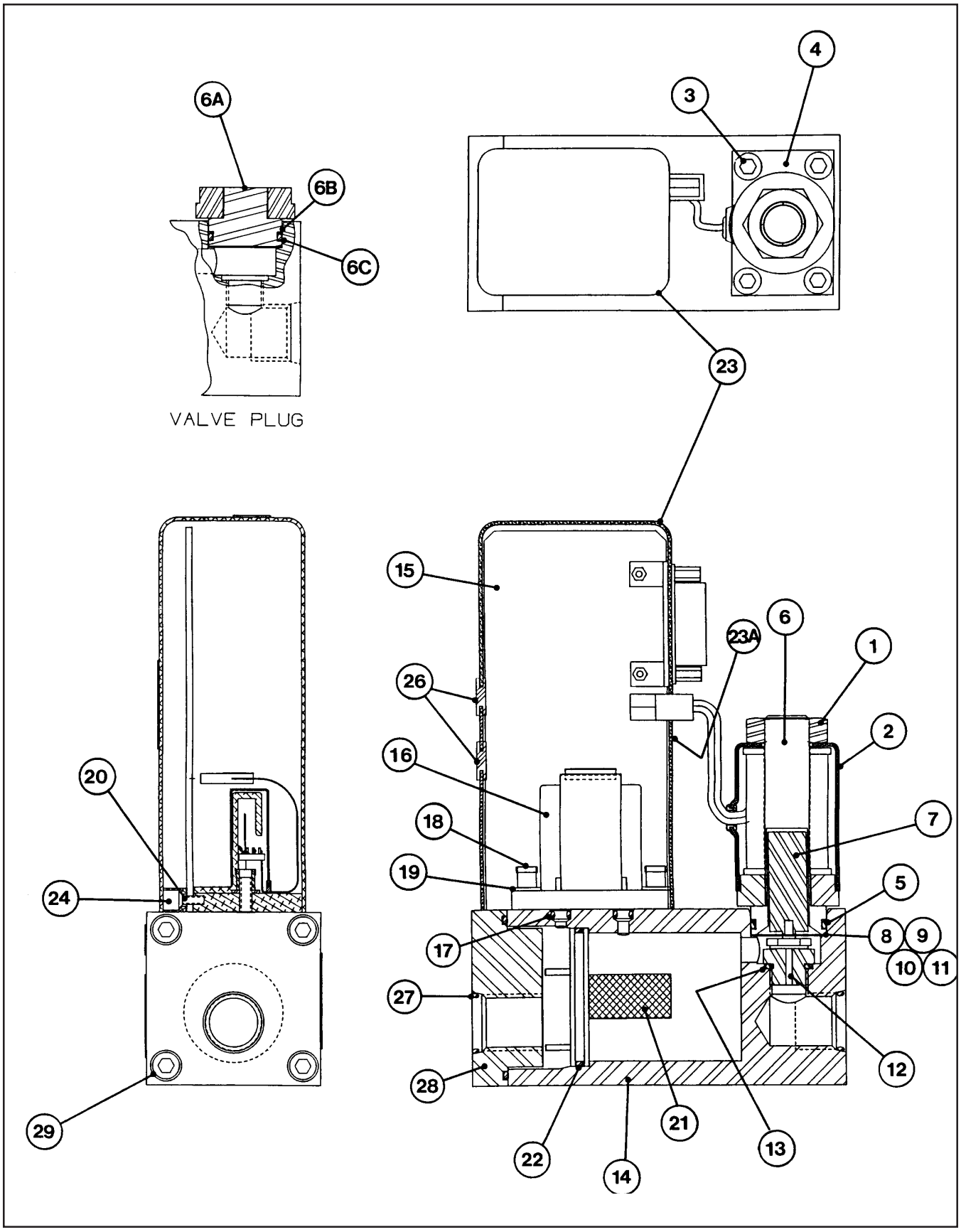
5-1 General

When ordering parts, please specify:

Brooks Serial Number
Model Number
Part Description
Part Number
Quantity

(Refer to Figure 5-1 and Tables 5-1 and 5-2).

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5-2 *Figure 5-1 Model 5851i Parts Drawing*

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Table 5-1 Model 5851i Replacement Parts List (Continued on next page)

Item No.	Quantity	Description		Part Number
1	1	Jam Nut		573B027ACK
2	1	Coil Assembly		S185Z271AAA
3	4	Screw, Valve		751C322AWA
4	1	Retaining Plate		715Z169CZ%
5	1	O-Ring, Valve Stem, Size 016		375B016***
6	1	Valve Stem, High Flow		949Z203QOA
6A	1	Valve Plug		953Z068BMT
6B	1	Valve Ring		763Z064***
6C	1	Valve O-Ring		375B016***
7	1	Valve Plunger Assembly, High Flow		S622Z165AAA
8	1	Lower Guide Spring		820Z083BMA
9	AR	Small Valve Spacer, 0.005" Thick		810A362BMA
		Small Valve Spacer, 0.010" Thick		810A363BMA
10	AR	Large Valve Spacer, 0.005" Thick		810A368BMA
		Large Valve Spacer, 0.010" Thick		810A361BMA
11	1	Valve Seat with Viton™ Insert		S715Z051AAG
		Valve Seat with Buna Insert		S715Z050AAG
		Valve Seat with Kalrez™ Insert		S715Z163AAA
		Valve Seat Solid 316 Stainless Steel		715Z181BNT
12	1	Orifice, Stainless Steel	ID 0.0040"	577Z275BMT
			ID 0.0067"	577Z277BMT
			ID 0.0091"	577Z280BMT
			ID 0.0120"	577Z283BMT
			ID 0.0160"	577Z286BMT
			ID 0.0210"	577Z289BMT
			ID 0.0260"	577Z293BMT
			ID 0.0310"	577Z296BMT
			ID 0.0360"	577Z300BMT
			ID 0.0410"	577Z305BMT
			ID 0.0465"	577Z308BMT
			ID 0.0550"	577Z310BMT
		(Refer to Section 4-6	ID 0.0635"	577Z312BMT
		for sizing)	ID 0.0700"	577Z314BMT
			ID 0.0760"	577Z316BMT
			ID 0.0820"	577Z319BMT
			ID 0.0935"	577Z322BMT
			ID 0.1065"	577Z328BMT
			ID 0.1200"	577Z333BMT
			ID 0.1405"	577C336BMT
13	1	O-Ring, Orifice, Size 0011		375B011***
14	1	Controller Body		S854Z157BMA
15	1	PC Board Assembly (D-Connector)		S097Y901AAA
16	1	Sensor Assembly		S774Z607AAA
17	2	O-Ring, Sensor, Size 004		375B004***
18	2	Allen Nut, Sensor-Body		753Q103ACZ
19	2	Lock Washer, Sensor		962D005AWA
20	5	Screw, Sensor-PC, Board-Cover		753L056AWZ
21	1	Restrictor Assembly and Components (Refer to Section 4-7 for sizing)		
22	1	O-Ring, Restrictor, Size 026		375B026***
23	1	Electronics Cover Can (D-Connector)		219Z431EA%
23A	1	Cover Plate (D-Connector)		852Z209EA%
24	1	PC Board Mounting Bracket		079Z135EAA
26	2	Pot Hole Plug		620Z434SXA

*** QTA = Viton™, SUA = Buna, TTA = Kalrez™
AR As required, NS Not Shown

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*Table 5-1 Model 5851*i *Replacement Parts List (Continued)*

Item No.	Quantity	Description		Part Number
NS	2	Fitting, 1/4" Compression, Swagelok		320B136BMA
		Fitting, 1/4" Male VCR, Cajon		315Z036BMA
		Fitting, 1/4" Male VCO, Cajon		315Z035BMA
		Fitting, 3/8" Compression		320B150BMA
		Fitting, 3/8" Male VCO (3/8" or 1/2" Tube)		315Z033BMA
		Fitting, 3/8" Male VCR (3/8" or 1/2" Tube)		315Z034BMA
27	2	O-Ring, Fitting, Size 906		375B906***
NS	2	O-Ring, VCO Gland, Size 010		375B010***
NS	1	O-Ring, End Block, Size 029		375B029***
NS	1	Interconnecting Cables	**Length**	**D-Connector**
		D-Connector on one end with no	5 Feet	S124Z361AAA
		termination on the other end	10 Feet	S124Z362AAA
			25 Feet	S124Z363AAA
			50 Feet	S124Z435AAA
NS	2	8-32 Mounting Screw		Customer Supplied
28	1	End Block with Integral Inlet Screen		S079Z200AAA
29	4	Screw, End Block		751Z105AAO

*** QTA = Viton, SUA = Buna, TTA = Kalrez
AR As required, NS Not Shown

Table 5-2 Tool and Spare Part Kits for 5850 Series

5850/5851 Series Service Tool Kit
P/N S778D017AAA

Permits the complete disassembly of the 5850*i* for servicing

Contains:

1 — O-Ring Removal Tool
1 — Potentiometer Adjustment Tool
1 — Ball Point Allen Wrench
1 — Phillips Screw Driver
1 — Nut Driver for Orifice
1 — Restrictor Removal Tool
1 — Common Screw Driver

5851 Header Removal Tool
P/N S817Z036AAA

0550/5851 Orifice Removal Tool
P/N S908Z049AAA

5850/5851 Series Break Out Board Assembly
P/N S273Z668AAA

Installs directly between mass flow controller and interconnecting cable. Allows convenient access to all signals for easy trouble-shooting of system.

Contains:

1 — Break Out PC Board
1 — 5 Foot Extension Cable
1 — Terminal PC Board

5850/5851 Series Valve Shim Kit
P/N S810A372BMA

Contains:
1 — .010" Large Spacer
2 — .005" Large Spacers
1 — .010" Small Spacer
2 — .005" Small Spacers

*** QTA = Viton, SUA = Buna, TTA = Kalrez

NOTE: Refer to Brooks' publication DS-5800 for additional accessories.

Additional publications available:
T-086 MFC Contamination Control in Semiconductor Processing Equipment Valve Application Guide/Service Manual

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Dansk

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Emne : Tillæg til instruktions manual.
Reference : CE mærkning af Masse Flow udstyr
Dato : Januar-1996.

Brooks Instrument har gennemført CE mærkning af elektronisk udstyr med succes, i henhold til regulativet om elektrisk støj (EMC direktivet 89/336/EEC).
Der skal dog gøres opmærksom på benyttelsen af signalkabler i forbindelse med CE mærkede udstyr.

Kvaliteten af signal kabler og stik:

Brooks lever kabler af høj kvalitet, der imødekommer specifikationerne til CE mærkning.
Hvis der anvendes andre kabel typer skal der benyttes et skærmet kabel med hel skærm med 100% dækning.
Forbindelses stikket type “D” eller “cirkulære”, skal være skærmet med metalhus og eventuelle PG-forskruninger skal enten være af metal eller metal skærmet.
Skærmen skal forbindes, i begge ender, til stikkets metalhus eller PG-forskruningen og have forbindelse over 360 grader.
Skærmen bør være forbundet til jord.
“Card Edge” stik er standard ikke af metal, der skal derfor ligeledes benyttes et skærmet kabel med hel skærm med 100% dækning.
Skærmen bør være forbundet til jord.
Forbindelse af stikket; venligst referer til vedlagte instruktions manual.
Med venlig hilsen,

Deutsch

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Subject : Nachtrag zur Bedienungsanleitung.
Referenz : CE Zertifizierung für Massedurchflußgeräte
Datum : Januar-1996.

Nach erfolgreichen Tests enstprechend den Vorschiften der Elektromagnetischen Verträglichkeit (EMC Richtlinie 89/336/EEC) erhalten die Brooks-Geräte (elektrische/elektronische Komponenten) das CE-Zeichen.
Bei der Auswahl der Verbindungskabel für CE-zertifizierte Geräte sind spezielle Anforderungen zu beachten.

Qualität der Verbindungskabel, Anschlußstecker und der Kabeldurchführungen

Die hochwertigen Qualitätskabel von Brooks entsprechen der Spezifikation der CE-Zertifizierung.
Bei Verwendung eigener Verbindungskabel sollten Sie darauf achten, daß eine
100 %igenSchirmababdeckung des Kabels gewährleistet ist.
“D” oder “Rund” -Verbindungsstecker sollten eine Abschirmung aus Metall besitzen.
Wenn möglich, sollten Kabeldurchführungen mit Anschlußmöglichkeiten für die Kabelabschrimung verwendet werden.
Die Abschirmung des Kabels ist auf beiden Seiten des Steckers oder der Kabeldurchführungen über den vollen Umfang von 360 ° anzuschließen.
Die Abschirmung ist mit dem Erdpotential zu verbinden.
Platinen-Steckverbindunger sind standardmäßige keine metallgeschirmten Verbindungen. Um die Anforderungen der CE-Zertifizierung zu erfüllen, sind Kabel mit einer 100 %igen Schirmababdeckung zu verwenden.
Die Abschirmung ist mit dem Erdpotential zu verbinden.
Die Belegung der Anschlußpins können Sie dem beigelegten Bedienungshandbuch entnehmen.

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English

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Subject : Addendum to the Instruction Manual.
Reference : CE certification of Mass Flow Equipment
Date : January-1996.

The Brooks (electric/electronic) equipment bearing the CE mark has been successfully tested to the regulations of the Electro Magnetic Compatibility (EMC directive 89/336/EEC).
Special attention however is required when selecting the signal cable to be used with CE marked equipment.

Quality of the signal cable, cable glands and connectors:

Brooks supplies high quality cable(s) which meets the specifications for CE certification.
If you provide your own signal cable you should use a cable which is overall completely screened with a 100% shield.
"D" or "Circular" type connectors used should be shielded with a metal shield. If applicable, metal cable glands must be used providing cable screen clamping.
The cable screen should be connected to the metal shell or gland and shielded at both ends over 360 Degrees.
The shield should be terminated to a earth ground.
Card Edge Connectors are standard non-metallic. The cables used must be screened with 100% shield to comply with CE certification.
The shield should be terminated to a earth ground.
For pin configuration : Please refer to the enclosed Instruction Manual.

Español

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Asunto : Addendum al Manual de Instrucciones.
Referencia : Certificación CE de los Equipos de Caudal Másico
Fecha : Enero-1996.

Los equipos de Brooks (eléctricos/electrónicos) en relación con la marca CE han pasado satisfactoriamente las pruebas referentes a las regulaciones de Compatibilidad Electro magnética (EMC directiva 89/336/EEC).
Sin embargo se requiere una atención especial en el momento de seleccionar el cable de señal cuando se va a utilizar un equipo con marca CE

Calidad del cable de señal, prensaestopas y conectores:

Brooks suministra cable(s) de alta calidad, que cumple las especificaciones de la certificación CE .
Si usted adquiere su propio cable de señal, debería usar un cable que esté completamente protegido en su conjunto con un apantallamiento del 100%.
Cuando utilice conectores del tipo "D" ó "Circular" deberían estar protegidos con una pantalla metálica. Cuando sea posible, se deberán utilizar prensaestopas metálicos provistos de abrazadera para la pantalla del cable.
La pantalla del cable deberá ser conectada al casquillo metálico ó prensa y protegida en ambos extremos completamente en los 360 Grados.
La pantalla deberá conectarse a tierra.
Los conectores estandar de tipo tarjeta (Card Edge) no son metálicos, los cables utilizados deberán ser protegidos con un apantallamiento del 100% para cumplir con la certificación CE.
La pantalla deberá conectarse a tierra.
Para ver la configuración de los pines: Por favor, consultar Manual de Instrucciones adjunto.

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Français

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Sujet : Annexe au Manuel d'Instructions.
Référence : Certification CE des Débitmètres Massiques à Effet Thermique.
Date : Janvier 1996.

Messieurs,

Les équipements Brooks (électriques/électroniques) portant le label CE ont été testés avec succès selon les règles de la Compatibilité Electromagnétique (directive CEM 89/336/EEC).
Cependant, la plus grande attention doit être apportée en ce qui concerne la sélection du câble utilisé pour véhiculer le signal d'un appareil portant le label CE.

Qualité du câble, des presse-étoupes et des connecteurs:

Brooks fournit des câbles de haute qualité répondant aux spécifications de la certification CE.
Si vous approvisionnez vous-même ce câble, vous devez utiliser un câble blindé à 100 %.
Les connecteurs « D » ou de type « circulaire » doivent être reliés à la terre.
Si des presse-étoupes sont nécessaires, ceux ci doivent être métalliques avec mise à la terre.
Le blindage doit être raccordé aux connecteurs métalliques ou aux presse-étoupes sur le pourtour complet du câble, et à chacune de ses extrémités.
Tous les blindages doivent être reliés à la terre.
Les connecteurs de type « card edge » sont non métalliques. Les câbles utilisés doivent être blindés à 100% pour satisfaire à la réglementation CE.
Tous les blindages doivent être reliés à la terre.
Se référer au manuel d'instruction pour le raccordement des contacts.

Greek

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Θέμα :Προσθήκη στο Εγχειρίδιο Οδηγιών.
Σχετικά :Πιστοποίηση CE των Οργάνων Μέτρησης Παροχής Μάζας.
Ημερομηνία :Ιανουάριος - 1996

Κυρίες και Κύριοι,

Τα όργανα (ηλεκτρικά/ηλεκτρονικά) της Brooks τα οποία φέρουν το σήμα CE έχουν επιτυχώς ελεγχθεί σύμφωνα με τους κανονισμούς της Ηλεκτρο-Μαγνητικής Συμβατότητας (EMC ντιρεκτίβα 89/336/EEC).
Οπωσδήποτε χρειάζεται ειδική προσοχή κατά τήν επιλογή του καλωδίου μεταφοράς του σήματος το οποίο (καλώδιο) πρόκειται να χρησιμοποιηθεί με όργανα που φέρουν το σήμα CE.

Ποιότητα του καλωδίου σήματος των στυπιοθλιπτών και των συνδέσμων .

Η Brooks κατά κανόνα προμηθεύει υψηλής ποιότητας καλώδια τα οποία πληρούν τις προδιαγραφές για πιστοποίηση CE.
Εάν η επιλογή του καλωδίου σήματος γίνει από σας πρέπει να χρησιμοποιήσετε καλώδιο το οποίο να φέρει εξωτερικά πλήρες πλέγμα και να παρέχει θωράκιση 100%.

Οι σύνδεσμοι τύπου "D" ή "Κυκλικοί" των καλωδίων, πρέπει να θωρακίζονται με μεταλλική θωράκιση. Εάν είναι εφαρμόσιμο, πρέπει να χρησιμοποιούνται μεταλλικοί στυπιοθλίπτες καλωδίων που να διαθέτουν ακροδέκτη σύνδεσης του πλέγματος του καλωδίου.
Το πλέγμα του καλωδίου πρέπει να συνδέεται στο μεταλλικό περίβλημα ή στον στυπιοθλίπτη και να θωρακίζεται και στα δύο άκρα κατά 360 μοίρες
Η θωράκιση πρέπει να καταλήγει σε κάποιο ακροδέκτη γείωσης.

Οι σύνδεσμοι καρτών είναι μη-μεταλλικοί, τα καλώδια που χρησιμοποιούνται πρέπει να φέρουν πλέγμα θωράκισης 100% για να υπακούουν στην πιστοποίηση CE.
Η θωράκιση πρέπει να καταλήγει σε κάποιο ακροδέκτη γείωσης.

Για την διάταξη των ακροδεκτών: Παρακαλούμε αναφερθείτε στο εσώκλειστο Εγχειρίδιο Οδηγιών.

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Italiano

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Oggetto : Addendum al manuale di istruzioni.
Riferimento : Certificazione CE dei misuratori termici di portata in massa
Data : Gennaio 1996.

Questa strumentazione (elettrica ed elettronica) prodotta da Brooks Instrument, soggetta a marcatura CE, ha superato con successo le prove richieste dalla direttiva per la Compatibilità Elettomagnetica (Direttiva EMC 89/336/EEC).
E' richiesta comunque una speciale attenzione nella scelta dei cavi di segnale da usarsi con la strumentazione soggetta a marchio CE.

Qualità dei cavi di segnale e dei relativi connettori:

Brooks fornisce cavi di elevata qualità che soddisfano le specifiche richieste dalla certificazione CE. Se l'utente intende usare propri cavi, questi devono possedere una schermatura del 100%.
I connettori sia di tipo "D" che circolari devono possedere un guscio metallico. Se esiste un passacavo esso deve essere metallico e fornito di fissaggio per lo schermo del cavo.
Lo schermo del cavo deve essere collegato al guscio metallico in modo da schermarlo a 360° e questo vale per entrambe le estemità.
Lo schermo deve essere collegato ad un terminale di terra.
I connettori "Card Edge" sono normalmente non metallici. Il cavo impiegato deve comunque avere una schermatura del 100% per soddisfare la certificazione CE.
Lo schermo deve essere collegato ad un terminale di terra.
Per il corretto cablaggio dei terminali occorre fare riferimento agli schemi del manuale di istruzioni dello strumento.

Nederlands

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Onderwerp : Addendum voor Instructie Handboek
Referentie : CE certificering voor Mass Flow Meters & Controllers
Datum : Januari 1996

Dames en heren,
Alle CE gemarkeerde elektrische en elektronische produkten van Brooks Instrument zijn met succes getest en voldoen aan de wetgeving voor Electro Magnetische Compatibiliteit (EMC wetgeving volgens 89/336/EEC).
Speciale aandacht is echter vereist wanneer de signaalkabel gekozen wordt voor gebruik met CE gemarkeerde produkten.

Kwaliteit van de signaalkabel en kabelaansluitingen:

- Brooks levert standaard kabels met een hoge kwaliteit, welke voldoen aan de specificaties voor CE certificering.
  Indien men voorziet in een eigen signaalkabel, moet er gebruik gemaakt worden van een kabel die volledig is afgeschermd met een bedekkingsgraad van 100%.
- "D" of "ronde" kabelconnectoren moeten afgeschermd zijn met een metalen connector kap. Indien kabelwartels worden toegepast, moeten metalen kabelwartels worden gebruikt die het mogelijk maken het kabelscherm in te klemmen
  Het kabelscherm moet aan beide zijden over 360° met de metalen connectorkap, of wartel verbonden worden.
  Het scherm moet worden verbonden met aarde.
- "Card-edge" connectors zijn standaard niet-metallisch. De gebruikte kabels moeten volledig afgeschermd zijn met een bedekkingsgraad van 100% om te voldoen aan de CE certificering.
  Het scherm moet worden verbonden met aarde.

Voor pin-configuraties a.u.b. verwijzen wij naar het bijgesloten instruktie handboek.
Hoogachtend,

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Norsk

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Vedrørende : Vedlegg til håndbok
Referanse : CE sertifisering av utstyr for massestrømsmåling og regulering
Dato : Januar 1996

Til den det angår

Brooks Instrument elektrisk og elektronisk utstyr påført CE-merket har gjennomgått og bestått prøver som beskrevet i EMC forskrift om elektromagnetisk immunitet, direktiv 89/336/EEC.
For å opprettholde denne klassifisering er det av stor viktighet at riktig kabel velges for tilkobling av det måletekniske utstyret.

Utførelse av signalkabel og tilhørende plugger:

- Brooks Instrument tilbyr levert med utstyret egnet kabel som møter de krav som stilles til CE-sertifisering.
- Dersom kunden selv velger kabel, må kabel med fullstendig, 100% skjerming av lederene benyttes.

"D" type og runde plugger og forbindelser må være utført med kappe i metall og kabelnipler må være utført i metall for jordet innfesting av skjermen. Skjermen i kabelen må tilknyttes metallet i pluggen eller nippelen i begge ender over 360°, tilkoblet elektrisk jord.

- Kort-kantkontakter er normalt utført i kunststoff. De tilhørende flatkabler må være utført med fullstendig, 100% skjerming som kobles til elektrisk jord på riktig pinne i pluggen, for å møte CE sertifiseringskrav.For tilkobling av medleverte plugger, vennligst se håndboken som hører til utstyret.

Vennlig hilsen

Português

Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.

Assunto : Adenda ao Manual de Instruções
Referência : Certificação CE do Equipamento de Fluxo de Massa
Data : Janeiro de 1996.

O equipamento (eléctrico/electrónico) Brooks com a marca CE foi testado com êxito nos termos do regulamento da Compatibilidade Electromagnética (directiva CEM 89/336/EEC).
Todavia, ao seleccionar-se o cabo de sinal a utilizar com equipamento contendo a marca CE, será necessário ter uma atenção especial.

Qualidade do cabo de sinal, buchas de cabo e conectores:

A Brooks fornece cabo(s) de qualidade superior que cumprem os requesitos da certificação CE.
Se fornecerem o vosso próprio cabo de sinal, devem utilizar um cabo que, na sua totalidade, seja isolado com uma blindagem de 100%.
Os conectores tipo "D" ou "Circulares" devem ser blindados com uma blindagem metálica. Se tal for necessário, deve utilizar-se buchas metálicas de cabo para o isolamento do aperto do cabo.
O isolamento do cabo deve ser ligado à blindagem ou bucha metálica em ambas as extremidades em 360º.
A blindagem deve terminar com a ligação à massa.
Os conectores "Card Edge" não são, em geral, metálicos e os cabos utilizados devem ter um isolamento com blindagem a 100% nos termos da Certificação CE..
A blindagem deve terminar com ligação à massa.
Relativamente à configuração da cavilha, queiram consultar o Manual de Instruções.

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Suomi
Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.
Asia : Lisäys Käyttöohjeisiin
Viite : Massamäärämittareiden CE sertifiointi
Päivämäärä : Tammikuu 1996
Brooksin CE merkillä varustetut sähköiset laitteet ovat läpäissyt EMC testit (direktiivi 89/336/EEC).
Erityistä huomiota on kuitenkin kiinnitettävä signaalikaapelin valintaan.
Signaalikaapelin, kaapelin läpiviennin ja liittimen laatu
Brooks toimittaa korkealaatuisia kaapeleita, jotka täyttävät CE sertifikaatin vaatimukset. Hankkiessaan signaalikaapelin itse, olisi hankittava 100%:sti suojattu kaapeli.
“D” tai “Circular” tyyppisen liitimen tulisi olla varustettu metallisuojalla. Mikälì mahdollista, tulisi käyttää metallisia kaapeliliittimiä kiinnitettäessä suojaa.
Kaapelin suoja tulisi olla liitetty metallisuojaan tai liittimeen molemmissa päissä 360°:n matkalta.
Suojan tulisi olla maadoitettu.
“Card Edge Connector”it ovat standarditoimituksina ei-metallisia. Kaapeleiden täytyy olla 100%: sesti suojattuja jotta ne olisivat CE sertifikaatin mukaisia.
Suoja on oltava maadoitettu.
Nastojen liittäminen; katso liitteenä oleva manuaali.
Ystävällisin terveisin,

Svensk
Brooks Instrument
407 West Vine St.
Hatfield, PA 19440
U.S.A.
Subject : Addendum to the Instruction Manual
Reference : CE certification of Mass Flow Equipment
Date : January 1996
Brooks (elektriska / elektronik) utrustning, som är CE-märkt, har testats och godkänts enligt gällande regler för elektromagnetisk kompabilitet (EMC direktiv 89/336/EEC).
Speciell hänsyn måste emellertid tas vid val av signalkabel som ska användas tillsammans med CE-märkt utrustning.
Kvalitet på signalkabel och anslutningskontakter:
Brooks levererar som standard, kablar av hög kvalitet som motsvarar de krav som ställs för CE-godkännande. Om man använder en annan signalkabel ska kabeln i sin helhet vara skärmad till 100%.
“D” eller “runda” typer av anslutningskontakter ska vara skärmade. Kabelgenomföringar ska vara av metall alternativt med metalliserad skärmning.
Kabelns skärm ska, i bada ändar, vara ansluten till kontakternas metallkåpor eller genomföringar med 360 graders skärmning.
Skärmen ska avslutas med en jordförbindelse.
Kortkontakter är som standard ej metalliserade, kablar som används måste vara 100% skarmade för att överensstämma med CE-certifieringen.
Skärmen ska avslutas med en jordförbindelse.
För elektrisk anslutning till kontaktstiften hänvisas till medföljande instruktionsmanual.

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