



114792-P1
Rev C, 9/95
Instruction Manual

MKS Type 167A Single Channel Flow Readout

Six Shattuck Road
Andover, MA 01810-2449
(800) 227-8766 or (978) 975-2350

Fax: (978) 975-0093
E-mail: mks@mksinst.com
Web site: <http://www.mksinst.com>



WARRANTY

167A Equipment

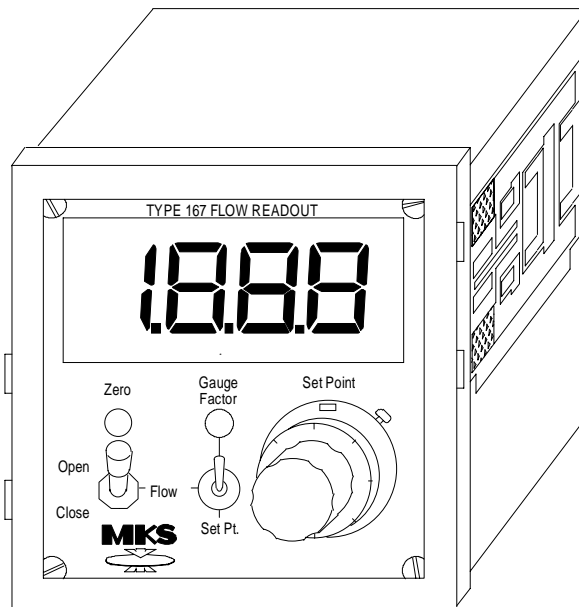
MKS Instruments, Inc. (**MKS**) warrants that the equipment described in the face of this warranty (the "equipment") manufactured by **MKS** shall be free from defects in materials and workmanship for a period of one year from date of shipment. For the period commencing with the date of shipment of this equipment and ending one year later, **MKS** will, at its option, either repair or replace any part which is defective in materials or workmanship without charge to the purchaser. The foregoing shall constitute the exclusive and sole remedy of the purchaser for any breach of **MKS** of this warranty.

The purchaser, before returning any equipment covered by this warranty, which is asserted to be defective by the purchaser, shall make specific written arrangements with respect to the responsibility for shipping the equipment and handling any other incidental charges with the **MKS** sales representative or distributor from which the equipment was purchased or, in the case of a direct purchase from **MKS**, with the **MKS** home office in Andover, Massachusetts, U.S.A.

This warranty does not apply to any equipment which has not been 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 consequential or incidental damages in connection with, or arising out of, the sale, performance, or use of the equipment covered by this warranty.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES BY **MKS**, EXPRESSED OR IMPLIED, INCLUDING THE IMPLIED WARRANTY OF MERCHANTABILITY, THE IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY WARRANTY AGAINST INFRINGEMENT OF ANY PATENT.

MKS Type 167A Single Channel Flow Readout



Copyright © 1995 by MKS Instruments, Inc.

All rights reserved. No part of this work may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or by any information storage or retrieval system, except as may be expressly permitted in writing by MKS Instruments, Inc.

Table of Contents

Safety Procedures and Precautions.....	1
Chapter One: General Information.....	3
Introduction	3
Customer Support.....	4
How This Manual is Organized.....	4
Instrument Overview	5
Dimensions	5
The Front Panel.....	7
The Back Panel	9
Chapter Two: Installation and Operation	13
How To Unpack the Type 167 Readout.....	13
Unpacking Checklist	13
Product Location and Requirements.....	14
Setup	15
How To Adjust the Gauge Factor.....	17
How To Adjust the Set Point	19
To Adjust the Set Point by Adjusting the Flow Rate in the Display	19
To Adjust the Set Point by Adjusting the Set Point Pot	20
How To Command the MFC Operation	22
To command an MFC to go to full open.....	22
To command an MFC to go to full close	22
To command an MFC to operate according to the set point	22
How To Zero the MFC	23
How To Adjust the Decimal Point	24
Chapter Three: Gas Correction Factor.....	25
General	25
How To Determine What Range MFC to Use	26
Appendix A: Product Specifications	27
Specifications	27

Table of Contents

Appendix B: Gas Correction Factors.....	29
Index	33

List of Figures

Figure 1: The Type 167 Readout, MFC, and Power Supply	3
Figure 2: Front View Dimensions.....	5
Figure 3: Side View Dimensions	5
Figure 4: Back View Dimensions	6
Figure 5: Five Unit Rack Dimensions.....	6
Figure 6: Panel Cutout Dimensions	6
Figure 7: Front Panel of the Type 167 Readout.....	7
Figure 8: Back Panel of the Type 167 Readout.....	9
Figure 9: Piggyback Power Connection of Several 167 Readouts	15
Figure 10: How to Wire the Terminal Block Connectors	16
Figure 11: The Set Point Pot	20

List of Tables

Table 1: Back Panel Type “D” Connector Pinout.....	10
Table 2: Back Panel Terminal Block Connector Pinout	11
Table 3: Gauge Factors for a Range of MFCs	17

Safety Procedures and Precautions

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 remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only. DO NOT replace components with the power cable connected.

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

Warning



The **WARNING** sign denotes a hazard. 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. 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.

This page intentionally left blank

Chapter One: General Information

Introduction

The Type 167A Single Channel Flow Readout is designed to provide complete display and set point control of any MKS mass flow controller (MFC), via front panel controls. Direct display in standard mass flow units (sccm, slm) is easily accomplished by the proper setting of the front panel precision scaling potentiometer (labeled Gauge Factor). This one-time setting scales the display for the desired process gas, as well as for the appropriate MFC Full Scale range.

The three position Open/Close/Flow switch on the front panel is used to operate an MFC according to a set point, or to send a digital low to fully open or fully close the MFC. In most cases, the fully closed position can be used to zero the MFC. A zero pot is conveniently located on the front panel for fine zero adjust of the MFC.

The Type 167 readout is used in conjunction with a single MFC and a ± 15 VDC, $\pm 5\%$ power supply. An optional 19 inch rack, and an optional rack with five 167 readouts installed, are available.

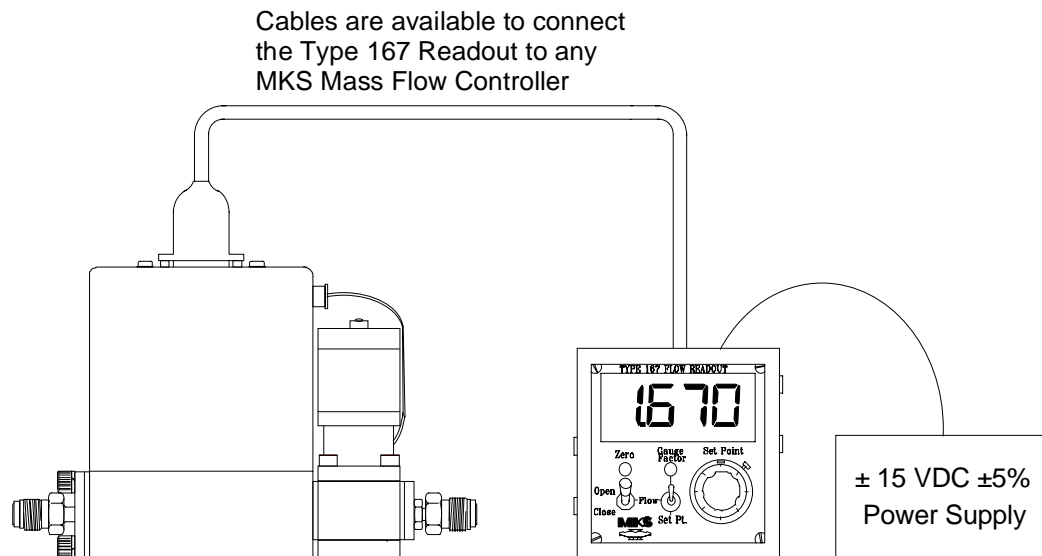


Figure 1: The Type 167 Readout, MFC, and Power Supply

Customer Support

Standard maintenance and repair services are available at all of our regional MKS Calibration and Service Centers in North America, Europe, Israel, Japan, Korea, and Taiwan. 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 167 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, radioactive, corrosive, or toxic materials.

How This Manual is Organized

This manual is designed to provide instructions on how to set up and install a Type 167 unit.

Before installing your Type 167 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 and Operation, explains environmental requirements and practical considerations to take into account when selecting the proper setting for the readout.

Chapter Three: Gas Correction Factor, describes, in a general way, how the readout 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.

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.

Instrument Overview

Dimensions

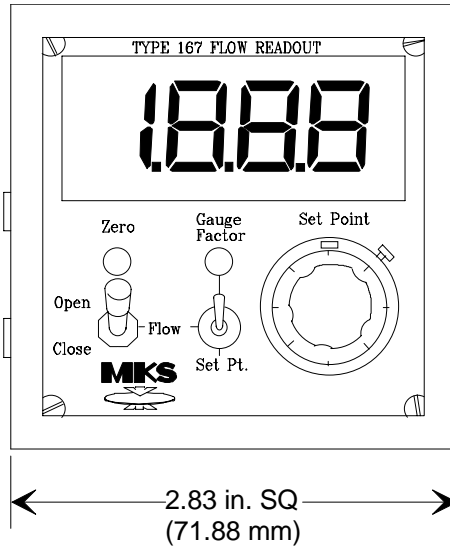


Figure 2: Front View Dimensions

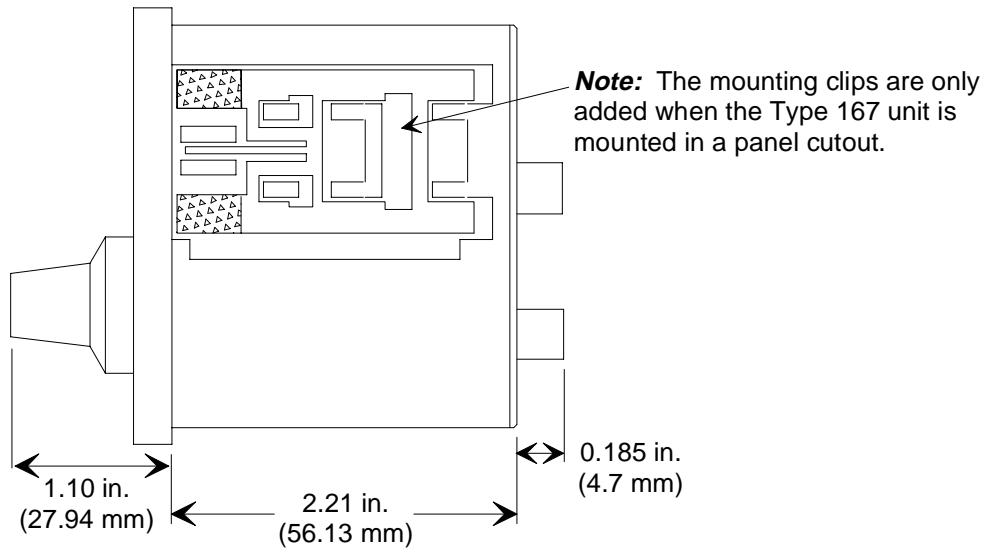


Figure 3: Side View Dimensions

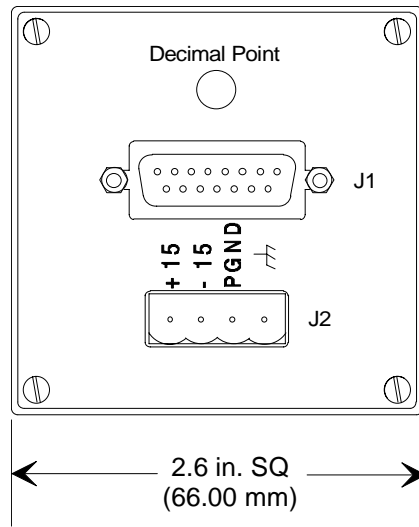


Figure 4: Back View Dimensions

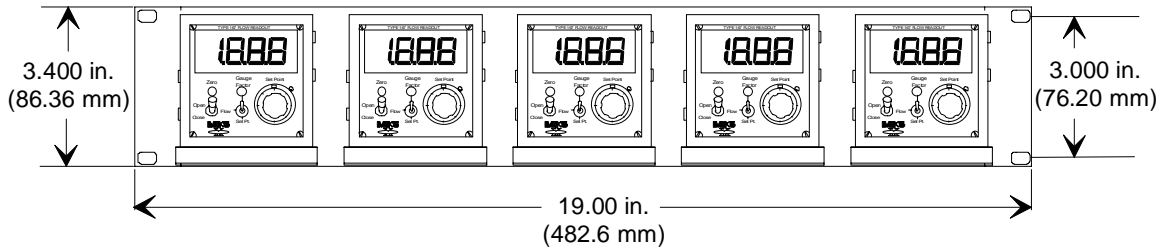


Figure 5: Five Unit Rack Dimensions

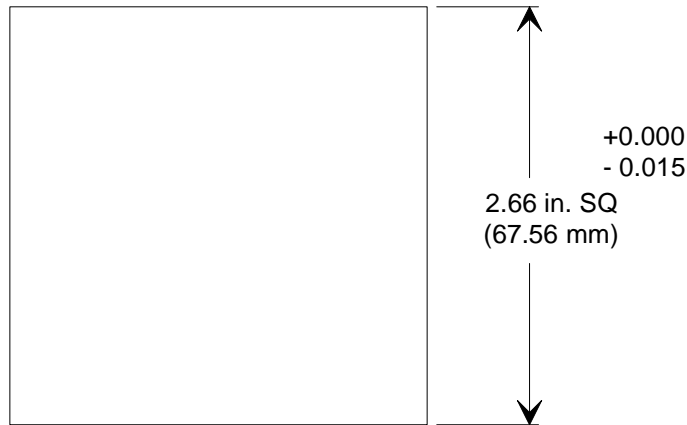


Figure 6: Panel Cutout Dimensions

The Front Panel

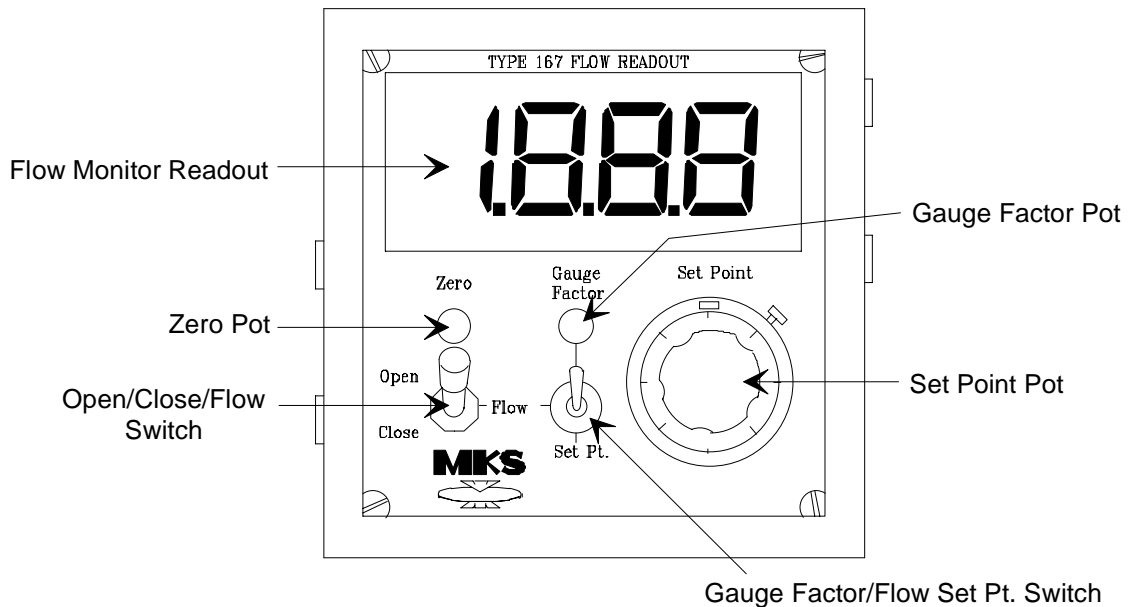


Figure 7: Front Panel of the Type 167 Readout

Flow Monitor Readout

The flow monitor readout is a red, 0.56", LED display. It has a 3½ digit DPM (Digit Panel Meter) which can display ± 1999 Full Scale. By adjusting the Gauge Factor, this display can show the gas-corrected flow in sccm or slm.

Zero Pot

The zero pot on the front panel of the 167 unit is used for fine zero adjustment of the MFC. Major zero adjustment must be done at the MFC.

Gauge Factor Pot

This pot is used for analog scaling of the 167 readout for different types of gases, different MFC Full Scale values, and units of sccm or slm. To enable this pot, the Gauge Factor/Flow/Set Pt. switch must be held in the Gauge Factor position while adjusting the pot with a small flat edge screwdriver.

Set Point Pot

The Set Point Pot is a precision 10-turn potentiometer used to adjust the set point voltage. The Set Point Pot is adjusted to a percent of the mass flow controllers' Full Scale times ten (%MFC F.S. x 10), thereby adjusting the set point voltage. The 167 readout controls according to this set point when the Gauge Factor/Flow/Set Pt. switch is in the FLOW position (flow mode), and displays the flow in engineering units (sccm or slm).

Open/Close/Flow Switch

Depending upon the switch position, the 167 readout causes the MFC to completely open (Open position), completely close (Close position), or vary its position according to the set point (Flow position).

- When placed in the Open position, the 167 readout sends a digital low (connector J1, pin 4) to the MFC, causing the valve to go to full open. This TTL signal overrides the set point signal.
- When placed in the Close position, the 167 readout sends a digital low (connector J1, pin 3) to the MFC, causing the valve to go to full close. This TTL signal overrides the set point signal.
- When in the Flow position, the 167 readout sends a set point voltage to the MFC.

Gauge Factor/Flow/Set Pt. Switch

This three position centering switch allows adjustment of the gas gauge factor or the control set point, and allows flow control of an MFC. The centering feature of the switch causes the switch to return to its center (Flow) position when it is released.

- When placed in the Gauge Factor position, the Gauge Factor can be set with the Gauge Factor pot. Adjustment of the pot configures the 167 readout to display the flow in specific engineering units. Refer to *How To Adjust the Gauge Factor*, on page 17, for an explanation of how to determine the correct Gauge Factor setting for different gases and different MFC Full Scale values.
- When placed in the Set Pt. position, the current set point is displayed and can be adjusted by using the Set Point pot.
- When placed in the Flow position, the MFC is allowed to follow the set point voltage from the Type 167 unit.

The Back Panel

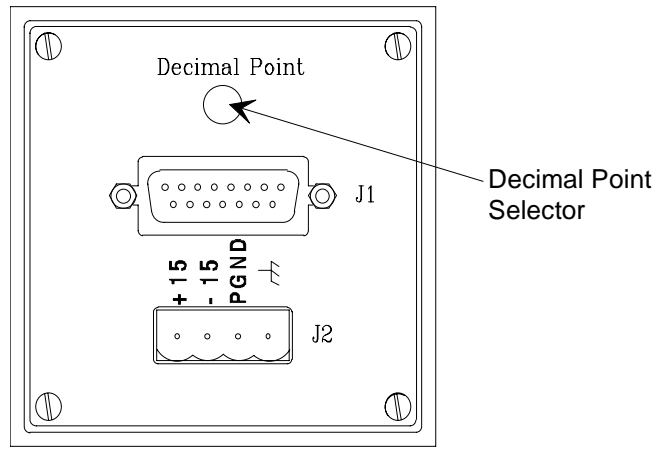


Figure 8: Back Panel of the Type 167 Readout

The back panel of the 167 readout has a decimal point selector, a 15-pin Type “D” connector (J1) for interfacing with an MFC, and a four position terminal block (J2) for input of ± 15 VDC to power the 167 readout, and an MFC.

Decimal Point Selector

This selector is used to set the appropriate decimal point in the front panel digital display.

Note



The placement of the decimal is for your convenience — it does *not* affect the signal output from the 167 readout to an MFC.

When setting the Gauge Factor, it is best to utilize all of the digits in the LED display. This maximizes the resolution of the readout and thus the accuracy of the reading.

For example, if a Gauge Factor of 200 is desired, adjust the Gauge Factor pot so that 1999 is shown in the display (it is not possible to display 200.0). For your convenience, the decimal may be placed between the last two digits so that 199.9 shows in the display (199.9 is the closest to 200.0 that the LED display can show).

It is also possible to set the decimal so that 1.999 or 19.99 or 199. is shown in the display. Regardless of where the decimal is, the 167 readout sends out the same signal. Since a display of 199.9 is the closest to the desired display of 200.0, it would be the best choice.

J1 (15 pin, Type “D” Connector)

Table 1 lists the pinout of the J1 connector.

Back Panel Type “D” Connector Pinout	
Pin	Assignment
1	No Connection
2	Flow In - MFC output is input here
3	$\overline{\text{CLOSE}}$
4	$\overline{\text{OPEN}}$
5	Power Ground
6	- 15 VDC
7	+ 15 VDC
8	Set Point Voltage Output to the MFC
9	5.000 VDC Reference Test Point (1 K ohm output impedance)
10	Flow Out - A 0 to 5 Volt zero-corrected output sent to some MFCs. For use with the MFC set point circuitry to ensure that the actual flow matches set point. This signal is used on all MKS MFCs.
11	Analog Return
12	Analog Return
13	No Connection
14	No Connection
15	Chassis Common

Table 1: Back Panel Type “D” Connector Pinout

Note

1. The overline on the $\overline{\text{OPEN}}$ and $\overline{\text{CLOSE}}$ inputs indicate that the line must be pulled low to activate the function.
2. Cable CB147-1 must be used to allow connection to the $\overline{\text{OPEN}}$ and $\overline{\text{CLOSE}}$ inputs.
3. A “No Connection” pin assignment indicates that the pin has no *internal* connection.

J2 (4 Position Terminal Block)

The J2 connector is located on the back panel of the readout.

Back Panel Terminal Block Connector Pinout	
Pin	Function
1	+ 15 VDC to power the 167 unit and the MFC
2	- 15 VDC to power the 167 unit and the MFC
3	Power Ground
4	Chassis Ground

Table 2: Back Panel Terminal Block Connector Pinout

This page intentionally left blank.

Chapter Two: Installation and Operation

How To Unpack the Type 167 Readout

MKS has carefully packed the Type 167 Single Channel Flow Readout 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.

Unpacking Checklist

Standard Equipment:

- Type 167 Unit
- Type 167 Instruction Manual (this book)

Optional Equipment:

- Electrical Connector Accessories Kit - 167A-K1 (contains mating connectors for the J1 and J2 connectors)
- The entire line of MKS mass flow controllers excluding the 4 to 20 mA Types 1749 and 1759

For more detailed information, contact MKS Instruments, Inc. (offices and telephone numbers are supplied on the inside back cover of this manual).

- 19" rack with 5 Type 167 readouts installed (MKS p/n 114783-G1)
- 19" rack designed to accept five Type 167 readouts (MKS p/n 114781-P1)
- Mounting panels
- 260 PS-1 and 260 PS-3 power supplies

Product Location and Requirements

- Operating ambient temperature must be in the range of 15° to 40° C (59° to 104° F)
- Input Power requirements are ± 15 VDC $\pm 5\%$, @ 30 mA (the 30 mA does not include the MFC)

Refer to the MFC instruction manual for additional current required to operate the MFC.

Setup

- The 167 readout should be mounted in such a manner as to provide adequate air circulation around the unit
- The Type 167 Readout can be mounted in a panel cutout, or in an optional 19" rack (holds up to 5 Type 167 readouts)

The dimensions for a panel cutout are 2.67 sq. in. + 000, - 0.15 (67.82 sq. mm). The dimensions of the optional 19" rack are given in Figure 5, page 6.

- If more than one 167 readout is being used, they can be powered through piggyback connections

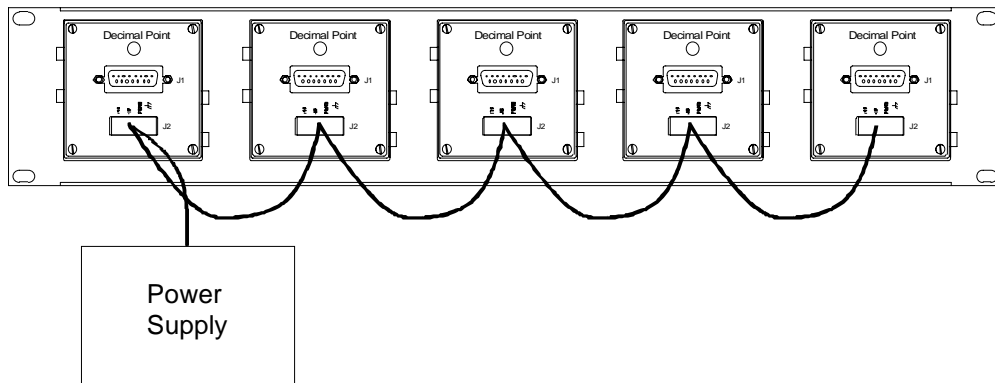


Figure 9: Piggyback Power Connection of Several 167 Readouts

Note



The type of power supply necessary, and the number of 167 units that can be piggybacked together, depends upon the amount of current required by the MFCs.

Wire the piggyback connections as shown in Figure 10, page 16.

Caution

Be sure to wire the terminal block connectors as shown. Improper wiring could cause permanent damage to the 167 units.

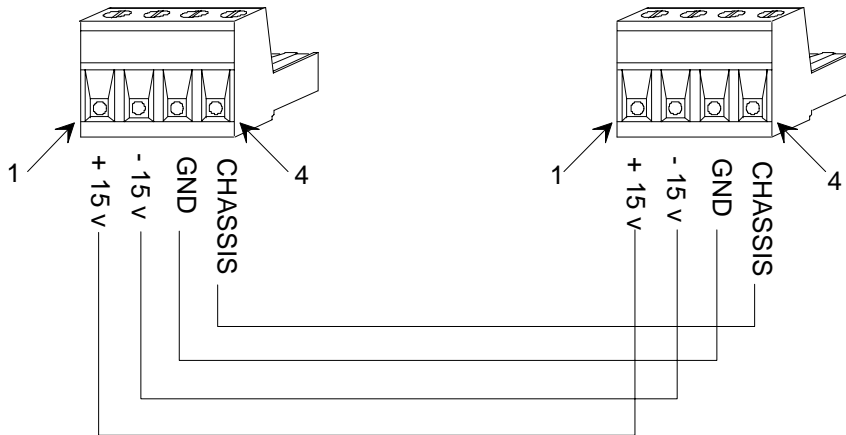


Figure 10: How to Wire the Terminal Block Connectors

- Connect the MFC cable to J1 on the 167 rear panel
- Connect the power supply cable to J2 on the 167 rear panel

How To Adjust the Gauge Factor

The *Gauge Factor* is a multiplier which adjusts the 167 readout to display the flow rate in units appropriate to the Full Scale of the MFC in use.

When nitrogen is used, adjustment of the Gauge Factor pot only needs to consider the appropriate Gauge Factor (refer to Table 3 for the appropriate Gauge Factor to use).

For nitrogen, adjustment of the Gauge Factor pot = Gauge Factor (see Table 3)

When any gas other than nitrogen is used, adjustment of the Gauge Factor pot should also incorporate a *Gas Correction Factor (GCF)*. *Chapter Three: Gas Correction Factor*, beginning on page 25, explains the GCF values, and *Appendix B: Gas Correction Factors*, beginning on page 29, lists gases and their GCFs.

If the gas is *not nitrogen*, then adjustment of the Gauge Factor pot = (Gauge Factor) x (GCF)

Gauge Factors for a Range of MFCs			
MFC F. S. Voltage	MFC Full Scale	Gauge Factor	167 Display at Full Scale
5V	10 sccm	100	10.00 sccm
5V	20 sccm	200	19.99 sccm
5V	50 sccm	50	50.0 sccm
5V	100 sccm	100	100.0 sccm
5V	200 sccm	200	199.9 sccm
5V	500 sccm	50	500 sccm
5V	1,000 sccm	100	1000 sccm
5V	2,000 sccm	200	1999 sccm
5V	5,000 sccm	50	5.0 slm
5V	10,000 sccm	100	10.00 slm
5V	20,000 sccm	200	19.99 slm
5V	50,000 sccm	50	50.0 slm

Table 3: Gauge Factors for a Range of MFCs

Note



If an MFC is calibrated with a gas other than nitrogen, then the Gas Correction Factor is 1.00 (one) when using that gas in the process.

To determine the Gauge Factor pot adjustment value needed to correctly adjust the Gauge Factor pot, follow these steps:

1. Look up the Gauge Factor in Table 3, page 17, for the MFC in use.
2. Multiply the Gauge Factor by the Gas Correction Factor (GCF) for the gas in use.
 - A. If using nitrogen (GCF = 1.00), this step is not necessary.
 - B. If using any gas other than nitrogen, refer to *Appendix B: Gas Correction Factors*, page 29, for the GCF.
3. Hold the Gauge Factor/Flow/Set Pt. switch in the Gauge Factor position.
The 167 readout responds by displaying the current gauge factor value.
4. Using a small flat edge screwdriver to access the Gauge Factor pot on the front panel, adjust the display until it reads the correct adjustment value.
Refer to Figure 7, page 7, for the location of the Gauge Factor pot.
5. Once the correct value is displayed, release the Gauge Factor/Flow/Set Pt. switch.
6. If appropriate, move the decimal point in the display by adjusting the rear panel Decimal Point selector.
Refer to Figure 8, page 9, for the location of the Decimal Point selector.

Examples

- A) For a 200 sccm Full Scale MFC with nitrogen: The Gauge Factor from Table 3 is 200, and the GCF from Appendix B is 1.00, so the Gauge Factor pot *adjustment* is 200.

$$\begin{aligned}\text{Adjustment} &= (\text{Gauge Factor})(\text{GCF for nitrogen}) \\ &= (200)(1.00) = 200\end{aligned}$$

Set the display to 1999 (and adjust the rear panel Decimal Point selector so the display reads 199.9).

- B) For a 2000 sccm Full Scale MFC with methane: The Gauge Factor from Table 3 is 200, and the GCF from Appendix B is 0.72, so the Gauge Factor pot *adjustment* is 144.

$$\begin{aligned}\text{Adjustment} &= (\text{Gauge Factor})(\text{GCF for methane}) \\ &= (200)(0.72) = 144\end{aligned}$$

Set the display to 1440 and adjust the Decimal Point selector so the display reads 144.0.

- C) For a 50 sccm Full Scale MFC with nitrogen: The Gauge Factor from Table 3 is 50, and the GCF from Appendix B is 1.00, so the Gauge Factor pot *adjustment* is 50.

$$\begin{aligned}\text{Adjustment} &= (\text{Gauge Factor})(\text{GCF for nitrogen}) \\ &= (50)(1.00) = 50\end{aligned}$$

Set the display to 500 and adjust the Decimal Point selector so the display reads 50.0.

How To Adjust the Set Point

Set the Gauge Factor before adjusting the set point.

The Set Point pot is used to adjust the set point voltage. It is adjusted to a percent of the mass flow controllers' Full Scale times ten (%MFC F.S. x 10). The 167 readout controls according to this set point when the Gauge Factor/Flow/Set Pt. switch is in the Flow position (flow mode), and displays the flow in engineering units (scm or slm).

The Set Point pot is adjusted by pushing the lock counterclockwise into its uppermost position, turning the dial, then locking the dial in the desired position. The set point can be adjusted in one of two ways: by turning the Set Point pot until the display shows the desired flow rate, or by determining the desired Set Point pot value and setting the pot to that value. Using the 167 display is more accurate than using the Set Point pot.

To Adjust the Set Point by Adjusting the Flow Rate in the Display

1. Hold the Gauge Factor/Flow/Set Pt. switch in the set point position (labeled Set Pt. on the front panel).

The 167 readout responds by displaying the set point flow rate in engineering units.

2. Unlock the Set Point pot by pushing the lock (black tab sticking out at the upper right quadrant of the Set Point pot) counterclockwise into its uppermost position.
3. Turn the Set Point pot until the display shows the desired flow rate.
4. Lock the Set Point pot by pushing the lock clockwise to its lowest position.
5. Release the Gauge Factor/Flow/Set point switch.

The switch returns to its center (Flow) position, and the 167 is in flow mode.

Note

The decimal point should have been adjusted when setting the Gauge Factor (refer to *How To Adjust the Gauge Factor* on page 17).

To Adjust the Set Point by Adjusting the Set Point Pot

1. Determine what percent of the MFC Full Scale equals the desired flow.

$$\% \text{ of MFC F.S.} = \frac{\text{GCF of N}_2}{\text{GCF}_x} \times \frac{\text{desired flow rate}}{\text{MFC F.S.}}$$

where GCF_x = the Gas Correction Factor for gas X

Appendix B: Gas Correction Factors, beginning on page 29, lists gas correction factors.

2. Multiply the percent by 10 to arrive at the set point value.
3. Hold the Gauge Factor/Flow/Set Pt. switch in the set point position (labeled Set Pt. on the front panel).

The 167 readout responds by displaying the set point flow rate in engineering units.

4. Unlock the Set Point pot by pushing the lock (black tab sticking out at the upper right quadrant of the Set Point pot) counterclockwise into its uppermost position.
5. Adjust the Set Point pot to the desired value.

For example, if the desired set point value is 850 (or 85% of the MFC Full Scale), adjust the Set Point pot as shown in Figure 11.

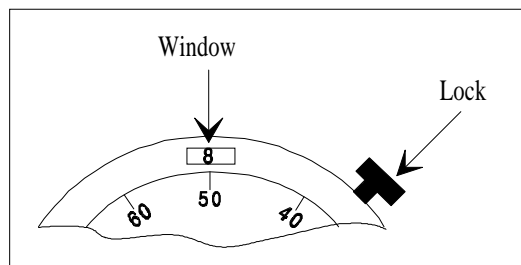


Figure 11: The Set Point Pot

6. Lock the Set Point pot by pushing the lock clockwise to its lowest position.
7. Release the Gauge Factor/Flow/Set Pt. switch.

The switch returns to its center (Flow) position, and the 167 is in flow mode.

Note



The decimal point should have been adjusted when setting the Gauge Factor (refer to *How To Adjust the Gauge Factor* on page 17).

Examples

- A). If the MFC F.S. = 100 sccm, and the desired flow rate is 100 sccm of nitrogen, then the desired percent of F.S. is 100%.

$$\% \text{ of F.S.} = \frac{\text{GCF of N}_2}{\text{GCF of N}_2} \times \frac{\text{desired flow rate}}{\text{MFC F.S.}} = \frac{1.00}{1.00} \times \frac{100 \text{ sccm}}{100 \text{ sccm}} = 100\%$$

Multiply the desired percent by 10 (100 x 10 = 1000).

Hold the Gauge Factor/Flow/Set Pt. switch in the Set Pt. position, unlock the Set Point pot, adjust the pot to 1000, then lock the pot.

If the Gauge Factor has been adjusted to maximize the resolution of the 167 display, then the display will read **100.0** at full scale flow.

- B). If the MFC F.S. = 100 sccm, and the desired flow rate is 50 sccm of neon (GCF = 1.46), then the desired percent of F.S. is 34%:

$$\% \text{ of F.S.} = \frac{\text{GCF of N}_2}{\text{GCF of Ne}} \times \frac{\text{desired flow rate}}{\text{MFC F.S.}} = \frac{1.00}{1.46} \times \frac{50 \text{ sccm}}{100 \text{ sccm}} = 34\%$$

Multiply the desired percent by 10 (34 x 10 = 340).

Hold the Gauge Factor/Flow/Set Pt. switch in the Set Pt. position, unlock the Set Point pot, adjust the pot to 680, then lock the pot.

If the Gauge Factor has been adjusted to maximize the resolution of the 167 display, then the display will read: **50.0** at full scale flow.

- C). If the MFC F.S. = 200 sccm, and the desired flow rate is 150 sccm of neon (GCF = 1.46), then the desired percent of F.S. is 51%:

$$\% \text{ of F.S.} = \frac{\text{GCF of N}_2}{\text{GCF of Ne}} \times \frac{\text{desired flow rate}}{\text{MFC F.S.}} = \frac{1.00}{1.46} \times \frac{150 \text{ sccm}}{200 \text{ sccm}} = 51\%$$

Multiply the desired percent by 10 (51 x 10 = 510).

Hold the Gauge Factor/Flow/Set Pt. switch in the Set Pt. position, unlock the Set Point pot, adjust the pot to 510, then lock the pot.

If the Gauge Factor has been adjusted to maximize the resolution of the 167 display, then the display will read: **150.0** at full scale flow.

How To Command the MFC Operation

To command an MFC to go to full open

- Lift the Open/Close/Flow switch and set it in the Open position

The 167 readout responds by sending a digital low to the MFC Open pin.

NOTE: Proper cabling (MKS CB147-1) is necessary to connect this low to the MFC.

To command an MFC to go to full close

- Lift the Open/Close/Flow switch and set it in the Close position

The 167 readout responds by sending a digital low to the MFC Close pin.

Note

Proper cabling (MKS CB147-1) is necessary to connect this low to the MFC.

To command an MFC to operate according to the set point

- Lift the Open/Close/Flow switch and set it in the Flow position

The 167 readout responds by sending a set point voltage to the MFC.

How To Zero the MFC

For mass flow controllers, any zero offset present is corrected to zero internally in the Type 167 readout and the zero-corrected signal is returned to the MFC PID (Proportional-Integral-Derivative) control circuitry. This is done to ensure that the displayed flow and actual controlled flow do not develop offsets relative to one another.

The Zero pot on the 167 readout is for fine tuning of the MFC zero. If the MFC reading is greater the $\pm 2\%$ of the MFC Full Scale, use the Zero Control pot on the MFC to bring the reading within 2% before using the 167 readout Zero pot.

Note

When zeroing an MFC, zero gas flow must be ensured. This can be accomplished by turning off a valve(s) in series with the MFC.

1. With zero gas flow ensured, apply power to the 167 readout and allow it to warm up and stabilize for at least 15 minutes.
2. Allow adequate warmup time for the MFC.

Consult the MFC operating manual for the proper warmup time interval.

3. Adjust the Zero pot on the front panel of the 167 readout until 0000 is displayed.

If unable to properly adjust the zero, use the zero pot on the MFC. After zeroing at the MFC, use the 167 readout for a final fine tuning of the zero.

Note

If the 167 readout's Zero pot has been adjusted to the end of its range, re-center the pot before making the above coarse adjustment at the MFC.

How To Adjust the Decimal Point

Decimal point adjustment is accomplished by using the Decimal Point selector located on the back panel of the 167 readout. This selector is used to set the appropriate decimal point in the front panel digital display.

Note

The placement of the decimal is for your convenience - it does *not* affect the signal output from the 167 readout to an MFC.

When setting the Gauge Factor, it is best to utilize all of the digits in the LED display. This maximizes the resolution of the readout and thus the accuracy of the reading.

For example, if a Gauge Factor of 200 is desired, adjust the Gauge Factor pot so that 1999 is shown in the display (it is not possible to display 200.0). For your convenience, the decimal may be placed between the last two digits so that 199.9 shows in the display (199.9 is the closest to 200.0 that the LED display can show).

It is also possible to set the decimal so that 1.999 or 19.99 or 1999. is shown in the display. Regardless of where the decimal is, the 167 readout sends out the same signal. Since a display of 199.9 is the closest to the desired display of 200.0, it would be the best choice.

Chapter Three: Gas Correction Factor

General

A Gas Correction Factor (GCF) is a number used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow meter (MFM) or mass flow controller (MFC). The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow meters and controllers are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1). The GCF of any other gas is determined by using the following equation:

$$\text{GCF}_X = \frac{(0.3106) (S)}{(d_X) (Cp_X)}$$

where:

GCF_X = Gas Correction Factor for gas X

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

Cp_X = Specific heat of gas X, cal/g°C

0.3106 = (Density of nitrogen) (Specific heat of nitrogen)

S = Molecular Structure correction factor where S =

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

Appendix B: Gas Correction Factors, beginning on page 29, lists the Gas Correction Factors for commonly used gases.

Note



When using the GCF, the flow reading accuracy may vary by $\pm 5\%$, however, the repeatability will remain $\pm 0.2\%$ of F.S.

How To Determine What Range MFC to Use

Mass flow controllers are available in ranges from 10 to 50,000 sccm. To determine which range MFC is needed, use the ratio of the GCF of nitrogen (1.00) to the GCF of the desired gas, to determine the ratio of the flow rate of nitrogen to the flow rate of the desired gas.

Example 1

Which range MFC should be selected to flow 100 sccm of argon (Ar),?

1. Find the Gas Correction Factor of Ar (Appendix A).
1.39 is the GCF for Ar.
2. Insert the GCF of Ar in the following formula:

$$\frac{(\text{GCF of N}_2)}{(\text{GCF of Ar})} = \frac{(x)}{(\text{Desired flow rate of Ar})} \quad \text{where } x \text{ is the flow rate of nitrogen (sccm).}$$

$$\frac{(1.00)}{(1.39)} = \frac{(x)}{(100 \text{ sccm Ar})}$$

$$x = 72 \text{ sccm N}_2$$

100 sccm of Ar will look like 72 sccm of N₂. This falls within the range of a 100 sccm MFC.

When calculating equivalent N₂ flows using gas correction factors, be sure to use a flow controller with a sufficient flow rate range. For example, if the calculated equivalent N₂ 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 N₂ = full scale.

Appendix A: Product Specifications

Specifications

Cabling	To MKS MFC with a Type “D” connector: CB147-1-10 To MKS MFC with a Edge Card connector: CB147-7-10 To MKS 260PS-1 power supply: CB260-7-10 Consult MKS for cables to other MFCs or power supplies
Compatible MFCs	Any MFC employing ± 15 VDC power input, and 0 to 5 VDC set point and output signals
Dimensions	2.83” x 2.83” x 2.48” (72 mm x 72 mm x 63 mm)
Display	3½ digit LED, ½” high digits
Front Panel Controls	
Flow set point	10-turn precision potentiometer
MFC zero	recessed potentiometer
Gauge Gas Correction Factor	recessed potentiometer
Open/Close/Flow switch	locking toggle switch
Gauge Factor/Set Point/Flow switch	toggle switch (spring-loaded to flow position)
Mounting	Square panel cutout 2.7” (68 mm) per side
Operating Temperature Range	15° to 40° C (59° to 104° F)
Power Requirements	± 15 VDC $\pm 5\%$, 30 mA (does not include the power required for the MFC)
Rear Panel Connectors	
J1	15-pin Type “D” connector (connects to the MFC)
J2	4-pin terminal block connector (to ± 15 VDC power)
Rear Panel Control	Decimal point selector switch

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

This page intentionally left blank.

Appendix B: Gas Correction Factors

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g ⁰ C	DENSITY g/l @ 0 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 Tetrafluoride (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 ₂ ClF ₅	0.164	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	CClF ₃	0.153	4.660	0.38
Cyanogen	C ₂ N ₂	0.2613	2.322	0.61
Deuterium	D ₂	1.722	0.1799	1.00
Diborane	B ₂ H ₆	0.508	1.235	0.44
Dibromodifluoromethane	CBr ₂ F ₂	0.15	9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl ₂ F ₂	0.1432	5.395	0.35
Dichlorofluoromethane (Freon - 21)	CHCl ₂ F	0.140	4.592	0.42
Dichloromethylsilane	(CH ₃) ₂ SiCl ₂	0.1882	5.758	0.25

(Table continued on next page)

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Dichlorosilane	SiH ₂ Cl ₂	0.150	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	C ₂ Cl ₂ F ₄	0.160	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	C ₂ H ₂ F ₂	0.224	2.857	0.43
2,2-Dimethylpropane	C ₅ H ₁₂	0.3914	3.219	0.22
Ethane	C ₂ H 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 ₃ F	0.1357	6.129	0.33
Freon - 12	CCl ₂ F 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 ₂ F	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 ₂ Cl ₃ F ₃	0.161	8.360	0.20
Freon - 114	C ₂ Cl ₂ F ₄	0.160	7.626	0.22
Freon - 115	C ₂ ClF ₅	0.164	6.892	0.24
Freon - 116	C ₂ F ₆	0.1843	6.157	0.24
Freon - C318	C ₄ F ₈	0.185	8.397	0.17
Freon - 1132A	C ₂ H ₂ F ₂	0.224	2.857	0.43
Helium	He	1.241	0.1786	.- - -2
Hexafluoroethane (Freon - 116)	C ₂ F ₆	0.1843	6.157	0.24
Hydrogen	H ₂	3.419	0.0899	.- - -2
Hydrogen Bromide	HBr	0.0861	3.610	1.00

(Table continued on next page)

Appendix B: Gas Correction Factors

GAS	SYMBOL	SPECIFIC HEAT, Cp cal/g°C	DENSITY g/l @ 0°C	CONVERSION FACTOR
Hydrogen Chloride	HCl	0.1912	1.627	1.00
Hydrogen Fluoride	HF	0.3479	0.893	1.00
Isobutylene	C ₄ H 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 ₃ F	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	0.74
Nitrogen Trifluoride	NF ₃	0.1797	3.168	0.48
Nitrous Oxide	N ₂ O	0.2088	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C ₄ F ₈	0.185	8.937	0.17
Oxygen	O ₂	0.2193	1.427	1.00
Pentane	C ₅ H ₁₂	0.398	3.219	0.21
Perfluoropropane	C ₃ F 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 ₃ H ₈	0.3885	1.967	0.36
Propylene	C ₃ H 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)

Appendix B: Gas Correction Factors

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 ₃ F	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 ₂ FCCLF ₂ or (C ₂ Cl ₃ F 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

¹Empirically defined

²Consult MKS Instruments, Inc. for special applications.

NOTE: Standard Pressure is defined as 760 mmHg (14.7 psia). Standard Temperature is defined as 0^oC.

Index

B

Back panel, 9

C

Cabling, 27

Companion products, 13

Connectors, 9, 10, 11, 16, 27

Customer support, 4

D

Decimal point, 24

Decimal point selector, 9

Dimensions, 5–6, 27

E

Engineering units, 3

Environmental requirements, 14

F

Front panel, 7

G

Gas Correction Factor, 17, 25–26, 29

Gauge Factor, 8, 9, 17, 24

Gauge Factor pot, 3, 7

I

Input power, 3, 14, 27

M

Manual organization, 4

Messages, definitions of, 1

MFC range, 26

O

Open/Close/Flow switch, 3, 8

P

Panel cutout, 6, 15

Panel mount, 13

Power requirements, 14, 27

Power supply, 13

R

Returning the product, 4, 13

S

Safety procedures and precautions, 1

Set point, 19

Set Point pot, 8

Specifications, 27

U

Unpacking, 13

V

Valve commands, 10, 22

Z

Zero, 23

Zero pot, 3, 7, 23