118719-P1
Rev B, 12/97
Instruction Manual

MKS Type 1679B
Mass-Flo® Controller

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WARRANTY
Type 1679B Equipment

MKS Instruments, Inc. (**MKS**) warrants that for two years from the date of shipment the equipment described above (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship and will correctly perform all date-related operations, including without limitation accepting data entry, sequencing, sorting, comparing, and reporting, regardless of the date the operation is performed or the date involved in the operation, provided that, if the equipment exchanges data or is otherwise used with equipment, software, or other products of others, such products of others themselves correctly perform all date-related operations and store and transmit dates and date-related data in a format compatible with **MKS** equipment. THIS WARRANTY IS **MKS'** SOLE WARRANTY CONCERNING DATE-RELATED OPERATIONS.

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This warranty does not apply to any equipment which has not been installed and used in accordance with the specifications recommended by **MKS** for the proper and normal use of the equipment. **MKS** shall not be liable under any circumstances for indirect, special, consequential, or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

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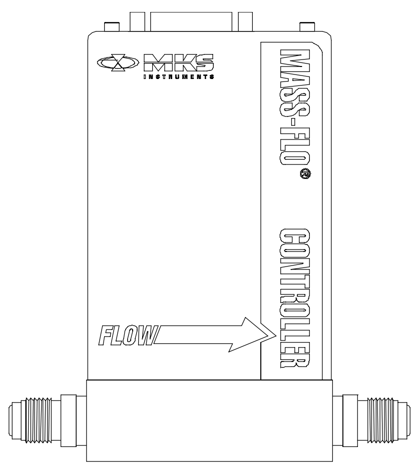
MKS Type 1679B
Mass-Flo® Controller



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Mass Flow Controller Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning 

The WARNING sign denotes a hazard to personnel. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.

Caution 

The CAUTION sign denotes a hazard to equipment. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.

Note 

The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

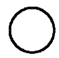
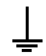
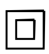
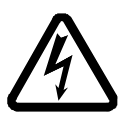
Definition of Symbols Found on the Unit			
 On (Supply) IEC 417, No.5007	 Off (Supply) IEC 417, No.5008	 Earth (ground) IEC 417, No.5017	 Protective earth (ground) IEC 417, No.5019
 Frame or chassis IEC 417, No.5020	 Equipotentiality IEC 417, No.5021	 Direct current IEC 417, No.5031	 Alternating current IEC 417, No.5032
 Both direct and alternating current IEC 417, No.5033-a	 Class ll equipment IEC 417, No.5172-a	 Three phase alternating current IEC 617-2 No.020206	
 Caution, refer to accompanying documents ISO 3864, No.B.3.1	 Caution, risk of electric shock ISO 3864, No.B.3.6	 Caution, hot surface IEC 417, No.5041	

Table 1: Definition of Symbols Found on the Unit

Safety Procedures and Precautions

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not attempt component replacement and internal adjustments. Any service must be made by qualified service personnel only.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with the wetted materials in this product, including any sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before removing it from a system, purge the unit completely with a clean, dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn for protection.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Carefully check all vacuum component connections to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

Never operate at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, install a suitable burst disc in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit or contaminate the process.

ALLOW THE UNIT TO WARM UP

If the unit is used to control dangerous gases, they should not be applied before the unit has completely warmed up. Use a positive shutoff valve to ensure that no erroneous flow can occur during warm up.

Chapter One: General Information

Introduction

The Type 1679B All Metal Mass-Flo® controller accurately measures and controls the mass flow rates of gases, largely independent of gas pressure or temperature. Based upon a patented MKS measurement technique, the instrument is a laminar flow device whose precise indication of mass flow is achieved through the use of a bypass element in parallel with a sensor tube. It is designed for use in gas flow applications that require the delivery of high purity and/or corrosive gases. The all metal design eliminates the permeation, outgassing, and particle generation problems inherent to all elastomeric-sealed flow controllers.

The 1679 controller has a three-inch footprint and features the ability to accept TTL level commands to remotely open and close the control valve. The controller includes a metal cover and RF bypass capacitors, and incorporates a design that virtually eliminates RFI and EMI interference. This all metal instrument is designed to provide maximum performance, reliability, and cleanliness.

The 1679 mass flow controller (MFC) can interface to complementary MKS equipment (Types 147/647, 160, 246, 247) to display the reading and to provide the power, and set point commands. (Additionally, the 167 unit can be used as a readout and set point generator, but it does not supply power; the 660 unit can be used as a power supply and readout, though it cannot send a set point to the flow controller.) Refer to the corresponding manuals for requirements and instructions.

The 1679 flow controller is available in a variety of types and configurations to suit specific needs. The options that must be specified when you order the flow controller include:

- *Connector:* Type “D” connector or recessed P.C. Edge Card connector
- *Range:* 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000, sccm (N_2 equivalent)
- *Fittings:* Cajon® 4-VCR® male compatible and ¼ inch Swagelok® compatible

All 1679 flow controllers have normally *closed* valves.

Design Features

The design of the 1679 flow controller incorporates an advanced flow sensor, a new control valve, and an optimized bypass. (U.S. and Foreign Patents on the sensor and valve)[1]. The latest generation two-element sensing circuit provides accurate, repeatable performance even in low flow ranges (< 10 sccm).

Low temperature effect from ambient temperature change and a low attitude sensitivity effect are also ensured. The new diaphragm actuated valve provides significant benefits over traditional solenoid valves in that there is a faster response time, less vibration sensitivity, and less sensitivity to changing line pressure. The newly optimized sensor/bypass arrangement provides a small flow splitting error for gases with different densities, which dramatically improves measurement accuracy when gases other than the calibration gas are used. The surface mount electronics feature optional pin-to-pin compatibility with other manufacturer's flow controllers. In addition, the variable valve control electronics provides for fast response to any set point.

Reliability

To help provide excellent reliability, the design contains a low mechanical and electronic components count and has successfully passed the following tests:

- STRIFE, including temperature cycling and vibration (sine and random tests)

and with an overall metal braided shielded cable, properly grounded at both ends:

- EMC Directive 89/336/EEC (Type "D" connectors only)

Cleanliness Features

The all metal sealed design of the flow controller ensures extremely low external leakage and eliminates a possible cause of particle generation. The design also incorporates minimal wetted surface area, zero dead space, and a unidirectional gas flow path. To further ensure its cleanliness, the 1679 controller is manufactured from 316L SCQ (double vacuum melted) stainless steel, and undergoes precision machining as well as a proprietary cleaning process. The instrument is assembled in a Class 100 clean room, cycled and purged to eliminate possible contaminants, tested to verify the release of no particles greater than 0.2µ meters, and metal-capped and double-bagged in an inert nitrogen environment.

[1]Protected by U.S. Patent Numbers 5,314,164 and 5,461,913 — Foreign Patents Pending.

How This Manual is Organized

This manual is designed to provide instructions on how to set up and install a Type 1679 unit.

Before installing your Type 1679 unit in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Safety Messages and Procedures* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One: General Information, (this chapter) introduces the product and describes the organization of the manual.

Chapter Two: Installation, explains environmental requirements and practical considerations to take into account when selecting the proper setting for the mass flow controller.

Chapter Three: Overview, describes, in a general way, how the flow controller operates in a gas flow system. This chapter also provides information on how to use a Gas Correction Factor when interpreting the output signal for a gas other than the calibration gas.

Chapter Four: Operation, explains how to start up and operate the mass flow controller. It also discusses how to override the control valve.

Chapter Five: Theory of Operation, provides additional information on how the flow controller operates.

Chapter Six: Maintenance, lists a few general practices to follow to ensure that the flow controller will perform optimally.

Chapter Seven: Troubleshooting, includes a table of hints for reference in the event that your flow controller malfunctions.

Appendix A: Product Specifications, lists the specifications of the instrument.

Appendix B: Gas Correction Factors, provides a table listing the gas correction factors for the most commonly used gases.

Appendix C: MFC Sizing Guidelines, is provided for reference and describes how to calculate the correct size MFC for an application. This information is useful if you need to purchase another MFC or if you plan to use your MFC in another, different application.

Appendix D: Model Code Explanation, provides model code information for the 1679 unit.

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers, listed on the back cover. In addition, MKS accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at all of our regional service centers. Should any difficulties arise in the use of your Type 1679 instrument, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an ERA Number (Equipment Return Authorization Number) from the MKS Calibration and Service Center before shipping. The ERA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

Chapter Two: Installation

How To Unpack the Type 1679 Controller

MKS has carefully packed the 1679 flow controller so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an ERA Number (Equipment Return Authorization Number) from the MKS Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Opening the Package

The Type 1679 controller is assembled, leak tested with helium, and calibrated in a clean room environment. The instrument is double-bagged in this environment to ensure maintenance of its particle free condition during shipment. It is very important to remove the bags according to clean room practices. To maintain at least a minimal level of clean room standards, follow the instructions below.

1. Remove the outer bag in an ante room (garmenting room) or transfer box.

   Do not allow this outer bag to enter the clean room.

2. Remove the inner bag in the clean room.

Unpacking Checklist

Standard Parts:

- The 1679 flow controller

Optional Accessories:

- Power Supply/Readout device
- Cabling to connect the flow controller to the readout device

Environmental Requirements

Follow the guidelines listed below when installing and using the 1679 flow controller.

1. Maintain the normal operating temperature between 0° and 50° C (32° and 122° F).
2. Observe the pressure limits:
   A. Maximum gas inlet pressure is 100 psig.
   B. Operational differential pressure is:

      10 to 40 psid for ≤ 5000 sccm units

      15 to 40 psid for 10,000 sccm units

      The standard orifice is sized for control over this range with the outlet at atmospheric pressure.
3. Provide power input at ±15 VDC (±5%) @ 200 mA.
   A. Maximum voltage/current at startup is ±15 VDC (±5%) @ 200 mA.
   B. Typical steady state voltage/current should be ±15 VDC (±5%) @ 100 mA.
4. Allow 2 minutes for warm-up time.
5. Use high purity gas and filters in line upstream of the MFC.
6. Leave the power to the instrument on at all times, for optimal performance.

For additional information refer to *Appendix A: Product Specifications,* page 33.

Setup

Follow the guidelines below when setting up the 1679 flow controller.

1. Set the controller into position where it will be connected to a gas supply.

   Placement of flow components in an orientation other than that in which they were calibrated (typically horizontal) may cause a small zero shift. The zero offset can be removed according to the instructions in *How To Zero the Flow Controller*, page 24.

2. Install the flow controller in the gas stream such that the flow will be in the direction of the arrow on the side of the controller.

3. Allow adequate clearance for the cable connector and tubing.

   Straight Shielded connectors require approximately 3" height. Right Angle connectors require approximately 2" height.

4. Position the flow controller to provide access to the zero potentiometer.

   The zero potentiometer is located on the inlet side of the flow controller body.

Refer to Figure 1, page 12, and Figure 2, page 13, for outline dimensions, and Figure 3, page 14, for mounting dimensions of the flow controller.

Dimensions

Note All dimensions are listed in inches with millimeters referenced in parentheses.

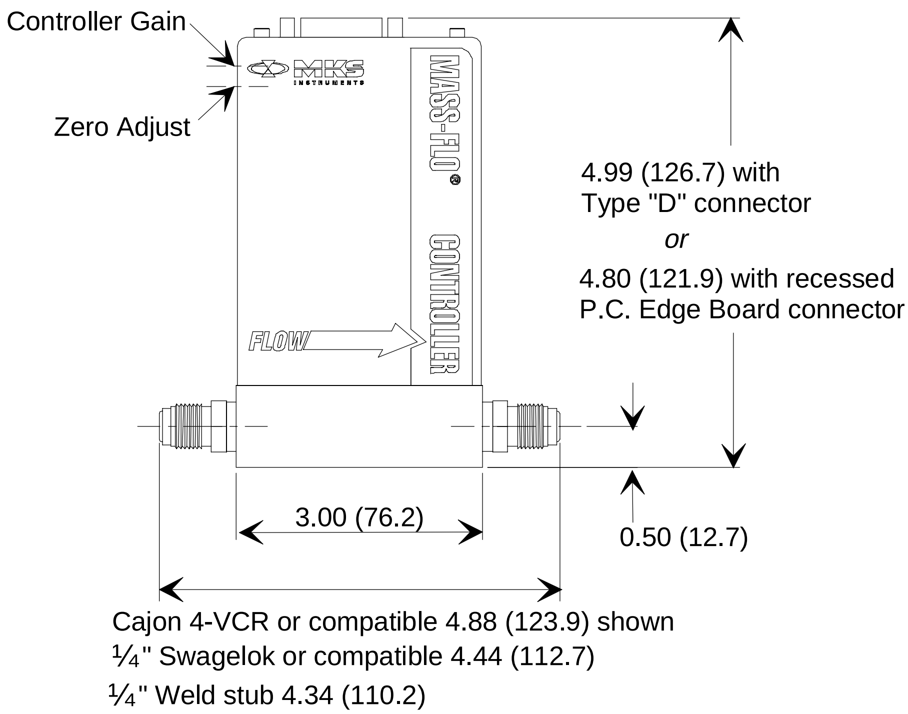


Figure 1: Outline Dimensions of the 1679 Flow Controller

Note The method used to measure the overall length of the unit varies with the type of fitting. For VCR compatible fittings, the unit is measured from mating face to mating face. For Swagelok compatible fittings, the unit is measured from fitting end to fitting end (less nut). Weld stubs are measured from end to end.

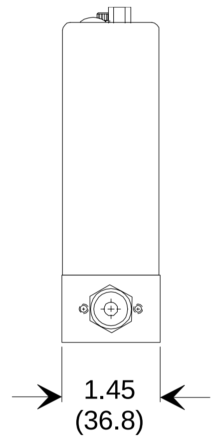


Figure 2: Side View of the 1679 Flow Controller

Gas Line Connections

Connect the gas line (via tubing) from the gas supply to the flow controller's inlet, and from the flow controller's outlet, to the downstream tubing.

Standard Fittings

The 1679 flow controller is equipped with Cajon 4-VCR male compatible fittings. For specific information regarding these fittings, refer to the manufacturer's documentation.

Optional Fittings

As an option, ¼ inch weld stub fittings or ¼" Swagelok (or compatible) fittings are available when specified.

Mounting a Type 1679 MFC

Tapped holes are provided in the base of the unit for mounting. Refer to Figure 3 for the size and location of the mounting holes.

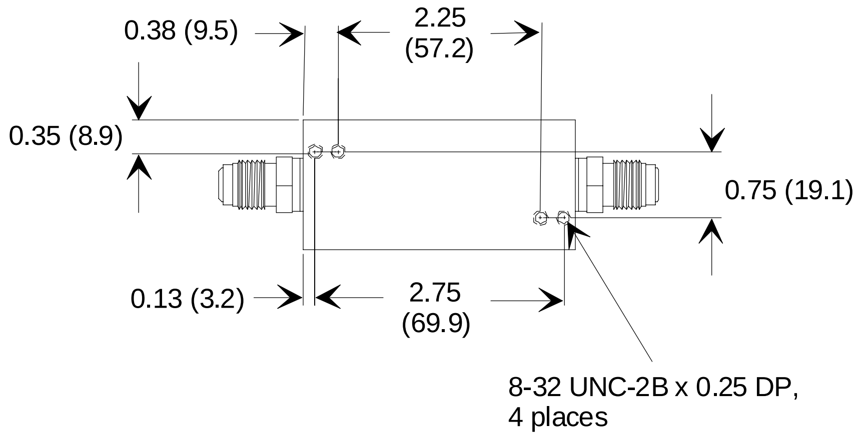


Figure 3: Mounting Dimensions of the 1679 Flow Controller

Chapter Three: Overview

Interface Cables

As of January 1, 1996, all products shipped to the European Community must comply with the EMC Directive 89/336/EEC, which covers radio frequency emissions and immunity tests. MKS products that meet these requirements are identified by application of the CE Mark.

This MKS product meets CE Mark requirements, per EMC Directive 89/336/EEC. To ensure compliance when installed, an overall metal braided shielded cable, properly grounded at both ends, is required during use.

Note

Units with an Edge Board connector or flying leads are not CE Mark compliant.

MKS offers a variety of interface cables, listed in Table 2.

Note

1. An overall metal braided, shielded cable, properly grounded at both ends, is required to meet CE Mark specifications.
2. To order an overall metal, braided, shielded cable, add an “S” after the cable type designation. For example, to order a standard connection cable to connect the 1679 MFC to a power supply with a 15-pin Type “D” connector, use part number CB259-5; for an overall metal braided, shielded cable use part number CB259S-5.

MKS Cables		
	Power Supply End	
MFC End	**15-Pin Type “D”**	**Flying Leads**
9-pin Type “D”	CB147-12	N/A
15-pin Type “D”	CB147-1 CB259-5	CB259-6
20-pin Edge Card	CB147-7 CB259-10	Non terminated CB259-12

Table 2: MKS Cables

Generic Shielded Cable Description

MKS offers a full line of cables for all MKS equipment. Should you choose to manufacture your own cables, follow the guidelines listed below:

1. The cable must have an overall metal *braided* shield, covering all wires. Neither aluminum foil nor spiral shielding will be as effective; using either may nullify regulatory compliance.

2. The connectors must have a metal case which has direct contact to the cable's shield on the whole circumference of the cable. The inductance of a flying lead or wire from the shield to the connector will seriously degrade the shield's effectiveness. The shield should be grounded to the connector before its internal wires exit.

3. With very few exceptions, the connector(s) must make good contact to the device's case (ground). "Good contact" is about 0.01 ohms; and the ground should surround all wires. Contact to ground at just one point may not suffice.

4. For shielded cables with flying leads at one or both ends; it is important at each such end, to ground the shield *before* the wires exit. Make this ground with absolute minimum length. Refer to Figures 4 and 5, page 17. (A ¼ inch piece of #22 wire may be undesirably long since it has approximately 5 nH of inductance, equivalent to 31 ohms at 1000 MHz). After picking up the braid's ground, keep wires and braid flat against the case. With very few exceptions, grounded metal covers are not required over terminal strips. If one is required, it will be stated in the Declaration of Conformity or in the instruction manual.

5. In selecting the appropriate type and wire size for cables, consider:

   A. The voltage ratings;

   B. The cumulative I^2R heating of all the conductors (keep them safely cool);

   C. The IR drop of the conductors, so that adequate power or signal voltage gets to the device;

   D. The capacitance and inductance of cables which are handling fast signals, (such as data lines or stepper motor drive cables); and

   E. That some cables may need internal shielding from specific wires to others; please see the instruction manual for details regarding this matter.

Example 1: Preferred Method To Connect Cable
(shown on a pressure transducer)

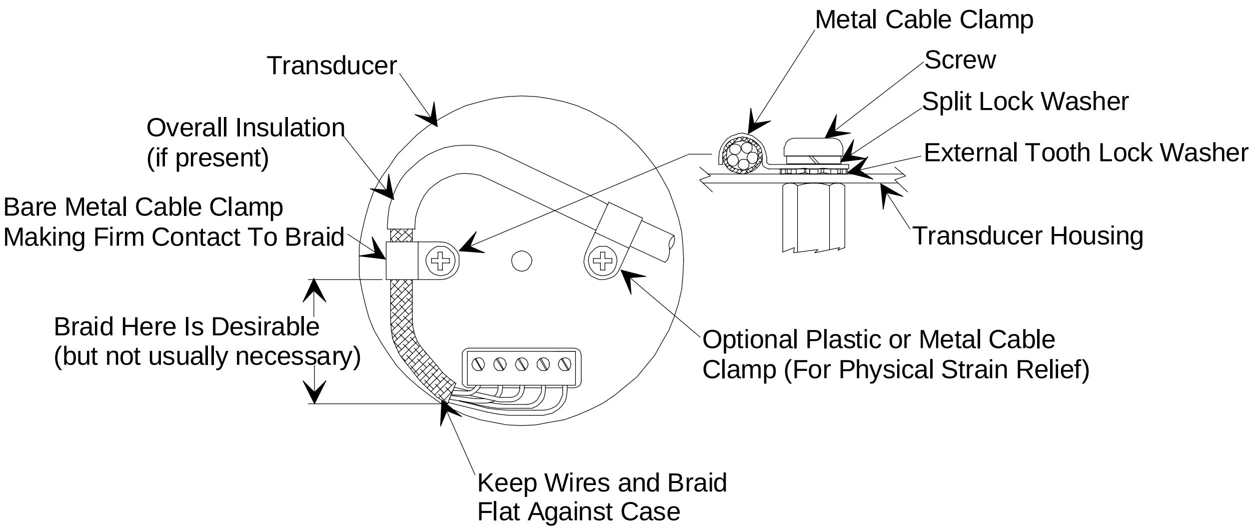


Figure 4: Preferred Method

Example 2: Alternate Method To Connect Cable
(shown on a pressure transducer)

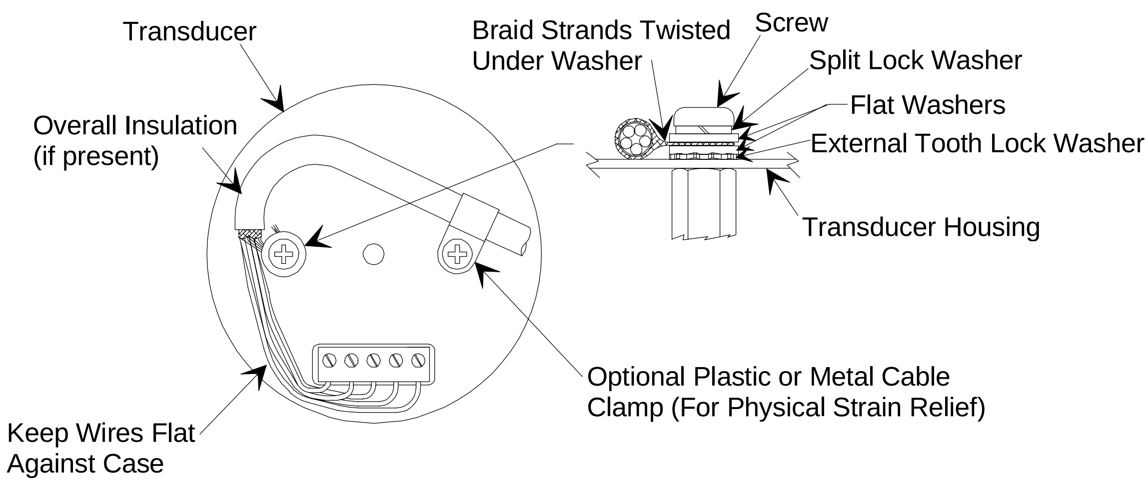


Figure 5: Alternate Method To Use When Cable Clamp is Not Available

Electrical Connections

If you are using the 1679 instrument with any equipment other than corresponding MKS power supply/readout units, consult the manufacturer's specifications for connection, and for proper electrical and power characteristics. Refer to *Appendix A: Product Specifications,* page 33, for electrical requirements of the Type 1679 flow controller.

The 1679 flow controller is available with a 9-pin Type "D" connector, a 15-pin Type "D" connector, or a 20-pin Edge Card connector.

Type "D" Connector

Table 3 lists the pinout of the 9-pin Type "D" connector.

9-Pin Type "D" Connector Pinout	
Pin Number	**Assignment**
1	Valve Open/Close*
2	Flow Output 0 to +5 VDC
3	Power Supply +15 VDC
4	Power Supply Ground
5	Power Supply -15 VDC
6	Set Point Input 0 to +5 VDC
7	Signal Ground
8	Signal Ground
9	Valve Test Point[2]
* Valve Open > +12 VDC; Valve Close < -12 VDC; Valve Normal Float	

Table 3: 9-Pin Type "D" Connector Pinout

Note

1. Chassis ground is not available on a separate pin. Instead, it is carried out through the cable shielding. Be sure that the connector on the other end of the cable is properly grounded to its chassis ground.
2. The 0 to 5 VDC flow signal output comes from pin 2 and is referenced to pin 7 (signal common).
3. Use any appropriate 0 to 5 VDC input signal of less than 20K ohm source impedance referenced to pin 7 as the set point signal to pin 8.

[2]Jumper select on Interface board. Default position is valve test point. Optional PID controller input may also be selected.

Table 4 lists the pinout of the 15-pin Type "D" connector.

15-Pin Type "D" Connector Pinout			
Pin Number	**Assignment**	**Pin Number**	**Assignment**
1	MKS Test Point	9	No Connection
2	Flow Signal Output (0 to +5 VDC)	10	Optional Input
3	Valve Close (TTL low)	11	Signal Ground
4	Valve Open (TTL low)	12	Signal Ground
5	Power Supply Ground	13	No Connection
6	-15 VDC	14	No Connection
7	+15 VDC	15	Chassis Ground
8	Set Point Input (0 to +5 VDC)		

Table 4: 15-Pin Type "D" Connector Pinout

Note

1. The "No Connection" pin assignment refers to a pin with no internal connection.
2. The 0 to 5 VDC flow signal output comes from pin 2 and is referenced to pin 12 (signal common).
3. Any appropriate 0 to 5 VDC input signal of less than 20K ohm source impedance referenced to pin 12 can be used to supply a set point signal to pin 8.

P. C. Edge Card Connector

Table 5 shows the pinout of the 20-pin Edge Card connector.

20-Pin Edge Card Connector Pinout			
Pin Number	**Assignment**	**Pin Number**	**Assignment**
1	Chassis Ground	A	Set Point Input (0 to +5 VDC)
2	Power Supply Ground	B	Signal Ground
3	Flow Output (0 to +5 VDC)	C	Signal Ground
4	+15 VDC	D	Valve Open (TTL low)
5	Optional Input	E	No Connection
6	No Connection	F	-15 VDC
7	Key	H	Key
8	No Connection	J	Valve Test Point
9	No Connection	K	No Connection
10	Signal Ground	L	Valve Close (TTL low)

Table 5: 20-Pin Edge Card Connector Pinout

Note

1. The “No Connection” pin assignment refers to a pin with no internal connection.
2. Pins 1 through 10 are located on one side of the gold finger connection and pins A through L are located on the opposite side of the gold finger connection.
3. The 0 to 5 VDC flow signal output comes from pin 3 and is referenced to pin B (signal ground).
4. Any appropriate 0 to 5 VDC input signal of less than 20K ohm source impedance referenced to pin B can be used to supply a set point signal to pin A.

The Gas Correction Factor (GCF)

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow controller. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1). *Appendix B: Gas Correction Factors*, page 37, lists the gas correction factors for the most commonly used gases. If the gas you are using is not listed in the appendix, you must calculate its GCF using the following equation:

$$GCF_x = \frac{(0.3106)\ (S)}{(d_x)\ (Cp_x)}$$

where:

GCF_x = Gas Correction Factor for gas X

d_x = Standard Density of gas X, g/l (at 0°C and 760 mmHg)

Cp_x = Specific Heat of gas X, cal/g °C

0.3106 = (Standard Density of nitrogen) (Specific Heat of nitrogen)

S = Molecular Structure correction factor where

S equals:

1.030	for Monatomic gases
1.000	for Diatomic gases
0.941	for Triatomic gases
0.880	for Polyatomic gases

Note

1. When using the GCF, the accuracy of the flow reading may vary by ±5%, however, the repeatability will remain ±0.2% of F.S.
2. All MKS readouts have Gas Correction Adjustment controls to provide direct readout.

How To Read the Flow Output Directly

If your readout equipment does not provide a GCF (gas correction factor) potentiometer, you must add a proper input divider to read the flow signal directly.

Using the values from the example above, and assuming a 1 Volt F.S. readout, the flow signal must be divided 2.44 to 1.00 Volts.

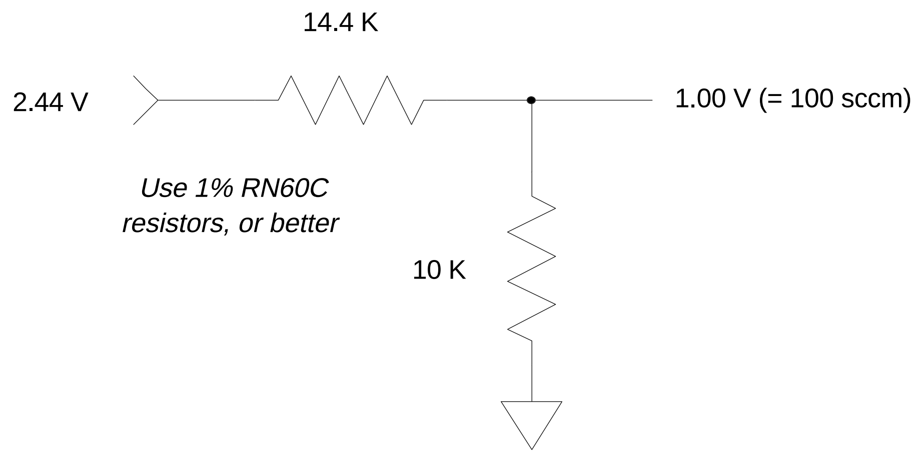


Figure 6: Wiring Diagram for an Input Divider

Note MKS Types 147/647, 167, 246, 247, 260, and 660 readouts provide gas correction factor adjustment.

Chapter Four: Operation

How To Start Up the Flow Controller

1. Leak test the fittings on the MFC using standard leak test procedures.

   Do *not* proceed to the next step until you are certain that there is no gas leakage.

2. Plug the power supply/readout cable (MKS or customer-supplied) into the connector (either a Type "D" or a P. C. Edge Card connector) located at the top of the flow controller.

   Plug the other end of the cable into an MKS or MKS-compatible power supply/readout unit.

3. Apply power to the MFC instrument.

   When power is first applied, the output signal jumps to over + 5.5 VDC.

   You can monitor the flow output signal as the heaters stabilize and the output approaches zero. Approximately 5 minutes after power up, the output signal should be within 10 mV (0.2% F. S.) of the final voltage at all specified flow rates.

Warning

If the instrument is being used to control dangerous gases, be sure that the system is *fully warmed up* before applying gases to the system. You may choose to install a positive shutoff valve to prevent inadvertent gas flow during the warm-up period.

Once the flow controller is completely warmed up, you can proceed to zero the unit as required.

How To Zero the Flow Controller

Ensure that no gas flow is entering the flow controller

1. Apply gas, at a regulated pressure, to the flow controller.

2. Close the positive shutoff valve downstream of the instrument.

3. Command the control valve open by either sending a full scale set point (5 VDC) or connecting the valve open pin to signal ground.

   15-pin Type "D" connector: Connect pin 4 (valve open) to pin 11 or 12 (signal ground)

   9-pin Type "D" connector: Supply +5 Volts to pin 1 (to open the valve)

   Edge Card connector: Connect pin D (valve open) to pins 10, B, or C (signal ground)

   A positive flow may occur momentarily while the gas pressure equalizes across the flow controller.

Adjust the Zero Pot

1. Once flow through the controller has stopped (reached zero flow), remove the set point or valve open command.

2. Turn the Zero pot (located on the inlet side of the flow controller) until the readout displays zero.

   Refer to Figure 1, page 12, for the location of the Zero pot.

   If you are using an MKS power supply/readout unit, the flow controller can also be zeroed at the front panel of the readout unit.

3. Open the positive shutoff valve.

   The controller may indicate a small, positive flow (<2.0% F. S.) due to a leak through its control valve. However, do ***not*** "zero out" this flow since it represents an actual flow measurement inherent in the system.

How To Adjust the Controller Gain

Adjust the controller gain if the flow signal oscillates. Reducing the controller gain will reduce the signal oscillation. The controller gain adjustment pot is located on the upstream side of the controller.

- *To decrease flow signal oscillation:* Turn the controller gain counter-clockwise to decrease the controller gain setting.

Note Lowering the supply pressure to the MFC will have the same effect as decreasing the gain since it will reduce the overflow/underflow effect of the valve.

If the MFC responds too slowly to a change in set point, you may need to increase the controller gain slightly. To increase the controller gain, turn the controller gain pot clockwise.

How To Override the Valve

The valve override feature enables the control valve to be fully opened (purged) or closed independent of the set point command signal. Refer to Table 4, page 19, or Table 5, page 20, for the appropriate pin locations.

For example, if the 1679 flow controller is equipped with a Type "D" connector:

To *open* the valve, apply a TTL low to pin 4 *or* connect pin 4 to signal ground (pin 12).

To *close* the valve, apply a TTL low to pin 3 *or* connect pin 3 to signal ground (pin 12).

For example, if the 1679 flow controller is equipped with an Edge Card connector:

To *open* the valve, apply a TTL low to pin D *or* connect pin D to signal ground (pin 10).

To *close* the valve, apply a TTL low to pin L *or* connect pin L to signal ground (pin 10).

Priority of the Commands

The 1679 flow controller executes commands based on a hierarchical command structure. The highest priority command is Valve Open, followed by Valve Close, and Set Point Control. Therefore, if the flow controller is operating under Set Point Control, you can send a Valve Open command to force the valve to the full open position.

Note

When both the Valve Close and Valve Open pins are pulled down, the Valve Open command takes precedence and the valve is moved to the open position.

Chapter Five: Theory of Operation

General Information

The 1679 Flow Controller measures the mass flow rate of a gas and controls the flow rate according to a given set point. The control range is from 2 to 100% of Full Scale (F. S.) with an accuracy of ± 1% of F. S (refer to *Appendix A: Product Specifications*, page 33).

Flow Path

Upon entering the flow controller, the gas stream passes first through the metering section of the instrument for its mass flow to be measured. The gas moves on through the control valve for its rate of flow to be regulated according to the given set point, and then exits the instrument at the established rate of flow.

The metering section consists of one of the following:

- A sensor tube for ranges $\leq$ 10 sccm (N_2 equivalent)
- A sensor tube and parallel bypass for ranges > 10 sccm (N_2 equivalent)

The geometry of the sensor tube, in conjunction with the specified full scale flow rate, ensures fully developed laminar flow in the sensing region. The bypass elements, in those instruments containing them, are specifically matched to the characteristics of the sensor tube to achieve a laminar flow splitting ratio which remains constant throughout each range.

Measurement Technique

The flow measurement is based on differential heat transfer between temperature sensing heater elements which are attached symmetrically to the sensor tube. This senses the thermal mass movement which is converted to mass flow via the specific heat, C_p, of the gas. The resulting signal is amplified to provide a 0 to 5 VDC output which is proportional to mass flow.

Control Circuitry

The controller employs the above measurement technique and utilizes a control circuit that provides drive current for the proportioning control valve. The flow controller accepts a 0.050 to 5 VDC set point signal, compares it to its own flow signal, and generates an error voltage. This error signal is then conditioned by a PID (Proportional-Integral-Derivative) algorithm and amplified so that it can reposition the controlling valve, thus reducing the controller error to within the resolution specification of the instrument.

The 1679 includes a zero set point recognition circuit which drives the valve closed if a set point of under 1% of F. S. (50 mV) is provided to the unit. Therefore, a minimum 50 mV set point is required for the unit to control.

Since the control valve is *normally closed*, the 1679 unit pulls the plug *away* from the seat to regulate the gas flow rate.

Chapter Six: Maintenance

General

In general, no maintenance is required other than proper installation and operation, and zero adjustment. If a controller fails to operate properly upon receipt, check for shipping damage, and check the power/signal cable for correct continuity. Any damage should be reported to the carrier and MKS Instruments immediately. If there is no obvious damage and the continuity is correct, obtain an ERA Number (Equipment Return Authorization Number) before returning the unit to MKS Instruments for service.

Zero Adjustment

For best accuracy and repeatability, you should check the zero setting periodically and reset it, if necessary. Refer to *How To Zero the Flow Controller*, page 24, for instructions on setting the zero. The frequency of checking the zero is dependent on the specific accuracy and repeatability required by your process. It is also recommended that the instrument be recalibrated annually if no other time interval has been specifically established. Refer to the inside of the back cover of this instruction manual for a complete list of MKS Calibration and Service centers.

Repair

Contact any authorized MKS Sales Office or Calibration and Service Center should you encounter any difficulties or problems using your flow controller.

Note If it is necessary to return the instrument to MKS for repair, please contact any of the MKS international service/calibration centers listed on the inside of the back cover of this manual for an ERA (Equipment Return Authorization) number to expedite handling and ensure proper servicing of your instrument.

Chapter Seven: Troubleshooting

Troubleshooting Chart

Troubleshooting Chart		
Symptoms	**Possible Cause**	**Remedy**
No output or overrange at zero (after warm-up)	Improper cable Valve override function applied Electronics malfunctioning	Check cable for type Disconnect valve override Return for service
Unit indicates a negative flow	Unit installed in gas stream backwards	Reinstall unit in proper flow direction
Controller does not track set point	Improper zero adjustment	Zero meter output, according to *How To Zero the Flow Controller*, page 24
Controller does not function	Electronics malfunctioning Valve sticking or contamination	Return for service Return for service
Oscillation	Too high a controller gain setting Incorrect upstream pressure regulator Upstream pressure too high	Reduce (turn counter-clockwise) Check manufacturers' specifications Reduce upstream pressure
Excessive closed conductance	Inadequate valve preload Upstream pressure too high	Return for service Reduce upstream pressure
Unit does not achieve full flow	Upstream pressure too low Excessive valve preload or contamination	Increase upstream pressure Return for service

Table 6: Troubleshooting Chart

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Appendix A: Product Specifications

Performance Specifications

Accuracy[3]	± 1% F.S.
Control Range 10, 20, and 50 sccm ≥ 100 sccm	 1 sccm to 100% F.S. 2% to 100% F.S.
Controller Settling Time[4] 10, 20, and 50 sccm ≥ 100 sccm	 ≤ 1.5 seconds (to within 2% of set point) ≤ 1 seconds (to within 2% of set point)
Full Scale Ranges (Nitrogen equivalent)	10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10,000 sccm
Maximum Inlet Pressure	100 psig
Operational Differential Pressure[5] ≤ 5000 sccm 10,000 sccm	 10 to 40 psid 15 to 40 psid
Pressure Coefficient	0.02% Rdg./psi
Repeatability	± 0.2% F.S.
Resolution (Measurement)	0.1% F.S.
Temperature Coefficients Zero Span	 < 0.05% F.S./° C (500 ppm) <0.08% of Rdg/° C (800 ppm)
Warm-Up Time (to within 0.2% of steady-state)	2 minutes

[3]Includes non-linearity, hysteresis, and non-repeatability referenced to 760 mmHg and 0° C.

[4]Controller settling time per SEMI E17-91.

[5]Operational differential pressure is referenced to an MFC outlet pressure at atmosphere. For downstream pressures greater than 30 psia, consult factory for the operating differential pressures.

Environmental Specifications

Storage Humidity Range	0 to 95% relative humidity, non-condensing
Operating Temperature Range	0° to 50° C (32° to 122° F)
Storage Temperature Range	-20° to 80° C (-4° to 176° F)

Electrical Specifications

Connector Options	15-pin Type "D" 9-pin Type "D" 20-pin Edge Card
Input Voltage/Current Required	
Maximum At Start Up (First 5 Seconds)[6]	±15 VDC (±5%) @ 200 mA
Typical At Steady State	±15 VDC (±5%) @ 100 mA
Output Impedance	< 1 ohm
Output Signal/Minimum Load	0 to 5 VDC into > 10K ohm
Set Point Command Signal (Controllers only)	0 to 5 VDC from < 20K ohm

[6] Add 100 mA to start up current if the valve is energized.

Physical Specifications

Body (height x width x length) *without fittings*	<5.0 in x ≤ 1.5 in x 3 in <12.7 cm x ≤ 3.8 cm x 7.6 cm
CE Compliance	EMC Directive 89/336/EEC[7] *Products with Edge Card connectors are not CE compliant.*
Fittings	
Standard	Cajon® 4-VCR® male compatible
Optional	¼” Weld stubs, ¼” Swagelok compatible
Leak integrity	
External (scc/sec He)	$< 1 \times 10^{-10}$
Through closed valve @ 25 psig inlet to atmosphere (760 Torr) outlet	
10, 20, and 50 sccm	≤ 1 sccm
≥ 100 sccm	≤ 2% F.S.
Materials wetted	
Body, Seals, and Valve	316L VIM/VAR, 316L, Nickel, Elgiloy, Ceramic
Weight	≤ 2.0 lbs (0.90 kg)

Due to continuing research and development activities, these product specifications are subject to change without notice.

[7] An overall metal braided shielded cable, properly grounded at both ends, is required during use.

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Appendix B: Gas Correction Factors

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Air	- - -	0.240	1.293	1.00
Ammonia	NH_3	0.492	0.760	0.73
Argon	Ar	0.1244	1.782	1.39[1]
Arsine	AsH_3	0.1167	3.478	0.67
Boron Trichloride	BCl_3	0.1279	5.227	0.41
Bromine	Br_2	0.0539	7.130	0.81
Carbon Dioxide	CO_2	0.2016	1.964	0.70[1]
Carbon Monoxide	CO	0.2488	1.250	1.00
Carbon Tetrachloride	CCl_4	0.1655	6.86	0.31
Carbon Tetraflouride (Freon - 14)	CF_4	0.1654	3.926	0.42
Chlorine	Cl_2	0.1144	3.163	0.86
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	0.1544	3.858	0.46
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	0.164	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	0.153	4.660	0.38
Cyanogen	C_2N_2	0.2613	2.322	0.61
Deuterium	D_2	1.722	0.1799	1.00
Diborane	B_2H_6	0.508	1.235	0.44
Dibromodifluoromethane	CBr_2F_2	0.15	9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	0.1432	5.395	0.35
Dichlorofluoromethane (Freon - 21)	$CHCl_2F$	0.140	4.592	0.42
Dichloromethysilane	$(CH_3)_2SiCl_2$	0.1882	5.758	0.25

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Dichlorosilane	SiH_2Cl_2	0.150	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	$C_2Cl_2F_4$	0.160	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	$C_2H_2F_2$	0.224	2.857	0.43
2,2-Dimethylpropane	C_5H_{12}	0.3914	3.219	0.22
Ethane	C_2H_6	0.4097	1.342	0.50
Fluorine	F_2	0.1873	1.695	0.98
Fluoroform (Freon - 23)	CHF_3	0.176	3.127	0.50
Freon - 11	CCl_3F	0.1357	6.129	0.33
Freon - 12	CCl_2F_2	0.1432	5.395	0.35
Freon - 13	$CClF_3$	0.153	4.660	0.38
Freon - 13 B1	$CBrF_3$	0.1113	6.644	0.37
Freon - 14	CF_4	0.1654	3.926	0.42
Freon - 21	$CHCl_2F$	0.140	4.592	0.42
Freon - 22	$CHClF_2$	0.1544	3.858	0.46
Freon - 23	CHF_3	0.176	3.127	0.50
Freon - 113	$C_2Cl_3F_3$	0.161	8.360	0.20
Freon - 114	$C_2Cl_2F_4$	0.160	7.626	0.22
Freon - 115	C_2ClF_5	0.164	6.892	0.24
Freon - 116	C_2F_6	0.1843	6.157	0.24
Freon - C318	C_4F_8	0.1866	8.93	0.164
Freon - 1132A	$C_2H_2F_2$	0.224	2.857	0.43
Helium	He	1.241	0.1786	1.39
Hexafluoroethane (Freon - 116)	C_2F_6	0.1843	6.157	0.24
Hydrogen	H_2	3.419	0.0899	1.00
Hydrogen Bromide	HBr	0.0861	3.610	1.00

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Hydrogen Chloride	HCl	0.1912	1.627	1.00
Hydrogen Fluoride	HF	0.3479	0.893	1.00
Isobutylene	C_4H_8	0.3701	2.503	0.29
Krypton	Kr	0.0593	3.739	1.543
Methane	CH_4	0.5328	0.715	0.72
Methyl Fluoride	CH_3F	0.3221	1.518	0.56
Molybdenum Hexafluoride	MoF_6	0.1373	9.366	0.21
Neon	Ne	0.246	0.900	1.46
Nitric Oxide	NO	0.2328	1.339	0.99
Nitrogen	N_2	0.2485	1.250	1.00
Nitrogen Dioxide	NO_2	0.1933	2.052	.- - -2
Nitrogen Trifluoride	NF_3	0.1797	3.168	0.48
Nitrous Oxide	N_2O	0.2088	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C_4F_8	0.1866	8.93	0.164
Oxygen	O_2	0.2193	1.427	1.00
Pentane	C_5H_{12}	0.398	3.219	0.21
Perfluoropropane	C_3F_8	0.194	8.388	0.17
Phosgene	$COCl_2$	0.1394	4.418	0.44
Phosphine	PH_3	0.2374	1.517	0.76
Propane	C_3H_8	0.3885	1.967	0.36
Propylene	C_3H_6	0.3541	1.877	0.41
Silane	SiH_4	0.3189	1.433	0.60
Silicon Tetrachloride	$SiCl_4$	0.1270	7.580	0.28
Silicon Tetrafluoride	SiF_4	0.1691	4.643	0.35
Sulfur Dioxide	SO_2	0.1488	2.858	0.69

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g^{o}C	DENSITY g/l @ 0^{o}C	CONVERSION FACTOR
Sulfur Hexafluoride	SF_6	0.1592	6.516	0.26
Trichlorofluoromethane (Freon - 11)	CCl_3F	0.1357	6.129	0.33
Trichlorosilane	$SiHCl_3$	0.1380	6.043	0.33
1,1,2-Trichloro - 1,2,2-Trifluoroethane (Freon - 113)	CCl_2FCClF_2 or ($C_2Cl_3F_3$)	0.161	8.360	0.20
Tungsten Hexafluoride	WF_6	0.0810	13.28	0.25
Xenon	Xe	0.0378	5.858	1.32

[1] Empirically defined

[2] Consult MKS Instruments, Inc. for special applications.

NOTE: Standard Pressure is defined as 760 mmHg (14.7 psia). Standard Temperature is defined as 0^{o}C.

Appendix C: MFC Sizing Guidelines

General Information

To select the correct MFC for an application, you must determine the:

- flow controller range
- appropriate valve configuration

The flow controller range depends on the desired flow rate and the gas correction factor for the gas to be used. MKS states the flow controller ranges based on flow rate of nitrogen; the flow rate for other gases may vary.

The proper valve configuration depends upon the flow range, inlet pressure, differential pressure across the unit, and density of the gas. Proper valve configurations have been established for all standard flow ranges flowing nitrogen under standard operating pressures. These configurations are suitable for virtually all gases and pressure conditions.

How To Determine the Flow Controller Range

The Type 1679 controller is available in ranges of 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, and 10,000 sccm (N_2 equivalent). To select the appropriate range, you must determine the flow rate of nitrogen that is equivalent to the flow rate of the desired gas. Calculate the ratio of the GCF of nitrogen (1.00) to the GCF of the desired gas (refer to *Appendix B: Gas Correction Factors*, page 37) as shown in the following example.

Example:

You need a flow rate of 250 sccm of argon (Ar). What range flow controller should you use?

1. Find the Gas Correction Factor of Ar (refer to *Appendix B: Gas Correction Factors,* page 37).

   The GCF for Ar is 1.39.

2. Insert the GCF of Ar in the following formula:

$$\frac{(\text{GCF of } N_2)}{(\text{GCF of Ar})} = \frac{(x)}{(\text{Desired flow rate of Ar})}$$

where x is the equivalent flow rate of nitrogen (sccm).

$$\frac{(1.00)}{(1.39)} = \frac{(x)}{(250\text{ sccm Ar})}$$

$$x = 180\text{ sccm } N_2$$

A flow rate of 250 sccm of Ar will produce a flow rate equivalent to 180 sccm of N_2. This falls within the range of a 200 sccm flow controller.

When calculating equivalent N_2 flows using gas correction factors, be sure to use a flow controller with a sufficient flow rate range. For example, if the calculated equivalent N_2 flow in the example shown above is 205 sccm, use a 500 sccm flow controller. The 500 sccm instrument can then be calibrated such that 205 sccm N_2 = full scale.

Note When using a gas with a density *higher* than nitrogen, be sure that the control valve Full Scale range can accommodate the desired flow rate. Please call the MKS Applications group if you have any questions.

How To Determine the Valve Configuration

1. Determine the maximum flow coefficient (C_V), for the gas of interest, using the equation:

$$C_V\,(\max) = \left(\text{Max. Flow Rate, sccm}\right)\left(\sqrt{\frac{\text{Gas Density}}{1.293}}\right)\left(C_V\ \text{Pressure Factor}\right)$$

where:

Gas Density is listed in *Appendix B: Gas Correction Factors*, page 37.

C_V Pressure Factor is listed in Table 7.

C_V Pressure Factors (multiplied by 100,000)										
P1 (psia)	**Differential Pressure (psid)**									
	50	**40**	**30**	**20**	**15**	**10**	**5**	**2**	**1**	**0.5**
165	0.042	0.046	0.052	0.063	0.072	0.087	0.122	0.192	0.272	0.384
150	0.044	0.048	0.055	0.066	0.075	0.092	0.128	0.202	0.285	0.403
125	0.049	0.054	0.061	0.073	0.083	0.101	0.141	0.221	0.312	0.441
100	0.058	0.062	0.069	0.082	0.094	0.113	0.158	0.248	0.349	0.493
75	0.077	0.077	0.082	0.097	0.110	0.132	0.183	0.286	0.404	0.570
50	0.116	0.116	0.116	0.123	0.138	0.164	0.226	0.352	0.495	0.699
30	—	—	0.194	0.194	0.194	0.220	0.297	0.458	0.642	0.904
25	—	—	—	0.232	0.232	0.246	0.329	0.503	0.704	0.991
20	—	—	—	0.291	0.291	0.291	0.373	0.565	0.789	1.109
15	—	—	—	—	0.387	0.387	0.441	0.659	0.915	1.283
10	—	—	—	—	—	0.578	0.581	0.821	1.131	1.578
5	—	—	—	—	—	—	1.156	1.232	1.643	2.261
2	—	—	—	—	—	—	—	2.890	2.905	3.725
1	—	—	—	—	—	—	—	—	5.779	5.811

Table 7: C_V Pressure Factors

2. Select the valve configuration with the C_V value that is closest to, though larger than, the C_V value calculated in step 1.

The C_V value represents the *maximum* flow rate for the unit. Choose the valve configuration *above* your calculated C_V value to ensure that the unit can deliver the required flow.

Valve Configuration Selection Guide		
Valve Configuration	**Nominal Range (N_2) sccm**	**Cv x 10^5**
1	10	2.44
2	20	4.88
3	50	12.21
4	100	24.42
5	200	48.84
6	500	122.11
7	1000	244.22
8	2000	488.44
9	5000	1221.11
10	10000	1924.47

Table 8: Valve Configuration Selection Guide

Example:

Suppose you need to flow boron trichloride at a rate of 250 sccm and the inlet pressure is 20 psia. Your process runs at atmospheric pressure, so the differential pressure is 5 psid.

1. Determine the maximum flow factor (C_V) for the gas of interest, using the equation listed in step 1, on page 43.

The *Gas Density* for boron trichloride, listed in *Appendix B: Gas Correction Factors*, page 37, is 5.227. The *C_V Pressure Factor*, read from Table 7, page 43, for a 20 psia inlet and 5 psid differential pressure, is 0.373. Therefore, our equation becomes:

$$C_V\,(\text{max}) = (250\text{ sccm})\left(\sqrt{\frac{5.227}{1.293}}\right)(0.373)$$

$$C_V = 187.5$$

2. Select the valve configuration with a C_V value that is closest to, though larger than, the C_V value calculated in step 1.

   A C_V value of 187.5 falls between 122.11 (configuration 6) and 244.22 (configuration 7). To ensure that the unit can deliver the 250 sccm flow, choose configuration 7.

Appendix D: Model Code Explanation

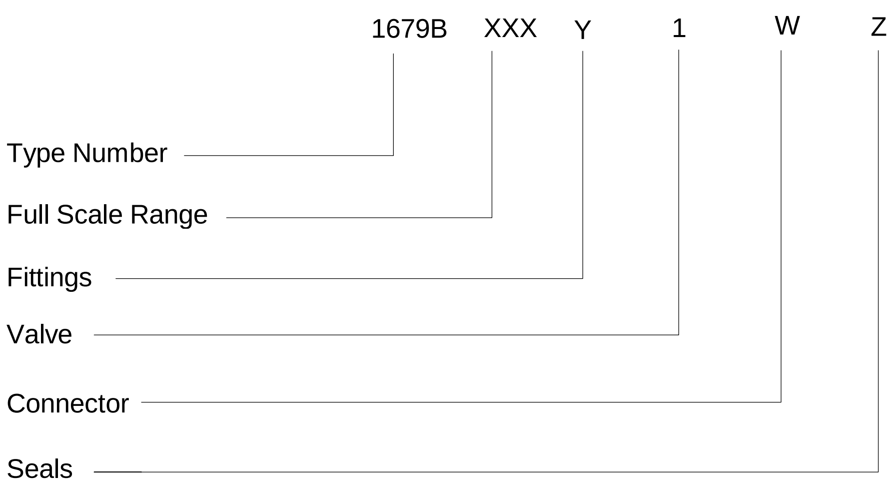
Model Code

Use the MKS Type 1679 Mass-Flo® Controller (MFC) when both gas flow control and measurement are required. The instrument is available with the flow control valve in a normally closed configuration. The desired options are identified in the model code when you order the unit.

The model code is identified as follows:

1679BXXXY1WZ

where:



Type Number (1679B)

This designates the model number of the instrument. The mass flow controller is identified as the Type 1679B.

Full Scale Range - sccm of Nitrogen (XXX)

The full scale range is indicated by a two digit / one letter code.

Full Scale Range	Ordering Code
10	11C
20	21C
50	51C
100	12C
200	22C
500	52C
1,000	13C
2,000	23C
5,000	53C
10,000	14C

Fittings (Y)

Three types of fittings are available, designated by a single letter code.

	Ordering Code
Cajon 4-VCR Male	R
Swagelok ¼" tube	S
¼" tube weld stub	A

Valve (1)

The valve configuration is designated by a single number code.

	Ordering Code
Normally Closed	1

Connector (W)

Five types of connectors are available, indicated by a single letter or number code.

	Ordering Code
9-pin Type “D”	A
15-pin Type “D”	B
20-pin Edge Card	C
Digital, RS-485*	5
Digital, DeviceNet®*	6

** Consult factory for availability*

Seals (Z)

The all-metal seals are indicated by a single letter code.

	Ordering Code
All-metal	M

How To Order a Mass Flow Controller

To order the Type 1679 MFC with a 500 sccm full scale range, Cajon 4-VCR fittings, a normally closed valve, 15-pin Type “D” connector, and an all-metal seal, the product code is:

1679B 52C R 1 B M

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