McMillan
FLOW PRODUCTS


# OPERATING MANUAL
# MODEL 8511 • RHODIUM SERIES

**ATTENTION!:** Read this manual completely before attempting to connect or operate this product. Failure to do so may result in injury to you or damage to the device. Keep this document for future reference.

**www.mcmflow.com**

Doc no. OM-85X 2405 2

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# TABLE OF CONTENTS

# 1 INTRODUCTION

## 1.1 SCOPE

This manual covers the McMillan Flow Products' RHODIUM Series Mass Flow Controllers, model 8511. It contains general product knowledge, installation and operating instructions, and important contact information.

## 1.2 NOTE

Please read these operating instructions before unpacking and putting this product into operation. Follow the instructions precisely as described herein. This product is only to be used, maintained, and serviced by persons familiar with these operating instructions and in accordance with local regulations applying to health & safety and prevention of accidents.

**CAUTION: TAKE CARE NOT TO DROP THE DEVICE AND PLEASE READ THE INSTALLATION SECTION OF THIS MANUAL BEFORE PROVIDING POWER OR TUBING CONNECTIONS TO THE UNIT. DAMAGE CAUSED BY IMPROPER INSTALLATION OR HANDLING WILL NOT BE REPAIRED UNDER WARRANTY.**

## 1.3 PRODUCT INSPECTION AND UNPACKING

McMillan Flow Products suitably packages all flow devices to prevent damage during shipping. If external damage is noted upon receipt of the package, please contact the shipping company immediately. McMillan Flow Products is not liable for damage to the device once it has left the manufacturing premises.

Open package from the top and remove all documentation and contents. Take care to remove all items and check them against the packing slip, as well as checking for any concealed shipping the packing if any shortages or damage is noted, please contact the shipping company and/or mcmillan flow products to resolve the problem.

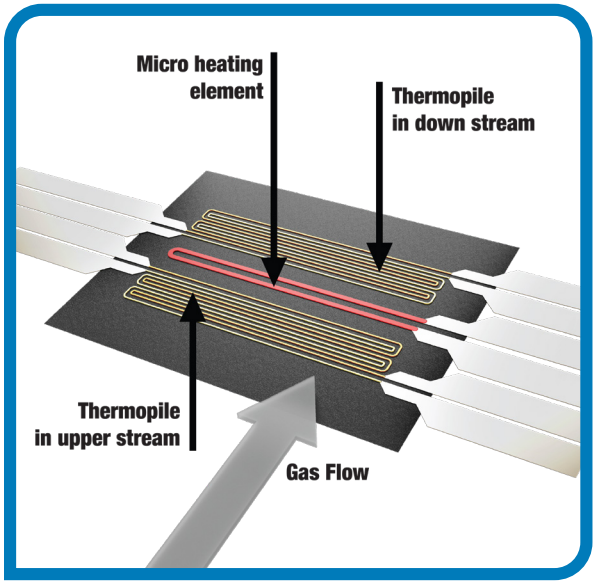
**SCOPE OF DELIVERY**

- RHODIUM Series Mass Flow Controller - Model 85XX
- Reference Card
- Any additional accessory options selected

## 1.4 PRODUCT SUMMARY

McMillan Flow Products offers OEM Mass Flow Controllers (MFC) for gases with outstanding value to our customers. The proprietary platinum-based MEMS thermal mass-flow technology guarantees excellent accuracy and repeatability in combination with high-speed response time, and an unmatched dynamic range. The advantages of this unique technology, combined with smart software processing and robust packaging, make McMillan Flow Products RHODIUM Series Mass Flow Controllers an ideal choice for demanding OEM applications.

MEMS technology utilizes a compact, reliable CMOS (Complementary Metal Oxide Semiconductor) sensor. This no-drift sensor module is comprised of both the electronic and mechanical elements on a single silicon chip, similar to the process used for integrated circuits.




Flow enters the unit, and a portion of the flow is redirected into a chamber and across the MEMS device. This device has two temperature sensors, one downstream from the other. Between the coils sits a small heating element, as shown in the image to the right. As the gas passes through the device, the smart electronics sense the difference in heat between the two sensors, since the upstream coil is not exposed to the heated gas. The downstream coil senses the heated gas and McMillan's advance sensing algorithm calculates the flow rate based on the difference in value. The precision manufacturing and compact size of the MEMS device ensure that the zero remains stable and the sensor is extremely repeatable.

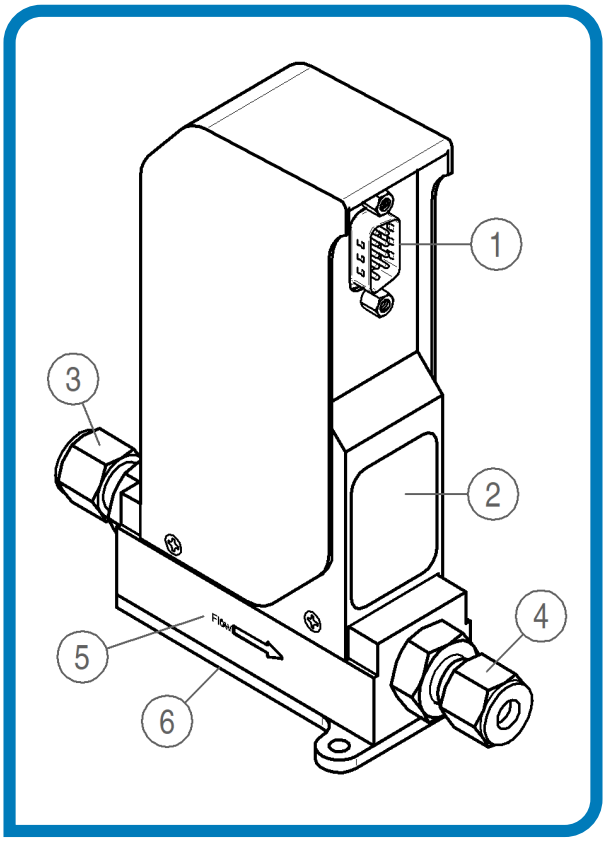
Flow then passes into the proportional solenoid valve. This valve is controlled by the active servo electronics, which compare a setpoint (supplied via analog input signal) to the actual flow rate provided by the flow sensor and adjust the valve accordingly.

**ADDITIONAL FEATURES**

- Exceptional Long-Term Stability
- Digitally Calibrated
- Full Temperature Compensation  32 to 122 °F  [ 0 to 50 °C ]
- Calorimetric Measurement Principle
- High Precision PID Controller

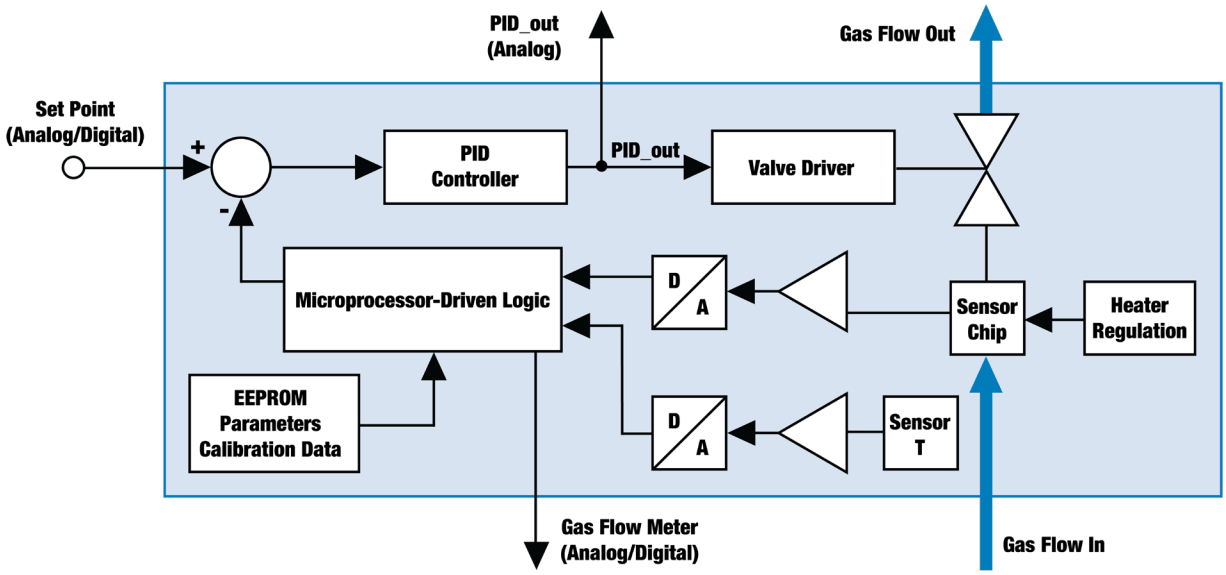
## 1.5 PRODUCT DIAGRAMS

### GENERAL PRODUCT OVERVIEW




| RHODIUM Series | |
|---|---|
| 1 | 9-Pin D-Sub male connection port |
| 2 | Data Label |
| 3 | Inlet Fitting |
| 4 | Outlet Fitting |
| 5 | Flow Direction |
| 6 | Mounting Plate |

### BLOCK DIAGRAM



## 1.6 SPECIFICATIONS

Except where noted, all specifications apply to operation at 25 °C

| RHODIUM Series | |
|---|---|
| **Flow Range** | See Section 5 for Flow Range Options |
| **Gas Type** | $N_2$ |
| **Calibration Conditions** | Reference Conditions:<br>Temperature: 32 °F [ 0 °C ]<br>Pressure: 760 mmHG [ 0.001 barg ] |
| **Accuracy** | ± 1.0% of full scale |
| **Repeatability** | ± 0.015% of full scale |
| **Response Time** | 4 ms |
| **Settling Time** | 150 ms |
| **Control Range** | 2% to 100% |
| **Operating Temperature** | 32 to 122 °F [ 0 to 50 °C ] |
| **Operating Humidity** | 5 to 95% relative humidity |
| **Pressure Range** | Operating: 0 to 130.5 psig [ 0 to 9 barg ]<br>Burst: 435.1 psig [ 30 barg ] |
| **Leak Tightness** | 1 x $10^8$ mBar l/s He |
| **Differential Pressure** | Min: 7.3 to 43.5 psig [ 0.5 to 3 barg ]<br>Max: 101.5 psig [ 7 barg ] |
| **Gas Compatibility** | Non-aggressive Gases |
| **Analog Input** | 0–5 VDC or 4–20 mA |
| **Analog Output** | 0–5 VDC or 4–20 mA |
| **Wetted Materials** | Aluminum<br>Silicon<br>Silicon Nitride<br>Gold<br>Platinum<br>Silicone Die-attach<br>Epoxy<br>Stainless Steel<br>Brass<br>FKM |
| **Fittings** | Stainless Steel<br>9/16-18 SAE<br>1/4” or 3/8” Tube Fitting with O-Ring Seal |

### ELECTRICAL INFORMATION

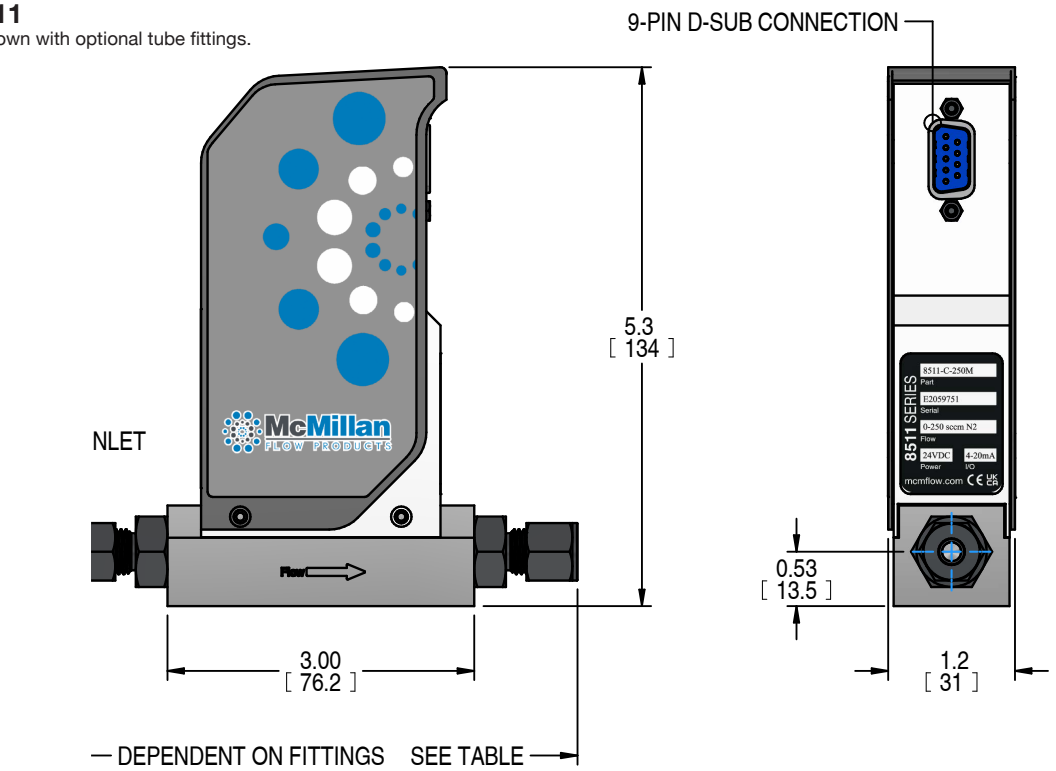
| RHODIUM Series | |
|---|---|
| **Voltage Supply DC** | Nominal = 24 V ± 10%<br>Ripple = < 50 mV |
| **Current Supply DC** | Typical = < 200 mA<br>Maximum = < 250 mA |
| **Warm-Up Time** | Deviation < ± 0.1% of full scale: 3 sec<br>Optimum Accuracy: 15 min |
| **Analog Output** | Resistive Load: > 2 Kohms<br>Capacitive Load: < 100 nF |

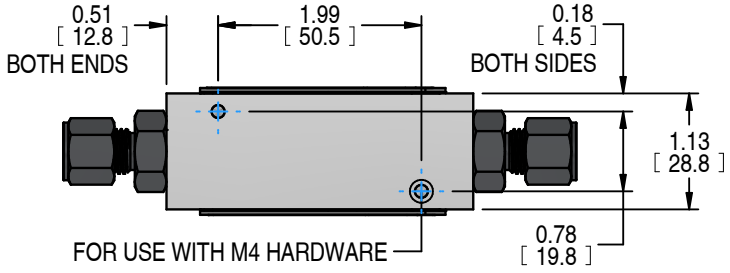
# 1.7 DIMENSIONS

Basic unit configurations are shown. Contact factory or an authorized representative for dimensions of units not shown.
All dimensions shown in inches [ mm ] unless otherwise noted.

## MODEL 8511

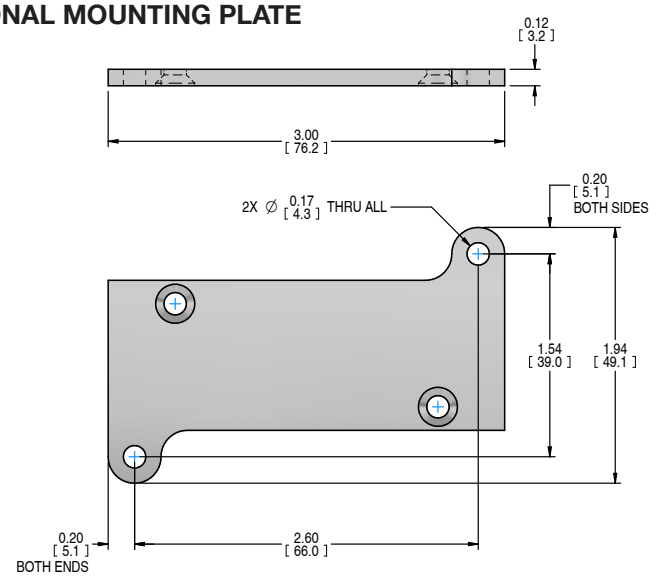
Standard unit shown with optional tube fittings.

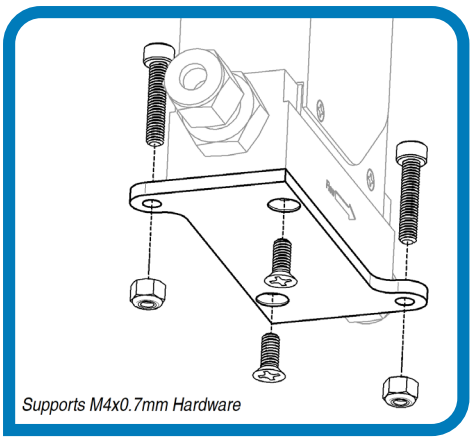



| FITTING | X |
|---|---|
| 1/4” | 4.36 |
| 3/8” | 4.48 |

## OPTIONAL MOUNTING PLATE



# 2 INSTALLATION

## 2.1 CHECK OPERATING CONDITIONS

Check to insure that the applications operating conditions are within the products specifications:

- Flow Rate
- Maximum Operating Pressure
- Maximum Operating Temperature

In general, the RHODIUM is subjected to the same loads as the piping into which it is installed. The RHODIUM should therefore be kept away from extreme loads, such as pressure surges with strong, dynamic pipe movements, vibrations in the proximity of centrifugal pumps, high temperature media, flooding etc. Avoid areas with strong magnetic fields, strong air flows or excessive vibration to allow for the most accurate results.

RHODIUM flow controllers are not designed to sense liquid flow and damage will result if liquid is passed through the sensor. The sensor is not suited for measuring aggressive or corrosive gases. Use only noncorrosive, dry, clean gases. Gas loaded with particles can contaminate the sensor.

It is recommended to install a safety shut-off valve upstream (before the inlet) of the controller.


**FAILURE TO COMPLY WITH ALL INSTRUCTIONS OUTLINED IN THIS MANUAL COULD RESULT IN PRODUCT DAMAGE AND/OR THE PRODUCT NOT FUNCTIONING AS INTENDED. DAMAGE CAUSED BY IMPROPER INSTALLATION OR HANDLING WILL NOT BE REPAIRED UNDER WARRANTY.**

## 2.2 MOUNTING THE FLOW CONTROLLER

The Model 8511 flow controller is designed with (2) M4 X 0.7mm mounting holes located on the underside of the base (Dimensions located on page 7). An optional mounting plate (Part Number 8511-MP) allows for the mounting hardware to be easily accessed from the top of the device. The plate may be ordered with the unit to allow for additional mounting configurations. It is recommended that the device be secured with mounting hardware, even if it is being installed into fixed plumbing.

**CAUTION: THE MODEL 8511 FLOW CONTROLLER SHOULD BE MOUNTED *VERTICALLY* AS THIS IS HOW THEY ARE CALIBRATED. ALL OTHER POSITIONS COULD CAUSE THE FLOW ACCURACY TO BE AFFECTED.**

## 2.3 TUBING CONNECTION INFORMATION

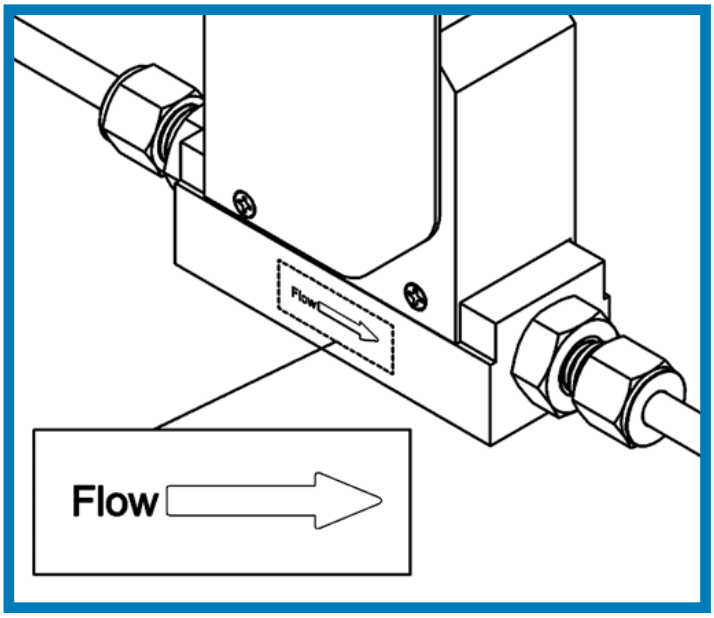



*Figure B3.1*

- All tubing used must be clean, dry, and purged with clean dry air before installation.

- For best results, match tubing I.D. to fittings and/or use largest possible I.D. to avoid increased pressure drop.

- Straight runs of 10x diameter on the inlet side and 5x diameter on the outlet side are recommended.

- The flow direction for this device is clearly marked on the flow body (see Figure B3.1). Do not reverse the flow direction or the device will not function as intended.

- If the gas being used may contain particles, an external inlet filter (20 micron) should be installed upstream (before) the unit.

- When connecting the device to any plumbing, take care not to over-tighten the fittings or leaking may occur. A backup wrench should be used to prevent the fitting from rotating whenever connections are adjusted (see figure B3.2).

- If new or different fittings are required, please contact the McMillan Flow Products service department for assistance.

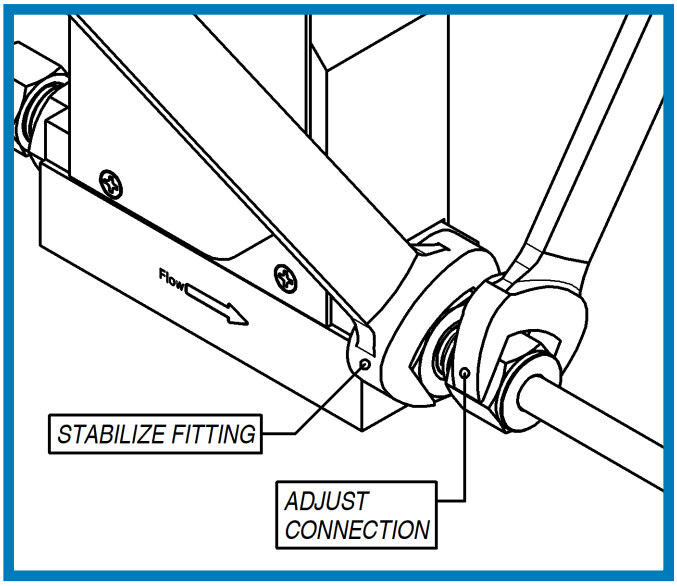



*Figure B3.2*

**<u>CAUTION:</u> ONLY USE THE FITTINGS INSTALLED BY MCMILLAN FLOW PRODUCTS WITH THE UNIT. IF THE FITTINGS ARE REMOVED, THE CALIBRATION OF THE UNIT MAY BE AFFECTED, AND LEAKING MAY OCCUR.**

## 2.4 ELECTRICAL CONNECTIONS

**CAUTION: INCORRECT WIRING MAY CAUSE SEVERE DAMAGE TO THE DEVICE. REVIEW ALL DIAGRAMS AND READ ALL INSTRUCTIONS CAREFULLY BEFORE MAKING ANY CONNECTIONS.**

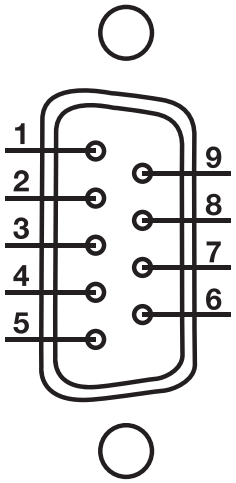
*

### CONNECTION OPTIONS

- 6ft D-Sub connector cable with pigtail leads
- 9-pin D-Sub adapter
- 6ft D-Sub connector extension cable
- 24V Power supply kit

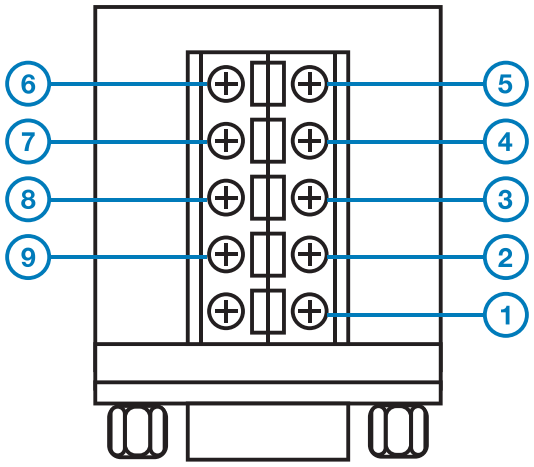
### MAIN CONNECTOR LAYOUT

A 9-Pin D-Sub male connection port is located on the back of the device




| PIN ASSIGNMENT | |
|---|---|
| 1 | +24 V Input Power |
| 2 | - Power Ground |
| 3 | Factory Use Only |
| 4 | Factory Use Only |
| 5 | Not Used |
| 6 | Analog Ground - |
| 7 | Analog Output |
| 8 | Analog Input |
| 9 | Valve Override |

### OPTIONAL D-SUB ADAPTER TERMINAL BOARD

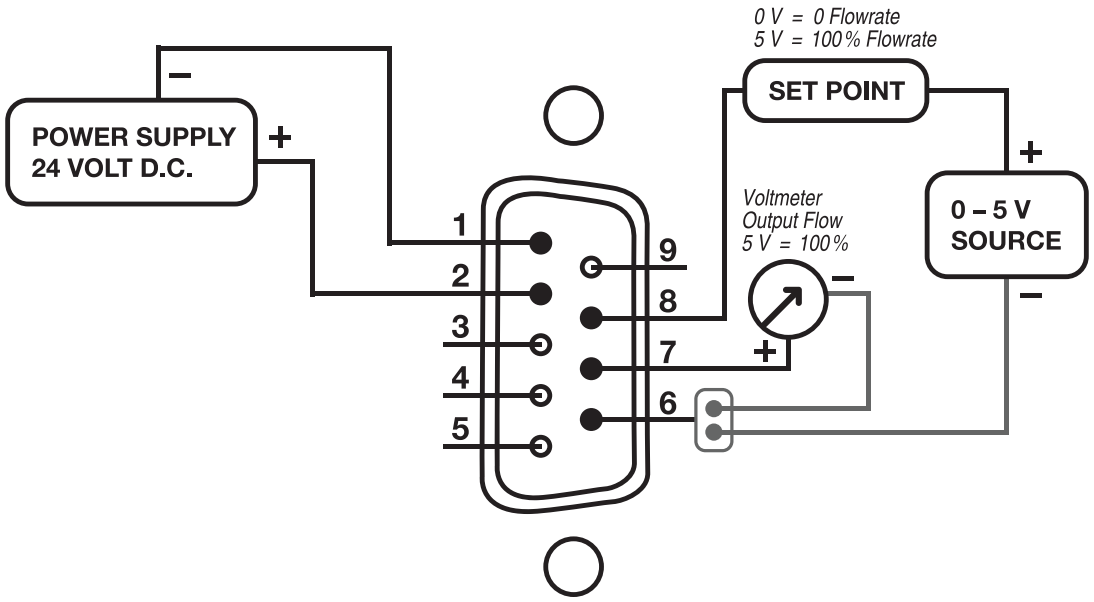



| PIN ASSIGNMENT | |
|---|---|
| 1 | +24 V Input Power |
| 2 | - Power Ground |
| 3 | Factory Use Only |
| 4 | Factory Use Only |
| 5 | Not Used |
| 6 | Analog Ground - |
| 7 | Analog Output |
| 8 | Analog Input |
| 9 | Valve Override |

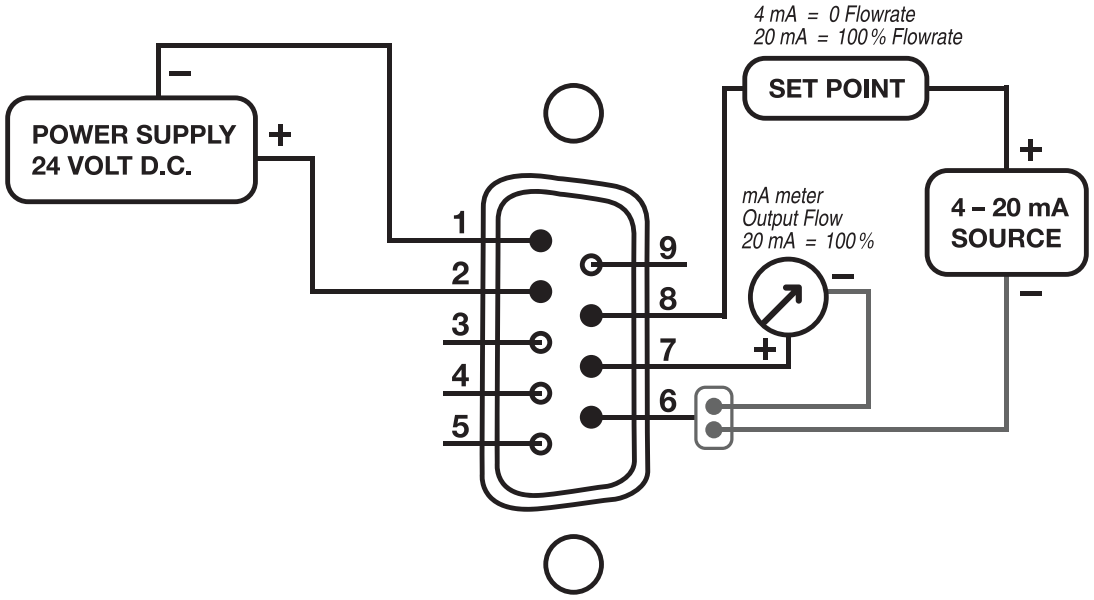
## 2.5 WIRING DIAGRAM EXAMPLES

Basic unit configurations are shown. Contact factory or an authorized representative for dimensions of units not shown.
All dimensions shown in inches [ mm ] unless otherwise noted.

### ANALOG 0-5 VDC




### ANALOG 4-20 mA



# 3 OPERATION

## 3.1 SAFETY WARNINGS

**CAUTION: THESE SENSORS EMPLOY A HEATED ELEMENT. THE HEATED ELEMENT IS ABOVE THE AMBIENT TEMPERATURE AND THE UNIT MUST *NOT* BE USED WITH FLAMMABLE OR EXPLOSIVE GASES OR MIXTURES.**

Unprofessional handling can cause injury or death. The use of mass flow controllers should only be performed by qualified personnel.

Do not use this product as a safety or emergency stop device or in any other application where failure of the product could result in personal injury or death.

For use of the device with gases that might be explosive in case of mixture with oxygen, and for use of the device with oxygen, special guidelines apply.

## 3.2 START UP

Before applying power to the unit, check all tubing and electrical connections. Once correct installation is verified, switch on the power. The unit should then be allowed to warm up for a minimum of 5 minutes before gas pressure is applied.

## 3.3 VERIFICATION OF ZERO

Flow through the unit should be stopped by sealing or capping the inlet of the flow controller.

**CAUTION: IT IS NOT ADEQUATE TO ONLY STOP FLOW BY TURNING OFF THE GAS SUPPLY OR CLOSING A VALVE AS THERE MAY BE A LEAK IN THE SYSTEM. THIS COULD GIVE A FALSE OUTPUT READING.**

After 5 minutes, the output should be stable at zero volts when there is no flow through the unit. If after 10-15 minutes the output is still not at zero volts, check first for leaks and correct wiring or contact our Service Department.

## 3.4 FLOW READINGS

Each RHODIUM Series flow controller is calibrated for a specific flow range and gas. These are shown on the unit's label as well as on the calibration certificate shipped with the controller from the factory.

By monitoring the voltage output signal, it is possible to determine the flow rate of the gas. Units are configured so that an output signal of 5.00 VDC or 20 mA is provided when maximum (full scale) flow is passing through the unit. The output signal is linear and scaled to enable calculation of flow rates within the unit's range.

## 3.5 FLOW CALCULATIONS

Use the following formulas to back-calculate your flow rate:

**0-5VDC**

( Full Scale ÷ 5 ) × Output Voltage = Current Flow Rate

**4-20 mA**

( Output mA 4 ) ÷ 16 × Full Scale = Current Flow Rate

**FLOW CALCUALTION EXAMPLES**

**0-5 VDC OUTPUT:**

| | |
|---|---|
| Full Scale Flow Rate: | 1000 sccm |
| Full Scale Output Signal | 5 VDC |
| Actual Output Signal | 3.5 VDC |
| Calculation | ( 1000 ÷ 5 ) × 3.5 = 700 sccm |

**4-20 mA OUTPUT:**

| | |
|---|---|
| Full Scale Flow Rate | 1000 sccm |
| Full Scale Output Signal | 20.0 mA |
| Actual Output Signal | 10.5 mA |
| Calculation | ( 10.5 4 ) ÷ 16 × 1000 = 406.25 sccm |

## 3.6 CHANGING THE FLOW RATE INPUT

The required flow rate is selected by adjusting your external input voltage or mA supply.

The normal control signal voltage is 0-5 VDC with 0 VDC corresponding to zero flow and 5 VDC indicating the maximum rated flow.

Units calibrated for 4-20 mA are setup similarly with 4 mA as zero flow and 20 mA as the maximum rated flow.

The input is linear and scaled allowing for different flow rates within the range of the device being utilized.

You can use the following formulas to calculate the input needed to reach a desired flow rate:

**0-5VDC**

( Desired Flow Rate ÷ Full Scale ) × 5 = Input Voltage Needed

**4-20 mA**

( Desired Flow Rate ÷ Full Scale ) × 16 + 4 = Input mA Needed

**INPUT CALCUALTION EXAMPLES**

**0-5 VDC OUTPUT:**

| | |
|---|---|
| Full Scale Flow Rate | 1000 sccm |
| Full Scale Output Signal | 5 VDC |
| Actual Output Signal | 400 sccm |
| Calculation | ( 400 ÷ 1000 ) × 5 = 2.0 VDC |

**4-20 mA OUTPUT:**

| | |
|---|---|
| Full Scale Flow Rate | 1000 sccm |
| Full Scale Output Signal | 20.0 mA |
| Actual Output Signal | 400 sccm |
| Calculation | ( 400 ÷ 1000 ) × 16 + 4 = 10.4 mA |

## 3.7 CONSIDERATIONS FOR ACTUAL VS. STANDARD CONDITIONS

The Model 8511 gas flow controller specifies its mass flow measurement in terms of volumetric flow at standard (STP) conditions.

Actual volumetric flow at actual (nonstandard) conditions can prove to contrast standard units being displayed if said conditions (pressure and temperature) are different than the standards the device was calibrated at.

Assuming that flow is being held constant over a known temperature and pressure, the following calculation can be made to solve for actual (nonstandard) flow from a standard volumetric flow rate.

**CALCULATION TO SOLVE FOR ACTUAL FLOW:**

**STANDARD (STP) CONDITIONS:**

$P_S$ = STP Pressure = 1 atm (1013.25 hPa)

$T_S$ = STP Temperature = 0 °C (273.15 K)

**VARIABLES:**

$\dot{V}_S$ = Volumetric Flow at Standard (STP) Conditions

$\dot{V}_X$ = Volumetric Flow at Actual Conditions

$P_X$ = Actual Pressure

$T_X$ = Actual Temperature

**FORMULA TO SOLVE FOR $\dot{V}_X$:**

$$\dot{V}_X = \dot{V}_S \cdot \frac{P_S}{P_X} \cdot \frac{T_X}{T_S}$$


**IT IS IMPORTANT TO NOTE THAT PRESSURE AND TEMPERATURE NEED TO BE CONVERTED TO REPRESENT ABSOLUTE UNITS**

***(hPa AND K IN THE EXAMPLE ABOVE)***

## 3.8 VOLUMETRIC FLOW AT ACTUAL CONDITIONS EXAMPLE

Let's examine the following situation. John is using his device at a higher altitude under colder temperatures. The device shows a volumetric flow rate of 70 sccm, but John can see that the application is using more gas than that.

Let's use the formula below to calculate the actual volumetric flow at John's actual conditions. John is in Denver, Colorado. His device is operating at 12.09 PSI and 25.16 °F. Converting to absolute units (hPa and K in this example) we are left with the following:

**EXAMPLE CALCULATION:**

**STANDARD (STP) CONDITIONS:**

$P_s$ = STP Pressure = 1 atm (1013.25 hPa)

$T_s$ = STP Temperature = 0 °C (273.15 K)

**VARIABLES:**

| | |
|---|---|
| $\dot{V}_s$ = Volumetric Flow at Standard (STP) Conditions | 70 sccm |
| $\dot{V}_x$ = Volumetric Flow at Actual Conditions | ??? $c^3/m$ |
| $P_x$ = Actual Pressure | 833.57 hPa |
| $T_x$ = Actual Temperature | 269.26 K |

**SOLVE FOR $\dot{V}_x$:**

$$\dot{V}_x = 70 \cdot \frac{1013.25}{833.57} \cdot \frac{269.26}{273.15}$$

$$\dot{V}_x = \mathbf{83.93\ c^3/m}$$

## 3.9 CONSIDERATIONS FOR MEASURING DIFFERENT GASES

MEMS thermal flow technologies depend on gas properties that make it difficult to use on gases that the device was not calibrated for.

Standard gas correction factors will not correlate, and more complex correction functions must be formulated. When considering using a gas outside of the calibrated medium, please contact McMillan Flow Products for more information.

# 4 MAINTENANCE

## 4.1 GENERAL PRODUCT CARE

**CAUTION: DO NOT DISASSEMBLE YOUR DEVICE AND/OR REMOVE THE ELECTRONICS COVER FOR ANY REASON. IF YOUR DEVICE APPEARS TO BE MALFUNCTIONING, PLEASE CONTACT THE MCMILLAN SERVICE DEPARTMENT.**

The RHODIUM Series flow controller requires no maintenance if operated properly and used within the recommended guidelines in this manual.

Inlet filters should be periodically checked and cleaned / replaced as necessary.

Regularly check all electrical and process connections for damage or deterioration. Work on the electronics can only be performed by the factory, or the warranty is otherwise voided.

## 4.2 RETURNING DEVICES FOR REPAIR / RECALIBRATION

To return a unit for repair or recalibration please contact the McMillan Service Department or follow the procedure detailed on the McMillan web site. A Return to Manufacturer Authorization (RMA) number will then be issued to enable the unit to be returned.

Please note that no returns will be accepted unless the RMA number is clearly indicated on the outside of all packages.

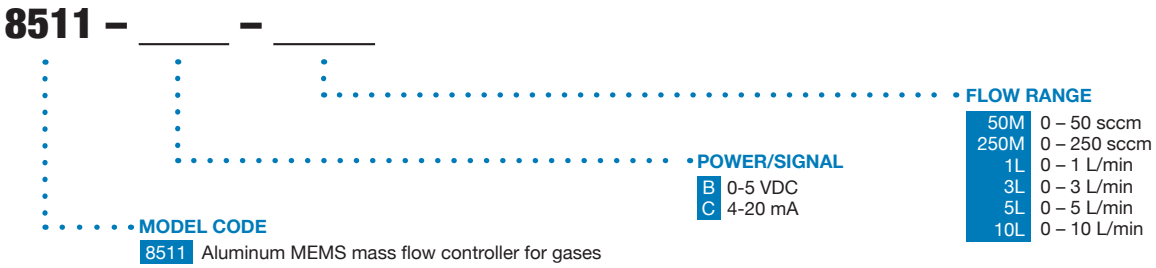
Once the unit has been received it will be evaluated and the cost of any repairs / recalibration determined. Once agreement has been received to pay for all the necessary work the unit will be processed and returned.
No charges will be made for Warranty Repairs (see section 6).

# 5 PART NUMBERS & ACCESSORIES

## 5.1 RHODIUM PART NUMBERS

**FORM PART NUMBER AS FOLLOWS:**

(Model) - (Power/Signal) - (Flow Range)




**EXAMPLES:**

8511-B-1L would provide an aluminum-bodied mass flow controller configured for analog 0-5 VDC input and output signals, requires 24 VDC power, and would measure and control from 0 – 1 L/min of Nitrogen ($N_2$).

8511-C-50M would provide an aluminum-bodied mass flow controller configured for analog 4-20 mA input and output signals, requires 24 VDC power, and would measure and control from 0 – 50 sccm of Nitrogen ($N_2$).

## 5.2 ACCESSORIES

| CODE | DESCRIPTION |
|---|---|
| 8511-MP | Mounting plate for 8511 |
| 9941-1-2M | Mating cable, 9-pin female D-SUB terminated with pigtail leads, 6.6 ft [ 2m ] |
| 9941-3 | Mating termination block, 9-pin female D-SUB terminal block & power receptacle for 24V |
| 9941-2-2M | Extension cable for 8511, 9-pin female D-SUB to male D-SUB, 6.6 ft [ 2m ] |
| 9691-4 | Universal 120/240 VAC power adapter - also requires 9941-3 |
| 9853-9-T4 | 316L SS 1/4” tube fittings with SAE 9/16-18 threads for 8511 (pair) |
| 9853-9-T6 | 316L SS 3/8” tube fittings with SAE 9/16-18 threads for 8511 (pair) |

# 6 LIMITED WARRANTY

**LIMITED WARRANTY**

To register your product and find detailed information about McMillan's one year standard warranty, please visit our website. Below you will find a QR code that will lead you directly to the warranty registration.

**www.mcmflow.com/customer-service/warranty-registration/**

# 7 CONTACTING MCMILLAN


| | |
|---|---|
| **EMAIL** | sales@mcmflow.com |
| **WEBSITE** | www.mcmflow.com |
| **MAILING ADDRESS** | McMillan Flow Products<br>P.O. Box 1340<br>Georgetown, Texas 78627 (U.S.A.) |
| **SHIPPING ADDRESS** | McMillan Flow Products<br>7075 RR 2338<br>Georgetown, TX 78633 (U.S.A.) |
| **TOLL-FREE** | (800) 861-0231 (U.S.A. only) |
| **DIRECT** | +1 (512) 863-0231 |


McMillan FLOW PRODUCTS

**www.mcmflow.com**

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