

Installation and Operation Manual

X -TMF-5965-5851EM-MFC-eng

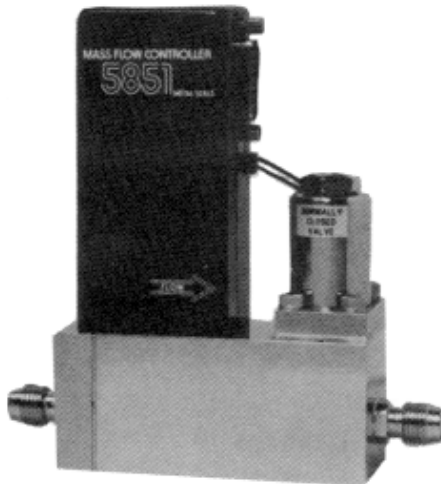
Part Number: 541B122AAG

September, 2009

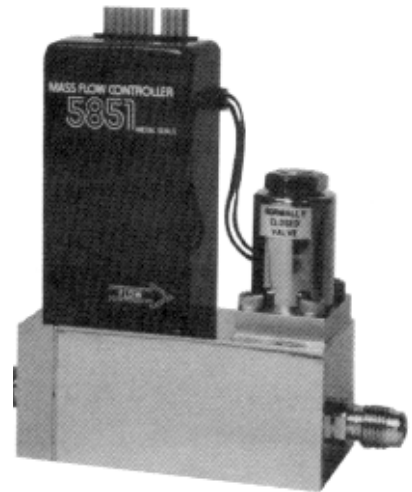
Brooks® Models 5965, 5851EM Mass Flow Controllers



*Model 5965
Mass Flow Controller
with Card Edge*



*Model 5851EM
Mass Flow Controller
with D-Connector*



*Model 5851EM Downported
Mass Flow Controller
with Card Edge*

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.

Installation and Operation Manual

X -TMF-5965-5851EM-MFC-eng

Part Number: 541B122AAG

September, 2009

Brooks® Models 5965, 5851EM

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 How to Use This Manual

This instruction manual is intended to provide the user with all the information necessary to install, operate and maintain the Brooks® Models 5965 and 5851EM

This manual is organized into the following sections:

Section 1.	Introduction
Section 2.	Installation
Section 3.	Operation
Section 4.	Maintenance & Troubleshooting
Section A	CE Certifications
Back Cover	Warranty, Local Sales/Service Contact Information

1-2 Description

The Brooks Model 5965 and 5851EM Mass Flow Controllers are used in gas flow handling systems where very low leakage and high performance are required. Models 5965 and 5851EM incorporate metal seals or welded joints, insuring leak integrity for high purity and high vacuum applications. Reducing the amount of internal threads makes the design less prone to system contamination. The control electronics and flow sensor designs utilized in the Model 5965 and 5851EM have been well-proven in precision gas delivery systems. Standard features include:

- High leak integrity (less than 10^{-10} atm-cc/sec He)
- Enhanced process (7 Ra) internal surface finish (standard for 5965)
- Electropolished wetted surfaces (standard for 5965)
- Vented-polished internal threads
- Wide flow range (10 slpm through 100 slpm)
- Insensitive to mounting attitude
- Full penetration welded fittings
- Negligible flow overshoot/undershoot
- Mechanically and electronically compatible with other mass flow controllers
- Available with all popular process connections
- Current (4-20 mA) input/output (optional)
- Normally open valve (optional)

Brooks® Models 5965, 5851EM

- **Fast response control** permits rapid gas settling times with minimal over/undershoot.
- **Soft start** provides a flow ramping function which slows down the introduction of process gas for those processes which cannot tolerate rapid flow transition. Refer to section 2-7 and Figure 1-1.
- **Valve override** permits the user to fully open and close the control valve independent of the command setting. Refer to Section 2-6.

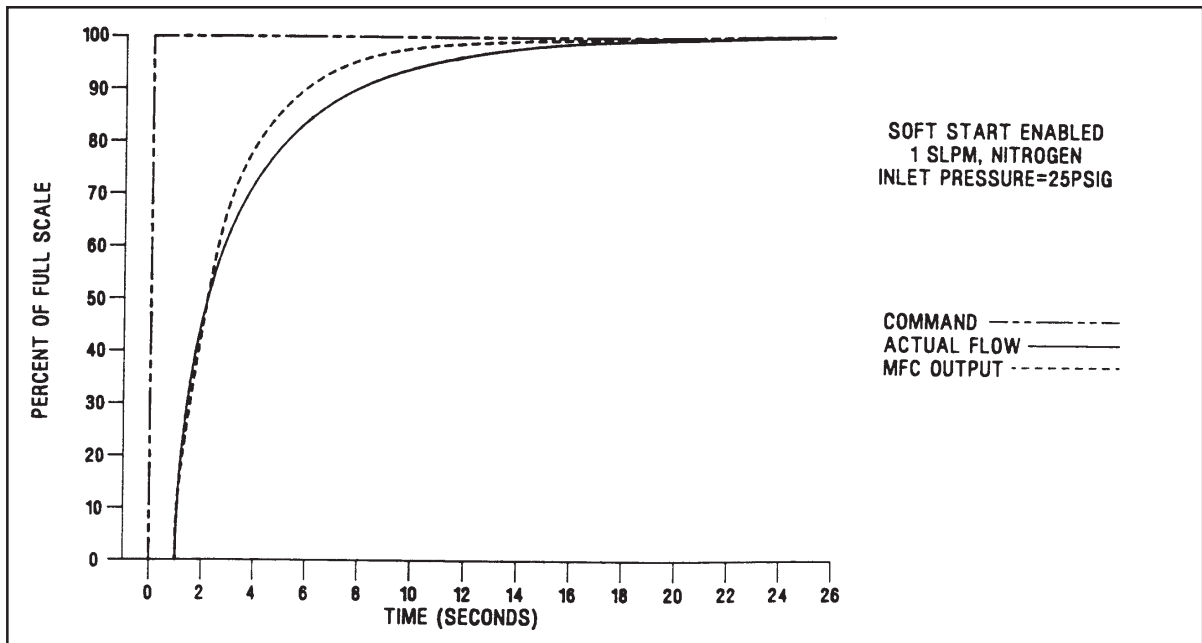


Figure 1-1 0 to 100% Command Step, Soft Start Enabled

- **Low command flow cutoff** (Auto shut-off) prevents the valve from opening whenever the setpoint is less than 2% of full scale.
- **Output limiting** prevents possible damage to delicate data acquisition devices by limiting the output signal of the mass flow controller.
- **Valve off (Note 1)** is accessed via Terminal J on the card Edge or Pin 4 on the D-Connector version. This feature allows the user to close, independent of the command signal, the control valve by supplying TTL level low signal to the proper terminal. This function is useful when performing repetitive flow operations or as a safety shutdown. Refer to section 2-6.
- **Valve test point/purge (Note 1)** is accessed via Terminal D on the Card Edge or Pin 7 on the D-Connector version. This feature allows the user to monitor the control valve voltage during operation. Also, grounding this terminal causes the control valve to fully open independently of the command signal. Refer to Section 2-6. Note: Grounding this terminal with a Model 5965/5851EM supplied with a normally open valve will cause the valve to fully close.

- **Remote transducer input (Note 1)** is accessed via terminal 5 on the Card Edge or Pin 15 on the D-Connector version. This feature allows the use of the integral control electronics and valve to regulate flow in response to the signal from an external 0-5 Vdc signal. The mass flow signal from the Model 5965/5851EM is still available for process monitoring. This function is enabled at the factory. Refer to section 2-6.

Note 1: Feature not available with 4-20 mA I/O option.

- **Fast response control** permits rapid gas settling times with minimal over/undershoot.

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.

PERFORMANCE CHARACTERISTICS:

Flow Ranges*

Any range from 10 - 100 slpm nitrogen equivalent; up to 200 slpm hydrogen

*Standard: 0°C and 101 kPa (760 Torr). Per SEMI Guideline E12-96.

Accuracy

±1% Full Scale, including linearity, at calibration conditions
68°F ± 3°F, 50% ± R.H.

Repeatability

0.25% of rate

Settling Time

Less than 3 seconds (6 seconds for 4-20 mA I/O option) to within 2% of Full Scale of final value for a 0-100% command step.

*Per SEMI Guideline E17-91.

Leak Integrity

Inboard to outboard 1×10^{-10} atm. cc/sec. Helium max.

Control Range

50 to 1 (with elastomeric valve seat)

33 to 1 (with metal valve seat)

Ambient Temperature Limits

Operating: 40°F to 150°F (5°C to 65°C)

Non-Operating: -13°F to 212°F (-25°C to 100°C)

Temperature Sensitivity

Zero: Less than ±0.075% full scale per degree C.

Span: Less than ±1.0% of rate shift over 10 - 50°C range.

PERFORMANCE CHARACTERISTICS (continued):**Pressure Equipment Directive (PED) 97/23/EC****Working Pressure**

1000 psi (70 bar) max.

Mounting Sensitivity

±0.5% maximum full scale deviation after re-zeroing.

ELECTRICAL CHARACTERISTICS:**Power Requirements**

Voltage Option: + 15 Vdc ±5% Watts power consumption

Current Option: +22.5 to +28 Vdc, 370 mA @ +28 Vdc

Class III Equipment: The dc main input shall be supplied from a SELV (Separate Extra-Low Voltage) source.

Electrical Connections

Card Edge: 30 micorinch gold over low stress nickel-plated copper

D-Connector: DA-15P

Electrical Pinouts

Card Edge: Compatible with Brooks Model 5965/5851EM as well as most competitive models

D-Connector: Compatible with Brooks Models 5850C, D and E.

Environmental Conditions

Installation category: "I"

Pollution degree: 2

Humidity: 50 - 80% Relative Humidity

Meter Altitude: 2,000 meters (6562 feet)

For Indoor Use ONLY

Mains supply voltage fluctuations not to exceed ±10% of nominal voltage

Command Input

Voltage Option: 0-5 Vdc. Input resistance 200 k ohm

Current Option: Input Resistance 75 ohm

Output Signal

Voltage I/O Option: 0-5 Vdc into 2,000 ohms or greater. Max. ripple 3 mV.

Current I/O Option: 0-5 Vdc into 2,000 ohms or greater. Maximum ripple 3 mVP-P jumper selectable 4-20 mAdc or 0-20 mAdc. Refer to Fiugre 2-5 for maximum loop resistance.

5 Volt Reference Output

5 Volts, ±0.2 (±0.01 Vdc). Maximum load 1 k ohms.

ELECTRICAL CHARACTERISTICS (continued):**Differential Pressure**

Voltage I/O option

Valve orifice sized for any pressure drop between 5 to 50 psi (Minimum pressure drop depends on gas and range). Refer to Orifice Sizing, Section 4-5.

Current I/O option

Valve orifice sized for any pressure drop between 5 to 1,500 psi (Maximum pressure drop depends on orifice size). Refer to Orifice Sizing, Section 4-5.

Power Supply Sensitivity

Voltage I/O Option: ± 0.09 full scale of percent power supply voltage variation of full scale.

Current I/O Option: negligible effect over +22.5 to +28 Vdc.

PHYSICAL CHARACTERISTICS:**⚠ 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.

Materials of Construction

316L, 316L VAR (Vacuum Arc Remelt), and high alloy ferritic stainless steel.

External seals: Nickel.

Internal seals: Nickel.

Valve Seat: 316L, Viton® fluoroelastomers, Buna-N, Kalrez® or Teflon®.

When 316L or Teflon seat is used, maximum inlet pressure is 50 psig and minimum controllable flow rate is 3% of full scale.

Dimensions

Refer to Figures 1-2 and 1-3

Process Connections

Integrally welded to body - standard:

1/4" male VCR™

3/8" male VCR (3/8" or 1/2" tube)

1/2" ACLIT™

1/2" ATW tube stub

CS Downport (5965 Series Only)

Surface Finish

5851EM: 32Ra, Passivated,

Electropolished optional

5965: 7Ra, Electropolished

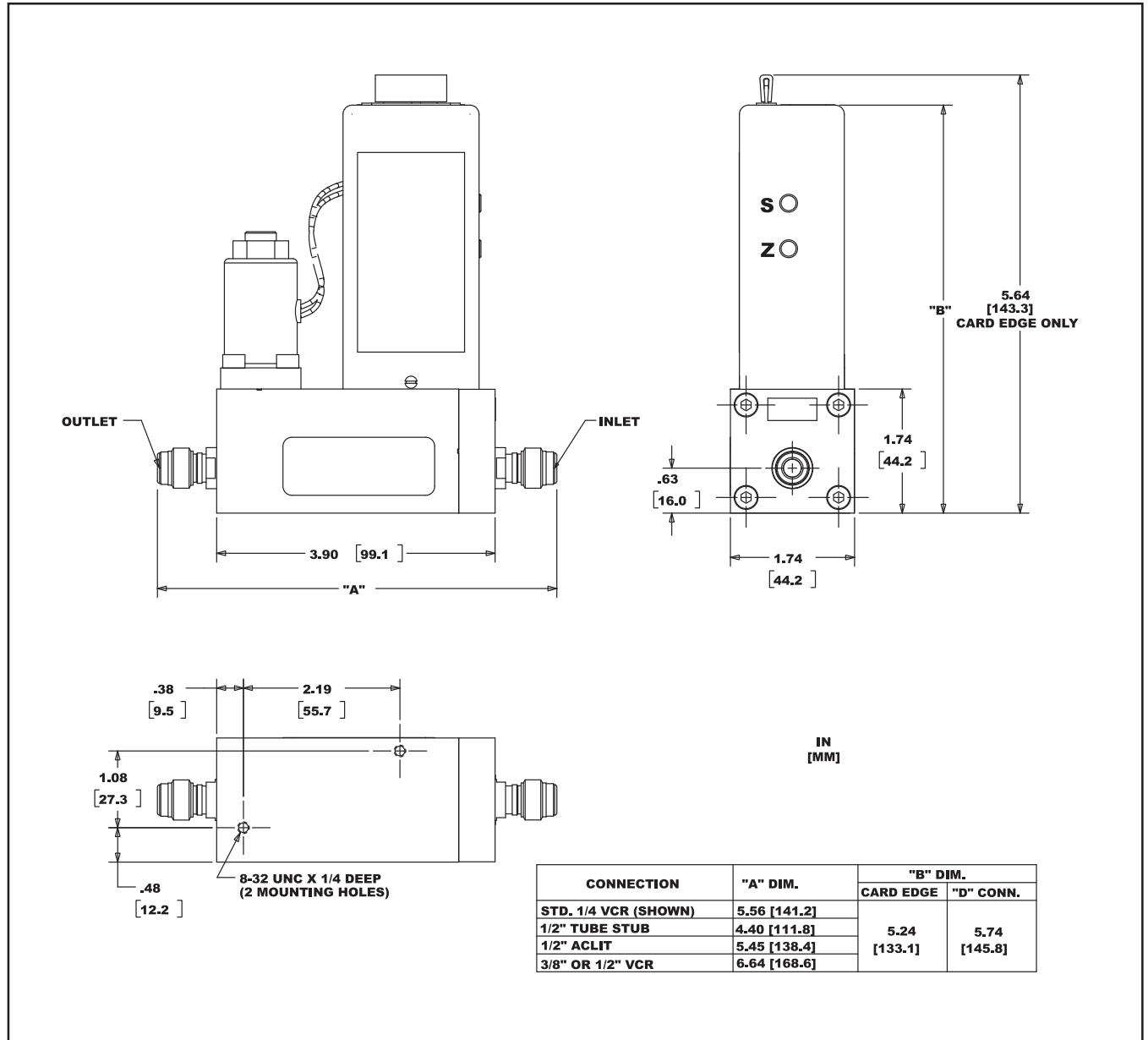


Figure 1-2 MFC/MFM Dimensional Drawing for Models 5965, 5851EM with D-Connector or Card Edge with VCR Fittings

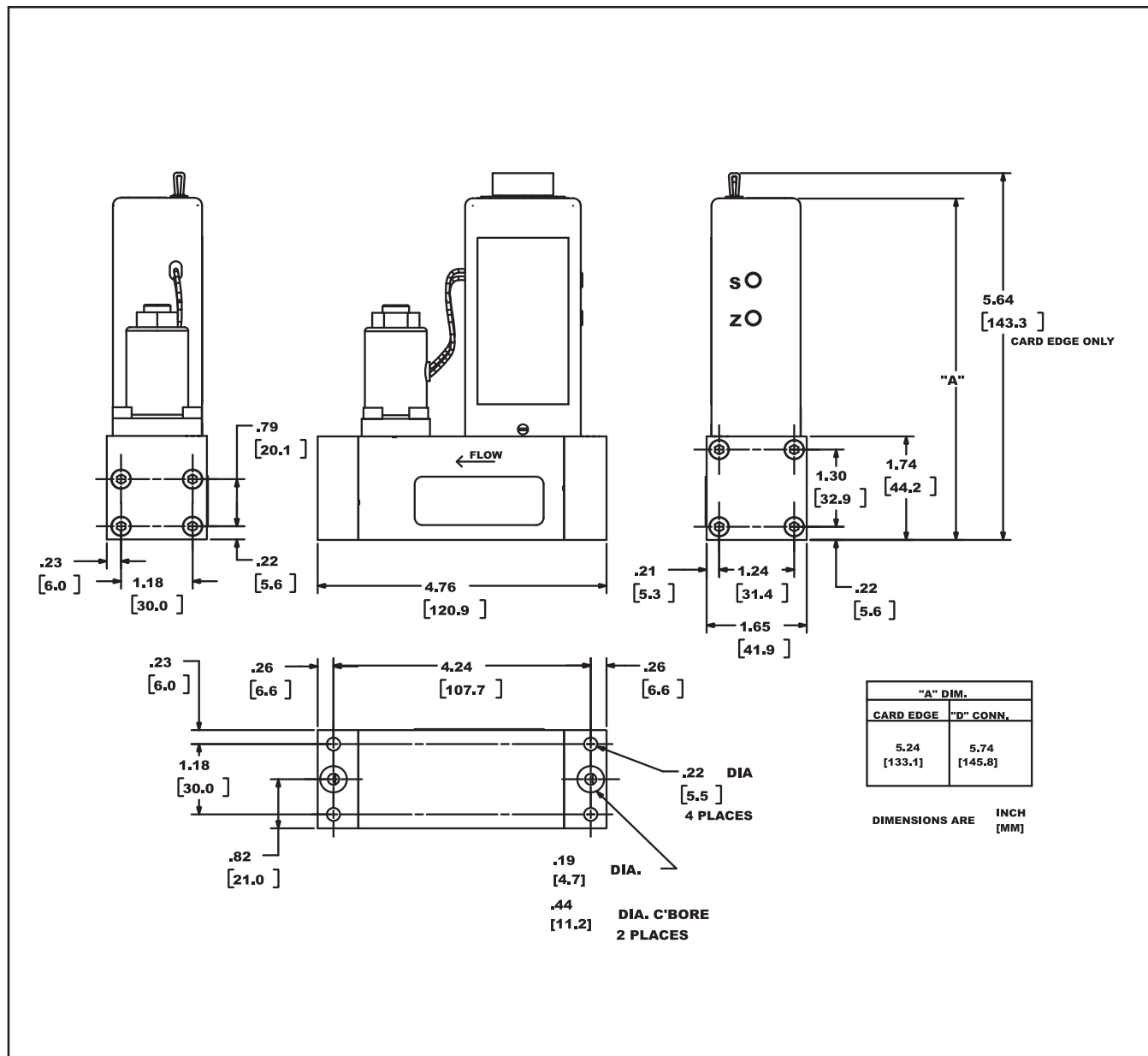


Figure 1-3 MFC/MFM Dimensional Drawing for Models 5965, 5851EM with D-Connector or Card Edge, Downported

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2-1 General

This section contains the procedures for the receipt and installation of the instrument. See Section 1 for dimensional and connection requirements. Do not attempt to start the system until the instrument has been permanently installed. It is important that the start-up procedures be followed in the exact sequence presented.

2-2 Receipt of Equipment

When the instrument 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 your nearest Product Service Department.

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

This device may have been assembled, calibrated and double-vacuum bagged in a Class 100 clean room. In your semi-clean area, remove the outer bag only. Pass your Model 5965/5851EM into your clean area. Note: Remove the second clean room compatible bag only when the equipment is ready to be tested and/or installed in your clean system.

Brooks Instrument

407 W. Vine Street
P.O. Box 903
Hatfield, PA 19440 USA
Toll Free (888) 554 FLOW (3569)
Tel (215) 362 3700
Fax (215) 362 3745
E-mail: BrooksAm@BrooksInstrument.com
www.BrooksInstrument.com

Brooks Instrument

Neonstraat 3
6718 WX Ede, Netherlands
P.O. Box 428
6710 BK Ede, Netherlands
Tel +31 (0) 318 549 300
Fax +31 (0) 318 549 309
E-mail: BrooksEu@BrooksInstrument.com

Brooks Instrument

1-4-4 Kitasuna Koto-Ku
Tokyo, 136-0073 Japan
Tel +81 (0) 3 5633 7100
Fax +81 (0) 3 5633 7101
Email: BrooksAs@BrooksInstrument.com

Brooks® Models 5965, 5851EM

2-3 Recommended Storage Practice

If intermediate or long-term storage of equipment is required, it is recommended that the equipment be stored in accordance with the following conditions:

- a. Within the original shipping container.
- b. Stored in a sheltered area, preferably a warm, dry, heated warehouse.
- c. Ambient temperature 21°C (70°F) nominal, 32°C (90°F) maximum, 45°F (7°C) minimum.
- d. Relative humidity 45% nominal, 60% maximum, 25% minimum.

2-4 Return Shipment

Prior to returning any instrument to the factory, contact your nearest Brooks location for a Return Materials Authorization Number (RMA#). This can be obtained from one of the following locations:

Brooks Instrument

407 W. Vine Street
P.O. Box 903
Hatfield, PA 19440 USA
Toll Free (888) 554 FLOW (3569)
Tel (215) 362 3700
Fax (215) 362 3745
E-mail: BrooksAm@BrooksInstrument.com
www.BrooksInstrument.com

Brooks Instrument

Neonstraat 3
6718 WX Ede, Netherlands
P.O. Box 428
6710 BK Ede, Netherlands
Tel +31 (0) 318 549 300
Fax +31 (0) 318 549 309
E-mail: BrooksEu@BrooksInstrument.com

Brooks Instrument

1-4-4 Kitasuna Koto-Ku
Tokyo, 136-0073 Japan
Tel +81 (0) 3 5633 7100
Fax +81 (0) 3 5633 7101
Email: BrooksAs@BrooksInstrument.com

Instrument must have been purged in accordance with the following:

! WARNING

Before returning the device purge thoroughly with a dry inert gas such as Nitrogen before disconnecting gas connections. Failure to correctly purge the instrument could result in fire, explosion or death. Corrosion or contamination may occur upon exposure to air.

All flow instruments returned to Brooks requires completion of Form RPR003-1, Brooks Instrument Decontamination Statement, along with a Material Safety Data Sheet (MSDS) for the fluid(s) used in the instrument. Failure to provide this information will delay processing by Brooks personnel. Copies of these forms can be downloaded from the Brooks website www.BrooksInstrument.com or are available from any Brooks Instrument location listed above.

2-5 Transit Precautions

To safeguard the instrument against transportation damage, it is recommended to keep the instrument in its factory container until ready for installation.

2-6 Removal from Storage

Upon removal from storage, a visual inspection should be conducted to verify the condition of the equipment is "as received". If the equipment has been in storage in conditions in excess of those recommended, the device should be subjected to a pneumatic pressure test in accordance with applicable vessel codes. Note: If the cleanliness of this device is critical, service should be performed by the factory or one of the authorized service centers.

2-7 Gas Connections

Prior to installation, make certain all piping is clean and free of obstructions. Install the piping in such a manner that permits easy access to the instrument if it needs to be removed for cleaning or test bench troubleshooting.

2-8 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
10 to 30 slpm	15 micron
Above 30 slpm	30 micron

2-9 Installation

Prior to installation, make certain all piping is clean and free of obstructions, for tubing installations. Install the piping in such a manner that permits easy access to the instrument if it needs to be removed for cleaning or test bench troubleshooting. For surface mount (downported) devices verify that the seal cavities are clean and free of lateral scratches.

⚠ 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.

Recommended installation procedures:

- The Models 5965 and 5851EM should be located in a **clean**, dry atmosphere relatively free from shock and vibration.
- Leave sufficient room for access to the electrical components, span and zero potentiometers.
- Install in such a manner that permits easy removal if the instrument requires servicing.

⚠ CAUTION

When used with a reactive (sometimes toxic gas) contamination or corrosion may occur as a result of plumbing leaks or improper purging. Plumbing should be checked carefully for leaks and the instrument purged with clean, dry N₂ before use.

- The Models 5965 and 5851EM Mass Flow Controller can be installed in any position. However, mounting in orientations other than the original factory calibration (see calibration data sheet) can result in a 0.5% maximum full scale shift after re-zeroing.

CAUTION

Use caution when installing surface mount (downported) controllers. Most metal seals can not be reused after compression. Follow the seal manufacturers' recommendations for installation. Tighten the mounting screws in 10 in-lb. increments such that the seal undergoes uniform compression. Final torque values depend on the screw and hardware material and lubrication.

- 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 Model 5965/5851EM Mass Flow Controller.

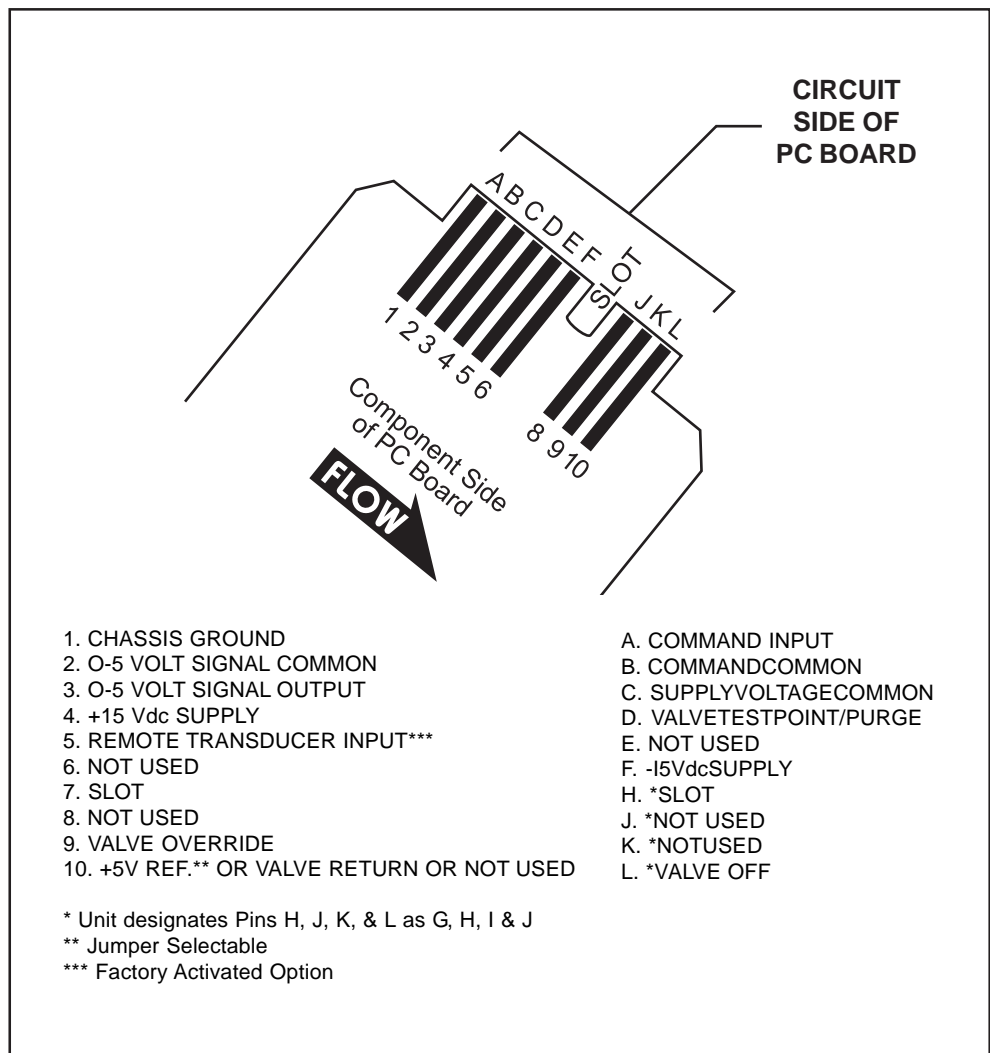


Figure 2-1 Model 5965/5851EM Card Edge Connector Arrangement

⚠ CAUTION

Since the Model 5965/5851EM control valve is not a positive shut-off, a separate solenoid valve have to be 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 which will result in a surge upon actuation of the controller. This surge can be reduced in magnitude by locating, close together, the controller and solenoid valve or by moving the solenoid valve upstream of the controller.

Note: The control valve in the Models 5965 and 5851EM 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. Controllers with 316L or Teflon valve seats may not shut off flow below 3% of full scale.

2-10 Electrical Interface

To insure proper operation, the Model 5965/5851EM must be connected per Figures 2-1 through 2-6 depending upon the type of printed circuit board and connector. As a minimum, the following connections must be made:

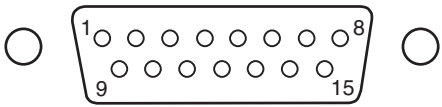
Voltage I/O Version

- Chassis Ground
- Signal Common
- Signal Output
- +15 Vdc Supply
- -15 Vdc Supply
- Command Input
- Command Common
- Supply Common
- Valve Return (Refer to Section 3-4 jumper configuration)

Current I/O Version

- Chassis Ground
- Signal Output Return
- Voltage or Current Signal Output
- 15-28 Vdc Supply
- Supply Common
- Voltage or Current
- Voltage or Current
- Command Return

Pin No.	Function	Color Code
1	Command Common (Command Pot "CCW")	Black
2	0-5 Volt Signal Output	White
3	External Valve Return (See Note 3)**	Red
4	Valve Off	Green
5	+15 Vdc Supply	Orange
6	-15 Vdc Supply	Blue
7	Valve Test Point/Purge	Wht/Blk
8	Cmd. Input or Cmd. Pot "S"	Red/Blk
9	Supply Voltage Common	Grn/Blk
10	0-5 Signal Common	Org/Blk
11	+5 Volt Reference Output (Cmd. Pot "CW")	Blu/Blk
12	Valve Override	Blk/Wht
13	Not Used	Red/Wht
14	Chassis Ground	Grn/Wht
15	Remote Transducer Input***	Blu/Wht

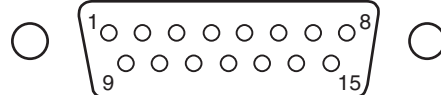


Note:

1. Cable shield tied to chassis ground in meter connector. Make no connection on customer end.
2. All power leads must be connected to power supply.
3. To use Pin 3 for external valve return, Jumper J1 must be moved to the B-D position and Pin 3 must be grounded at the customer's system.
4. Pin 9 is normally used for external valve return and can be used for cables up to 10 feet in length.

** Jumper Selectable
 *** Factory Activated Option

Figure 2-2 D-Connector Pin Arrangement (Voltage I/O Version)



1. SETPOINT RETURN	9. SUPPLY COMMON
2. VOLTAGE SIGNAL OUTPUT	10. SIGNAL OUTPUT RETURN
3. NOT USED	11. 5V REFERENCE OUTPUT
4. CURRENT SIGNAL OUTPUT	12. VALVE OVERRIDE INPUT
5. +15 TO +28 Vdc SUPPLY	13. NOT USED
6. NOT USED	14. CHASSIS GROUND
7. CURRENT SETPOINT INPUT	15. NOT USED
8. VOLTAGE SETPOINT INPUT	

Figure 2-3 D-Connector Pin Arrangement (Current I/O Version)

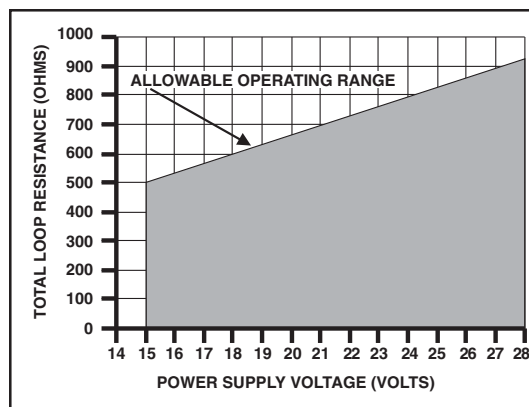


Figure 2-4 Maximum Allowable Loop Resistance

Electrical Hookup (Voltage I/O Version)

For installations which replace Unit Instrument's UFC-1000's, (Card Edge version) Pin 10 is frequently grounded. In these situations the 5 Volt reference output must be disabled. Refer to Section 2-7.

For installations which will be connected to Brooks secondary electronics, the Card Edge version must have the 5 Volt reference enabled on pin 10. Refer to section 2-7. If the Model 5965/5851EM was shipped as a system with Brooks secondary electronics then the electronics will already be configured properly.

Remote Set-Point (Command) Input

If the mass flow controller is to be commanded by an external 0-5 Vdc signal, the command potentiometer is not used.

The command input hookup is as follows:

A. Card Edge Connector

Connect the external command voltage to Terminal A, and external command return to Terminal B. Refer to Figures 2-1 and 3-3..

B. D-Connector

Connect the external command voltage to Terminal 9 and external command return to Terminal 1. Refer to Figures 2-2 and 3-4.

Valve Override

The valve override function allows full opening and closing of the valve independent of the command setting. The unique command reset feature prevents flow overshoot when the controller goes from valve override closed to normal control. The valve override for the mass flow controller is as follows:

- a. To open the valve, apply +15 Vdc to the valve override terminal.
- b. To close the valve, apply -15 Vdc to the valve override terminal.
- c. Isolating the valve override terminal returns the controller to normal operation.

A. Card Edge

The valve override function can be accessed from Terminal 9. Refer to Figure 2-1. Note: For normal operation Terminal 9 must be left open (floating).

B. D-Connector

The valve override function is accessed from Terminal 12. Refer to Figures 2-2 and 2-3.

Valve Test Point Purge

Refer to Figures 2-1, 2-2, and 2-3. The valve voltage can be monitored on Pin D of the card Edge version and Pin 7 of the D-connector version. This voltage relative to circuit common is proportional to the valve voltage per the following equation:

Valve Voltage = 14.2 Voltage at the valve voltage test point (TP3)

Grounding the valve test point pin will cause the valve to open fully regardless of command input voltage. Note: For normally open valves grounding this pin will cause the valve to fully close.

Valve Off

Refer to Figures 2-1, 2-2 and 2-3. The control valve can be forced closed regardless of command input signal by applying a TTL level low (<0.4 Vdc) to Terminal L of the Card Edge version or Pin 4 of the D-Connector version. A TTL level high or floating at this pin has no effect.

⚠ CAUTION

Do not ground terminal 10 when 5 volt reference output is enabled. Irreparable damage to the PC board may result.

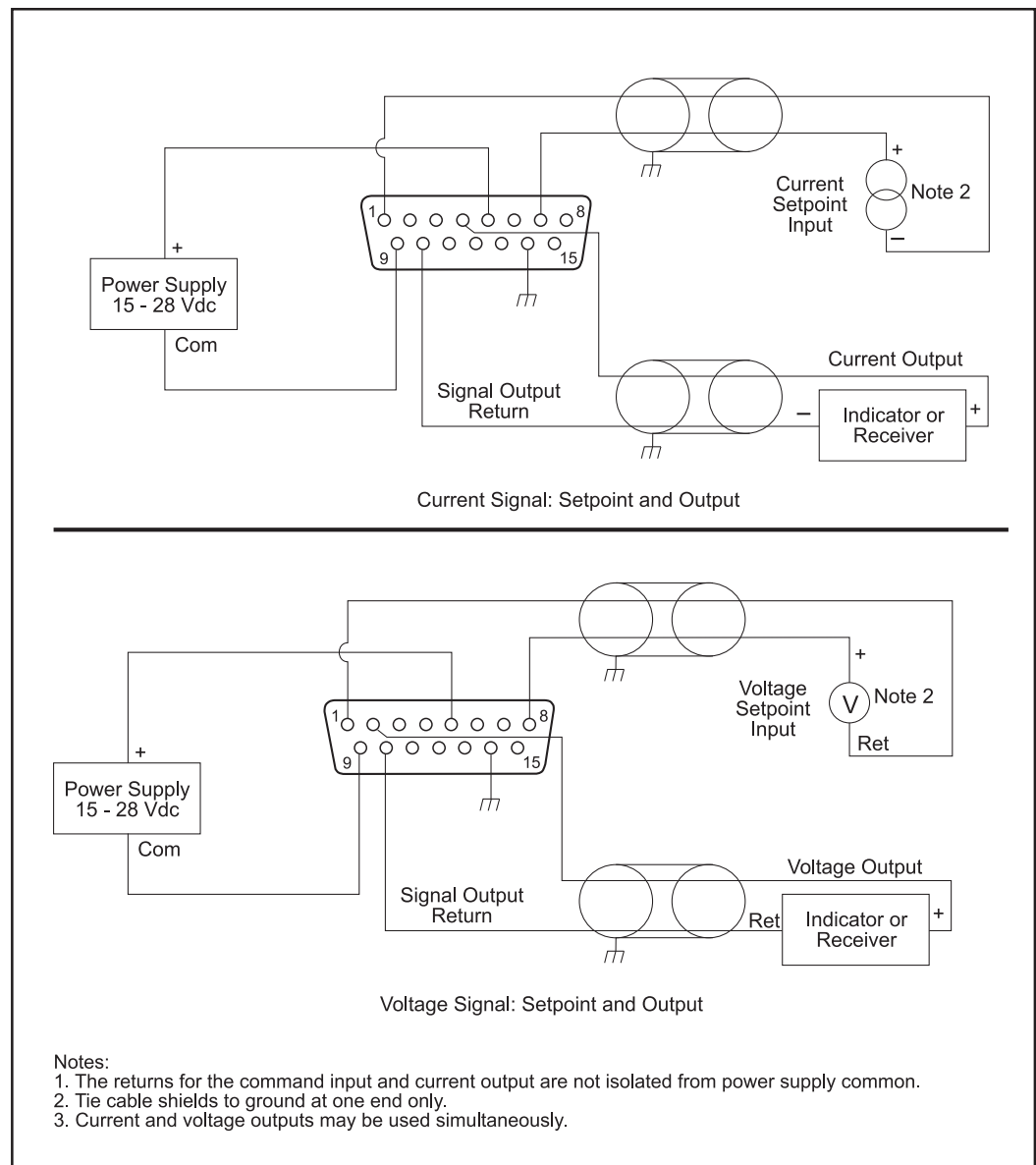


Figure 2-5 Common Electrical Hookups Current I/O Version

Brooks® Models 5965, 5851EM

Electrical Hookup (Current I/O Option)**Setpoint (Command) Input**

The Model 5965/5851EM Mass Flow Controller can be used with a current (4-20 mA_{dc}) or voltage (0-5 V_{dc}) 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 2-10. To use the voltage setpoint, connect the voltage signal to Pin 9 and the voltage setpoint return to Pin 1 of the D-Connector and configure the PC board per Section 2-10.

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 V_{dc} signal proportional to the mass flow rate. Pin 4 indicates the flowrate with either a 0-20 mA_{dc} or 4-20 mA_{dc} current signal as determined by jumpers on the PC board (refer to Section 2-T for jumper positions). Both the current and voltage signals are returned on Pin 10 of the D-Connector.

Supply

The power for the mass flow controller is connected to Pin 5 (+22.5 to +28 V_{dc}) and Pin 9 (supply common) of the D-Connector. Refer to Section 1-3 for the power requirements.

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 V_{dc} 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).

2-11 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 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 hookup. Refer to Figure 3-3 through 3-5 for PC board jumper locations and functions.

Configuring PC Board (Voltage I/O Option) 5 Volt Reference Output Valve Drive Configuration

A. Card Edge

Refer to Figures 2-1 and 3-3. Terminal 10 can be jumper selected as 5 Volt reference output, external valve return or “not used”. The 5 Volt reference output is required by Brooks secondary electronics, or if a potentiometer is to be used to generate the command signal. To enable the 5 Volt reference output on Terminal 10 place the yellow jumper at J1 in the D-E position. To disable the 5 Volt reference output place the yellow jumper at J1 in the E-F position.

CAUTION

Do not ground terminal 10 when 5 volt reference output is enabled. Irreparable damage to the PC board may result.

To minimize the effect of resistance in the connection wiring, a separate “external valve return” can be accessed on pin 10. To enable this feature, place the black jumper at J1 in the B-D position and connect Terminal 10 to power supply common. If the “external valve return” is not enabled, place the black jumper at J1 in the B-C position.

Note: If the “external valve return” feature is not enabled, the valve voltage is returned internally on the printed circuit board and the connection wiring resistance must be less than 0.2 ohms.

B. D-Connector

Refer to Figures 2-2 and 3-4 for D-Connector (Voltage I/O Version) or Figures 2-3 and 3-5 for D-Connector (Current I/O Version). The 5 Volt reference is always available on Pin 11.

To minimize the effect of resistance in the connection wiring, a separate “external valve return” can be accessed on pin 3. To enable this feature place the black jumper at J1 in the B-D position and connect pin 3 to power supply common. If the “external valve return” is not enabled, place the black jumper at J1 in the B-C position.

Note: If the “external valve return” feature is not enabled, the valve voltage is returned internally on the printed circuit board and the connection wiring resistance must be less than 0.2 ohms.

Soft Start

Refer to Figures 3-3, 3-4 and 3-5. To enable soft start, place the red jumper on the controller printed circuit board at J2 in the right hand (SS) position.

To disable soft start, place the red jumper on the controller printed circuit board at J2 in the left hand (N) position.

Brooks® Models 5965, 5851EM**Remote Transducer Input (Factory Installed Option)**

Refer to Figures 3-3, 3-4 and 3-5. To allow the Model 5965/5851EM control circuitry and valve to be used with an 0-5 Vdc external transducer signal, a green jumper is moved to the lower two pins at J7. With this feature enabled a 0-5 Vdc signal may be applied to the external transducer input terminal. The Model 5965/5851EM controller circuitry will modulate the valve position to increase or decrease the flow rate to maintain the transducer output at the desired set point. The control circuitry is reverse acting, e.g., for an increase in transducer output the flow will correspondingly be decreased.

Configuring PC Board (Current I/O Option)**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 JB 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).

3-1 Theory of Operation

The thermal mass flow sensing technique used in the Model 5851EM works as follows:

Constant power (p) is provided to the heater winding which is located at the midpoint of the sensor tube. Refer to Figure 3-1. During no flow conditions, the heat reaching each temperature sensor is equal. Therefore the temperatures T1 and T2, are equal. When gas flows through the tube, the upstream sensor is cooled and the downstream sensor is heated producing a temperature difference. The temperature difference T2-T1 is directly proportional to the gas mass flow. The equation is:

$$\Delta T = A * P * Cp * m$$

Where:

- ΔT = Temperature difference T2 - T1 (K)
- Cp = 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 (s²-K²/kJ²)

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.

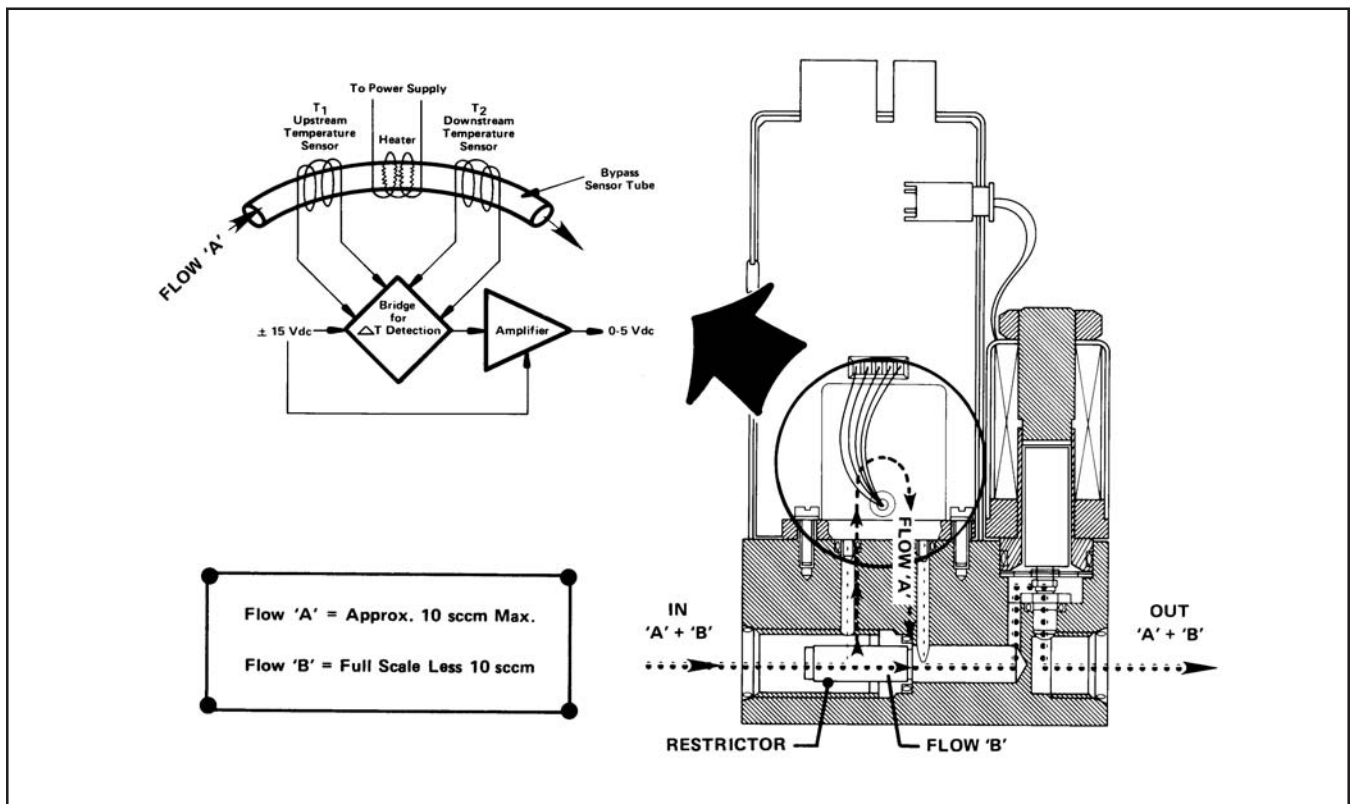


Figure 3-1 Flow Sensor Operational Diagram

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

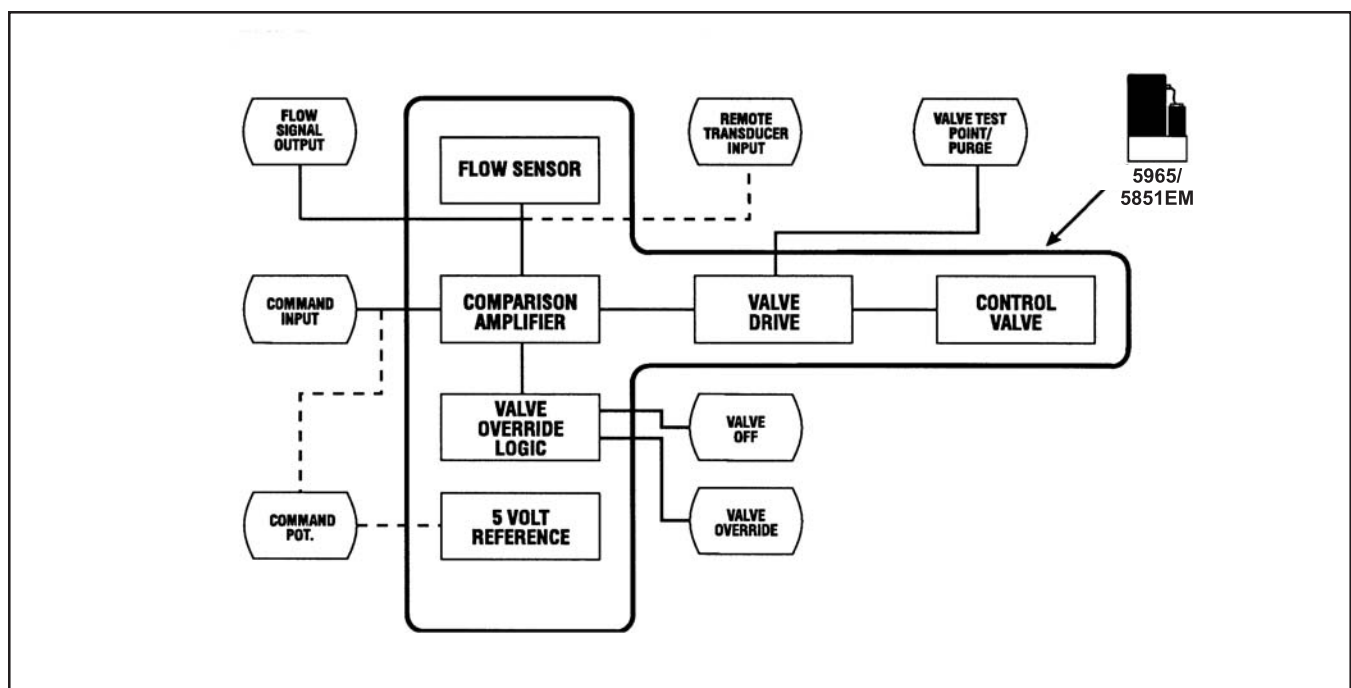
In addition to the mass flow sensor, the Model 5965/5851EM mass flow controller has an integral control valve and control circuit as shown in Figure 3-2. The control circuit senses any difference between the flow sensor signal and adjusts the current in the modulating solenoid valve to increase or decrease the flow.

3-2 Operating Procedure

⚠ 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.

- Apply power to the controller and allow approximately 45 minutes for the instrument to warm up and stabilize its temperature.
- Turn on the gas supply.
- Command zero percent (0%) flow and observe the controller's output signal. If the output is not zero mVdc (± 10 mVdc), check for leaks and, if none are found, refer to the re-zeroing procedure in Section 3-3.



3-2 Figure 3-2 Flow Control System Block Diagram

- d. Set the command for the desired flow rate to assume normal operation.
Note: If a separate positive shut-off solenoid valve is not installed, a flow signal may result from leak-through. Leak-through is more significant with stainless steel and Teflon valve seats.

3-3 Zero Adjustment

Each Model 5965/5851EM is factory adjusted to provide a zero +10 mVdc signal (or a 4 mAdc +.05 mAdc signal, Current I/O Version) at zero flow. 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 in an unpressurized line, 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, 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 3-6) until the desired output signal is obtained.

3-4 Calibration Procedure

Note 1: If the valve has been disassembled and any of the following parts have been replaced, the device must be returned to Brooks Instrument for control valve adjustment before the Model 5965/5851EM may be calibrated.

- orifice
- valve stem
- plunger
- plunger extension
- lower guide spring
- valve seat
- gland nut

Note 2: calibration of the Model 5965/5851EM mass flow controller requires the use of a Digital Voltmeter (DVM) and a precision flow standard calibrator such as the Brooks Instrument's 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 4-4). size the orifice for actual operating conditions (refer to Section 4-5).

⚠ CAUTION

For the Card Edge model (Figure 3-3), do not ground Pin 10 with the 5 volt reference enabled. Irreparable damage to the printed circuit board will result.

Brooks® Models 5965, 5851EM

Note 4: If Brooks secondary electronics are being used as a power supply during the calibration, the 5 volt reference must be enabled on the card Edge version for proper operation (see Section 2-7). Remember to deactivate the 5 Volt reference before installing the calibrated mass flow controller in the system where Terminal 10 is grounded.

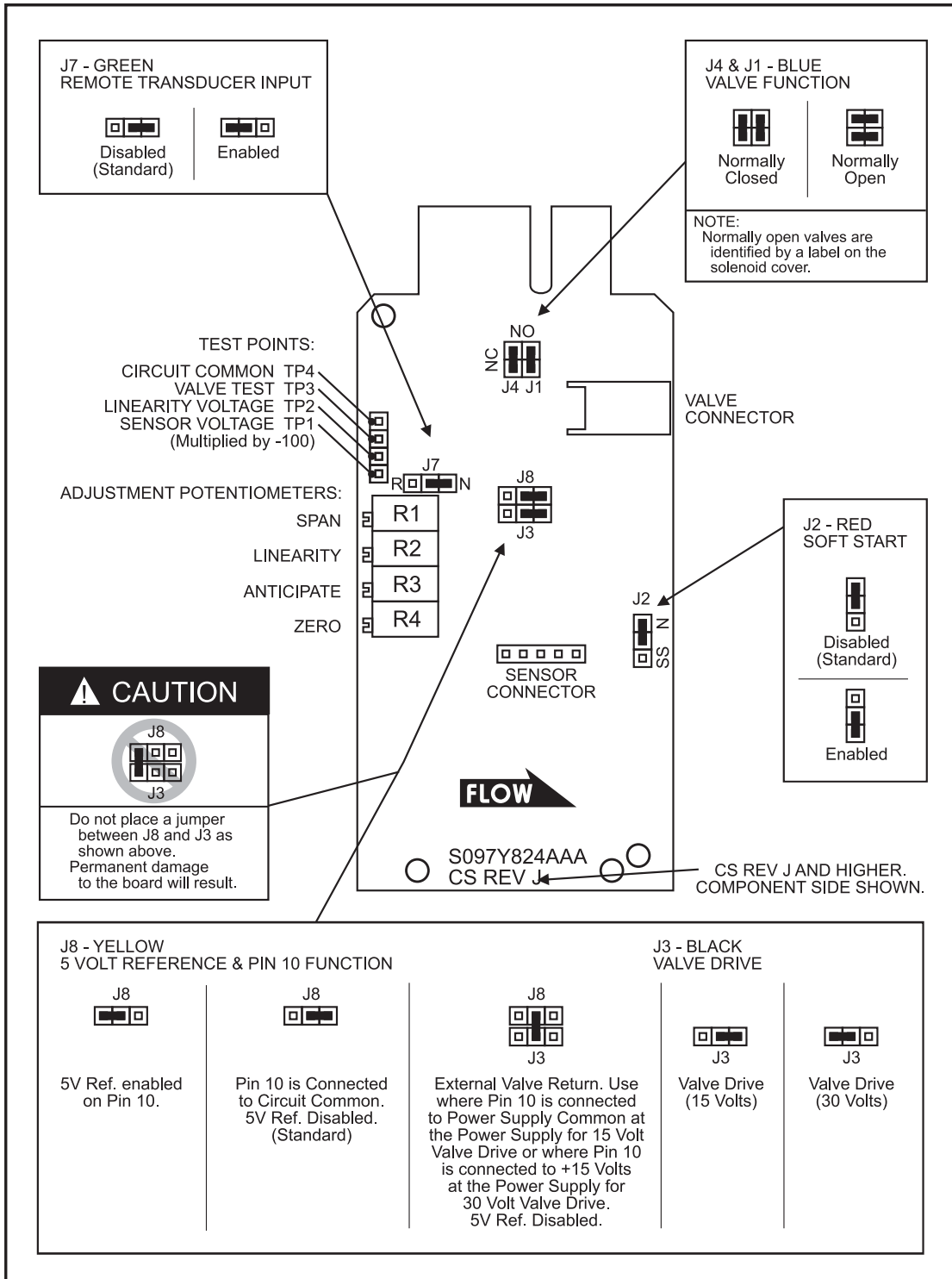


Figure 3-3 Card Edge PC Board Jumper Location and Function

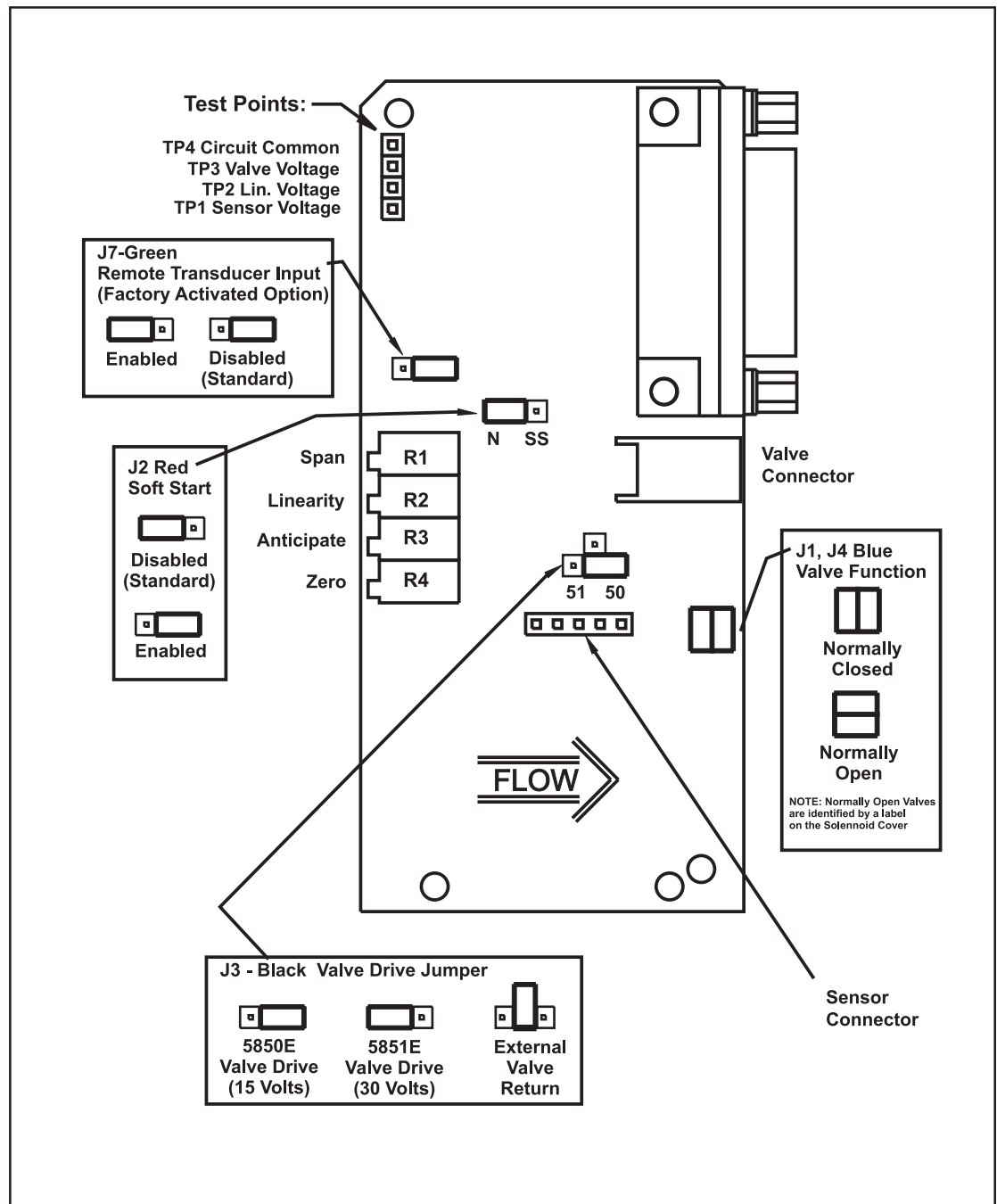


Figure 3-4 D-Connector PC Board Jumper Location and Function (Voltage I/O Version)

Brooks® Models 5965, 5851EM

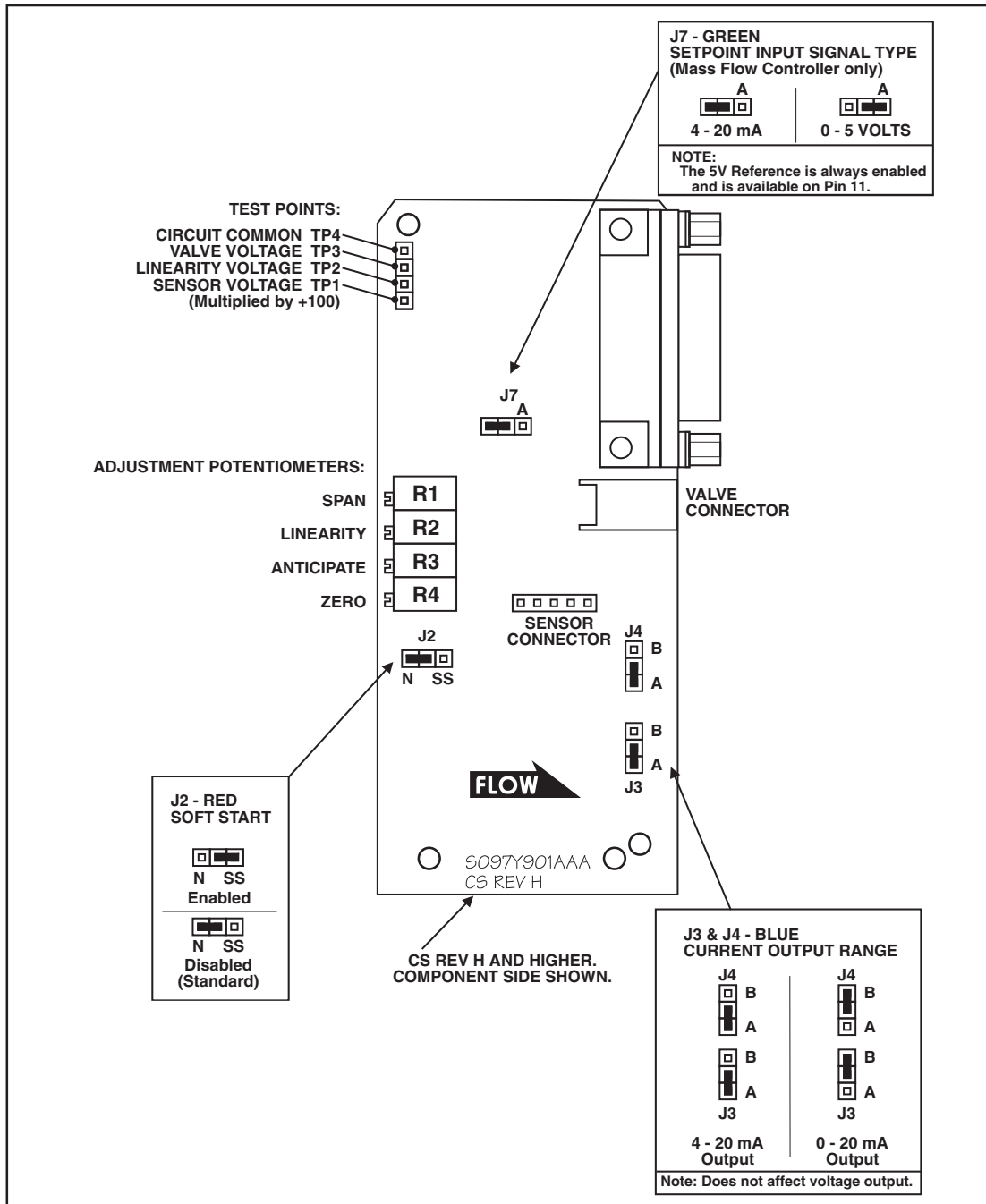


Figure 3-5 D-Connector PC Board Jumper Location and Function (Current I/O Version)

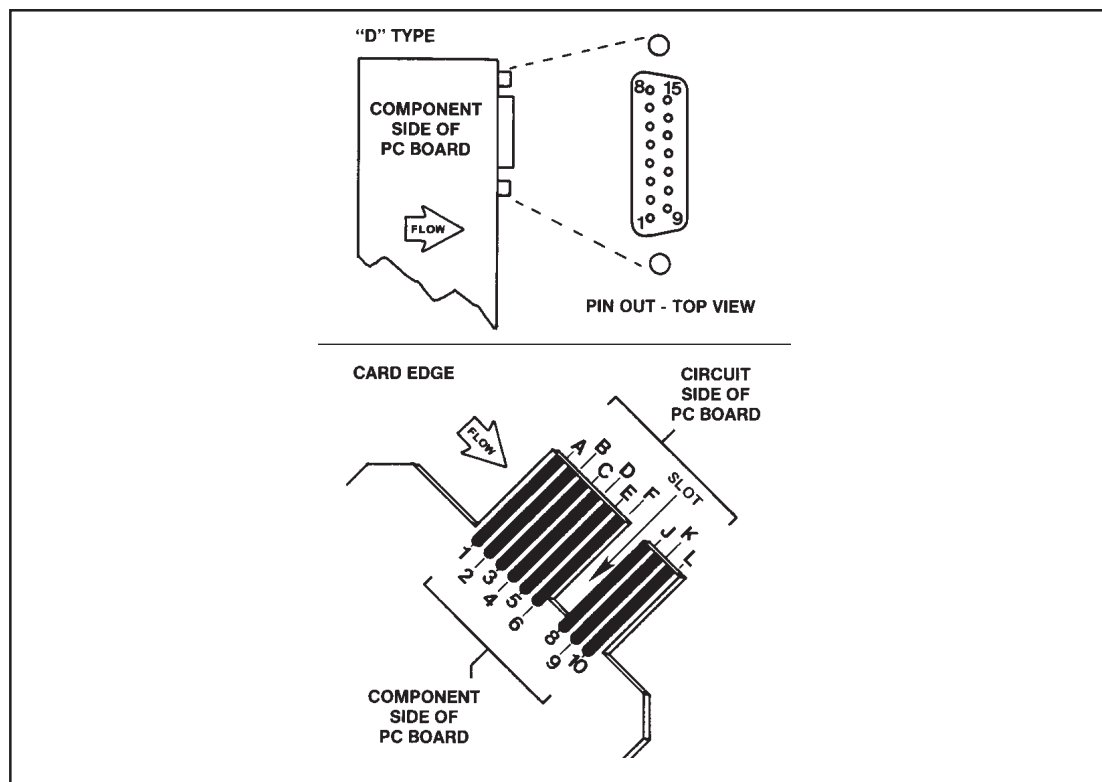


Figure 3-6 Model 5851EM Calibration Connections

Note 5: when calibrating the current I/o Version, it is easiest to calibrate using 0-5 vdc command and flow signals. Refer to section 2, Figures 2-4, 2-6 and 3-5 for proper hookups. After calibration, the Model 5965/5851EM may be reconfigured for Current I/O operation with negligible change in calibration.

- 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 and will cause abnormal heat-up of the control valve. with this abnormally warm valve, the meter will be difficult to calibrate. This situation can be prevented by switching the valve override "closed" when there is no gas flow or by setting the command to less than one percent (1%). Also, avoid unnecessary periods with the valve override "open".

Note: For Model 5965/5851EMs with normally open valves this condition can be prevented by switching the valve override "open" or by setting the command to 100% when there is no gas flow. Also, avoid unnecessary periods with valve override "closed".

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- b. Adjust the anticipate potentiometer with 20 clockwise full turns. Next, adjust the anticipate potentiometer with 10 counterclockwise turns to center the potentiometer. This will provide a rough adjustment of this circuit and make the flow more stable for calibration.
- c. Connect the DVM positive lead to the 0-5 Volt signal output (Terminal 3 Card Edge, Pin 2 D-Connector) and the negative lead to signal common (TP4). Adjust the zero potentiometer for an output of zero mv +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 or Teflon valve seats do not provide tight shut-off. A 0-3% leak-through is typical. For metal or Teflon seat controllers, close a downstream shut-off valve and observe the zero signal.
- e. Set the command potentiometer (connected to Terminals A, B and 10 of the Card Edge connector and Terminals 1, 9 and 11 of the D-Connector) for 100% of flow (5.000 V). Connect the DVM positive lead to TP2 (linearity voltage) and the negative lead to TP4 (circuit common). Adjust the linearity potentiometer for an output of 0.0 V (zero Volts).
- f. Connect the DVM positive lead to TP1 (-100x sensor voltage) and the negative lead to TP4 (circuit common). The command potentiometer should still be set at 100% flow (5.000 V). 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:

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

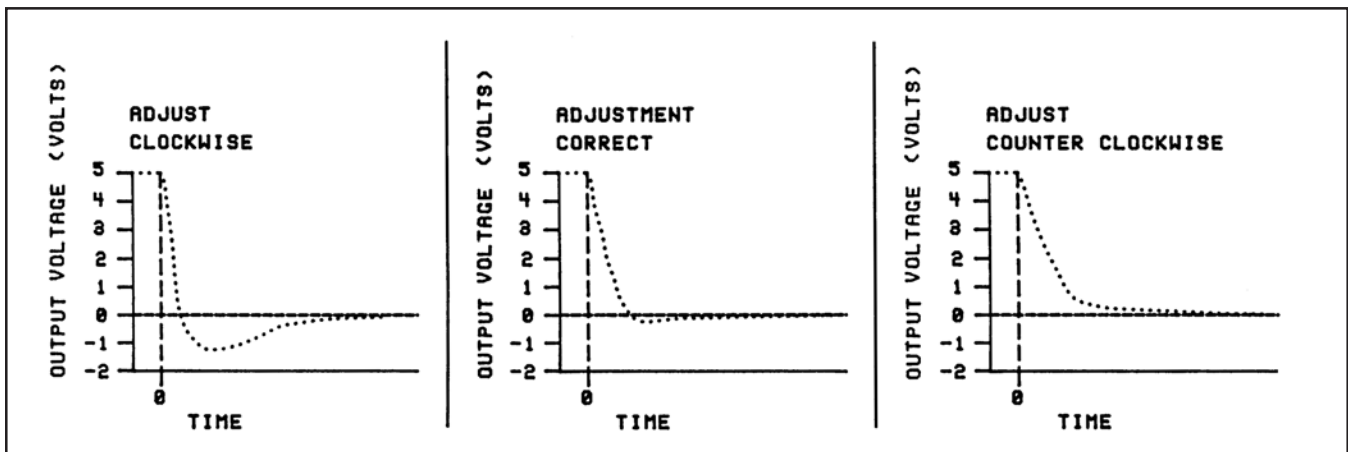


Figure 3-7 Fast Response Adjustment

Note: The voltage at TP1 is -100 times the output voltage (+100 times for Current I/O Version) of the sensor. This voltage can range from -1.2 to -12 Volts (+1.2 to 12 Volts for the Current I/O Version), however, it is recommended that this voltage stay between -2.0 and -9.0 (+2 and +9 for Current I/O Version) Volts for proper operation. If the recommended voltage range exceeds the desired range, accuracy and/or signal stability may not be achieved. If one of the limits is reached, check the restrictor and orifice sizing procedures. Refer to Sections 4-5 and 4-6 respectively.

- g. Set the command potentiometer for zero percent of flow. Connect the DVM positive lead to flow signaloutput (Terminal 3 Card Edge, Pin 2 D-Connector) and the negative lead to TP4. Readjust the zero potentiometer for an output of zero mV \pm 2 mV as necessary.
- h. Set the command potentiometer for 50% of flow (2.500 V) and measure the flow rate. Calculate the error as a percentage of full scale.

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

Example:

What is the percent of full scale error when full scale flow rate is equal to 100 slpm?

Measured flow rate = 48.5 slpm

Desired flow rate = 50.0 slpm

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

- i. Calculate theTP2 correction voltage:
(error recorded in Step h) x 0.450 Volts

Example:

Error = -1.5%

TP2 correction voltage = -1.5 x 0.450 = -0.675 Volts

NewTP2 voltage = zero volts + (-0.675) = -0.675 Volts

- j. Set the command potentiometer for 100% flow (5.000 V). 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% (5.000 V). Connect the DVM positive lead to TP2 (linearity voltage) and the negative lead to TP4 (circuit common). Calculate a newTP2 voltage as follows:

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$$\text{New TP2 voltage} = \frac{\text{error recorded in Step "i"}}{1} \times 0.450\text{V} + \text{measured TP2 voltage}$$

Example:

Controller error = 0.7%

Measured TP2 voltage = -0.567 Volts

TP2 correction = $0.7 \times 0.450 = 0.315$ 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. It is recommended however, that this voltage stay 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 4-6).

3-5 Response

Two methods of adjusting the step response of the Model 5965/5851EM mass flow controllers can be used.

Adjustment #1 describes a method that will get the step response close to optimum quickly and without any flow measuring equipment. This method should be used when the response time of the flow controller is not critical to overall system performance.

Adjustment #2 describes a method that will allow adjustment of your Model 5965/5851EM 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.

Response Adjustment #1 (Specification not Guaranteed)

Note: This procedure requires an oscilloscope, chart recorder or a DVM with a sample speed of three samples, or greater, per second to monitor the rate of change of the output signal.

- a. Set the command potentiometer for 100% of flow (5.000 V), and wait about 45 seconds for the flow output signal to stabilize.
- b. Step the command signal to zero percent 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 zero percent flow indicates the adjustment required of the anticipate potentiometer (refer to Figure 3-7).
 1. If the flow signal decays to -.05 to -.5 Volt, then rises to zero Volts, the anticipate potentiometer is properly adjusted.
 2. If the flow signal decays rapidly and goes below -.5 Volt before rising to zero Volt, the anticipate potentiometer must be adjusted clockwise and Steps a and b repeated.
 3. If the flow signal decays slowly and does not go below -.5 Volt, the anticipate potentiometer must be adjusted counterclockwise and Steps a and b repeated.

Response Adjustment #2 (Specification Guaranteed)

Adjustment of the anticipate potentiometer to obtain a flow rate performance to be within 2% of flow rate commanded in less than three seconds (six seconds for Current I/O Version) after command 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 Model 5965/5851EM and a storage oscilloscope or recorder.

- a. Make a step change in command to the controller from zero to 100% of full scale flow and record the output signal of the fast response flowmeter which is in series with the Model 5965/5851EM.
- b. If this signal shows more than 4% overshoot, adjust the anticipate potentiometer one-half to one turn counterclockwise. If the signal does not show overshoot, but is not within 2% full scale of final value after three seconds (six seconds for Current I/O Version), adjust the anticipate potentiometer one-half to one turn clockwise. Set the command potentiometer for zero percent 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 Overview

	<p>⚠ WARNING</p> <p>METER/CONTROLLER SEAL COMPATIBILITY</p>
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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.

⚠ 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 flowmeter from the system after exposure to toxic, pyrophoric, flammable or corrosive gas, purge the flowmeter thoroughly with a dry inert gas such as Nitrogen before disconnecting the gas connections. Failure to correctly purge the flowmeter could result in fire, explosion or death. Corrosion or contamination of the flowmeter upon exposure to air, may also occur.

⚠ CAUTION

It is important that this MFC/MFM only be serviced by properly trained and qualified personnel.

No routine maintenance is required on the Models 5965 and 5851EM. If an in-line filter is used, the filtering element should periodically be replaced.

4-2 Troubleshooting

CAUTION

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

A. System Checks

The Models 5965 and 5851EM are 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 a low resistance common connection, correct power supply voltage and that signals are reaching and leaving the controller. The breakout board, P/N S273Z649AAA Card Edge version or P/N S273Z668AAA D-Connector version 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 set-point, 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 Figures 3-5 through 3-9.

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. Failure to correctly purge the controller could result in fire, explosion or death. Corrosion or contamination of the mass flow controller, upon exposure to air, may also occur.

B. Bench Troubleshooting

1. Properly connect the mass flow controller to a ± 15 Vdc power supply command voltage source (+27.5 +28 Vdc for Current I/O version) and connect an output signal readout device (4-112 Digit Voltmeter recommended) to Terminals 2 and 3 or D-Connector pins 2 and 10 (refer to Figs.2-2,2-3 and 2-9. Apply power, set the command voltage 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.

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 4 .
Output stays at zero level regardless of command and there is no flow through the controller.	Clogged Sensor tube and restrictor and/or a clogged orifice. Closed or clogged flow path up- or downstream of the controller. Clogged Control Valve. Internal reference being used as the command source and the yellow jumper is in the wrong position. -15 volts applied to the valve override input Defective printed circuit board. Valve voltage not returned, Pin L at common. "Valve-off" pin grounded.	Clean sensor. Refer to cleaning procedure, Section 4. Open valve(s). Clean filter(s). Remove any foreign material from gas delivery system. Check TP3 with the command at 100%. If the voltage is more negative than -11V, disassemble and repair the control valve. Refer to Sections 4-3 and 4-4. Refer to Section 3-4, Figure 3-3. Check valve override input. Refer to Section 2-6 for terminal assignments. Replace printed circuit board. Refer to Section 4-3. Check jumper for external valve return. Refer to Section 3-4. Check "Valve-Off" input. Refer to Section 2-6 for terminal assignments.
Output signal stays at +6.8 Volts (26 mA for Current I/O Vers.) regardless of command and there is flow	Valve stuck open or leaky. +15 Volts applied to the valve override input. Defective printed circuit board. Command input floating. Pin D connected to common.	Clean and/or adjust control valve. Refer to cleaning procedure and/or Section 4-2D. Check the valve override terminal. Refer to Section 2-6 for terminal assignments through the controller. Replace printed circuit board. Refer to Section 4-3. Connect command signal. Refer to Section 2-6 for terminal assignments. Remove Pin D from common.
Output signal follows set-point at higher commands but will not go to zero.	Leaky control valve Excessive resistance in valve voltage return line.	Disassemble and repair valve. Refer to Section 4-3. Reduce wiring resistance or reconfigure controller for "External Valve Return." Refer to Section 3-4.
Output signal follows set-point at lower commands but does not reach full scale.	Insufficient inlet pressure or pressure drop. Partially clogged sensor Partially clogged valve. Valve out of adjustment. Valve guide spring failure.	Adjust pressures, inspect in-line filters and clear/replace as necessary. Check calibration. Refer to Section 3-7. Disassemble and repair control valve. Refer to Section 4-3. Adjust valve. Refer to Section 4-4. Check valve spring.
Controller grossly out of calibration. Flow is higher than desired.	Partially clogged sensor.	Clean sensor. Refer to the cleaning procedure, Section 4-2D.
Controller grossly out of calibration. Flow is lower than desired.	Partially clogged restrictor.	Replace restrictor. Refer to Section 4-3.
Controller oscillates.	Pressure drop or inlet pressure excessive. Oversized orifice. Valve out of adjustment. Anticipate potentiometer out of adjustment. Faulty pressure regulator. Defective printed circuit board.	Adjust pressures. Check orifice size. Refer to Section 4-6. Adjust valve. Refer to Section 4-4. Adjust anticipate potentiometer. Refer to Section 3-8. Check regulator output. Replace printed circuit board. Refer to Section 4-3.

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 5.000 Volts. Vary the command voltage over the 2-to-100% range and verify that the output signal follows the setpoint.

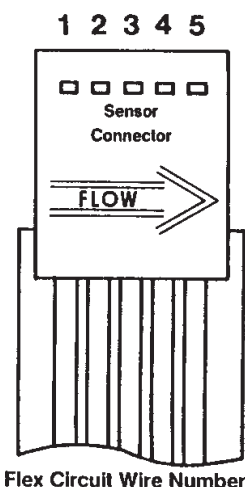
Apply +15 Volts to the valve override input (refer to Figs. 2-2, 2-3 and 2-4 for terminal assignments) and verify that the output exceeds 5.000Volts.

Apply -15 Volts to the valve override terminal (connect valve override pin +0 ground for current I/O versions) and verify that the output signal falls below 0.100 Volts. 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 is most likely elsewhere. Table 4-1 lists possible malfunctions which may be encountered during bench troubleshooting.

Table 4-2 Sensor Troubleshooting

SENSOR SCHEMATIC

PIN NO.	FUNCTION
1	Heater
2	Upstream Temperature Sensor (Su)
3	Downstream Temperature Sensor (Sd)
4	Sensor Common
5	Heater Common



Flex Circuit Wire Numbers

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

OHMMETER CONNECTION	RESULT IF ELECTRICALLY FUNCTIONAL
Pin 1 or 4 to meter body	Open circuit on ohmmeter. If either heater (1) or sensor common (4) are shorted, an ohmmeter reading will be obtained.
Pin 4 to Pin 2	Nominal 1100 ohms reading, depending on temperature and ohmmeter current.
Pin 4 to Pin 3	
Pin 5 to Pin 1	Nominal 1200 ohm reading.

C. Sensor Troubleshooting

If it is believed the sensor coils are either open or shorted, troubleshoot using Table 4-2. If any of the steps do not produce expected results, the sensor assembly is defective. Return to Brooks Instrument for sensor replacement.

Note: Do not attempt to disassemble the sensor.

D. Cleaning Procedures

No routine external cleaning is required for Brooks thermal mass flow controller. Should the Models 5965 or 5851EM Mass Flow Controller require cleaning due to deposition, return the device to Brooks Instrument for servicing by trained technicians.

4-3 Gas Conversion Factors

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. A list of sensor conversion factors is given in Table 4-5. 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.

$$\text{Actual Gas Flow Rate} = \text{Output Reading} \times \frac{\text{Factor of the New Gas}}{\text{Factor of the Calibration Gas}}$$

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 $75 \times 0.773 = 57.98$ sccm

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

$$\text{Sensor Conversion Factor}_{\text{Mixture}} = \frac{100}{P_1} \frac{1}{\text{Sensor Conversion Factor}_1} + \frac{100}{P_2} \frac{1}{\text{Sensor Conversion Factor}_2} + \frac{100}{P_3} \frac{1}{\text{Sensor Conversion Factor}_3}$$

Where,

P_1 = percentage (%) of gas 1 (by volume)

P_2 = percentage (%) of gas 2 (by volume)

P_n = percentage (%) of gas n (by volume)

Table 4-3 Conversion Factors (Nitrogen Base)

GAS NAME	FORMULA	SENSOR FACTOR	ORIFICE FACTOR	DENSITY (kg/m ³)
Acetylene	C ₂ H ₂	0.615	0.970	1.173
Air	Mixture	0.998	1.018	1.293
Allene	C ₃ H 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 ₂ BrF ₃	0.326	2.397	7.165
Bromotrifluoromethane f-13B1	CBrF ₃	0.412	2.303	6.615
1,3-Butadiene	C ₄ H ₆	0.354	1.413	2.491
Butane	C ₄ H ₁₀	0.257	1.467	2.593
1-Butene	C ₄ H ₈	0.294	1.435	2.503
CIS-2-Butene	C ₄ H ₈	0.320	1.435	2.503
Trans-2-Butene	C ₄ H ₈	0.291	1.435	2.503
Carbon Dioxide	CO ₂	0.773	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 ₄ H ₉ Cl	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 ₂ CLF ₅	0.243	2.397	7.165
Chlorotrifluoroethylene	C ₂ CLF 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 ₄ H ₈	0.387	1.413	2.491
Cyclopropane	C ₃ H ₆	0.505	1.224	1.877
Deuterium	D ₂	0.995	0.379	0.177
Diborane	B ₂ H ₆	0.448	1.000	1.235
Diboromodifluoromethane f-12B2	CBr ₂ F ₂	0.363	2.652	8.768
1,2-Dibromotetrafluoroethane f-114B2	C ₂ Br ₂ F ₄	0.215	2.905	10.53
Dichlorodifluoromethane f-12	CCL ₂ F ₂	0.390	2.099	5.492
Dichlorofluoromethane f-21	CHCL ₂ F	0.456	1.985	4.912
Dichlorosilane	SiH ₂ CL ₂	0.442	1.897	4.506
1,2-Dichloroethane	C ₂ H ₄ CL ₂	0.382	1.879	4.419
1,2-Dichlorotetrafluoroethane f-114	C ₂ CL ₂ F ₄	0.231	2.449	7.479
2,2 Dichloro	C ₂ HC ₁₂ F ₃	0.259	2.336	6.829
1,1-Difluoro-1-Chloroethane	C ₂ H ₃ CLF ₂	0.341	1.957	4.776
1,1-Difluoroethane	CH ₃ CHF ₂	0.415	1.536	2.940
1,1-Difluoroethylene	CH ₂ :CF ₂	0.458	1.512	2.860
Diethylsilane	C ₄ H ₁₂ Si	0.183	1.775	3.940
Difluoromethane f-32	CF ₂ H ₂	0.627	1.360	2.411
Dimethylamine	(CH ₃) ₂ NH	0.370	1.269	2.013
Dimethylether	(CH ₃) ₂ O	0.392	1.281	2.055
2,2-Dimethylpropane	C(CH ₃) ₄	0.247	1.613	3.244
Disilane	Si ₂ H ₆	0.332	1.493	2.779
Ethane	C ₂ H ₆	0.490	1.038	1.357
Ethanol	C ₂ H ₅ O	0.394	1.282	2.057
Ethylacetylene	C ₄ H ₆	0.365	1.384	2.388
Ethyl Chloride	C ₂ H ₅ CL	0.408	1.516	2.879

Table 4-3 Conversion Factors (Nitrogen Base) Continued

GAS NAME	FORMULA	SENSOR FACTOR	ORIFICE FACTOR	DENSITY (kg/m ³)
Ethylene	C ₂ H ₄	0.619	1.000	1.261
Ethylene Oxide	C ₂ H ₄ O	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 ₂ HBrClF ₃	0.257	2.654	8.814
Helium	He	1.386	0.378	0.178
Hexafluoroacetone	F ₃ CCOCF ₃	0.219	2.434	7.414
Hexaflorobenzine	C ₆ F ₆	0.632	2.577	8.309
Hexafluoroethane f-116	C ₂ F ₆	0.255	2.219	6.139
Hexafluoropropylene (HFP)	C ₃ F ₆	0.249	2.312	6.663
Hexamethyldisilane (HMDS)	(CH ₃) ₆ Si ₂	0.139	2.404	7.208
Hexane	C ₆ H ₁₄	0.204	1.757	3.847
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 ₂ Se	0.837	1.695	3.613
Hydrogen Sulfide	H ₂ S	0.850	1.108	1.539
Iodine Pentafluoride	IF ₅	0.283	2.819	9.907
Isobutane	C ₄ H ₁₀	0.260	1.440	2.593
Isobutene	C ₄ H ₈	0.289	1.435	2.503
Isopentane	C ₅ H 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 ₃ H ₄	0.473	1.196	1.782
Methyl Bromide	CH ₃ Br	0.646	1.834	4.236
3-Methyl-1-butene	C ₅ H ₁₀	0.252	1.584	3.127
Methyl Chloride	CH ₃ CL	0.687	1.347	2.308
Methyl Fluoride	CH ₃ F	0.761	1.102	1.518
Methyl Mercaptan	CH ₄ S	0.588	1.313	2.146
Methyl Silane	CH ₃ Si	0.393	1.283	2.061
Methyl Trichlorosilane (MTS)	CH ₃ Cl ₃ Si	0.267	2.310	6.675
Methyl Vinyl Ether	C ₃ H ₆ O	0.377	1.435	2.567
Monoethanolamine	C ₂ H ₇ NO	0.305	1.477	2.728
Monoethylamine	C ₂ HH ₃ NH ₂	0.359	1.269	2.013
Monomethylamine	CH ₃ NH 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 ₂ O ₃	0.443	1.649	3.389
Nitrosyl Chloride	NOCL	0.644	1.529	2.913
Nitrous Oxide	N ₂ O	0.752	1.259	1.964
Octofluorocyclobutane	C ₄ F 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 ₂ HF ₅	0.287	2.070	5.360
Pentane (n-Pentane)	C ₅ H ₁₂	0.212	1.605	3.222
Perchloryl Fluoride	CLO ₃ F	0.448	1.905	4.571
Perfluorobutane	C ₄ F ₁₀	0.738	2.918	10.61
Perfluoro-2-Butene	C ₄ F ₈	0.268	2.672	8.933
Perfluoromethyl-vinylether	PMVE	0.296	2.029	5.131
Perfluoropropane	C ₃ F ₈	0.179	2.591	8.396

Table 4-3 Conversion Factors (Nitrogen Base) Continued

GAS NAME	FORMULA	SENSOR FACTOR	ORIFICE FACTOR	DENSITY (kg/m³)
Pentane (n-Pentane)	C ₅ H 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 ₃ CH ₂ CH ₃)	C ₃ H ₈	0.343	1.274	2.008
Propylene (Propene)	C ₃ H 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 ₂ F ₂	0.423	1.931	4.648
Tetrachloromethane	CCL ₄	0.344	2.345	6.858
Tetrafluoroethylene (TFE)	C ₂ F ₄	0.361	1.905	4.526
Tetrafluorohydrazine	N ₂ F ₄	0.367	1.926	4.624
Trichlorofluoromethane f-11	CCL ₃ F	0.374	2.244	6.281
Trichlorosilane	SiHCL ₃	0.329	2.201	6.038
Trimethoxyborane (TMB)	B(OCH ₃) ₃	0.300	1.929	4.638
1,1,2-Trichloro-1,1,2-Trifluoroet f-113	C ₂ CL ₃ F ₃	0.231	2.520	7.920
Trimethylamine	(CH ₃) ₃ N	0.316	1.467	2.639
Tungsten Hexafluoride	WF ₆	0.227	3.264	13.28
Uranium Hexafluoride	UF ₆	0.220	3.548	15.70
Vinyl Bromide	C ₂ H ₃ Br	0.524	1.985	4.772
Vinyl Chloride	C ₂ H ₃ CL	0.542	1.492	2.788
Vinyl Fluoride	C ₂ H ₃ F	0.576	1.281	2.046
Water Vapor	H ₂ O	0.861	0.802	0.804
Xenon	Xe	1.383	2.180	5.851

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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:

$$\text{Mixture Factor} = \frac{100}{\frac{20}{1.386} + \frac{80}{.876}} = .945$$

Nitrogen equivalent flow = 20/.945 = 21.16 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 4-5 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 pressure and/or temperature.

4-4 Orifice Sizing

The Orifice Sizing Nomograph, Figure 4-4, 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
Flow Rate: 2,000 sccm
Outlet Pressure: 30 psig
Inlet Pressure: 50 psig

1. Determine Nitrogen equivalent flow rate (refer to Table 4-5).

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

OR

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

Where:

Q_{NITROGEN} = Nitrogen equivalent flow rate (sccm)

Q_{GAS} = Desired flow rate of the gas (sccm)

ρ_{NITROGEN} = Density of Nitrogen at 70°F

ρ_{GAS} = Density of the gas (taken at customer temperature)

SG_{GAS} = Specific gravity of the gas (taken at customer temperature)

Refer to Table 4-5 for densities.

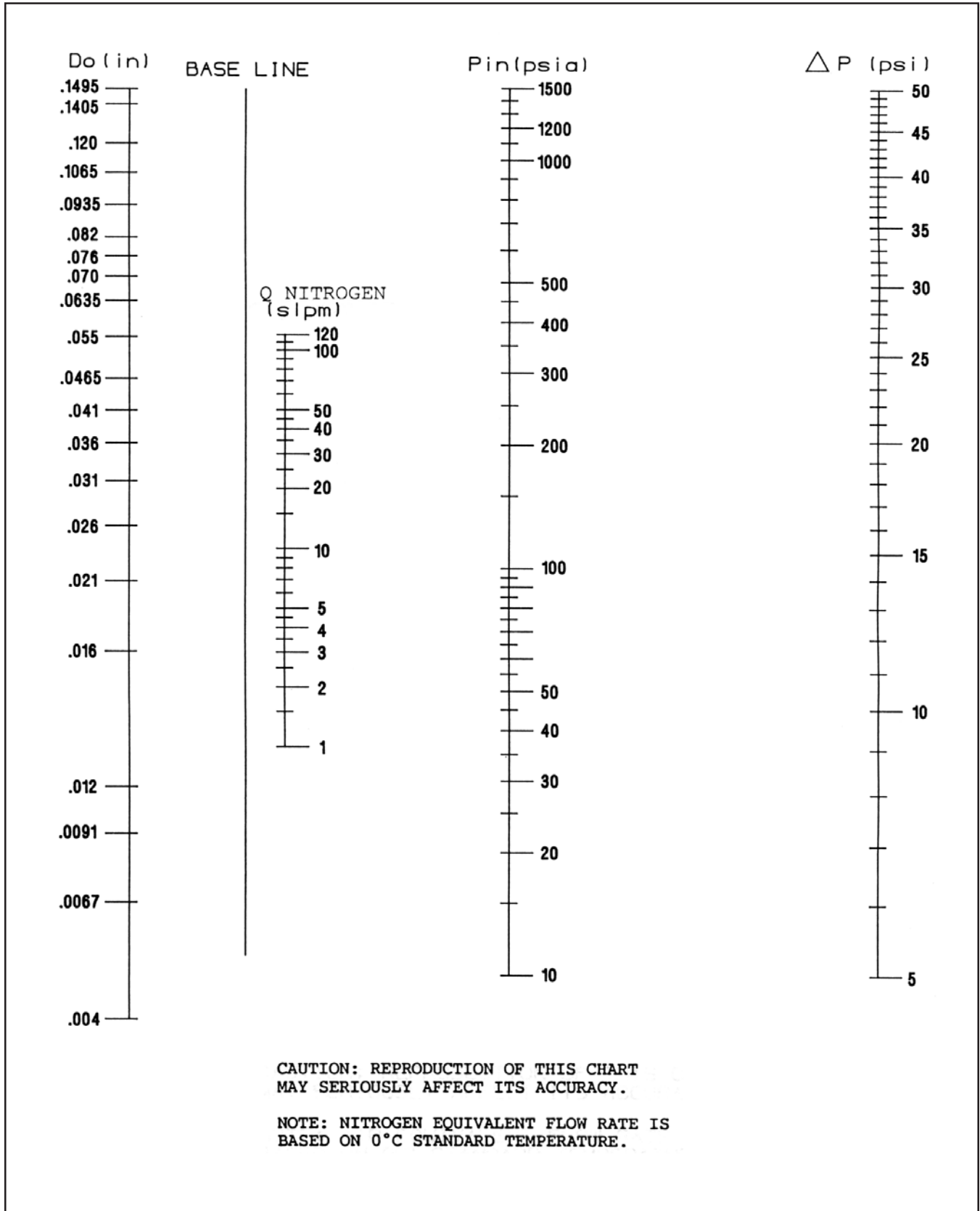


Figure 4-1 Model 5965/5851EM Orifice Sizing Nomograph

Example:

$$\begin{aligned}
 Q_{\text{gas}} &= 2,000 \text{ sccm} \\
 \sqrt{\frac{P_{\text{GAS}}}{P_{\text{NITROGEN}}}} &= .269 \\
 Q_{\text{NITROGEN}} &= Q_{\text{GAS}} \times \sqrt{\frac{P_{\text{GAS}}}{P_{\text{NITROGEN}}}} \\
 &= 2,000 \times .269 \\
 &= 538 \text{ sccm Nitrogen}
 \end{aligned}$$

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

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

Where P_1 = percentage by volume of gas 1
 P_2 = percentage by volume of gas 2
 P_n = percentage by volume of gas n

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

$$\begin{aligned}
 \text{Orifice Conversion Factor Mixture} &= \frac{20(.378)}{100} + \frac{80(1.598)}{100}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{Nitrogen}} &= Q_{\text{gas}} (\text{orifice conversion factor}) \\
 &= 20 \times 1.439 \\
 &= 28.78 \text{ slpm Nitrogen}
 \end{aligned}$$

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

$$\begin{aligned}
 \text{Outlet Pressure} &\text{ — } 30 \text{ psig} + 14.7 = 44.7 \text{ psia} \\
 \text{Inlet Pressure} &\text{ — } 50 \text{ psig} + 14.7 = 64.7 \text{ psia}
 \end{aligned}$$

3. Determine Critical Pressure Drop

Critical pressure drop occurs when the outlet pressure (psia) is less than half the inlet pressure (psia) or

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

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

$$Dp = \frac{P_{\text{in}}}{2}$$

Dp = Pressure drop (psi)

P_{in} = Inlet pressure (psia)

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

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

$$\text{Then } Dp = 64.7 - 44.7 = 20 \text{ psi}$$

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 4-5, the .007 size orifice would be selected.

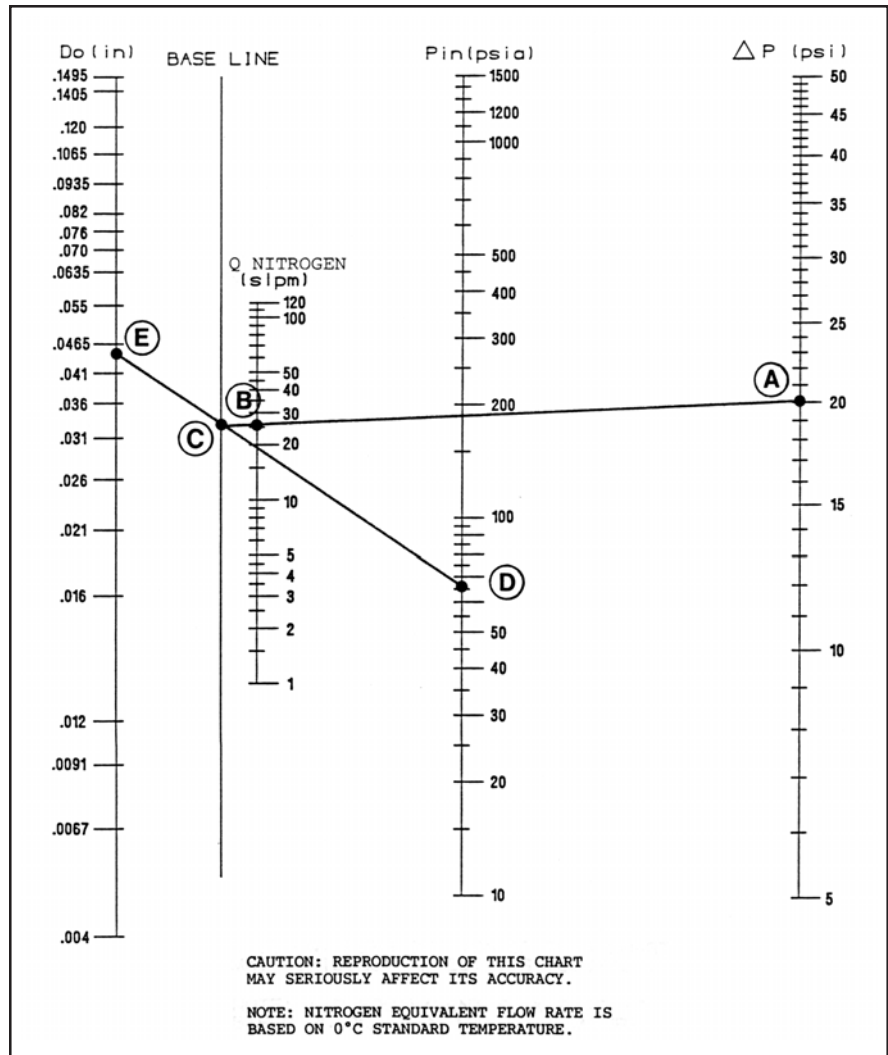


Figure 4-2 Example Nomograph

4-5 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 (active area) 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 3-3, 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. See Section 4-3, Disassembly and Assembly, for restrictor removal and installation.

Restrictors

The Model 5965/5851EM mass flow controller/device uses one type of restrictor assembly depending on full scale flowrate and expected service conditions.

1. Sintered element for nitrogen equivalent flow rates from 10 to 100 slpm

Sizing

All Model 5965/5851EM Series Restrictor Assemblies are factory adjusted to provide a specific pressure drop for each flow rate. This corresponds to the desired full scale flow rate. A list of restrictor assemblies used in the Model 5965/5851EM mass flow controller/device is shown in Table 4-6.

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 4-5.

Nitrogen equivalent flow = $30/0.499 = 60.1$ slpm Nitrogen

In the example, the restrictor should be sized for a 60.1 slpm flow rate.

Note: If the calculated flow rate is such that two different size restrictors could be used, always select the larger size.

If a mixture of two or more gases is being used, the restrictor selection must be based on a Nitrogen equivalent flow rate of the mixture.

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:

$$\text{Mixture Factor} = \frac{100}{\frac{20}{1.386} + \frac{80}{.876}} = .945$$

Nitrogen equivalent flow = 20/.945 = 21.16 slpm Nitrogen. In this example a Size 4 Wire Mesh Assembly would be selected.

Table 4-4 Model 5965/5851EM Standard Restrictors

Range slpm Nitrogen Equivalent Flow*	Restrictor Element Combination	Part Number
4.6 to 15	1-40 micron (1 inch)	S613E666BMG
15 to 26	1-40 micron	S613E657BMG
26 to 42	2-40 micron	S613E658BMG
42 to 60	3-40 micron	S613E659BMG
60 to 79	2-40 micron/1-60 micron	S613E661BMG
79 to 93	1-40 micron/2-60 micron	S613E663BMG
93 to 130	3-60 micron	S613E655BMG
130 to 400	3-60 micron	S613E662BMG
400 to 600	3-100 micron	S613E656BMG

* Based on 0°C Standard Reference Temperature

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

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-forskrninger skal enten være af metal eller metal skærmet.

Skærmen skal forbindes, i begge ender, til stikkets metalhus eller PG-forskrningen 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 entsprechend den Vorschriften 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 %igen Schirmabdeckung des Kabels gewährleistet ist.

"D" oder "Rund" -Verbindungsstecker sollten eine Abschirmung aus Metall besitzen.

Wenn möglich, sollten Kabeldurchführungen mit Anschlußmöglichkeiten für die Kabelabschirmung 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-Steckverbindungen sind standardmäßige keine metallgeschirmten Verbindungen. Um die Anforderungen der CE-Zertifizierung zu erfüllen, sind Kabel mit einer 100 %igen Schirmabdeckung zu verwenden.

Die Abschirmung ist mit dem Erdpotential zu verbinden.

Die Belegung der Anschlußpins können Sie dem beigelegten Bedienungshandbuch entnehmen.

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.

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).

Οποσδήποτε χρειάζεται ειδική προσοχή κατά την 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 "Κυκλικό" των καλωδίων, πρέπει να θωρακίζονται με μεταλλική θωράκιση. Εάν είναι εφαρμόσιμο, πρέπει να χρησιμοποιούνται μεταλλικοί στυπιοθλιπτες καλωδίων που να διαθέτουν ακροδέκτη σύνδεσης του πλέγματος του καλωδίου.

Το πλέγμα του καλωδίου πρέπει να συνδέεται στο μεταλλικό περιβλήμα ή στον στυπιοθλιπτη 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.

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 Elettromagnetica (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 estremità.

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 producten 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 producten.

Kwaliteit van de signaalkabel en kabelansluitingen:

- 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 instructie handboek.

Hoogachtend,

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 jordnet 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 requisitos 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 360°.

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.

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 sertifiointivaatimukset. Hankkiessaan signaalikaapelin itse, olisi hankittava 100%:sti suojattu kaapeli.

”D” tai ”Circular” tyyppisen liittimen tulisi olla varustettu metallisuojaalla. Mikäli 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 sertifiointimukaisia.

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 kompatibilitet (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 ändrar, 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% skärmade för att överensstämma med CE-certifieringen.

Skärmen ska avslutas med en jordförbindelse.

För elektrisk anslutning till kontaktstiften hänvisas till medföljande instruktionsmanual.

Installation and Operation Manual

X-TMF-5965-5851EM-MFC-eng

Part Number: 541B122AAG

September, 2009

Brooks® Models 5965, 5851EM

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Brooks® Models 5965, 5851EM

LIMITED WARRANTY

Seller warrants that the Goods manufactured by Seller will be free from defects in materials or workmanship under normal use and service and that the Software will execute the programming instructions provided by Seller until the expiration of the earlier of twelve (12) months from the date of initial installation or eighteen (18) months from the date of shipment by Seller. Products purchased by Seller from a third party for resale to Buyer ("Resale Products") shall carry only the warranty extended by the original manufacturer.

All replacements or repairs necessitated by inadequate preventive maintenance, or by normal wear and usage, or by fault of Buyer, or by unsuitable power sources or by attack or deterioration under unsuitable environmental conditions, or by abuse, accident, alteration, misuse, improper installation, modification, repair, storage or handling, or any other cause not the fault of Seller are not covered by this limited warranty, and shall be at Buyer's expense.

Goods repaired and parts replaced during the warranty period shall be in warranty for the remainder of the original warranty period or ninety (90) days, whichever is longer. This limited warranty is the only warranty made by Seller and can be amended only in a writing signed by an authorized representative of Seller.

BROOKS SERVICE AND SUPPORT

Brooks is committed to assuring all of our customers receive the ideal flow solution for their application, along with outstanding service and support to back it up. We operate first class repair facilities located around the world to provide rapid response and support. Each location utilizes primary standard calibration equipment to ensure accuracy and reliability for repairs and recalibration and is certified by our local Weights and Measures Authorities and traceable to the relevant International Standards.

Visit www.BrooksInstrument.com to locate the service location nearest to you.

START-UP SERVICE AND IN-SITU CALIBRATION

Brooks Instrument can provide start-up service prior to operation when required.

For some process applications, where ISO-9001 Quality Certification is important, it is mandatory to verify and/or (re)calibrate the products periodically. In many cases this service can be provided under in-situ conditions, and the results will be traceable to the relevant international quality standards.

CUSTOMER SEMINARS AND TRAINING

Brooks Instrument can provide customer seminars and dedicated training to engineers, end users and maintenance persons.

Please contact your nearest sales representative for more details.

HELP DESK

In case you need technical assistance:

- Americas 1 888 554 FLOW
Europe +31 (0) 318 549 290
Asia +81 (0) 3 5633 7100

Due to Brooks Instrument's commitment to continuous improvement of our products, all specifications are subject to change without notice.

TRADEMARKS

- Brooks Brooks Instrument, LLC
Freon E.I. DuPont de Nemours & Co.
Kalrez DuPont Dow Elastomers
Teflon E.I. DuPont de Nemours & Co.
VCO Cajon Co.
VCR Cajon Co.
Viton DuPont Performance Elastomers
Vol-U-Meter Brooks Instrument, LLC



Brooks Instrument
407 West Vine Street
P.O. Box 903
Hatfield, PA 19440-0903 USA
T (215) 362 3700
F (215) 362 3745
E-Mail BrooksAm@BrooksInstrument.com
www.BrooksInstrument.com

Brooks Instrument
Neonstraat 3
6718 WX Ede, Netherlands
T +31 (0) 318 549 300
F +31 (0) 318 549 309
E-Mail BrooksEu@BrooksInstrument.com

Brooks Instrument
1-4-4 Kitasuna Koto-Ku
Tokyo, 136-0073 Japan
T +81 (0) 3 5633 7100
F +81 (0) 3 5633 7101
E-Mail BrooksAs@BrooksInstrument.com

