ALICAT SCIENTIFIC

Operating Manual

MC Series

MCR Series

MCS Series

MCV Series

Precision Gas Mass Flow Controllers

Innovative Flow and Pressure Solutions

CE NIST

Note: Although we provide assistance on Alicat Scientific products both personally and through our literature, it is the complete responsibility of the user to determine the suitability of any product to their application.

Alicat Scientific, Inc.'s Wide-Range Laminar Flow Element Patent: The wide-range laminar flow element and products using the wide-range laminar flow element are covered by U.S. Patent Number: 5,511,416. Manufacture or use of the wide-range laminar flow element in products other than Alicat Scientific products or other products licensed under said patent will be deemed an infringement.

Limited Lifetime Warranty

Alicat Scientific, Inc. warrants to the original purchaser (hereinafter referred to as "Buyer") that instruments manufactured by Alicat Scientific (hereinafter referred to as "Product") shall be free from defects in materials and workmanship for the life of the Products.

Under this warranty, the Product will be repaired or replaced at manufacturer's option, without charge for parts or labor when the Product is carried or shipped prepaid to the factory together with proof of purchase.

The foregoing shall constitute the exclusive and sole remedy in lieu of other remedies of the Buyer for any breach by Alicat Scientific of this warranty to the maximum extent permitted by law.

This warranty does not apply to any Product which has not been installed or used in accordance with the Product operation and installation specifications provided to Buyer verbally or in writing by Alicat Scientific for the proper and normal use of the Product.

Buyer agrees hereunder that Alicat reserves the right to void any warranty, written or implied, if upon Alicat's examination of Product shall disclose to Alicat's satisfaction that the Product failure was due solely, or in part, to accident, misuse, neglect, abuse, alteration, improper installation, unauthorized repair or improper testing by Buyer or agent of Buyer.

Alicat Scientific 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 Products covered by this warranty.

Alicat Scientific does not recommend, warrant or assume responsibility for the use of the Products in life support applications or systems.

Alicat's warranties as herein above set forth shall not be enlarged, diminished or affected by, and no obligation or liability shall arise or grow out of Alicat's rendering of technical advice in connection with Buyer's order of the Products furnished hereunder.

If Product becomes obsolete, Alicat Scientific, at its own discretion, reserves the right to repair the Product with available replacement parts or upgrade the Product to a current, commercially available version of the original Product. Should upgrading the Product be deemed necessary by Alicat, Buyer hereby agrees to pay an upgrade fee equal to seventy percent of the retail value of the replacement Product. Alicat Scientific hereunder makes no claim that replacement Products will look, function or operate in the same or similar manner as the original product.

When a Product is returned to Alicat Scientific for recalibration this service is considered normal preventative maintenance. Recalibration of Product shall not be treated as a warranty service unless recalibration of Product is required as the result of repairs to Product pursuant to this Warranty. **Failure to recalibrate Product on a yearly basis will remove any and all obligations regarding repair or replacement of Product as outlined by this Warranty to Buyer from Alicat Scientific.**

This Warranty is in lieu of all other relevant warranties, expressed or implied, including the implied warranty of merchantability and the implied warranty of fitness for a particular purpose, and any warranty against infringement of any patent.

Continued use or possession of Products after expiration of the applicable warranty period stated above shall be conclusive evidence that the warranty is fulfilled to the full satisfaction of Buyer.

Alicat makes no warranty as to experimental, non-standard or developmental Products.

Accessories purchased from Alicat are not covered by this warranty.

Conformity / Supplemental Information:

The product complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC (including 93/68/EEC) and carries the CE Marking accordingly. Contact the manufacturer for more information.

Thank you for purchasing an Alicat Gas Flow Controller.

Please take the time to read the information contained in this manual. This will help to ensure that you get the best possible service from your instrument. This manual covers the following Alicat Scientific instruments:

MC Series Mass Gas Flow Controllers

MCR Series Mass Gas Flow Controllers

This includes MC and MCR Series devices labeled as approved for CSA Class 1 Div 2 and ATEX Class 1 Zone 2 hazardous environments. See pages 82 and 83 for Special Conditions regarding the use of CSA/ATEX labeled devices.

MCS Series Mass Gas Flow Controllers

MCRS Series Mass Gas Flow Controllers

MCS and MCRS Series Flow Controllers are for use with certain aggressive gases (see page 55)

MCQ Series Mass Gas Flow Controllers

MCRQ Series Mass Gas Flow Controllers

MCQ and MCRQ Series Flow Controllers are for use with certain high pressure applications (see page 61)

MCV Series Mass Gas Flow Controllers

MCV Series Flow Controllers have an integrated shut-off valve and are built for use with applications that require tight shut-off (see pages 26 and 52).

MCP Series Mass Gas Flow Controllers

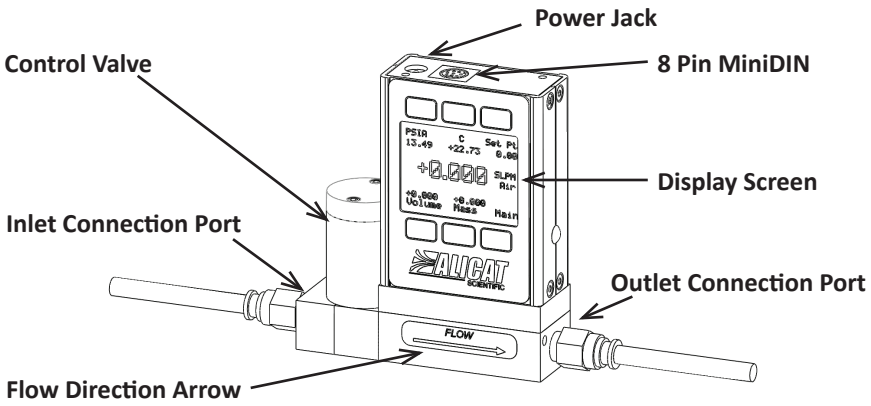
MCP Series Flow Controllers are built with a high performance control valve for use with certain lower pressure applications (see page 53)

Unless otherwise noted, the instructions in this manual are applicable to all of the above instruments.

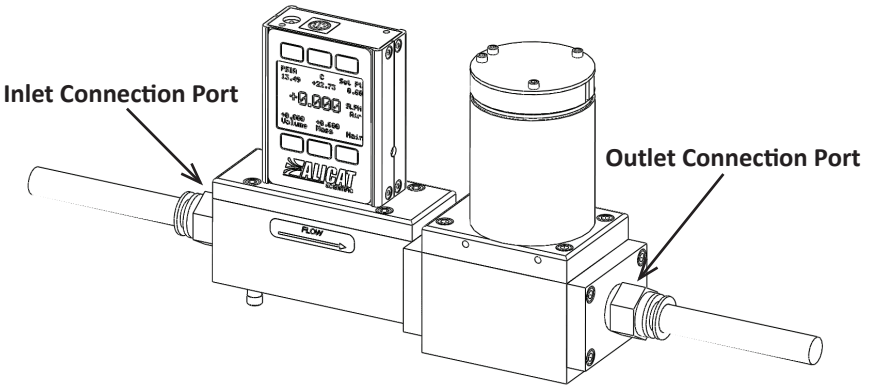
Full specifications for each device can be found on pages 44 through 61.

Please contact Alicat at 1-888-290-6060 or info@alicat.com if you have any questions regarding the use or operation of this device.

GETTING STARTED



Small Valve Mass Flow Controller shown with an upstream valve configuration and connection port fittings



Large Valve Mass Flow Controller shown with a downstream valve configuration and connection port fittings

MOUNTING

MC Series Gas Flow Controllers have holes on the bottom for mounting to flat panels. See pages 48-51.

Small valve controllers (MC Series) can usually be mounted in any position.

Large valve controllers (MCR Series) should be mounted so that the valve cylinder is vertical and upright. Mounting a large valve controller in another position increases the risk of leakage when the controller is being held closed by the spring force.

PLUMBING

Your controller is shipped with plastic plugs fitted in the port openings. To lessen the chance of contaminating the flow stream do not remove these plugs until you are ready to install the device.

Make sure that the gas will flow in the direction indicated by the flow arrow.

Standard MC Series Gas Flow Controllers have female inlet and outlet port connections. Welded VCR and other specialty fittings may have male ports.

The inlet and outlet port sizes (process connections) for different flow ranges are shown on pages 44-51.

Controllers with M5 (10-32) ports have O-ring face seals and require no sealant or tape. Do not use tape with welded or o-ring fittings.

For non M5 (10-32) ports use thread sealing Teflon® tape to prevent leakage around the port threads.
Do not wrap the first two threads. This will minimize the possibility of getting tape into the flow stream and flow body.

Do not use pipe dopes or sealants on the process connections as these compounds can cause permanent damage to the controller should they get into the flow stream.

When changing fittings, carefully clean any tape or debris from the port threads.

We recommend that a 20 micron filter be installed upstream of controllers with full scale ranges of 1(S)LPM or less and a 40 micron filter be installed upstream of controllers with full scale ranges above 1(S)LPM.

No straight runs of pipe are required upstream or downstream of the controller.

PRESSURE

Maximum operating line pressure is 145 PSIG (1 MPa).
NOTE: MC-100SLPM controllers have a maximum operating line pressure of 130 PSIG.

If the line pressure is higher than 145 PSIG (1 MPa), use a pressure regulator upstream from the flow controller to reduce the pressure to 145 PSIG (1 MPa) or less.

NOTE: Alicat **MCQ** and **MCRQ** Series controllers are built for certain high pressure applications and have a maximum line pressure of 320 PSIA (see page 60).

Many Alicat controllers are built for specific applications. Two controllers with the same flow range and part number may look and act quite differently depending upon the application the controller was built for. Care should be taken when moving a controller from one application to another.

CAUTION! ***EXCEEDING THE MAXIMUM SPECIFIED LINE PRESSURE MAY CAUSE PERMANENT DAMAGE TO THE SOLID-STATE DIFFERENTIAL PRESSURE TRANSDUCER.***

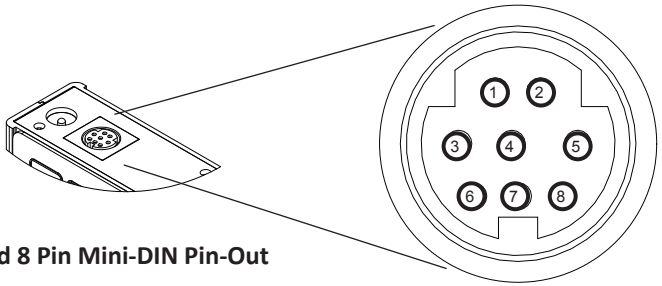
POWER AND SIGNAL CONNECTIONS

Power can be supplied to your controller through either the power jack (power jack not available on CSA/ATEX approved devices) or the 8 pin Mini-DIN connector.

An AC to DC adapter which converts line AC power to DC voltage and current as specified below is required to use the power jack.

Small Valve controllers require a 12-30Vdc power supply with a 2.1 mm female positive center plug capable of supplying 250 mA. **NOTE:** 4-20mA analog output requires at least 15 Vdc.

Large Valve controllers require a 24-30 Vdc power supply with a 2.1 mm female positive center plug capable of supplying at least 750mA.



Standard 8 Pin Mini-DIN Pin-Out

Pin	Function	Mini-DIN cable color
1	Inactive or 4-20mA Primary Output Signal	Black
2	Static 5.12 Vdc or Secondary Analog Output (4-20mA, 5Vdc, 10Vdc) or Basic Alarm	Brown
3	RS-232 Input Signal	Red
4	Analog Input Signal	Orange
5	RS-232 Output Signal	Yellow
6	0-5 Vdc (or 0-10 Vdc) Output Signal	Green
7	Power In (as described above)	Blue
8	Ground (common for power, communications and signals)	Purple

Note: The above pin-out is applicable to all the flow meters and controllers with the Mini-DIN connector. The availability of different output signals depends on the options ordered. **Underlined Items** in the above table are optional configurations that are noted on the unit's calibration sheet.

CAUTION! ***DO NOT CONNECT POWER TO PINS 1 THROUGH 6 AS PERMANENT DAMAGE CAN OCCUR!***

It is common to mistake Pin 2 (labeled 5.12 Vdc Output) as the standard 0-5 Vdc analog output signal. In fact Pin 2 is normally a constant 5.12 Vdc that reflects the system bus voltage and can be used as a source for the set-point signal.

For 6 Pin Locking Industrial Connector, DB9, DB15 and PROFIBUS Pin-outs see pages 73 to 81.

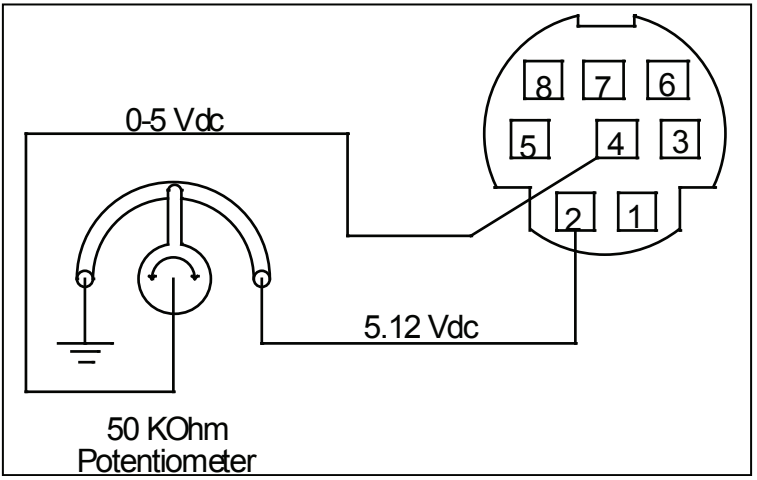
INPUT SIGNALS

Analog Input Signal

Apply analog input to Pin 4 as shown on page 8.

For 6 Pin Locking Connector, DB9, DB15 and PROFIBUS Pin-outs see pages 73 to 81.

Standard 0-5 Vdc is the standard analog input signal. Apply the 0-5 Vdc input signal to pin 4, with common ground on pin 8. The 5.12 Vdc output on pin 2 can be wired through a 50K ohm potentiometer and back to the analog input on pin 4 to create an adjustable 0-5 Vdc input signal source as shown below.



Simple method for providing set-point to controllers

Optional 0-10 Vdc: If specified at time of order, a 0-10 Vdc input signal can be applied to pin 4, with common ground on pin 8.

Optional 4-20 mA: If specified at time of order, a 4-20 mA input signal can be applied to pin 4, with common ground on pin 8.

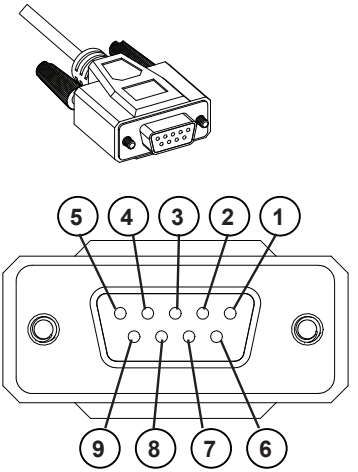
NOTE: This is a current sinking device. The receiving circuit is essentially a 250 ohm resistor to ground.

NOTE: 4-20mA output requires at least 15 Vdc power input.

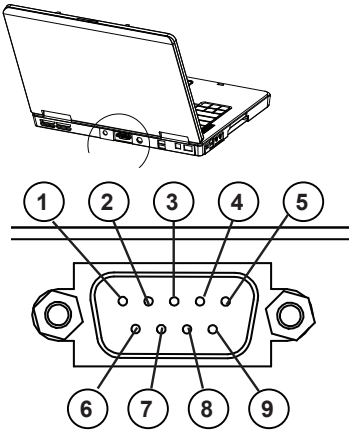
CAUTION! ***DO NOT CONNECT THIS DEVICE TO "LOOP POWERED" SYSTEMS, AS THIS WILL DESTROY PORTIONS OF THE CIRCUITRY AND VOID THE WARRANTY. IF YOU MUST INTERFACE WITH EXISTING LOOP POWERED SYSTEMS, ALWAYS USE A SIGNAL ISOLATOR AND A SEPARATE POWER SUPPLY.***

RS-232 / RS-485 Digital Input Signal

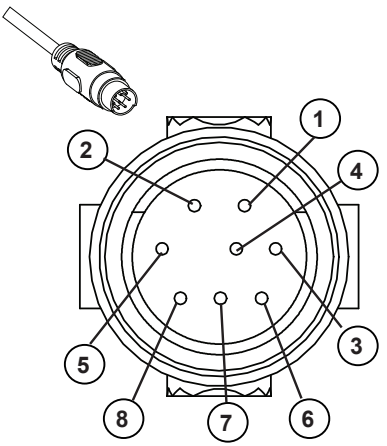
To use the RS-232 or RS-485 input signal, connect the RS-232 / RS-485 Output Signal (Pin 5), the RS-232 / RS-485 Input Signal (Pin 3), and Ground (Pin 8) to your computer serial port as shown below. (See page 27 for details on accessing RS-232 / RS-485 input.)



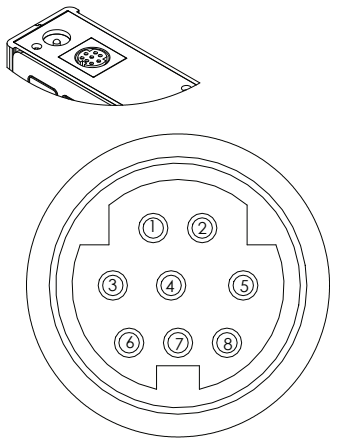
Serial Cable End



PC Serial Port



8 Pin MiniDIN Cable End



8 Pin MiniDIN Connector

9 Pin Serial Connection		8 Pin MiniDIN Connection	
Pin	Function	Function	Pin
5	Ground	Ground	8
3	Transmit	Receive	3
2	Receive	Transmit	5

DB9 to Mini-DIN Connection for RS-232 / RS-485 Signals

OUTPUT SIGNALS

RS-232 / RS-485 Digital Output Signal

To use the RS-232 or RS-485 output signal, it is necessary to connect the RS-232 / RS-485 Output Signal (Pin 5), the RS-232 / RS-485 Input Signal (Pin 3), and Ground (Pin 8) to your computer serial port as shown on page 8. (See page 27 for details on accessing RS-232 / RS-485 output.)

Standard Voltage (0-5 Vdc) Output Signal

MC Series flow controllers equipped with a 0-5 Vdc (optional 0-10 Vdc) will have this output signal available on Pin 6. This output is generally available in addition to other optionally ordered outputs. This voltage is usually in the range of 0.010 Vdc for zero flow and 5.0 Vdc for full-scale flow. The output voltage is linear over the entire range. Ground for this signal is common on Pin 8.

Optional 0-10 Vdc Output Signal

If your controller was ordered with a 0-10 Vdc output signal, it will be available on Pin 6. (See the Calibration Data Sheet that shipped with your controller to determine which output signals were ordered.) This voltage is usually in the range of 0.010 Vdc for zero flow and 10.0 Vdc for full-scale flow. The output voltage is linear over the entire range. Ground for this signal is common on Pin 8.

Optional Current (4-20 mA) Output Signal

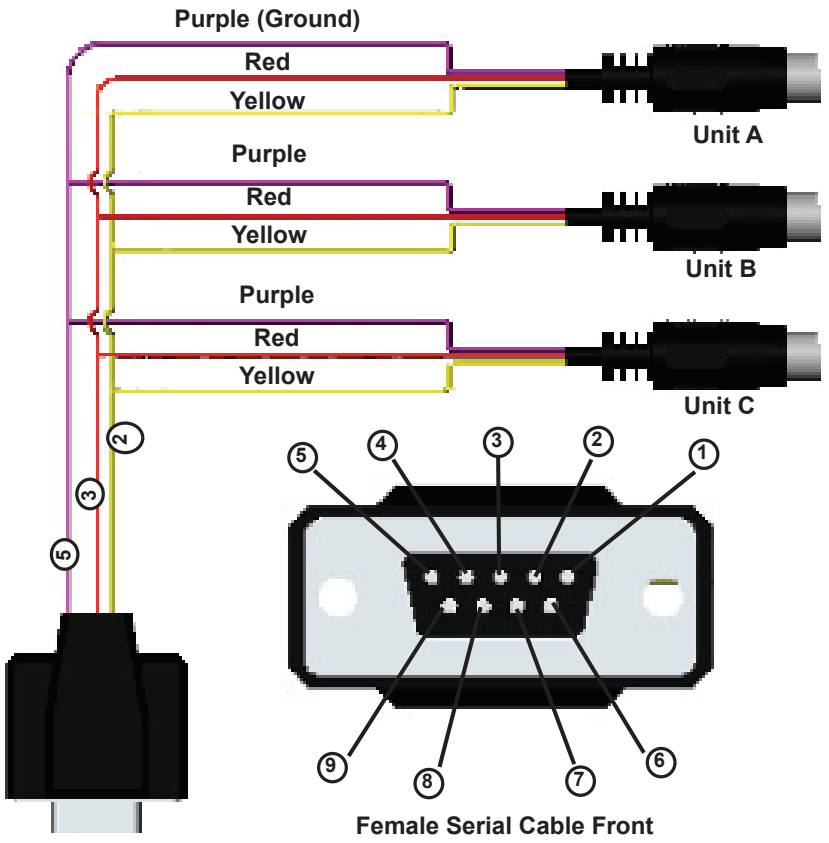
If your controller was ordered with a 4-20 mA current output signal, it will be available on Pin 1. (See the Calibration Data Sheet that shipped with your controller to determine which output signals were ordered.) The current signal is 4 mA at 0 flow and 20 mA at the controller's full scale flow. The output current is linear over the entire range. Ground for this signal is common on Pin 8. (Current output units require 15-30Vdc power.)

Optional 2nd Analog Output Signal

You may specify an optional 2nd analog output on Pin 2 at time of order. (See the Calibration Data Sheet that shipped with your controller to determine which output signals were ordered.) This output may be a 0-5 Vdc, 0-10 Vdc, or 4-20 mA analog signal that can represent any measured parameter. With this optional output, a controller could output the mass flow rate (0-5 Vdc on pin 6) and the absolute pressure (0-5 Vdc on pin 2).

If your device is CSA/ATEX approved or equipped with the optional six pin industrial connector, please contact Alicat.

CAUTION! ***DO NOT CONNECT THIS DEVICE TO "LOOP POWERED" SYSTEMS, AS THIS WILL DESTROY PORTIONS OF THE CIRCUITRY AND VOID THE WARRANTY. IF YOU MUST INTERFACE WITH EXISTING LOOP POWERED SYSTEMS, ALWAYS USE A SIGNAL ISOLATOR AND A SEPARATE POWER SUPPLY.***



Typical Multiple Device (Addressable) Wiring Configuration

The easiest way to connect multiple devices is with a Multi-Drop Box (see page 69).

Information for Alicat TFT (Color Display) Instruments

Alicat TFT (color display) instruments have a high contrast back-lit LCD display. TFT instruments operate in accordance with Alicat standard operating instructions for our monochrome menus and displays with the following differences.

Multi-Color Display Color Codes:

GREEN: Green labels identify the parameters and/or adjustments associated with the button directly above or below the label.

WHITE: The color of each parameter is displayed in white while operating under normal conditions.

RED: The color of a parameter is displayed in red when operating conditions for that parameter exceed 128% of the device's specifications.

YELLOW: Yellow is the equivalent of the selection arrow on the monochrome display.

LCD Contrast:
LCD contrast is ranged from 1 to 11 on color displays with 11 being the greatest contrast.

Display On/Off:
Pushing the button under the Alicat name will turn the device display on or off. This feature is not available on monochrome displays.

Technical Data for TFT (Color Display) Meters, Gauges and Controllers

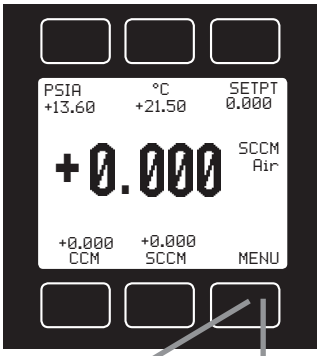
The following specifications are applicable to Alicat **TFT** (color display) meters, gauges and controllers only. All other operating specifications are shown in the Technical Data page for standard Alicat instruments. All standard device features and functions are available and operate in accordance with the Alicat operating manual provided with the device.

Specification	Meter or Gauge	Small Valve Controller	Large Valve Controller
Supply Voltage	7 to 30 Vdc	12 to 30 Vdc	24 to 30 Vdc
Supply Current	80 mA @ 12Vdc 70 mA @ 24Vdc	290 mA @ 12Vdc 200 mA @ 24Vdc	780 mA @ 24Vdc

DISPLAYS AND MENUS

The device screen defaults to **Main** display as soon as power is applied to the controller.

Main

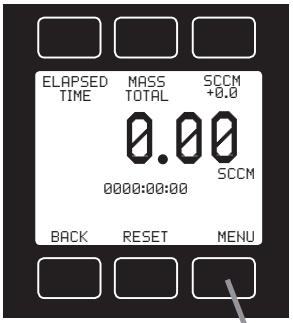


The **Main** display shows pressure, temperature, set-point, volumetric flow and mass flow.

Pressing the button adjacent to a parameter will make that parameter the primary display unit.

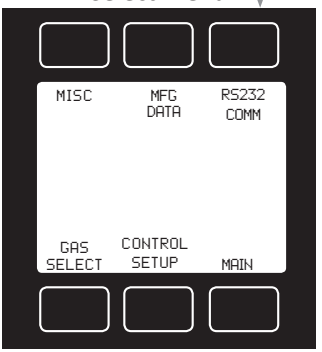
By hitting the **MENU** button at the bottom right of the screen you will enter the **Select Menu** display.

Totalizer (option only)



If your controller was ordered with the **Totalizer** option (page 66), pushing the **MENU** button once will bring up the **Totalizing Mode** display. Pushing **MENU** a second time will bring up the **Select Menu** display.

Select Menu

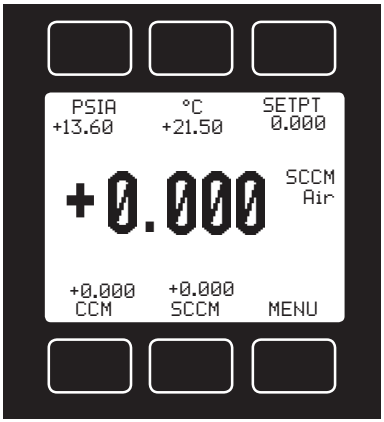


Select Menu

From **Select Menu** you can change the selected gas, interact with your RS-232 / RS-485 settings, read manufacturer's data or access the control set-up display.

Push **MAIN** to return to the Main display.

MAIN



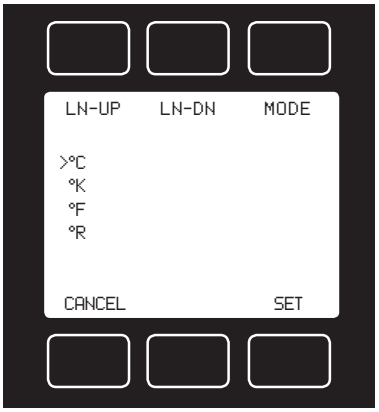
This mode defaults on power up, with mass flow as the primary displayed parameter.

The following parameters are displayed in the Main mode.

Gas Absolute Pressure: This sensor references hard vacuum and reads incoming pressure both above and below local atmospheric pressure. This parameter is moved to the primary display by pushing the button above **PSIA**.

The engineering unit associated with absolute pressure is pounds per square inch absolute (PSIA). This can be converted to gage pressure (PSIG) by subtracting local atmospheric pressure from the absolute pressure reading:

PSIG = PSIA – (Local Atmospheric Pressure)



Gas Temperature: MC Series flow controllers measure the incoming temperature of the gas flow. The temperature is displayed in degrees Celsius (°C). This parameter is moved to the primary display by pushing the button above **°C**.

Pushing the button again allows you to select ºC (Celsius), ºK (Kelvin), ºF (Fahrenheit) or ºR (Rankine) for the temperature scale.

To select a temperature scale, use the LN-UP and LN-DN buttons to position the arrow in front of the desired scale.

Press SET to record your selection and return to the MAIN display. The selected temperature scale will be displayed on the screen.

Set Point: The set-point (**SETPT**)is shown in the upper right of the display.

For information on changing the set-point see SETPT SOURCE, page 18.

Volumetric Flow Rate: This parameter is located in the lower left of the display. It is moved to the primary display by pushing the button below **CCM** in this example. Your display may show a different unit of measure.

Mass Flow Rate: The mass flow rate is the volumetric flow rate corrected to a standard temperature and pressure (typically 14.696 psia and 25°C).

This parameter is located in the lower middle of the display. It can be moved to the primary display by pushing the button below **SCCM** in this example. Your display may show a different unit of measure preceded by the letter **S**.

To get an accurate volumetric or mass flow rate, the gas being measured must be selected. See Gas Select, page 21.

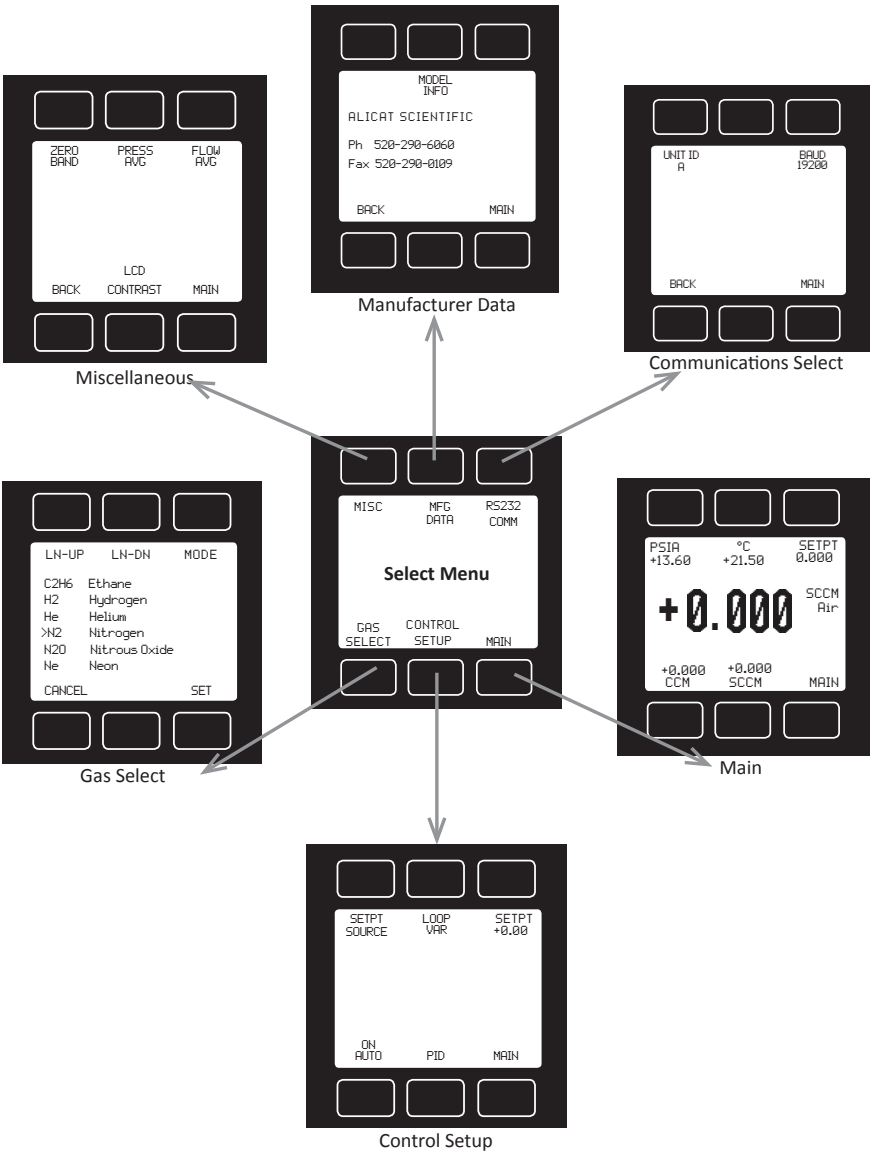
MENU: Pressing **MENU** switches the screen to the **Select Menu** display.

Flashing Error Message: An error message (**MOV** = mass overrange, **VOV** = volumetric overrange, **POV** = pressure overrange, **TOV** = temperature overrange) flashes when a measured parameter exceeds the range of the sensor. When any item flashes, neither the flashing parameter nor the mass flow measurement is accurate. Reducing the value of the flashing parameter to within specified limits will return the unit to normal operation and accuracy. **If the unit does return to normal operation contact Alicat**.

SELECT MENU

From Select Menu you can change the selected gas, interact with your RS-232 / RS-485 settings, read manufacturer's data and access the control setup screen.

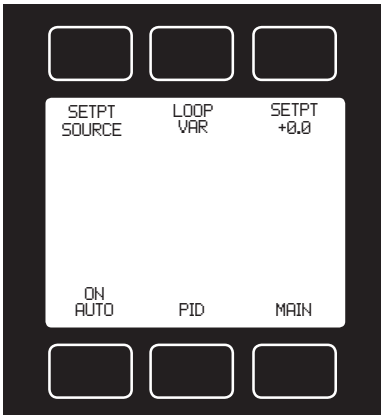
Press the button next to the desired operation to bring that function to the screen.



An explanation for each screen can be found on the following pages.

CONTROL SETUP

Control Setup is accessed by pressing the button below Control Setup on the Select Menu display. From this screen you can select your set-point source, choose a loop variable and adjust the PID terms.



Press BACK to return to the Select Menu display.

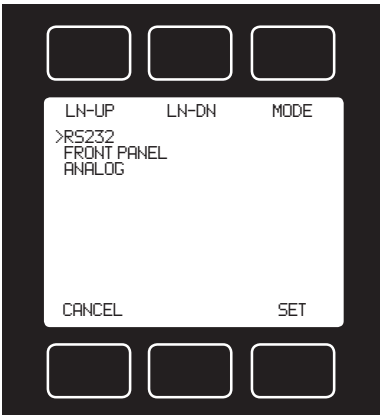
Press MAIN to return to the MAIN display

SETPT SOURCE – Pressing the button above SETPT SOURCE will allow you to select how the set point will be conveyed to your controller.

Use the line-up and line-down buttons to move the arrow in front of the desired option. Then press SET.

Press CANCEL to return to the previous display.

The controller will ignore any set-point except that of the selected set-point source and it will remember which input is selected even if the power is disconnected.



RS-232 (or RS-485) refers to a remote digital RS-232 / RS-485 set-point applied via a serial connection to a computer or PLC as described in the installation and RS-232 / RS-485 sections of this manual.

Front Panel refers to a set-point applied directly at the controller.

Front Panel input must be selected prior to changing the set-point at the device.

Analog refers to a remote analog set-point applied to Pin 4 of the Mini-DIN connector as described in the installation section of this manual. ***The standard analog input is 0-5 Vdc.***

To determine what type of analog set-point your controller has, refer to the Calibration Data Sheet that was included with your controller.

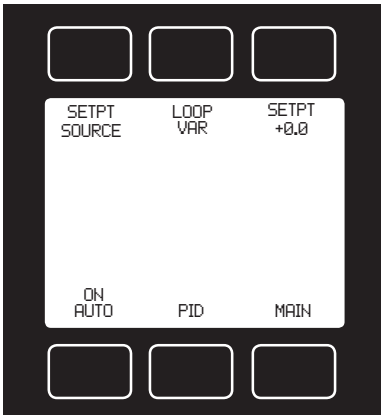
If nothing is connected to Pin 4, and the controller is set for analog control, the set-point will float.

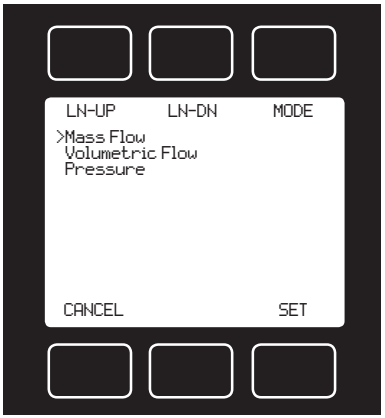
NOTE: If your controller has the **IPC** (Integrated Potentiometer Control) option, the IPC dial will operate with the ANALOG set-point source selected.

SETPT refers to the **set-point**. This parameter may be changed using the display only if **FRONT PANEL** is selected as the Input. Press **SETPT.** Then use SELECT to choose the decimal with the arrow and the UP and DOWN buttons to change the value. Press SET to record your value. Press CLEAR to return to zero.

CAUTION! ***Never leave a Controller with a non-zero set-point if no pressure is available to make flow. The controller will apply full power to the valve in an attempt to reach the set-point. When there is no flow, this can make the valve very HOT!***

CONTROL SETUP (continued)





LOOP VAR—The selection of what variable to close the loop on is a feature unique to Alicat mass flow controllers.

Pressing the **LOOP VAR** button on the Control Setup screen will allow you to change what variable is controlled.

Use the line-up and line-down buttons to move the arrow in front of the desired option.

When the mass flow controller is supplied with the **control valve upstream** of the electronics portion of the system, the unit can be set to control on outlet pressure (absolute pressures only) or volumetric flow rate, instead of mass flow rate.

The change from mass to volume can usually be accomplished without much, if any, change in the P and D settings.

When you change from controlling flow to controlling pressure, sometimes fairly radical changes must be made to the P & D variables. *See page 20* – **PID TUNING**.

Contact Alicat if you are having difficulties with this procedure.

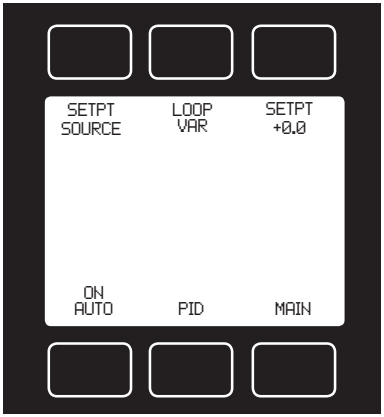
ON AUTO / OFF AUTO—refers to the standard auto-tare or "auto-zero" feature.

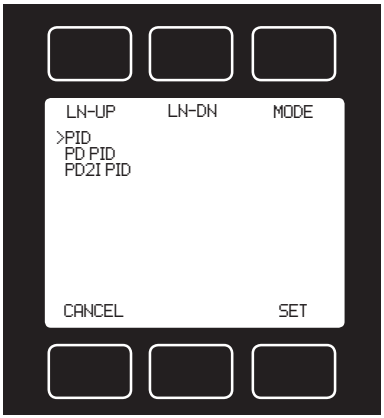
The auto-tare feature automatically tares (takes the detected signal as zero) the unit when it receives a zero set-point for more than two seconds.

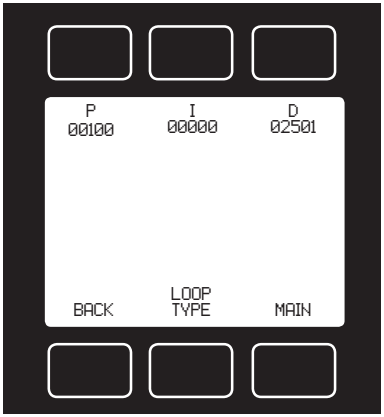
A zero set-point results in the closing of the valve and a known "no flow" condition. This feature makes the device more accurate by periodically removing any cumulative errors associated with drift.

It is recommended that the controller be left in the default auto-tare ON mode unless your specific application requires that it be turned off.

PID TUNING







PID Values determine the performance and operation of your proportional control valve. These terms dictate control speed, control stability, overshoot and oscillation. All units leave the factory with a generic tuning designed to handle most applications. If you encounter issues with valve stability, oscillation or speed, fine tuning these parameters may resolve the problem.

Alicat controllers allow you to adjust the Proportional, Integral and Differential terms of the PID control loop.

To change the PID loop parameters, push the button below **PID**.

Press **LOOP TYPE.** Then use the LN-UP and LN-DN buttons to select the appropriate PID control algorithm. Press SET.

See the following page for descriptions of the PID Loop Types (PID Control Algorithms).

P refers to the Proportional term of the PID loop.

I refers to the Integral term of the PID loop.

D refers to the Differential term of the PID loop.

Press P, I or D. Then use SELECT to choose the decimal with the arrow and the UP and DOWN buttons to change the value. Press SET to record your value. Press CLEAR to return to zero.

Before changing the P, I or D parameter, please record the initial value so that it can be returned to the factory setting if necessary.

Valve tuning can be complex. If you would like assistance, please contact Alicat for technical support.

The PID algorithm is an industry standard PID algorithm. It is divided into three segments.

The first compares the process value to the set-point to generate a proportional error. The proportional error is multiplied by the 'P' gain, with the result added to the output drive register.

The second integrates the proportional error times the 'I' gain over time and adds the result to the output drive register.

The third operates on the present process value minus the process value during the immediately previous evaluation cycle. This 'velocity' term is multiplied by the 'D' gain, with the result subtracted from the output drive register.

Increasing the 'P' gain will promote the tendency of the system to overshoot, ring, or oscillate. Increasing the 'D' gain will reduce the tendency of the system to overshoot. 'I' gain is used to control the rate at which the process value converges upon the set-point.

The PD PID algorithm is the PID algorithm used on most Alicat controllers. It is a simplified version of the above described PID method. It is divided into two segments:

The first compares the process value to the set-point to generate a proportional error. The proportional error is multiplied by the 'P' gain, with the result added to the output drive register.

The second operates on the present process value minus the process value during the immediately previous evaluation cycle. This 'velocity' term in multiplied by the 'D' gain, with the result subtracted from the output drive register.

The above additions to and subtractions from the output drive register are carried over from process cycle to process cycle, thus performing the integration function automatically.

Increasing the 'P' gain will promote the tendency of the system to overshoot, ring, or oscillate. Increasing the 'D' gain will reduce the tendency of the system to overshoot.

The reduction in the number of variables from three to two, greatly simplifies the tuning process.

The PD2I PID algorithm is used primarily for high performance pressure and flow control applications. It exhibits two basic differences from the PD PID algorithm that most controllers utilize.

1. Instead of applying a damping function based upon the rate of change of the process value, it applies a damping function based upon the square of the rate of change of the process value.

2. The damping function is applied directly to the proportional error term before that term is used in the proportional and integral functions of the algorithm. This provides a certain amount of 'look ahead' capability in the control loop.

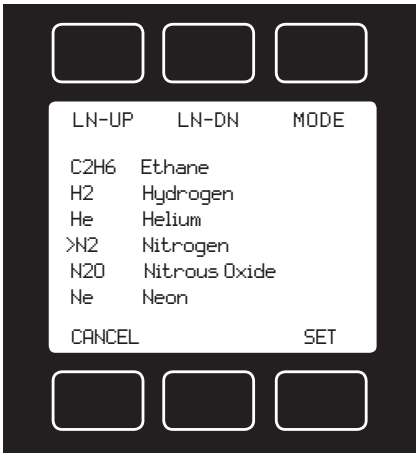
Because of these differences, you will note the following:

1. Increasing 'P' gain can be used to damp out overshoot and slow oscillations in pressure controllers. You will know that 'P' gain is too high, when the controller breaks into fast oscillations on step changes in set-point. On flow controllers, too high a 'P' gain results in slower response times. Too low a 'P' gain results in overshoot and/or slow oscillation. A good starting value for 'P' gain is 200.

2. If the unit was originally shipped with the PD2I algorithm selected, the 'D' gain value should be left at or near the factory setting because it relates primarily to the system phase lags. If you are changing from the default algorithm to the PD2I algorithm, you should start with a 'D' gain value of 20.

3. The 'I' gain is used to control the rate at which the process converges to the set-point, after the initial step change. Too low a value for 'I' gain shows up as a process value that jumps to near the set-point and then takes awhile to converge the rest of the way. Too high a value for 'I' gain results in oscillation. A good starting value for the 'I' gain is 200.

GAS SELECT



Gas Select is accessed by pressing the button below **GAS SELECT** on the Select Menu display.

To select a gas, use the LN-UP and LN-DN buttons to position the arrow in front of the desired gas.

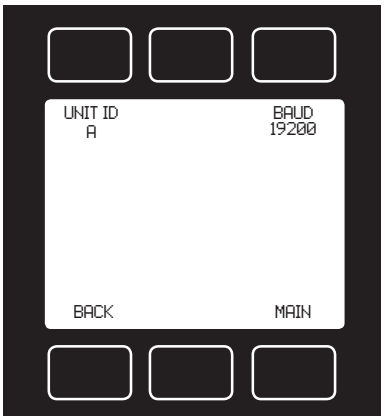
Press MODE and then PG-UP or PG-DN to view a new page in the gas list.

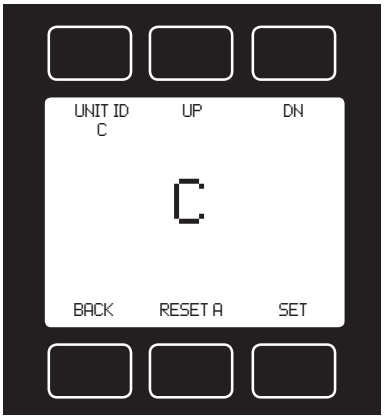
Press SET to record your selection and return to the MAIN display. The selected gas will be displayed on the screen.

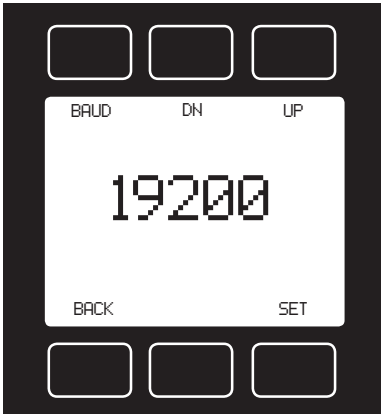
Note: Gas Select may not be available on units ordered with a custom gas or blend.

Alicat Standard Gas Select List	
Air	Air
Ar	Argon
CH4	Methane
CO	Carbon Monoxide
CO2	Carbon Dioxide
C2H6	Ethane
H2	Hydrogen
He	Helium
N2	Nitrogen
N2O	Nitrous Oxide
Ne	Neon
O2	Oxygen
C3H8	Propane
n-C4H10	normal-Butane
C2H2	Acetylene
C2H4	Ethylene
i-C2H10	iso-Butane
Kr	Krypton
Xe	Xenon
SF6	Sulfur Hexafluoride
C-25	75% Argon / 25% CO2
C-10	90% Argon / 10% CO2
C-8	92% Argon / 8% CO2
C-2	98% Argon / 2% CO2
C-75	75% CO2 / 25% Argon
A-75	75% Argon / 25% Helium
A-25	75% Helium / 25% Argon
A1025	90% Helium / 7.5% Argon / 2.5% CO2 (Praxair - Helistar® A1025)
Star29	90% Argon / 8% CO2 / 2% Oxygen (Praxair - Stargon® CS)
P-5	95% Argon / 5% Methane

COMMUNICATION SELECT







Access **Communication Select** by pressing the button above **RS232 COMM** or **RS485 COMM** on the **Select Menu** display.

Unit ID – Valid unit identifiers are the letters A-Z and @. The identifier allows you to assign a unique address to each device so that multiple units can be connected to a single RS-232 or RS-485 computer port.

Press **UNIT ID**. Use the UP and DOWN buttons to change the Unit ID. Press SET to record the ID. Press Reset to return to the previously recorded Unit ID.

Any Unit ID change will take effect when Communication Select is exited.

If the symbol @ is selected as the Unit ID, the device will enter streaming mode when Communication Select is exited.

See RS-232 Communications (page 26) for information about the streaming mode.

Baud – Both this instrument and your computer must send/receive data at the same baud rate. The default baud rate for this device is 19200 baud.

Press **BAUD**. Use the UP and DOWN buttons to select the baud rate that matches your computer. The choices are 38400, 19200, 9600, or 2400 baud. Press SET to record the baud rate.

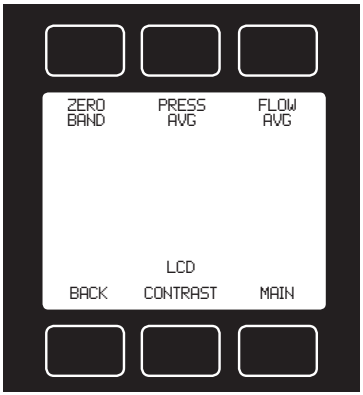
Any baud rate change will not take effect until power to the unit is cycled.

MISCELLANEOUS

Miscellaneous is accessed by pressing the **MISC** button on the Select Menu display.

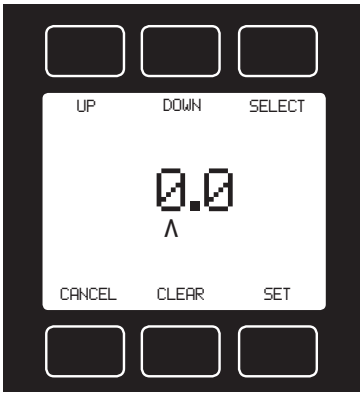
NOTE: All Miscellaneous changes are recorded when you exit Miscellaneous.

ZERO BAND refers to Display Zero Deadband. Zero deadband is a value below which the display jumps to zero. This deadband is often desired to prevent electrical noise from showing up on the display as minor flows or pressures that do not exist. Display Zero Deadband does not affect the analog or digital signal outputs.



ZERO BAND can be adjusted between 0 and 3.2% of the sensor's Full Scale (FS).

Press **ZERO BAND.** Then use SELECT to choose the decimal with the arrow and the UP and DOWN buttons to change the value. Press SET to record your value. Press CLEAR to return to zero.

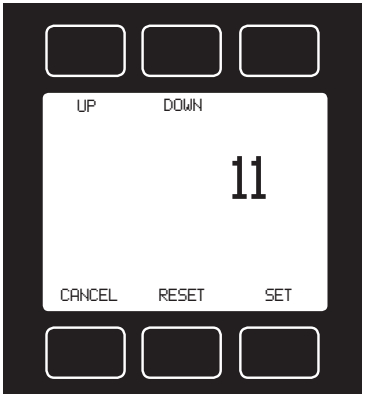


Pressure Averaging and Flow Averaging may be useful to make it easier to read and interpret rapidly fluctuating pressures and flows. Pressure and flow averaging can be adjusted between 1 (no averaging) and 256 (maximum averaging). These are geometric running averages where the number between 1 and 256 can be considered roughly equivalent to the response time constant in milliseconds. This can be effective at "smoothing" high frequency process oscillations such as those caused by diaphragm pumps.

Press **PRESS AVG.** Then use SELECT to choose the decimal with the arrow and the UP and DOWN buttons to change the value.

Press **FLOW AVG**. Then use SELECT to choose the decimal with the arrow and the UP and DOWN buttons to change the value. Press SET to record your value. Press CLEAR to return to zero.

Setting a higher number will equal a smoother display.

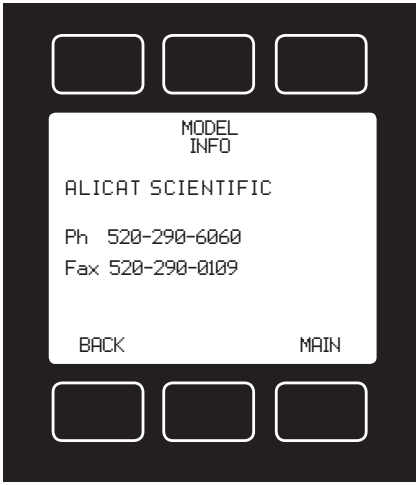


LCD CONTRAST: The display contrast can be adjusted between 0 and 30, with zero being the lightest and 30 being the darkest.

Use the UP and DOWN buttons to adjust the contrast. Press SET when you are satisfied.

Press CANCEL to return to the MISC display.

MANUFACTURER DATA



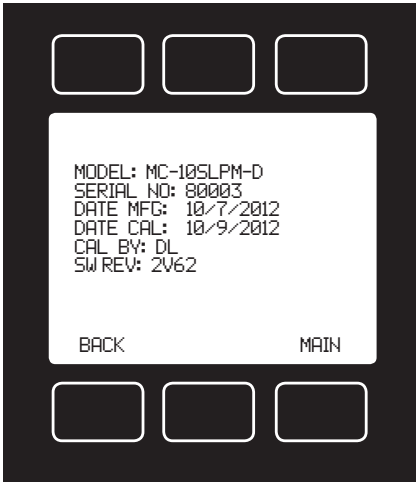
Manufacturer Data is accessed by pressing the **MFG DATA** button on the Select Menu display.

The initial display shows the name and telephone number of the manufacturer.

Press **MODEL INFO** to show important information about your flow device including the model number, serial number, and date of manufacture.

Press BACK to return to the MFG DATA display.

Push MAIN to return to the Main display.



MCV Controller Operating Notes

Alicat's MCV mass flow controller is equipped with an integrated Swagelok® positive shutoff valve.

The normally closed valve is air actuated and will remain closed until it is connected to an air source supplying between 60 and 120 psig of air pressure.

Once the appropriate amount of air pressure is supplied to the shutoff valve, it will open, allowing flow through the mass controller. Air pressure must be removed from the shutoff valve in order for the valve to close.

A common method for actuating the shutoff valve incorporates a three-way solenoid valve (below).

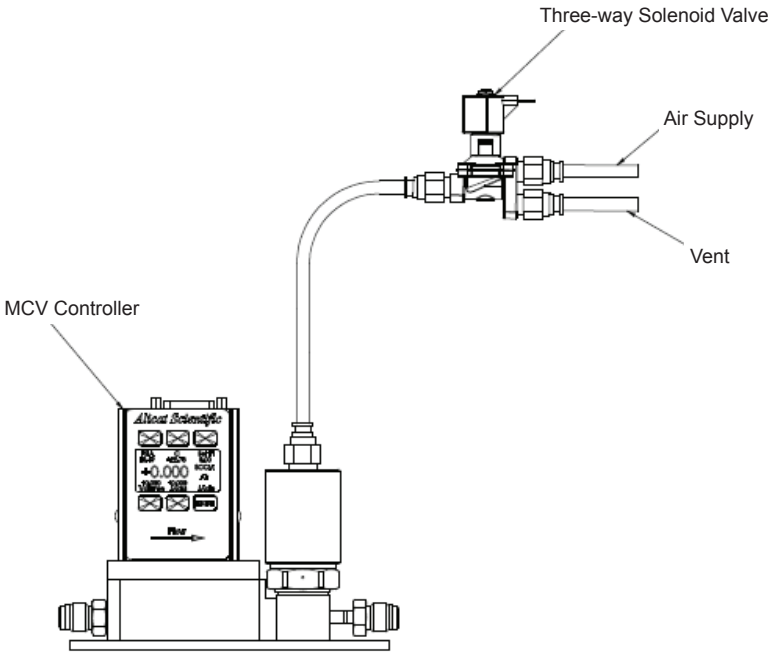
Air pressure is applied to one side of the solenoid valve while the other side of the solenoid is left open to atmosphere.

When the solenoid is energized, air pressure is delivered to the shutoff valve, allowing it to open.

When the solenoid is returned to a relaxed state, air pressure is removed from the shutoff valve, allowing it to close. The air pressure is vented to atmosphere.

Solenoid valves for use with the MCV mass flow controller can be ordered from Alicat.

Note: All standard MC Series device features and functions are available on the MCV Series and operate in accordance with the standard MC Series operating instructions.



MCV controller and three-way solenoid valve.

Configuring HyperTerminal®:

1. Open your HyperTerminal® RS-232 / RS-485 terminal program (installed under the "Accessories" menu on all Microsoft Windows® operating systems).
2. Select "Properties" from the file menu.
3. Click on the "Configure" button under the "Connect To" tab. Be sure the program is set for: 19,200 baud (or matches the baud rate selected in the RS-232 / RS-485 communications menu on the meter) and an 8-N-1-None (8 Data Bits, No Parity, 1 Stop Bit, and no Flow Control) protocol.
4. Under the "Settings" tab, make sure the Terminal Emulation is set to ANSI or Auto Detect.
5. Click on the "ASCII Setup" button and be sure the "Send Line Ends with Line Feeds" box is not checked and the "Echo Typed Characters Locally" box and the "Append Line Feeds to Incoming Lines" boxes are checked. Those settings not mentioned here are normally okay in the default position.
6. Save the settings, close HyperTerminal® and reopen it.

In Polling Mode, the screen should be blank except the blinking cursor. In order to get the data streaming to the screen, hit the "Enter" key several times to clear any extraneous information. Type "*@=@" followed by "Enter" (or using the RS-232 / RS-485 communication select menu, select @ as identifier and exit the screen). If data still does not appear, check all the connections and com port assignments.

Changing From Streaming to Polling Mode:

When the meter is in the Streaming Mode (*RS-485 units do not have a streaming mode*), the screen is updated approximately 10-60 times per second (depending on the amount of data on each line) so that the user sees the data essentially in real time. It is sometimes desirable, and necessary when using more than one unit on a single RS-232 line, to be able to poll the unit.

In Polling Mode the unit measures the flow normally, but only sends a line of data when it is "polled". Each unit can be given its own unique identifier or address. Unless otherwise specified each unit is shipped with a default address of capital A. Other valid addresses are B thru Z.

Once you have established communication with the unit and have a stream of information filling your screen:

1. Type *@=A followed by "Enter" (or using the RS-232 / RS-485 communication select menu, select A as identifier and exit the screen) to stop the streaming mode of information. Note that the flow of information will not stop while you are typing and you will not be able to read what you have typed. Also, the unit does not accept a backspace or delete in the line so it must be typed correctly. If in doubt, simply hit enter and start again. If the unit does not get exactly what it is expecting, it will ignore it. If the line has been typed correctly, the data will stop.

2. You may now poll the unit by typing A followed by “Enter”. This does an instantaneous poll of unit A and returns the values once. You may type A “Enter” as many times as you like. Alternately you could resume streaming mode by typing *@=@ followed by “Enter”. Repeat step 1 to remove the unit from the streaming mode.

3. To assign the unit a new address, type *@=New Address, e.g. *@=B. Care should be taken not to assign an address to a unit if more than one unit is on the RS-232 / RS-485 line as all of the addresses will be reassigned. Instead, each should be individually attached to the RS-232 / RS-485 line, given an address, and taken off. After each unit has been given a unique address, they can all be put back on the same line and polled individually.

Sending a Set-point via RS-232 / RS-485: To send a set-point via RS-232 / RS-485, “Serial” must be selected under the “Input” list in the control set up mode. To give controllers a set-point, or change an existing point, simply type in a number between 0 and 65535 (2% over range), where 64000 denotes full-scale flow rate, and hit “Enter”.

The set-point column and flow rates should change accordingly. If they do not, try hitting “Enter” a couple of times and repeating your command. The formula for performing a linear interpolation is as follows:

Value = (Desired Set-point X 64000) / Full Scale Flow Range

For example, if your device is a 100 SLPM full-scale unit and you wish to apply a set-point of 35 SLPM you would enter the following value:

22400 = (35 SLPM X 64000) / 100 SLPM

If the controller is in polling mode as described in *Changing from Streaming Mode to Polling Mode*, the set-point must be preceded by the address of the controller. For example, if your controller has been given an address of D, the set-point above would be sent by typing:

D22400 followed by “Enter”

To adjust the Proportional and Differential (P&D) terms via RS-232 / RS-485:

Type *@=A followed by “Enter” to stop the streaming mode of information.

To adjust the “P” or proportional term of the PID controller, type *R21 followed by “Enter”.

The computer will respond by reading the current value for register 21 between 0-65535. It is good practice to write this value down so you can return to the factory settings if necessary. Enter the value you wish to try by writing the new value to register 21. For example, if you wished to try a "P" term of 220, you would type *W21=**220** followed by "Enter" where the bold number denotes the new value.

The computer will respond to the new value by confirming that 21=220. To see the effect of the change you may now poll the unit by typing A followed by "Enter". This does an instantaneous poll and returns the values once. You may type A "Enter" as many times as you like. Alternately you could resume streaming mode by typing *@=@ followed by "Enter". Repeat step 3 to remove the unit from the streaming mode.

To adjust the "D" or proportional term of the PID controller, type *R22 followed by "Enter".

The computer will respond by reading the current value for register 22 between 0-65535. It is good practice to write this value down so you can return to the factory settings if necessary. Enter the value you wish to try by writing the new value to register 22. For example, if you wished to try a "D" term of 25, you would type *W22=**25** followed by "Enter" where the bold number denotes the new value.

The computer will respond to the new value by confirming that 22=25. To see the effect of the change you may now poll the unit by typing A followed by "Enter". This does an instantaneous poll and returns the values once. You may type A "Enter" as many times as you like. Alternately you could resume streaming mode by typing *@=@ followed by "Enter". Repeat.

You may test your settings for a step change by changing the set-point. To do this type A32000 (A is the default single unit address, if you have multiple addressed units on your RS-232 / RS-485 line the letter preceding the value would change accordingly.) followed by "Enter" to give the unit a ½ full scale set-point. Monitor the unit's response to the step change to ensure it is satisfactory for your needs. Recall that the "P" term controls how quickly the unit goes from one set-point to the next, and the "D" term controls how quickly the signal begins to "decelerate" as it approaches the new set-point (controls the overshoot).

Gas Select – The selected gas can be changed via RS-232 / RS-485 input. To change the selected gas, enter the following commands:

In Streaming Mode: $$#<Enter>

In Polling Mode: Address$$#<Enter> (e.g. B$$#<Enter>)

Where # is the number of the gas selected from the table below. Note that this also corresponds to the gas select menu on the flow controller screen:

#	GAS	
0	Air	Air
1	Argon	Ar
2	Methane	CH4
3	Carbon Monoxide	CO
4	Carbon Dioxide	CO2
5	Ethane	C2H6
6	Hydrogen	H2
7	Helium	He
8	Nitrogen	N2
9	Nitrous Oxide	N2O
10	Neon	Ne
11	Oxygen	O2
12	Propane	C3H8
13	normal-Butane	n-C4H10
14	Acetylene	C2H2
15	Ethylene	C2H4
16	iso-Butane	i-C2H10
17	Krypton	Kr
18	Xenon	Xe
19	Sulfur Hexafluoride	SF6
20	75% Argon / 25% CO2	C-25
21	90% Argon / 10% CO2	C-10
22	92% Argon / 8% CO2	C-8
23	98% Argon / 2% CO2	C-2
24	75% CO2 / 25% Argon	C-75
25	75% Argon / 25% Helium	A-75
26	75% Helium / 25% Argon	A-25
27	90% Helium / 7.5% Argon / 2.5% CO2 (Praxair - Helistar® A1025)	A1025
28	90% Argon / 8% CO2 / 2% Oxygen (Praxair - Stargon® CS)	Star29
29	95% Argon / 5% Methane	P-5

For example, to select Propane, enter: $$12<Enter>

Collecting Data:

The RS-232 / RS-485 output updates to the screen many times per second. Very short-term events can be captured simply by disconnecting (there are two telephone symbol icons at the top of the HyperTerminal® screen for disconnecting and connecting) immediately after the event in question. The scroll bar can be driven up to the event and all of the data associated with the event can be selected, copied, and pasted into Microsoft® Excel® or other spreadsheet program as described below.

For longer term data, it is useful to capture the data in a text file. With the desired data streaming to the screen, select “Capture Text” from the Transfer Menu. Type in the path and file name you wish to use. Push the start button. When the data collection period is complete, simply select “Capture Text” from the Transfer Menu and select “Stop” from the sub-menu that appears.

Data that is selected and copied, either directly from HyperTerminal® or from a text file can be pasted directly into Excel®. When the data is pasted it will all be in the selected column. Select “Text to Columns...” under the Data menu in Excel® and a Text to Columns Wizard (dialog box) will appear. Make sure that “Fixed Width” is selected under Original Data Type in the first dialog box and click “Next”. In the second dialog box, set the column widths as desired, but the default is usually acceptable. Click on “Next” again. In the third dialog box, make sure the column data format is set to “General”, and click “Finish”. This separates the data into columns for manipulation and removes symbols such as the plus signs from the numbers. Once the data is in this format, it can be graphed or manipulated as desired.

For extended term data capture see: “Sending a Simple Script to HyperTerminal®” on page 33.

Data Format:

The data stream on the screen represents the flow parameters of the main mode in the units shown on the display.

For mass flow controllers, there are six columns of data representing pressure, temperature, volumetric flow, mass flow, set-point, and the selected gas

The first column is absolute pressure (normally in PSIA), the second column is temperature (normally in °C), the third column is volumetric flow rate (in the units specified at time of order and shown on the display), the fourth column is mass flow (also in the units specified at time of order and shown on the display), the fifth column is the currently selected set-point value, the sixth column designates the currently selected gas. For instance, if the controller was ordered in units of SCFM, the display on the controller would read 2.004 SCFM and the last two columns of the output below would represent volumetric flow and mass flow in CFM and SCFM respectively.

+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air
+014.70 +025.00 +02.004 +02.004 2.004 Air

MC Series Mass Flow Controller Data Format

Note: On units with the totalizer function, the sixth column will be the totalizer value, with gas select moving to a seventh column.

Sending a Simple Script File to HyperTerminal®

It is sometimes desirable to capture data for an extended period of time. Standard streaming mode information is useful for short term events, however, when capturing data for an extended period of time, the amount of data and thus the file size can become too large very quickly. Without any special programming skills, the user can use HyperTerminal® and a text editing program such as Microsoft® Word® to capture text at user defined intervals.

1. Open your text editing program, MS Word for example.

2. Set the cap lock on so that you are typing in capital letters.

3. Beginning at the top of the page, type A<Enter> repeatedly. If you're using MS Word, you can tell how many lines you have by the line count at the bottom of the screen. The number of lines will correspond to the total number of times the flow device will be polled, and thus the total number of lines of data it will produce.
For example:
A
A
A
A
A
A

will get a total of six lines of data from the flow meter, but you can enter as many as you like.

The time between each line will be set in HyperTerminal.

4. When you have as many lines as you wish, go to the File menu and select save. In the save dialog box, enter a path and file name as desired and in the "Save as Type" box, select the plain text (.txt) option. It is important that it be saved as a generic text file for HyperTerminal to work with it.

5. Click Save.

6. A file conversion box will appear. In the "End Lines With" drop down box, select CR Only. Everything else can be left as default.

7. Click O.K.

8. You have now created a "script" file to send to HyperTerminal. Close the file and exit the text editing program.

9. Open HyperTerminal and establish communication with your flow device as outlined in the manual.

10. Set the flow device to Polling Mode as described in the manual. Each time you type A<Enter>, the meter should return one line of data to the screen.

11. Go to the File menu in HyperTerminal and select "Properties".

12. Select the "Settings" tab.

13. Click on the "ASCII Setup" button.

14. The “Line Delay” box is defaulted to 0 milliseconds. This is where you will tell the program how often to read a line from the script file you’ve created. 1000 milliseconds is one second, so if you want a line of data every 30 seconds, you would enter 30000 into the box. If you want a line every 5 minutes, you would enter 300000 into the box.

15. When you have entered the value you want, click on OK and OK in the Properties dialog box.

16. Go the Transfer menu and select “Send **Text** File…” (NOT Send File…).

17. Browse and select the text “script” file you created.

18. Click Open.

19. The program will begin “executing” your script file, reading one line at a time with the line delay you specified and the flow device will respond by sending one line of data for each poll it receives, when it receives it.

You can also capture the data to another file as described in the manual under “Collecting Data”. You will be simultaneously sending it a script file and capturing the output to a separate file for analysis.

Operating Principle

All M Series Gas Flow Meters (and MC Series Gas Flow Controllers) are based on the accurate measurement of volumetric flow. The volumetric flow rate is determined by creating a pressure drop across a unique internal restriction, known as a Laminar Flow Element (LFE), and measuring differential pressure across it. The restriction is designed so that the gas molecules are forced to move in parallel paths along the entire length of the passage; hence laminar (streamline) flow is established for the entire range of operation of the device. Unlike other flow measuring devices, in laminar flow meters the relationship between pressure drop and flow is linear. The underlying principle of operation of the 16 Series flow meters is known as the Poiseuille Equation:

$$Q = (P_1 - P_2)\varepsilon r^4/8\eta L \qquad \text{(Equation 1)}$$

Where:

Q	=	Volumetric Flow Rate
P_1	=	Static pressure at the inlet
P_2	=	Static pressure at the outlet
r	=	Radius of the restriction
η	=	(eta) absolute viscosity of the fluid
L	=	Length of the restriction

Since ε, r and L are constant; Equation 1 can be rewritten as:

$$Q = K (\Delta P/\eta) \qquad \text{(Equation 2)}$$

Where K is a constant factor determined by the geometry of the restriction. Equation 2 shows the linear relationship between volumetric flow rate (Q) differential pressure (ΔP) and absolute viscosity (η) in a simpler form.

Gas Viscosity: In order to get an accurate volumetric flow rate, the gas being measured must be selected (see Gas Select Mode, page 14). This is important because the device calculates the flow rate based on the viscosity of the gas at the measured temperature. If the gas being measured is not what is selected, an incorrect value for the viscosity of the gas will be used in the calculation of flow, and the resulting output will be inaccurate in direct proportion to the difference in the two gases viscosities.

Gas viscosity, and thus gas composition, can be very important to the accuracy of the meter. Anything that has an effect on the gas viscosity (e.g. water vapor, odorant additives, etc.) will have a direct proportional effect on the accuracy. Selecting methane and measuring natural gas for instance, will result in a fairly decent reading, but it is not highly accurate (errors are typically < 0.6%) because natural gas contains small and varying amounts of other gases such as butane and propane that result in a viscosity that is somewhat different than pure methane.

Absolute viscosity changes very little with pressure (within the operating ranges of these meters) therefore a true volumetric reading does not require a correction for pressure. Changes in gas temperature do affect viscosity. For this reason, the M Series internally compensates for this change.

Other Gases: M Series Flow Meters can easily be used to measure the flow rate of gases other than those listed as long as "non-corrosive" gas compatibility is observed. For example, a flow meter that has been set for air can be used to measure the flow of argon.

The conversion factor needed for measuring the flow of different gases is linear and is simply determined by the ratio of the absolute viscosity of the gases. This factor can be calculated as follows:

$$Q_{og} = Q_1 [\eta_1 / \eta_{og}]$$

Where: Q_1 = Flow rate indicated by the flow meter
η_1 = Viscosity of the calibrated gas at the measured temp.
Q_{og} = Flow rate of the alternate gas
η_{og} = Viscosity of the alternate gas at the measured temp.

Say we have a meter set for air and we want to flow argon through it. With argon flowing through the meter, the display reads 110 SLPM. For ease of calculation, let us say the gas temperature is 25°C. What is the actual flow of argon?

Q_{og} = Actual Argon Flow Rate
Q_1 = Flow rate indicated by meter (110 SLPM)
η_1 = Viscosity of gas selected or calibrated for by the meter at the measured temp.
η_{og} = Viscosity of gas flowing through the meter at the measured temp.

At 25°C, the absolute viscosity of Air (η_1) is 184.918 micropoise.
At 25°C, the absolute viscosity of Argon (η_{og}) is 225.593 micropoise.

$$Q_{og} = Q1 (\eta\ 1 / \eta_{og})$$
$$Q_{og} = 110 \text{ SLPM } (184.918 / 225.593)$$
$$Q_{og} = 90.17 \text{ SLPM}$$

So, the actual flow of Argon through the meter is 90.17 SLPM. As you can see, because the Argon gas is more viscous than the Air the meter is set for, the meter indicates a higher flow than the actual flow.

A good rule of thumb is: "At a given flow rate, the higher the viscosity, the higher the indicated flow."

Volume Flow vs. Mass Flow: At room temperature and low pressures the volumetric and mass flow rate will be nearly identical, however, these rates can vary drastically with changes in temperature and/or pressure because the temperature and pressure of the gas directly affects the volume. For example, assume a volumetric flow reading was used to fill balloons with 250 mL of helium, but the incoming line ran near a furnace that cycled on and off, intermittently heating the incoming helium. Because the volumetric meter simply measures the volume of gas flow, all of the balloons would initially be the same size. However, if all the balloons are placed in a room and allowed to come to an equilibrium temperature, they would generally all come out to be different sizes. If, on the other hand, a mass flow reading were used to fill the balloons with 250 <u>standard</u> mL of helium, the resulting balloons would initially be different sizes, but when allowed to come to an equilibrium temperature, they would all turn out to be the same size.

This parameter is called corrected mass flow because the resulting reading has been compensated for temperature and pressure and can therefore be tied to the mass of the gas. Without knowing the temperature and pressure of the gas and thus the density, the mass of the gas cannot be determined.

Once the corrected mass flow rate at standard conditions has been determined and the density at standard conditions is known (see the density table at the back of this manual), a true mass flow can be calculated as detailed in the following example:

Mass Flow Meter Reading = 250 SCCM (Standard Cubic Centimeters/Minute)
Gas: Helium
Gas Density at 25C and 14.696 PSIA = .16353 grams/Liter
True Mass Flow = (Mass Flow Meter Reading) X (Gas Density)
True Mass Flow = (250 CC/min) X (1 Liter / 1000 CC) X (.16353 grams/Liter)
True Mass Flow = 0.0409 grams/min of Helium

Volumetric and Mass Flow Conversion: In order to convert volume to mass, the density of the gas must be known. The relationship between volume and mass is as follows:

Mass = Volume x Density

The density of the gas changes with temperature and pressure and therefore the conversion of volumetric flow rate to mass flow rate requires knowledge of density change. Using ideal gas laws, the effect of temperature on density is:

$$\rho_a / \rho_s = T_s / T_a$$

Where:	ρ_a	=	density @ flow condition
	T_a	=	absolute temp @ flow condition in °Kelvin
	ρ_s	=	density @ standard (reference) condition
	T_s	=	absolute temp @ standard (reference) condition in °Kelvin
	ºK	=	ºC + 273.15 Note: ºK=ºKelvin

The change in density with pressure can also be described as:

$$\rho_a / \rho_s = P_a / P_s$$

Where:	ρ_a	=	density @ flow condition
	P_a	=	flow absolute pressure
	ρ_s	=	density @ standard (reference) condition
	P_s	=	Absolute pressure @ standard (reference) condition

Therefore, in order to determine mass flow rate, two correction factors must be applied to volumetric rate: temperature effect on density and pressure effect on density.

Compressibility: Heretofore, we have discussed the gases as if they were "Ideal" in their characteristics. The ideal gas law is formulated as:

$$PV=nRT$$

where: P = Absolute Pressure
V = Volume (or Volumetric Flow Rate)
n = number moles (or Molar Flow Rate)
R = Gas Constant (related to molecular weight)
T = Absolute Temperature

Most gases behave in a nearly ideal manner when measured within the temperature and pressure limitations of Alicat products. However, some gases (such as propane and butane) can behave in a less than ideal manner within these constraints. The non-ideal gas law is formulated as:

$$PV=ZnRT$$

Where: "Z" is the compressibility factor. This can be seen in an increasingly blatant manner as gases approach conditions where they condense to liquid. As the compressibility factor goes down (Z=1 is the ideal gas condition), the gas takes up less volume than what one would expect from the ideal gas calculation.

This reduces to: $P_a V_a / Z_a T_a = P_s V_s / Z_s T_s$, eliminating R and n.

Alicat mass flow meters model gas flows based upon the non-ideal gas characteristics of the calibrated gas. The flow corrections are normally made to 25 C and 14.696 PSIA and the compressibility factor of the gas under those conditions. This allows the user to multiply the mass flow rate by the density of the real gas at those standard conditions to get the mass flow rate in grams per minute.

Because we incorporate the compressibility factor into our 'full gas model'; attempts to manually compute mass flows from only the P, V, and T values shown on the display will sometimes result in modest errors.

Note: Although the correct units for mass are expressed in grams, kilograms, etc. it has become standard that mass flow rate is specified in SLPM (standard liters / minute), SCCM (standard cubic centimeters / minute) or SmL/M (standard milliliters / minute).

This means that mass flow rate is calculated by normalizing the volumetric flow rate to some standard temperature and pressure (STP). By knowing the density at that STP, one can determine the mass flow rate in grams per minute, kilograms per hour, etc.

STP is usually specified as the sea level conditions; however, no single standard exists for this convention. Examples of common reference conditions include:

0°C	and	14.696 PSIA
25°C	and	14.696 PSIA
0°C	and	760 torr (mmHG)
70°F	and	14.696 PSIA
68°F	and	29.92 inHG
20°C	and	760 torr (mmHG)

MC Series Flow Controllers reference 25ºC and14.696 PSIA (101.32kPa) - unless ordered otherwise and specified in the notes field of the calibration sheet.

STANDARD GAS DATA TABLES: Those of you who have older Alicat products (manufactured before October 2005) may notice small discrepancies between the gas property tables of your old and new units. Alicat Scientific, Inc. has incorporated the latest data sets from NIST (including their REFPROP 7 data) in our products' built-in gas property models. Be aware that the calibrators that you may be using may be checking against older data sets such as the widely distributed Air Liquide data.

This may generate apparent calibration discrepancies of up to 0.6% of reading on well behaved gases and as much as 3% of reading on some gases such as propane and butane, unless the standard was directly calibrated on the gas in question.

As the older standards are phased out of the industry, this difference in readings will cease to be a problem. If you see a difference between the Alicat meter and your in-house standard, in addition to calling Alicat Scientific at (520) 290-6060, call the manufacturer of your standard for clarification as to which data set they used in their calibration. This comparison will in all likelihood resolve the problem.

Gas Number	Short Form	Long Form	Viscosity* 25 deg C 14.696 PSIA	Density** 25 deg C 14.696 PSIA	Compressibility 25 deg C 14.696 PSIA
0	Air	Air	184.918	1.1840	0.9997
1	Ar	Argon	225.593	1.6339	0.9994
2	CH4	Methane	111.852	0.6569	0.9982
3	CO	Carbon Monoxide	176.473	1.1453	0.9997
4	CO2	Carbon Dioxide	149.332	1.8080	0.9949
5	C2H6	Ethane	93.540	1.2385	0.9924
6	H2	Hydrogen	89.153	0.08235	1.0006
7	He	Helium	198.457	0.16353	1.0005
8	N2	Nitrogen	178.120	1.1453	0.9998
9	N2O	Nitrous Oxide	148.456	1.8088	0.9946
10	Ne	Neon	311.149	0.8246	1.0005
11	O2	Oxygen	204.591	1.3088	0.9994
12	C3H8	Propane	81.458	1.8316	0.9841
13	n-C4H10	normal-Butane	74.052	2.4494	0.9699
14	C2H2	Acetylene	104.448	1.0720	0.9928
15	C2H4	Ethylene	103.177	1.1533	0.9943
16	i-C4H10	iso-Butane	74.988	2.4403	0.9728
17	Kr	Krypton	251.342	3.4274	0.9994
18	Xe	Xenon	229.785	5.3954	0.9947
19	SF6	Sulfur Hexafluoride	153.532	6.0380	0.9887
20	C-25	75% Argon / 25% CO2	205.615	1.6766	0.9987
21	C-10	90% Argon / 10% CO2	217.529	1.6509	0.9991
22	C-8	92% Argon / 8% CO2	219.134	1.6475	0.9992
23	C-2	98% Argon / 2% CO2	223.973	1.6373	0.9993
24	C-75	75% CO2 / 25% Argon	167.451	1.7634	0.9966
25	A-75	75% Argon / 25% Helium	230.998	1.2660	0.9997
26	A-25	75% Helium / 25% Argon	234.306	0.5306	1.0002
27	A1025	90% Helium / 7.5% Argon / 2.5% CO2 (Praxair - Helistar® A1025)	214.840	0.3146	1.0003
28	Star29	90% Argon / 8% CO2 / 2% Oxygen (Praxair - Stargon® CS)	218.817	1.6410	0.9992
29	P-5	95% Argon / 5% Methane	223.483	1.5850	0.9993
*in micropoise (1 Poise = gram / (cm) (sec)) ** Grams/Liter (NIST REFPROP 7 database)					

Gas Viscosities, Densities and Compressibilities at 25° C

Gas Number	Short Form	Long Form	Viscosity* 0 deg C 14.696 PSIA	Density** 0 deg C 14.696 PSIA	Compressibility 0 deg C 14.696 PSIA
0	Air	Air	172.588	1.2927	0.9994
1	Ar	Argon	209.566	1.7840	0.9991
2	CH4	Methane	103.657	0.7175	0.9976
3	CO	Carbon Monoxide	165.130	1.2505	0.9994
4	CO2	Carbon Dioxide	137.129	1.9768	0.9933
5	C2H6	Ethane	86.127	1.3551	0.9900
6	H2	Hydrogen	83.970	0.08988	1.0007
7	He	Helium	186.945	0.17849	1.0005
8	N2	Nitrogen	166.371	1.2504	0.9995
9	N2O	Nitrous Oxide	136.350	1.9778	0.9928
10	Ne	Neon	293.825	0.8999	1.0005
11	O2	Oxygen	190.555	1.4290	0.9990
12	C3H8	Propane	74.687	2.0101	0.9787
13	n-C4H10	normal-Butane	67.691	2.7048	0.9587
14	C2H2	Acetylene	97.374	1.1728	0.9905
15	C2H4	Ethylene	94.690	1.2611	0.9925
16	i-C4H10	iso-Butane	68.759	2.6893	0.9627
17	Kr	Krypton	232.175	3.7422	0.9991
18	Xe	Xenon	212.085	5.8988	0.9931
19	SF6	Sulfur Hexafluoride	140.890	6.6154	0.9850
20	C-25	75% Argon / 25% CO2	190.579	1.8309	0.9982
21	C-10	90% Argon / 10% CO2	201.897	1.8027	0.9987
22	C-8	92% Argon / 8% CO2	203.423	1.7989	0.9988
23	C-2	98% Argon / 2% CO2	208.022	1.7877	0.9990
24	C-75	75% CO2 / 25% Argon	154.328	1.9270	0.9954
25	A-75	75% Argon / 25% Helium	214.808	1.3821	0.9995
26	A-25	75% Helium / 25% Argon	218.962	0.5794	1.0002
27	A1025	90% Helium / 7.5% Argon / 2.5% CO2 (Praxair - Helistar® A1025)	201.284	0.3434	1.0002
28	Star29	90% Argon / 8% CO2 / 2% Oxygen (Praxair - Stargon® CS)	203.139	1.7918	0.9988
29	P-5	95% Argon / 5% Methane	207.633	1.7307	0.9990
*in micropoise (1 Poise = gram / (cm) (sec)) ** Grams/Liter (NIST REFPROP 7 database)					

Gas Viscosities, Densities and Compressibilities at 0° C

TROUBLESHOOTING

Display does not come on or is weak.
Check power and ground connections. Please reference the technical specifications (pages 44-47) to assure you have the proper power for your model.

Flow reading is approximately fixed either near zero or near full scale regardless of actual line flow.
Differential pressure sensor may be damaged. A common cause of this problem is instantaneous application of high-pressure gas as from a snap acting solenoid valve upstream of the meter. If you suspect that your pressure sensor is damaged please discontinue use of the controller and contact Alicat.

Displayed mass flow, volumetric flow, pressure or temperature is flashing and message MOV, VOV, POV or TOV is displayed:
Our flow meters and controllers display an error message (MOV = mass overrange, VOV = volumetric overrange, POV = pressure overrange, TOV = temperature overrange) when a measured parameter exceeds the range of the sensors in the device. When any item flashes on the display, neither the flashing parameter nor the mass flow measurement is accurate. Reducing the value of the flashing parameter to within specified limits will return the unit to normal operation and accuracy. If the unit does not return to normal contact Alicat.

After installation, there is no flow.
Alicat MC controllers incorporate normally closed valves and require a set-point to operate. Check that your set-point signal is present and supplied to the correct pin and that the correct set-point source is selected under the SETPT SOURCE list in the control set up display. Also check that the unit is properly grounded.

The flow lags below the set-point.
Be sure there is enough pressure available to make the desired flow rate. If either the set-point signal line and/or the output signal line is relatively long, it may be necessary to provide heavier wires (especially ground wiring) to negate voltage drops due to line wire length. An inappropriate PID tuning can also cause this symptom if the D term is too large relative to the P term. See pages 17 and 18 for more information on PID tuning.

Controller is slow to react to a set-point change or imparts an oscillation to the flow.
An inappropriate PID tuning can cause these symptoms. Use at conditions considerably different than those at which the device was originally set up can necessitate a re-tuning of the PID loop. See pages 20 and 21 for more information on PID tuning.

The output signal is lower than the reading at the display.
This can occur if the output signal is measured some distance from the meter, as voltage drops in the wires increase with distance. Using heavier gauge wires, especially in the ground wire, can reduce this effect.

Meter does not agree with another meter I have in line.
Volumetric meters are affected by pressure drops. Volumetric flow meters should not be compared to mass flow meters. Mass flow meters can be compared against one another provided there are no leaks between the two meters and they are set to the same standard temperature and pressure. Both meters must also be calibrated (or set) for the gas being measured. M Series mass flow meters are normally set to Standard Temperature and Pressure conditions of 25° C and 14.696 PSIA. Note: it is possible to special order meters with a customer specified set of standard conditions. The calibration sheet provided with each meter lists its standard conditions.
When performing this comparison it is best to use the smallest transition possible between the two devices. Using small transitions will minimize lag and dead volume.

RS-232 / RS-485 Serial Communications is not responding.
Check that your meter is powered and connected properly. Be sure that the port on the computer to which the meter is connected is active. Confirm that the port settings are correct per the RS-232 instructions in this manual (Check the RS-232 / RS-485 communications select screen for current meter readings). Close Hyperterminal® and reopen it. Reboot your PC. See pages 10, 11 and 27 for more information on RS-232 / RS-485 signals and communications.

Slower response than specified.
MC Series Controllers feature a programmable Geometric Running Average (GRA). Depending on the full scale range of the meter, it may have the GRA set to enhance the stability/readability of the display, which would result in slower perceived response time. Please see “Pressure Averaging” and “Flow Averaging” on page 24.

Jumps to zero at low flow.
MC Series Controllers feature a programmable zero deadband. The factory setting is usually 0.5% of full scale. This can be adjusted between NONE and 3.2% of full scale. See page 24.

Discrepancies between old and new units.
Please see “Standard Gas Data Tables” explanation on page 38.

Maintenance and Recalibration

General: MC Series Flow Controllers require minimal maintenance. They have no moving parts. The single most important thing that affects the life and accuracy of these devices is the quality of the gas being measured. The controller is designed to measure CLEAN, DRY, NON-CORROSIVE gases. A 20 micron filter (50 micron for 50LPM and up) mounted upstream of the controller is highly recommended. Moisture, oil, and other contaminants can affect the laminar flow elements and/or reduce the area that is used to calculate the flow rate. This directly affects the accuracy.

Recalibration: The recommended period for recalibration is once every year. A label located on the back of the controller lists the most recent calibration date. The controller should be returned to the factory for recalibration within one year from the listed date. Before calling to schedule a recalibration, please note the serial number on the back of the instrument. The Serial Number, Model Number, and Date of Manufacture are also available on the Model Info display (page 25).

Cleaning: MC Series Flow Controllers require no periodic cleaning. If necessary, the outside of the controller can be cleaned with a soft dry cloth. Avoid excess moisture or solvents.

For repair, recalibration or recycling of this product contact:

Alicat Scientific, Inc.
7641 N Business Park Drive
Tucson, Arizona 85743
USA
Ph. 520-290-6060
Fax 520-290-0109
e-mail: info@alicat.com
Web site: www.alicat.com

Technical Data for Micro-Flow and Ultra-Low Flow MC Mass Flow Controllers

0 to 0.5SCCM Full Scale through 0 to 50SCCM Full Scale

The following specifications are for the standard configuration of the product. There are many options available.

Specification	Mass Controller	Description
Accuracy	± (0.8% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
High Accuracy Option	± (0.4% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
Repeatability	± 0.2%	Full Scale
Operating Range	1/2% to 100%	Full Scale
Turndown Ratio	200 : 1	
Typical Response Time	100	Milliseconds (Adjustable)
Standard Conditions (STP)	25ºC & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to +50	ºCelsius
Zero Shift	0.02%	Full Scale / ºCelsius / Atm
Span Shift	0.02%	Full Scale / ºCelsius / Atm
Humidity Range	0 to 100%	Non–Condensing
Controllable Flow Rate	102.4%	Full Scale
Maximum Pressure	145	PSIG
Input /Output Signal Digital	Mass Flow, Volumetric Flow, Pressure & Temperature	RS-232 Serial or RS-485 Serial or PROFIBUS or DeviceNet™[2]
Input / Output Signal Analog	Mass Flow	0-5Vdc
Optional Input / Output Signal Secondary Analog	Mass Flow, Volumetric Flow, Pressure or Temperature	0-5 Vdc or 0-10Vdc or 4-20mA
Electrical Connections	8 Pin Mini-DIN, DB9 or DB15	
Supply Voltage	12 to 30 Vdc (15-30Vdc for 4-20mA outputs)	
Supply Current	0.250Amp	
Mounting Attitude Sensitivity	None	
Warm-up Time	< 1	Second
Wetted Materials[2]	303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, Brass, 430FR Stainless Steel, Silicon, Glass.	

1. If selecting PROFIBUS or DeviceNet™ no analog signal is available. PROFIBUS / DeviceNet™ units do not have the display. See PROFIBUS or DeviceNet™ specifications for PROFIBUS or DeviceNet™ supply voltages and currents.
2. If your application demands a different material, please contact info@alicat.com or 888-290-6060 for available options.

Mechanical Specifications

Full Scale Flow Mass Controller	Mechanical Dimensions	Process Connections[1]	Pressure Drop[2] (PSID)
0.5SCCM to 50SCCM	3.9”H x 3.4”W x 1.1”D	**M-5 (10-32) Female Thread***	1.0

Units ≤50SCCM F.S. are shipped with M-5 (10-32) Male Buna-N O-ring face seal to 1/8” Female NPT fittings.
These adaptor fittings were selected for customer convenience in process connection. It should be noted that the 1/8” Female NPT introduces additional dead volume. To minimize dead volume, please see Accessories for the M-5 (10-32) Male to 1/8”OD compression fitting.

1. Compatible with Beswick®, Swagelok® tube, Parker®, face seal, push connect and compression adapter fittings.
2. Venting to atmosphere. Lower Pressure Drops Available, Please contact info@alicat.com or 888-290-6060.

0.5SCCM to 50SCCM approximate shipping weight: 1.1 lb.

Technical Data for Low Flow MC Mass Flow Controllers

0 to 100SCCM Full Scale through 0 to 20SLPM Full Scale

The following specifications are for the standard configuration of the product. There are many options available.

Specification	Mass Controller	Description
Accuracy	± (0.8% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
High Accuracy Option	± (0.4% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
Repeatability	± 0.2%	Full Scale
Operating Range	1/2% to 100%	Full Scale
Turndown Ratio	200 : 1	
Typical Response Time	100	Milliseconds (Adjustable)
Standard Conditions (STP)	25ºC & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to +50	ºCelsius
Zero Shift	0.02%	Full Scale / ºCelsius / Atm
Span Shift	0.02%	Full Scale / ºCelsius / Atm
Humidity Range	0 to 100%	Non–Condensing
Controllable Flow Rate	102.4%	Full Scale
Maximum Pressure	145	PSIG
Input /Output Signal Digital	Mass Flow, Volumetric Flow, Pressure & Temperature	RS-232 Serial or RS-485 Serial or PROFIBUS or DeviceNet™[2]
Input / Output Signal Analog	Mass Flow	0-5Vdc
Optional Input / Output Signal Secondary Analog	Mass Flow, Volumetric Flow, Pressure or Temperature	0-5 Vdc or 0-10Vdc or 4-20mA
Electrical Connections	8 Pin Mini-DIN, DB9 or DB15	
Supply Voltage	12 to 30 Vdc (15-30Vdc for 4-20mA outputs)	
Supply Current	0.250Amp (at 12 Vdc, declining with increased supply voltage)	
Mounting Attitude Sensitivity	None	
Warm-up Time	< 1	Second
Wetted Materials[2]	303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, Brass, 430FR Stainless Steel, Silicon, Glass.	

1. If selecting PROFIBUS or DeviceNet™ no analog signal is available. PROFIBUS / DeviceNet™ units do not have the display. See PROFIBUS or DeviceNet™ specifications for PROFIBUS or DeviceNet™ supply voltages and currents.
2. If your application demands a different material, please contact info@alicat.com or 888-290-6060 for available options.

Mechanical Specifications

Full Scale Flow Mass Controller	Mechanical Dimensions	Process Connections[1]	Pressure Drop[2] (PSID)
100SCCM to 500SCCM	4.1”H x 3.6”W x 1.1”D	1/8” NPT Female	1.0
1SLPM			1.5
2SLPM			3.0
5SLPM			2.0
10SLPM			5.5
20SLPM			20.0

1. Compatible with Beswick®, Swagelok® tube, Parker®, face seal, push connect and compression adapter fittings.
2. Lower Pressure Drops Available, Please contact info@alicat.com or 888-290-6060.

100SCCM to 20SLPM approximate weight: 1.2lb

Technical Data for Moderate Flow MC Mass Flow Controllers

0 to 50SLPM Full Scale through 0 to 100SLPM Full Scale

The following specifications are for the standard configuration of the product. There are many options available.

Specification	Mass Controller	Description
Accuracy	± (0.8% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
High Accuracy Option	± (0.4% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
Repeatability	± 0.2%	Full Scale
Operating Range	1/2% to 100%	Full Scale
Turndown Ratio	200 : 1	
Typical Response Time	100	Milliseconds (Adjustable)
Standard Conditions (STP)	25ºC & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to +50	ºCelsius
Zero Shift	0.02%	Full Scale / ºCelsius / Atm
Span Shift	0.02%	Full Scale / ºCelsius / Atm
Humidity Range	0 to 100%	Non–Condensing
Controllable Flow Rate	102.4%	Full Scale
Maximum Pressure	50SLPM = 145 100SLPM = 130	PSIG
Input /Output Signal Digital	Mass Flow, Volumetric Flow, Pressure & Temperature	RS-232 Serial or RS-485 Serial or PROFIBUS or DeviceNet™[2]
Input / Output Signal Analog	Mass Flow	0-5Vdc
Optional Input / Output Signal Secondary Analog	Mass Flow, Volumetric Flow, Pressure or Temperature	0-5 Vdc or 0-10Vdc or 4-20mA
Electrical Connections	8 Pin Mini-DIN, DB9 or DB15	
Supply Voltage	24 to 30 Vdc	
Supply Current	0.750Amp	
Mounting Attitude Sensitivity	Control response somewhat sensitive to inverted operation.	
Warm-up Time	< 1	Second
Wetted Materials[2]	303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, 416 Stainless Steel, Nickel, Silicon, Glass.	

1. If selecting PROFIBUS or DeviceNet™ no analog signal is available. PROFIBUS / DeviceNet™ units do not have the display. See PROFIBUS or DeviceNet™ specifications for PROFIBUS or DeviceNet™ supply voltages and currents.
2. If your application demands a different material, please contact info@alicat.com or 888-290-6060 for available options.

Mechanical Specifications

Full Scale Flow Mass Controller	Mechanical Dimensions	Process Connections[1]	Pressure Drop[2] (PSID)
50SLPM	4.4”H x 6.4”W x 2.3”D	1/4” NPT Female	9.0
100SLPM			11.7

1. Compatible with Beswick®, Swagelok® tube, Parker®, face seal, push connect and compression adapter fittings.
2. Lower Pressure Drops Available, Please contact info@alicat.com or 888-290-6060.

50SLPM to 100SLPM approximate weight: 6.4 lb.

Technical Data for High Flow MCR Mass Flow Controllers

0 to 100SLPM Full Scale through 0 to 3000SLPM Full Scale

The following specifications are for the standard configuration of the product. There are many options available.

Specification	Mass Controller	Description
Accuracy	± (0.8% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
High Accuracy Option[1]	± (0.4% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
Repeatability	± 0.2%	Full Scale
Operating Range	1/2% to 100%	Full Scale
Turndown Ratio	200 : 1	
Typical Response Time	100	Milliseconds (Adjustable)
Standard Conditions (STP)	25ºC & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to +50	ºCelsius
Zero Shift	0.02%	Full Scale / ºCelsius / Atm
Span Shift	0.02%	Full Scale / ºCelsius / Atm
Humidity Range	0 to 100%	Non–Condensing
Controllable Flow Rate	102.4%	Full Scale
Maximum Pressure	145	PSIG
Input /Output Signal Digital	Mass Flow, Volumetric Flow, Pressure & Temperature	RS-232 Serial or RS-485 Serial or PROFIBUS or DeviceNet™[2]
Input / Output Signal Analog	Mass Flow	0-5Vdc
Optional Input / Output Signal Secondary Analog	Mass Flow, Volumetric Flow, Pressure or Temperature	0-5 Vdc or 0-10Vdc or 4-20mA
Electrical Connections	8 Pin Mini-DIN, DB9 or DB15	
Supply Voltage	24 to 30 Vdc	
Supply Current	0.750Amp	
Mounting Attitude Sensitivity	Control response somewhat sensitive to inverted operation.	
Warm-up Time	< 1	Second
Wetted Materials[3]	303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, 416 Stainless Steel, Nickel, Silicon, Glass.	

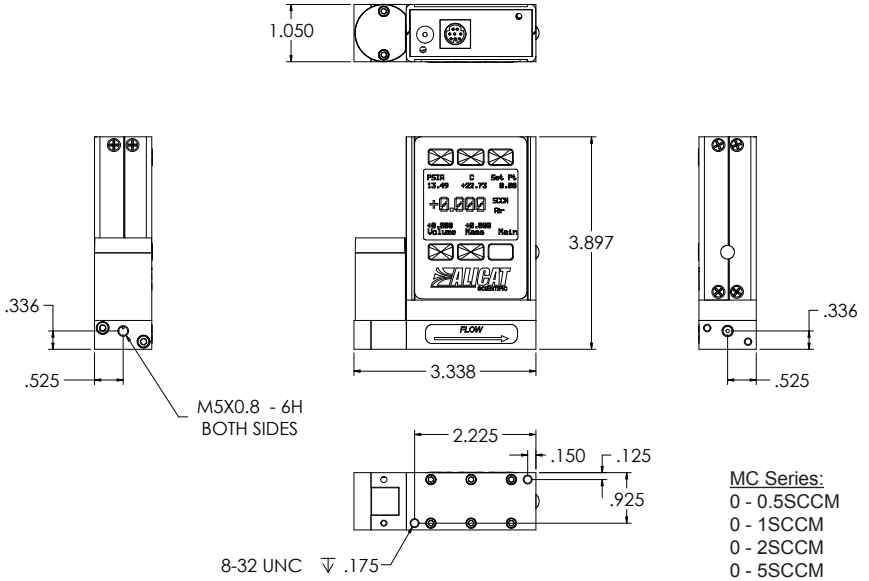
1. High Accuracy option not available for units ranged over 500SLPM.
2. If selecting PROFIBUS or DeviceNet™ no analog signal is available. PROFIBUS / DeviceNet™ units do not have the display. See PROFIBUS or DeviceNet™ specifications for PROFIBUS or DeviceNet™ supply voltages and currents.
3. If your application demands a different material, please contact info@alicat.com or 888-290-6060 for available options.

Mechanical Specifications

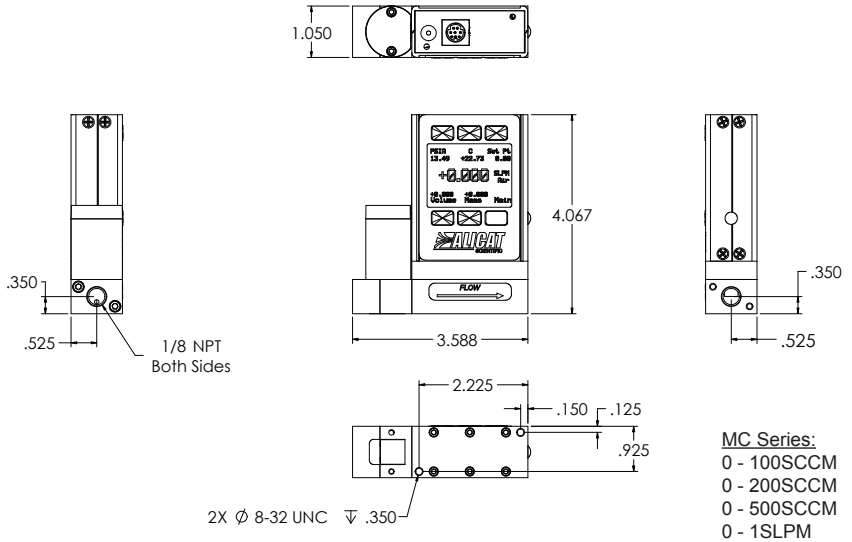
Full Scale Flow Mass Controller	Mechanical Dimensions	Process Connections[1]	Pressure Drop[2] (PSID)
100SLPM	5.5”H x 7.7”W x 2.3”D	1/4” NPT Female	3.2
250SLPM	5.5”H x 7.7”W x 2.3”D	1/2” NPT Female	2.4
500SLPM	5.5”H x 7.4”W x 2.3”D	3/4” NPT Female	6.5
1000SLPM			14.0
1500SLPM			17.0
2000SLPM	5.5”H x 8.1” W x 2.9” D		28.6
3000SLPM	5.5”H x 8.9” W x 2.9” D	1-1/4” NPT Female	16.8

1. Compatible with Beswick®, Swagelok® tube, Parker®, face seal, push connect and compression adapter fittings.
2. Venting to atmosphere. Lower Pressure Drops Available, Please contact info@alicat.com or 888-290-6060.

MCR-100SLPM to 1500SLPM approximate weight: 9.0 lb.
MCR-2000SLPM to 3000SLPM approximate weight: 12.0 lb.

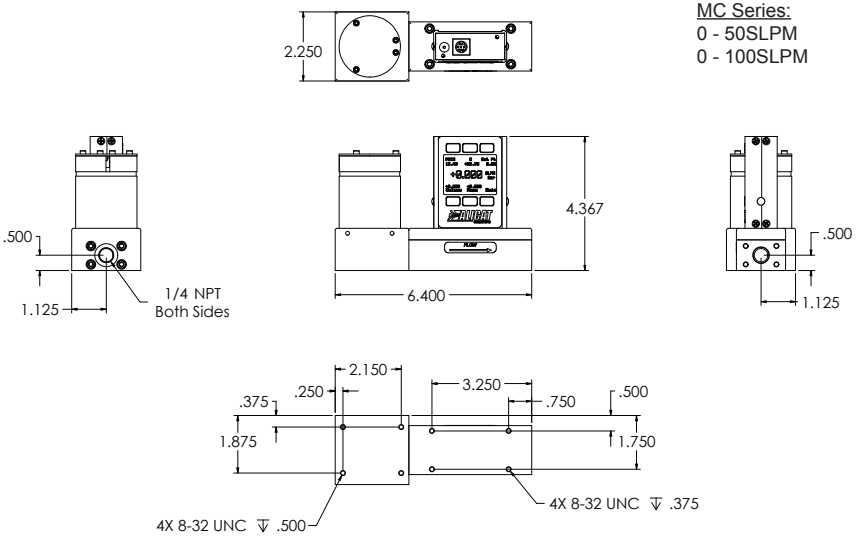


MC Series:
0 - 0.5SCCM
0 - 1SCCM
0 - 2SCCM
0 - 5SCCM
0 - 10SCCM
0 - 20SCCM
0 - 50SCCM

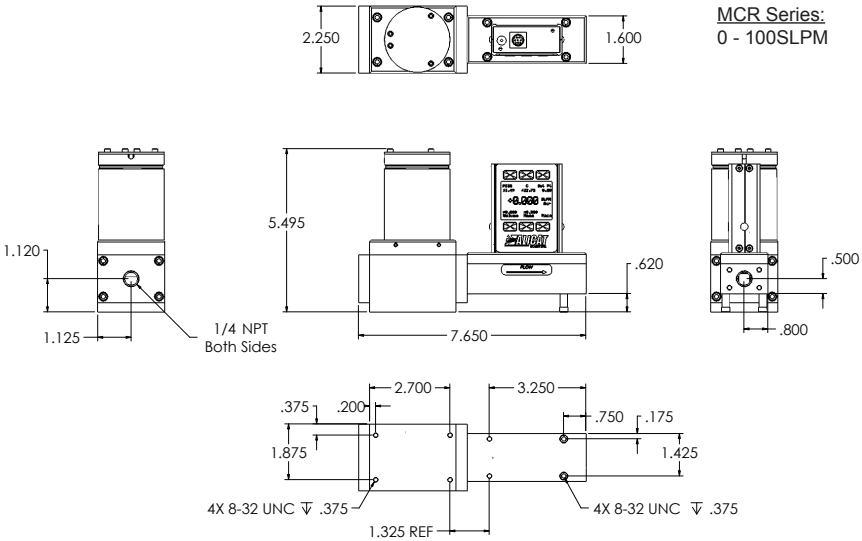


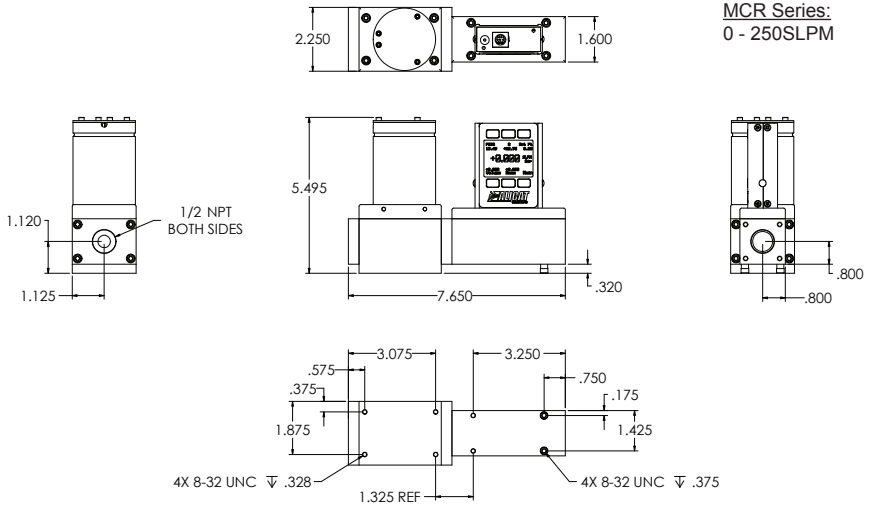
MC Series:
0 - 100SCCM
0 - 200SCCM
0 - 500SCCM
0 - 1SLPM
0 - 2SLPM
0 - 3SLPM
0 - 5SLPM
0 - 10SLPM
0 - 20SLPM

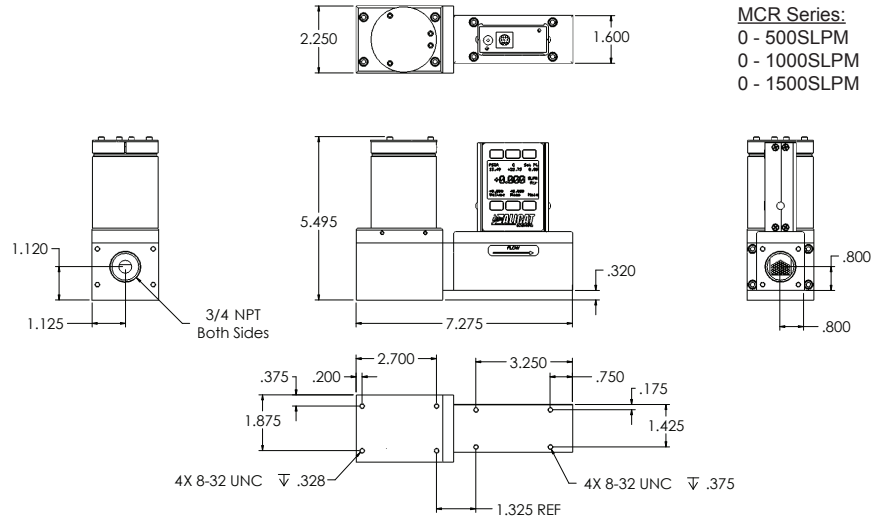
MC Series:
0 - 50SLPM
0 - 100SLPM



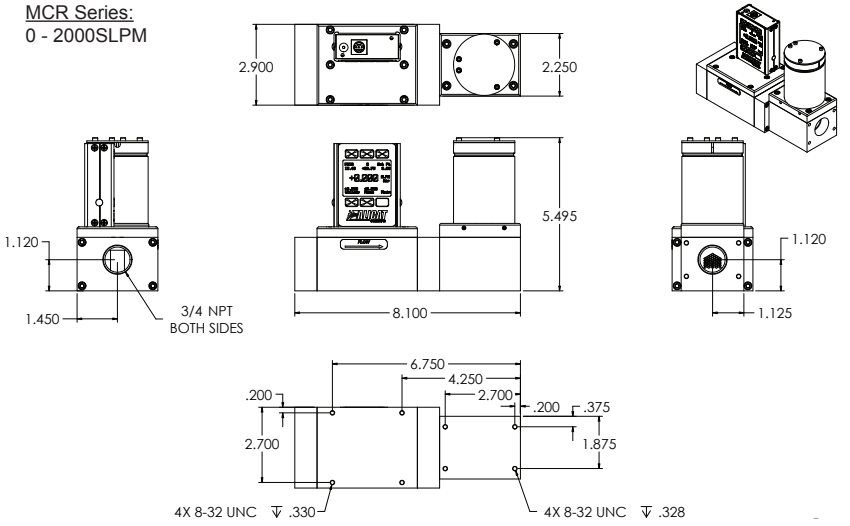
MCR Series:
0 - 100SLPM



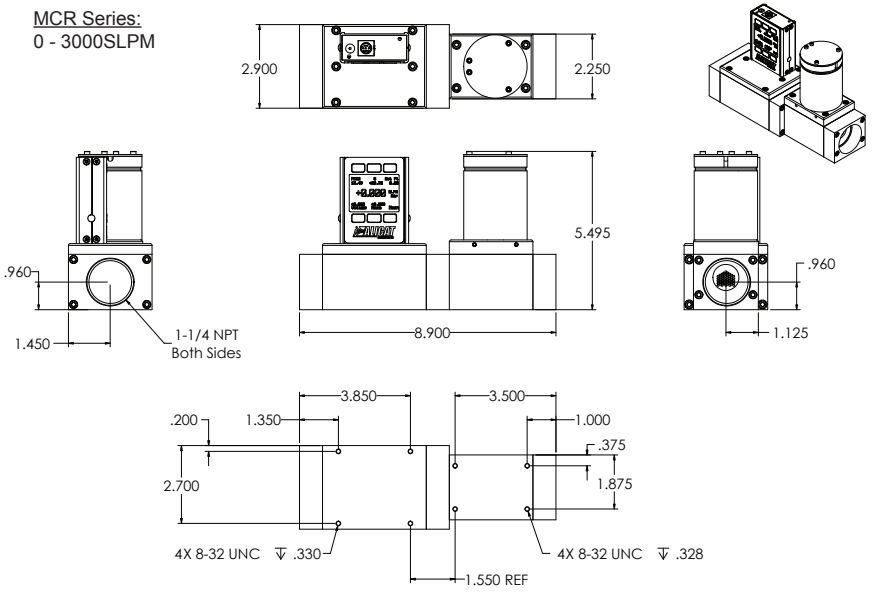

MCR Series:
0 - 250SLPM
2.250
1.600
1.120
1/2 NPT
BOTH SIDES
1.125
5.495
7.650
.320
.800
.800
3.075
3.250
.575
.375
.750
.175
1.875
1.425
4X 8-32 UNC ↧ .328
1.325 REF
4X 8-32 UNC ↧ .375


MCR Series:
0 - 500SLPM
0 - 1000SLPM
0 - 1500SLPM
2.250
1.600
1.120
1.125
3/4 NPT
Both Sides
5.495
7.275
.320
.800
.800
2.700
3.250
.375
.200
.750
.175
1.875
1.425
4X 8-32 UNC ↧ .328
1.325 REF
4X 8-32 UNC ↧ .375

MCR Series:
0 - 2000SLPM



MCR Series:
0 - 3000SLPM



Technical Data for MCV Mass Flow Controller for Vacuum Applications
0 to 0.5SCCM Full Scale through 0 to 20SLPM Full Scale

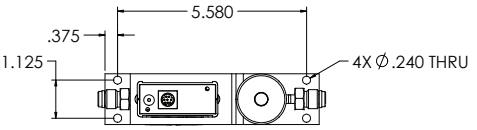
Specification	MCV Mass Controller	Description
Accuracy	± (0.8% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
High Accuracy Option[1]	± (0.4% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
Repeatability	± 0.2%	Full Scale
Operating Range	1/2% to 100%	Full Scale
Turndown Ratio	200 : 1	
Typical Response Time	100	Milliseconds (Adjustable)
Standard Conditions (STP)	25ºC & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to +50	ºCelsius
Zero Shift	0.02%	Full Scale / ºCelsius / Atm
Span Shift	0.02%	Full Scale / ºCelsius / Atm
Humidity Range	0 to 100%	Non–Condensing
Controllable Flow Rate	102.4%	Full Scale
Maximum Pressure	145	PSIG
Input /Output Signal Digital	Mass Flow, Volumetric Flow, Pressure & Temperature	RS-232 Serial or RS-485 Serial or PROFIBUS or DeviceNet™[2]
Input / Output Signal Analog	Mass Flow	0-5Vdc
Optional Input / Output Signal Secondary Analog	Mass Flow, Volumetric Flow, Pressure or Temperature	0-5 Vdc or 0-10Vdc or 4-20mA
Electrical Connections	8 Pin Mini-DIN, DB9 or DB15	
Supply Voltage	12 to 30 Vdc (15-30Vdc for 4-20mA outputs)	
Supply Current	0.300Amp	
Mounting Attitude Sensitivity	None	
Warm-up Time	< 1	Second
Integrated Valve Leak Integrity	1 x 10^{-9} atm sccm/sec Helium max	
Wetted Materials[3]	316L,303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, Brass, 430FR Stainless Steel, Silicon, Glass, PCTFE.	

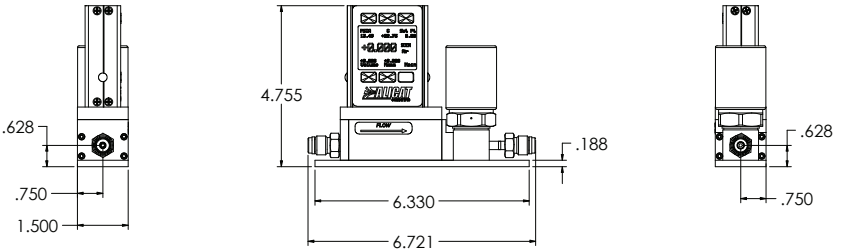
1. High Accuracy Option not available for ranges below 5SCCM.
2. If selecting PROFIBUS or DeviceNet™ no analog signal is available. PROFIBUS / DeviceNet™ units do not have the display. See PROFIBUS or DeviceNet™ specifications for PROFIBUS or DeviceNet™ supply voltages and currents.
3. If your application demands a different material, please contact info@alicat.com or 888-290-6060 for available options.

Mechanical Specifications

Full Scale Flow MCV Controller	Mechanical Dimensions	Process Connections
0.5SCCM to 20SLPM	4.8"H x 6.8"W x 1.5"D	1/4" VCR® Male
Welded VCR® fittings (process connections) are recommended for MCV applications. Please contact Alicat.		

MCV Series
All ranges





Technical Data for MCP Moderate Flow Mass Flow Controllers

0 to 50SLPM Full Scale through 0 to 250SLPM Full Scale

NOTICE: The following specifications are applicable to Alicat MCP Series Mass Flow Controllers only. **Please note maximum pressure of 80 PSIG.**

Specification	Mass Controller	Description
Accuracy	± (0.8% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
High Accuracy Option	± (0.4% of Reading + 0.2% of Full Scale)	At calibration conditions after tare
Repeatability	± 0.2%	Full Scale
Operating Range	1% to 100%	Full Scale
Turndown Ratio	200 : 1	
Typical Response Time	100	Milliseconds (Adjustable)
Standard Conditions (STP)	25ºC & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to +50	ºCelsius
Zero Shift	0.02%	Full Scale / ºCelsius / Atm
Span Shift	0.02%	Full Scale / ºCelsius / Atm
Humidity Range	0 to 100%	Non–Condensing
Controllable Flow Rate	102.4%	Full Scale
Maximum Pressure	80	PSIG
Input /Output Signal Digital	Mass, Volumetric, Pressure & Temperature	RS-232 Serial
Input / Output Signal Analog	Mass Flow	0-5Vdc
Optional Input / Output Signal Secondary Analog	Mass, Volumetric, Pressure or Temperature	0-5 Vdc or 0-10Vdc or 4-20mA
Electrical Connections	8 Pin Mini-DIN, DB9 or DB15	
Supply Voltage	12 to 30 Vdc	
Supply Current	0.250Amp	
Mounting Attitude Sensitivity	None	
Warm-up Time	< 1	Second
Wetted Materials[2]	303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, Brass, 410 &416 Stainless Steel.	

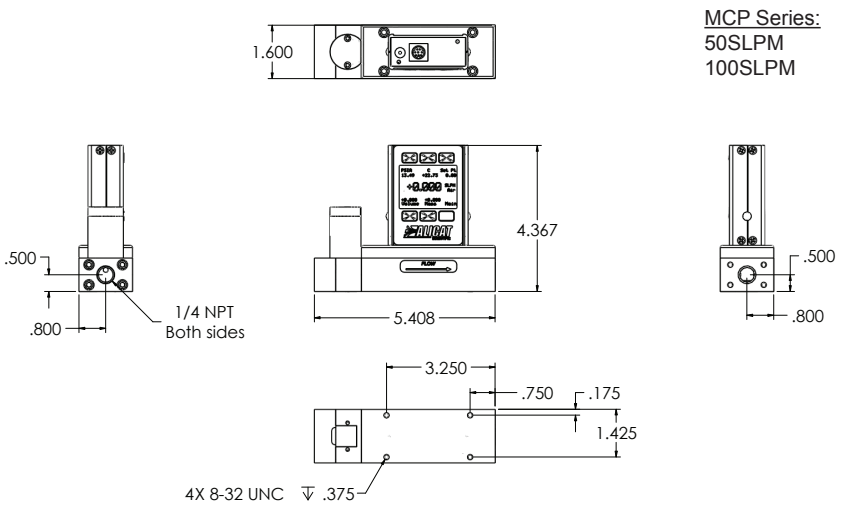
1. If your application demands a different material, please contact Info@alicat.com or 888-290-6060 for available options.

Mechanical Specifications

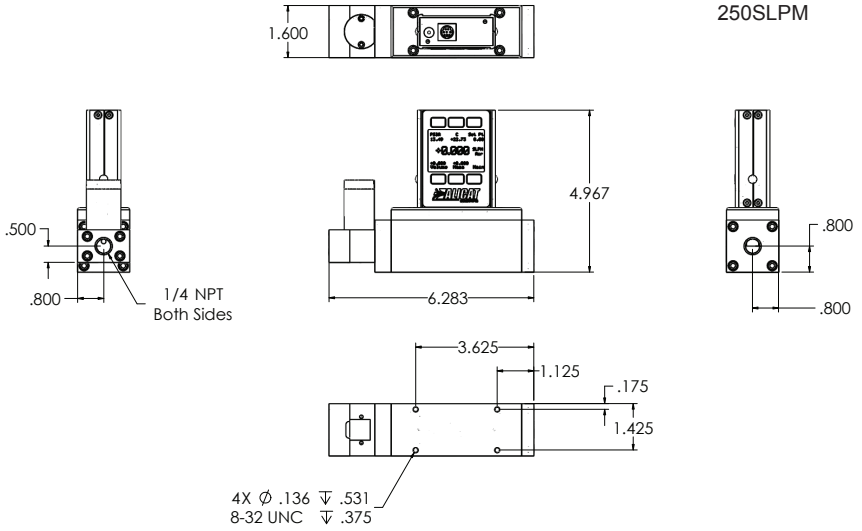
Full Scale Flow Mass Controller	Mechanical Dimensions	Process Connections[1]	Pressure Drop[2] (PSID)
50SLPM	4.4”H x 5.4”W x 1.6”D	1/4” NPT Female	7
100SLPM			20
250SLPM	5.0”H x 6.3”W x 1.6”D	1/4” NPT Female	60

1. Compatible with Beswick®, Swagelok® tube, Parker®, face seal, push connect and compression adapter fittings.
2. Lower Pressure Drops Available, Please contact Info@alicat.com or 888-290-6060.

MCP Series:
50SLPM
100SLPM



MCP Series:
250SLPM



Technical Data for Alicat MCS and MCRS Series Mass Flow Controllers

Alicat MCS and MCRS instruments are built for use with aggressive gases. For the most part, these instruments maintain the specifications of equivalently ranged MC and MCR Series devices.

Standard Compatible Gas List for MCS and MCRS Controllers

0	Air	Air
1	Argon	Ar
2	Methane	CH4
3	Carbon Monoxide	CO
4	Carbon Dioxide	CO2
5	Ethane	C2H6
6	Hydrogen	H2
7	Helium	He
8	Nitrogen	N2
9	Nitrous Oxide	N2O
10	Neon	Ne
11	Oxygen	O2
12	Propane	C3H8
13	normal-Butane	n-C4H10
14	Acetylene	C2H2
15	Ethylene	C2H4
16	iso-Butane	i-C4H10
17	Krypton	Kr
18	Xenon	Xe
19	Sulfur Hexafluoride	SF6
20	75%Ar / 25% CO2	C-25
21	90% Ar / 10% CO2	C-10
22	92% Ar / 8% CO2	C-8
23	98% Ar / 2% CO2	C-2
24	75% CO2 / 25% Ar	C-75
25	75% Ar / 25% He	A-75
26	75% He / 25% Ar	A-25
27	90% He / 7.5% Ar / 2.5% CO2 Helistar® A1025	A1025
28	90% Ar / 8% CO2 / 2% O2 Stargon® CS	Star29
29	95% Ar / 5% CH4	P-5
30	Nitric Oxide	NO
31	Nitrogen Triflouride	NF3
32	Ammonia	NH3
34	Hydrogen Sulfide	H2S
36	Propylene	C3H6
In addition, the following gases are available upon request:		
Nitrogen Dioxide to 0.5% in an inert carrier		NO2
Refrigerant gases to 100%		
Other gases to 1000 ppm in an inert carrier		

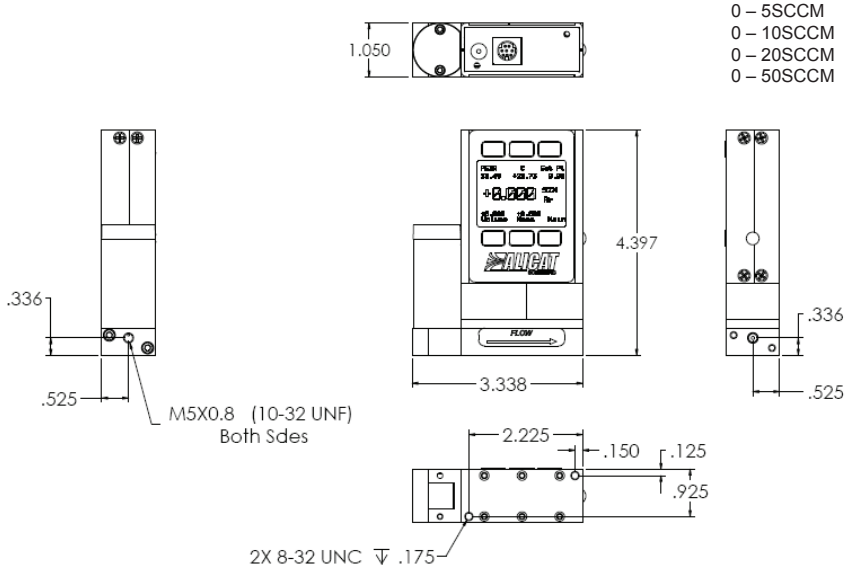
If your application requires another gas or gas mixture, please contact Info@alicat.com or call 888-290-6060.

Please refer to Alicat's Technical Data and Specifications for the equivalently ranged MC and MCR Series instrument for all operating specifications except:

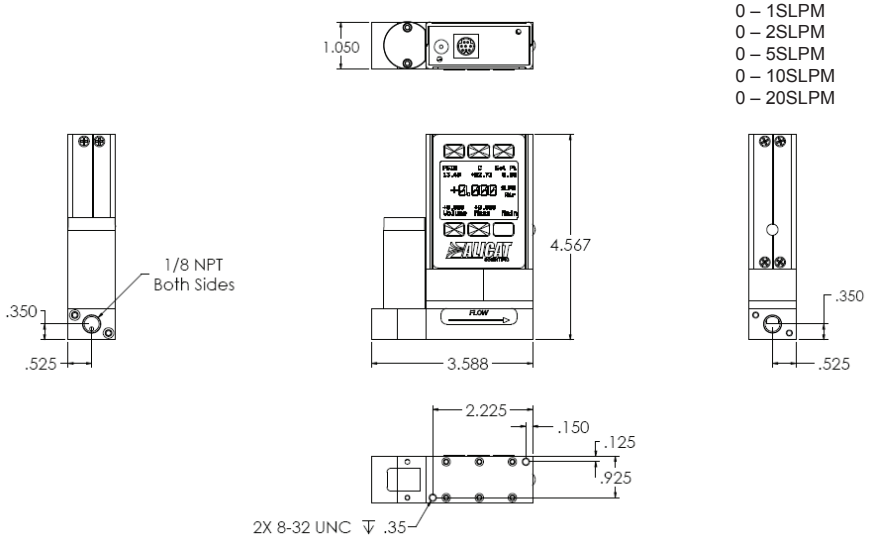
Operating Range	1% to 100%	Full Scale
Turndown Ratio	100 : 1	
Wetted Materials	316LSS, 303SS, 430FRSS, FFKM (Kalrez) standard, Viton, EPDM as needed for some gases.	

The dimensions of MCS and MCRS instruments may vary from their standard MC and MCR Series counterparts. Dimensional drawings for MCS and MCRS instruments are shown on pages 56 -60

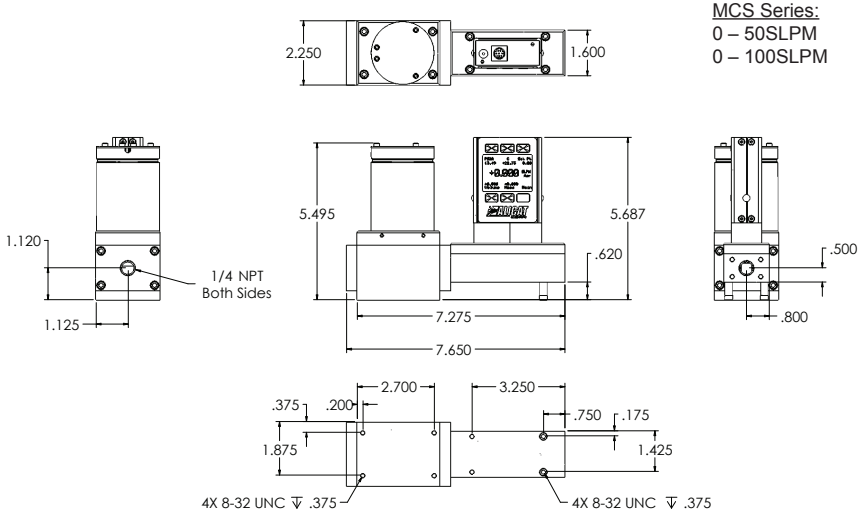
MCS Series:
0 – 0.5SCCM
0 – 1SCCM
0 – 2SCCM
0 – 5SCCM
0 – 10SCCM
0 – 20SCCM
0 – 50SCCM



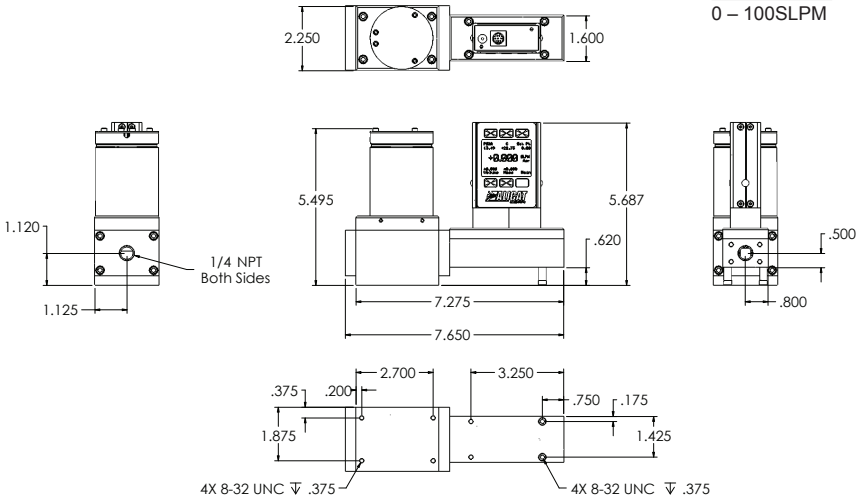
MCS Series:
0 – 100SCCM
0 – 200SCCM
0 – 500SCCM
0 – 1SLPM
0 – 2SLPM
0 – 5SLPM
0 – 10SLPM
0 – 20SLPM



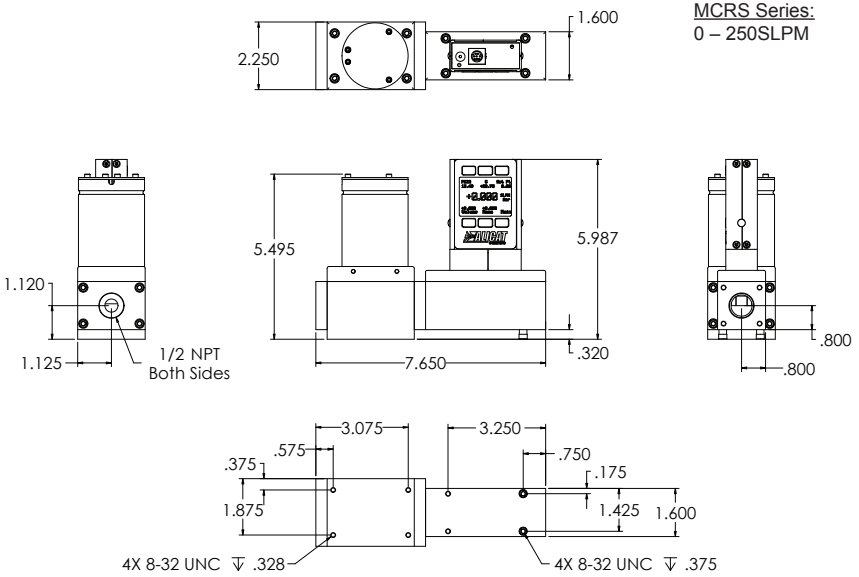
MCS Series:
0 – 50SLPM
0 – 100SLPM



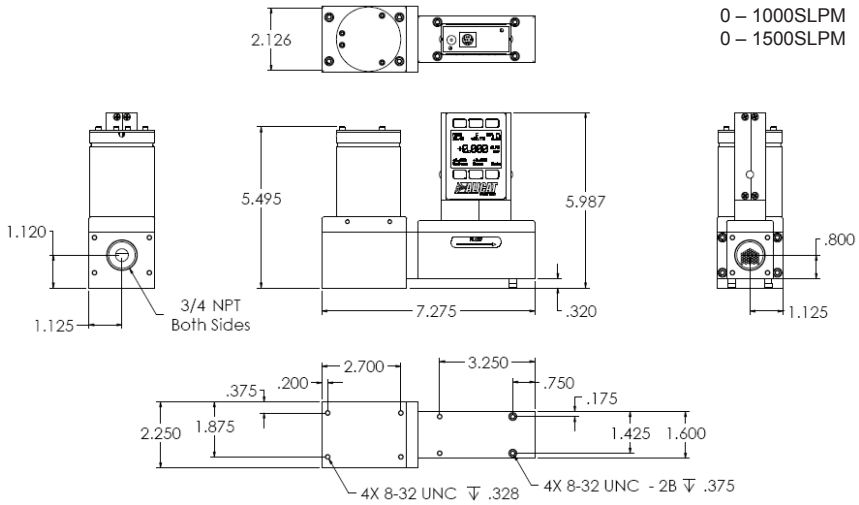
MCRS Series:
0 – 100SLPM



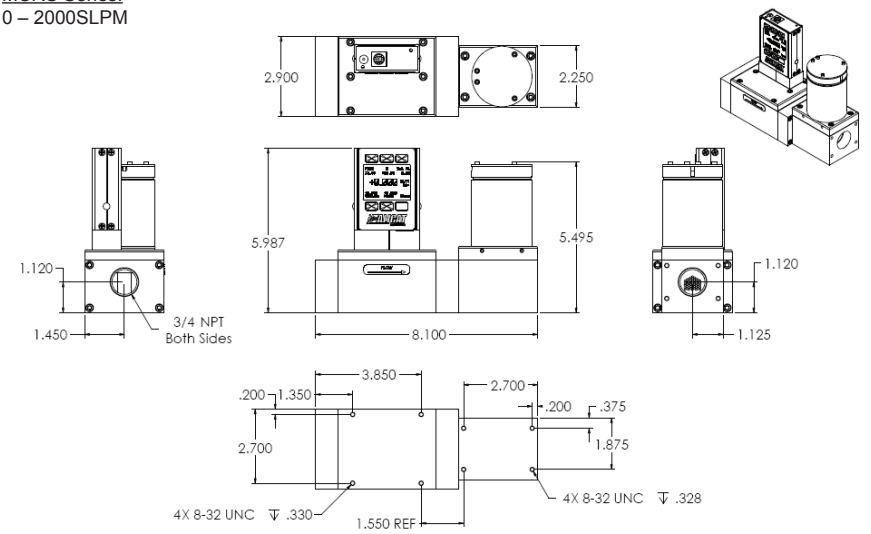
MCRS Series:
0 – 250SLPM



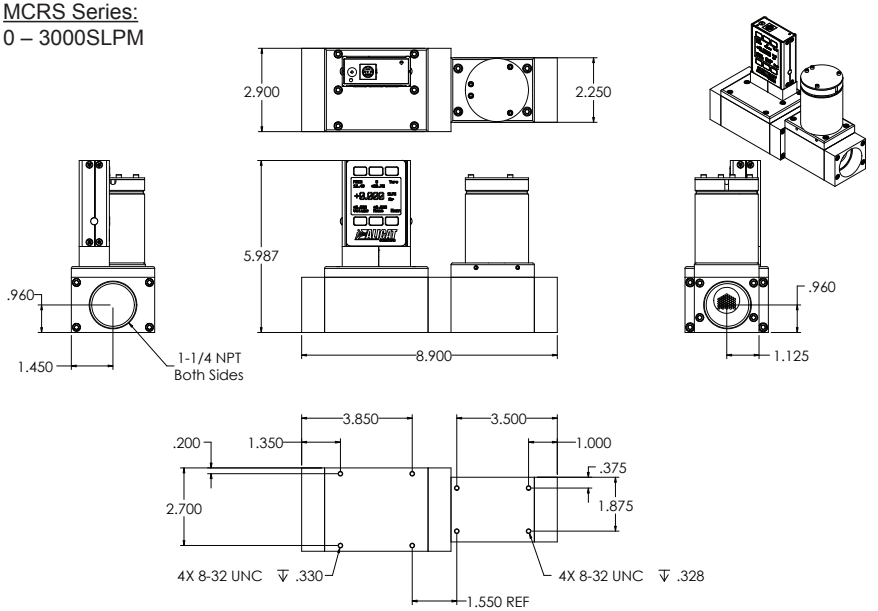
MCRS Series:
0 – 500SLPM
0 – 1000SLPM
0 – 1500SLPM



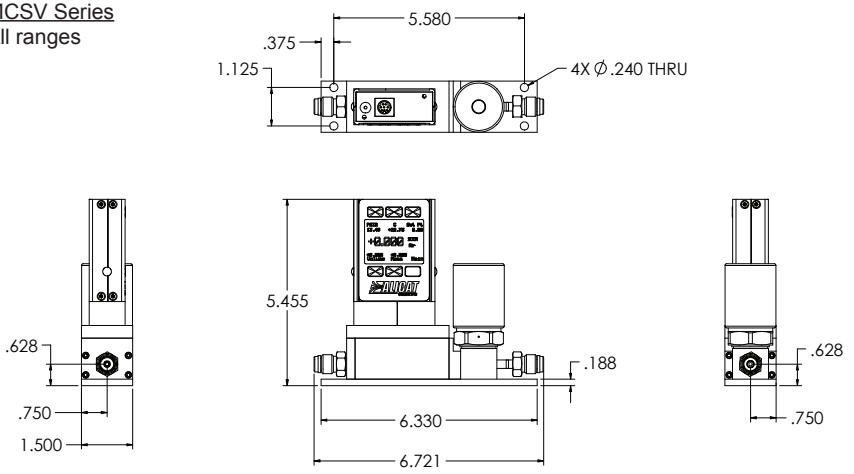
MCRS Series:
0 – 2000SLPM



MCRS Series:
0 – 3000SLPM



MCSV Series
All ranges



Technical Data for Alicat MCQ and MCRQ Series Mass Flow Controllers

Alicat MCQ and MCRQ units are for high pressure applications. The flow rate is dependent on the pressure in that lower pressures will yield lower flow rates. The Q series devices are highly specialized and should only be ordered after consulting Alicat.

MCQ units are calibrated for operation at high pressure. Optimal performance is achieved at higher operating pressures.

Minimum Operating Pressure – 30PSIA

Maximum Operating Pressure – 320PSIA

NOTE: Volumetric flow is reduced as compared to mass range with a typical 50% reduction. This may vary based on application or customer requirements.

MCQ Flow rates with 0.010" valves

	Pressure PSIG									
Gas	30	60	90	120	150	180	210	240	270	300
Acetylene	1.43	2.38	3.34	4.30	5.25	6.21	7.17	8.12	9.08	10.04
Air	1.44	2.41	3.37	4.34	5.31	6.27	7.24	8.21	9.17	10.14
Argon	1.34	2.24	3.14	4.03	4.93	5.83	6.73	7.63	8.53	9.43
Butane										
Carbon Dioxide	1.13	1.89	2.65	3.41	4.17	4.93	5.69	6.45	7.21	7.97
Carbon Monoxide	1.47	2.45	3.43	4.42	5.40	6.39	7.37	8.36	9.34	10.32
Deuterium	3.86	6.45	9.04	11.63	14.23	16.82	19.41	22.00	24.59	27.18
Ethane	1.30	2.18	3.05	3.93	4.80	5.68	6.56	7.43	8.31	9.18
Ethylene	1.38	2.30	3.23	4.16	5.08	6.01	6.93	7.86	8.78	9.71
Helium	4.18	6.98	9.79	12.59	15.40	18.20	21.01	23.81	26.62	29.43
Hydrogen	5.47	9.14	12.81	16.48	20.15	23.82	27.49	31.16	34.83	38.50
Iso-Butane	0.90									
Krypton	0.92	1.54	2.16	2.78	3.40	4.02	4.64	5.26	5.88	6.50
Methane	1.87	3.12	4.38	5.63	6.88	8.14	9.39	10.64	11.90	13.15
Neon	1.87	3.12	4.38	5.63	6.88	8.14	9.39	10.64	11.90	13.15
Nitrogen	1.47	2.45	3.44	4.42	5.41	6.39	7.38	8.36	9.35	10.33
Nitrous Oxide	1.13	1.88	2.64	3.40	4.15	4.91	5.67	6.42	7.18	7.93
Oxygen	1.38	2.30	3.22	4.15	5.07	6.00	6.92	7.85	8.77	9.69
Propane	1.05	1.76	2.47	3.18						
Propylene	1.08	1.81	2.54	3.27	4.00					
Sulfur Hexafluoride	0.57	0.95	1.33	1.71	2.09	2.47	2.85	3.24	3.62	4.00
Xenon	0.74	1.23	1.72	2.22	2.71	3.21	3.70	4.20	4.69	5.18

The physical dimensions of the MCQ and MCRQ controllers are equal to those of equally ranged MCS and MCRS units. See pages 56-60

NOTICE: The following specifications are applicable to Alicat PROFIBUS enabled meters, gauges and controllers only.

All other operating specifications are shown in the Technical Data page for standard Alicat instruments.

All standard device features and functions are available and operate in accordance with the standard Alicat Scientific device operating manual provided with the device.

Specification	Meter or Gauge	Small Valve Controller	Large Valve Controller	Description
Input /Output Signal Digital				PROFIBUS DP
Electrical Connections	DB9			
Supply Voltage:	7 to 30 Vdc	12 to 30 Vdc	24 to 30 Vdc	
Supply Current	80mA @ 12Vdc 65mA @ 24Vdc	295mA @ 12Vdc 280mA @ 24Vdc	780mA @ 24Vdc	

Power and Signal Connections:

Connect to the device using two DB9 connectors.

The female top connection is PROFIBUS.

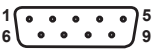
The male connection on the side is power and RS-232 or RS-485.

Pin out diagrams for all PROFIBUS enabled Alicat devices are shown:

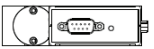
TOP

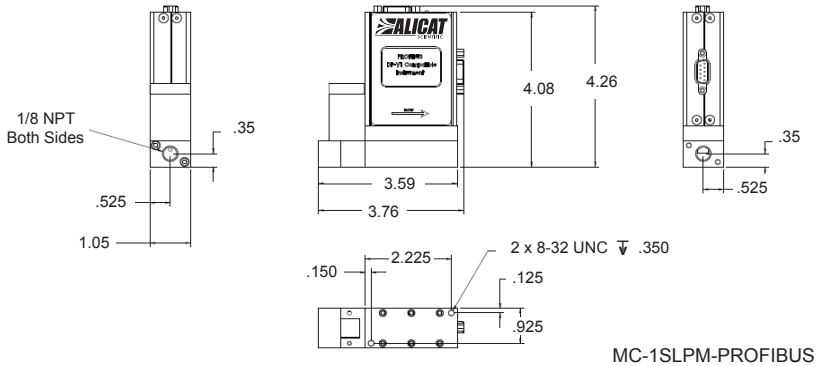
1. NC
2. OPT GND
3. DP
4. RTS
5. DGD
6. VP
7. OPT 7 to 30VDC
8. DN
9. NC

SIDE



1. NC
2. RS232RX
3. RS232TX
4. NC
5. GND
6. NC
7. 7 to 30VDC
8. GND
9. NC





MC-1SLPM-PROFIBUS

PROFIBUS MC1SLPM shown to provide PROFIBUS connector dimensions only. Flow body and valve dimensions will vary with range. Please see Alicat's device specifications for complete dimensions.

PROFIBUS units do not have a display screen.

Information for Alicat DeviceNet™ Compatible Instruments

DeviceNet™ OVERVIEW

Alicat DeviceNet™ compatible instruments support the Predefined Master/ Slave Connection Set.

There are two connectors on the Alicat meter/controller. The DeviceNet™ standard M12 Micro Connector found on the top of the unit is required for DeviceNet™ operations.

The other connector is a DB9 (on the side of the unit) provided for convenience and is not necessary for operation of the DeviceNet™ compatible Alicat meter/ controller. The DB9 connector can be used for RS-232 communication (see DB9 pin-out as shown Below).

DeviceNet™ CONNECTION

Utilizing the standard DeviceNet™ M12 micro connector allows the Alicat meter/controller to be easily attached to a DeviceNet™ network.

The pin out as defined in Volume Three of the DeviceNet™ Standard applies and is repeated here.

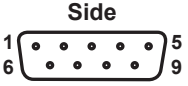
PIN	Description	Wire Color
1	Drain	Bare
2	V+ (24VDC)	RED
3	V- (GND)	BLACK
4	CAN-H	WHITE
5	CAN-L	BLUE

MAC ID

All devices on a DeviceNet™ must have unique MAC ID. Alicat units can either be programmed with a customer requested ID or they will be defaulted to 63. In either case when an Alicat unit is attached to a DeviceNet™ and powered up it will send out a duplicate MAC request.

If there already is a device on the network with the same address, the Alicat device will decrement its address and try again until it finds an unoccupied address. Once it finds a unique address, it stores that address into its nonvolatile memory, enabling it to come back on at the same address.

To utilize the DB9 pinout on your DeviceNet™ compatible instrument, follow the pin-out diagram shown here.



1. NC
2. RS232RX
3. RS232TX
4. NC
5. GND
6. NC
7. 7 to 30VDC
8. GND
9. NC

BAUD RATE

The following baud rates are available: 125K 250K 500K

The default baud rate is 125K Baud. You may specify the baud rate at the time of order.

The baud rate can be changed by using a set attribute single DeviceNet™ service request to the DeviceNet™ Object Class 03 Instance 01 Attribute ID 02.

A setting of 0 is 125K baud, 1 is 250K baud, and 2 is 500K baud. In order for a change of baud rate to take affect the unit will have to be power cycled.

SUPPORTED DEVICE TYPE: Mass Flow Controller Device Type 0x1A

SUPPORTED CLASSES: Identity Object Class 0x01

SUPPORTED ATTRIBUTES:

Attribute	Services	Description	Default Value
1	Get	Vendor ID	1174 (0x0496)
2	Get	Device Type	0x1A (Mass Flow)
3	Get	Product Code	See Product Codes
4	Get	Revision (Maj, Min)	0x01,0x01
5	Get	Status	0x00
6	Get	Serial Number	0x########
7	Get	Product Name	Alicat Scientific Inc MFC

DeviceNet™ Object Class 0x03 DeviceNet™ Assembly Object Class 0x04
Connection Object Class 0x05 S-Device Supervisor Class 0x30

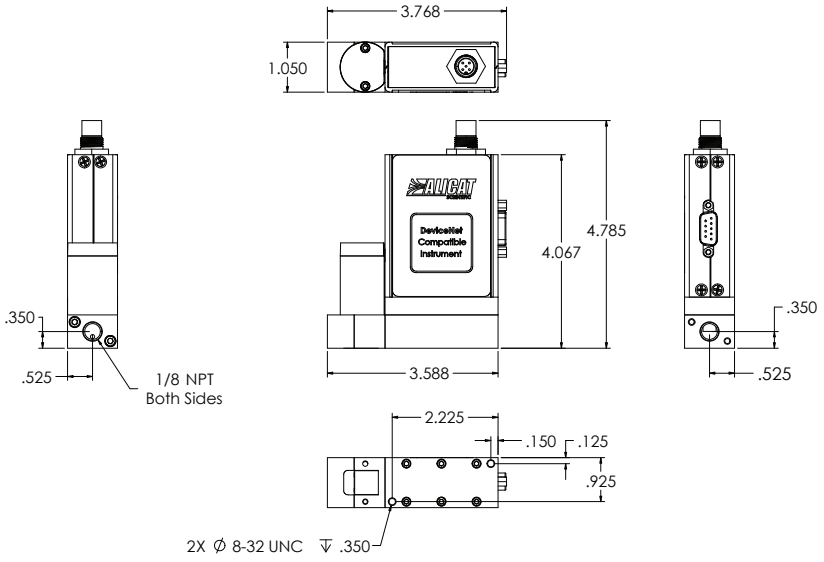
Technical Data for **DeviceNet™** Meters, Gauges and Controllers

NOTICE: The following specifications are applicable to Alicat DeviceNet™ enabled meters, gauges and controllers only.

All other operating specifications are shown in the Technical Data page for standard Alicat instruments.

All standard device features and functions are available and operate in accordance with the standard Alicat operating manual provided with the device.

Specification	Meter or Gauge	Small Valve Controller	Large Valve Controller	Description
Input /Output Signal Digital				DeviceNet™
Electrical Connections	M12 Micro Connector			
Supply Voltage:	7 to 30 Vdc	12 to 30 Vdc	24 to 30 Vdc	
Supply Current	80mA @ 12Vdc 65mA @ 24Vdc	295mA @ 12Vdc 280mA @ 24Vdc	780mA @ 24Vdc	

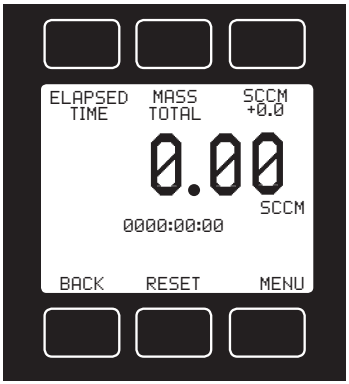


DeviceNet™ MC10SLPM shown to provide DeviceNet™ connector dimensions only. Flow body and valve dimensions will vary with range. Please see Alicat's device specifications for complete dimensions.

DeviceNet™ units do not have a display screen.

Option: Totalizing Mode

Meters and Controllers can be purchased with the Totalizing Mode option. This option adds an additional mode screen that displays the total flow (normally in the units of the main flow screen) that has passed through the device since the last time the totalizer was cleared.



The Totalizing Mode screen is accessed by pushing the TOTAL button on the MAIN display.

MASS TOTAL – The counter can have as many as six digits. At the time of order, the customer must specify the range. This directly affects the maximum count. For instance, if a range of 1/100ths of a liter is specified on a meter which is totalizing in liters, the maximum count would be 9999.99 liters. If the same unit were specified with a 1 liter range, the maximum count would be 999999 liters.

Rollover – The customer can also specify at the time of order what the totalizer is to do when the maximum count is reached. The following options may be specified:

No Rollover – When the counter reaches the maximum count it stops counting until the counter is cleared.

Rollover – When the counter reaches the maximum count it automatically rolls over to zero and continues counting until the counter is cleared.

Rollover with Notification – When the counter reaches the maximum count it automatically rolls over to zero, displays an overflow error, and continues counting until the counter is cleared.

ELAPSED TIME: The small numbers below the mass total show the elapsed time since the last reset in hours, minutes and seconds. The maximum measurable elapsed time is 6553.5 hours (about nine months). The hours count resets when RESET is pushed, an RS-232 or RS-485 clear is executed or on loss of power. Press ELAPSED TIME to show this as the primary display.

RESET – The counter can be reset to zero at any time by pushing the RESET button. To clear the counter via RS-232 or RS-485, establish serial communication with the meter or controller as described in the RS-232 or RS-485 section of the manual. To reset the counter, enter the following commands:

In Streaming Mode: $$T <Enter>

In Polling (addressable) Mode: Address$$T <Enter> (e.g. B$$T <Enter>)

Alicat Portable Meters and Gauges

Alicat Portable Flow Meters and Gauges use a common 9 Volt battery located in the top section of your meter.

Output signals from the flow meter are passed through the female connector on top of the flow meter. Turn the switch on top of the flow meter “off” when the meter is not in use.

Normal (9V alkaline) battery life is approximately 8 hours (30-40 hours with a 9V-lithium battery), however many factors can affect this.

Note: Alicat recommends the use of non-rechargeable 9V-lithium batteries in all MB TFT (color display portable) meters and gauges.

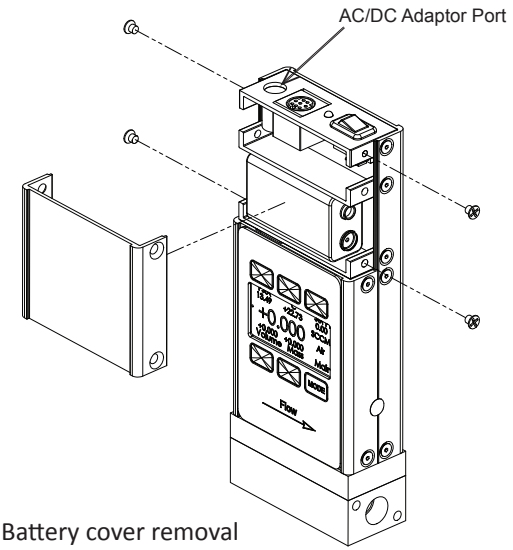
Replace the battery as often as required. A yellow LED indicates low voltage and that the battery should be replaced.

A false signal can result when the voltage drops below its normally regulated level.

Alicat Portable Flow Meters and Gauges can also be powered by an optional AC/DC plug-in wall adaptor. With the adaptor plugged into the flow meter, the battery is bypassed and the meter will operate solely off the adaptor power supply.

Replacing the Battery:

1. Remove the four Phillips head screws from the front cover and gently remove it as shown below.
2. Remove the 9V battery, pulling the top of the battery out first.
3. Disconnect the old battery from the harness and replace it with a new battery.
4. Install the new battery bottom end first and replace the back cover so that the cushioning pad presses directly down on the battery.
5. Replace the four Phillips head screws.



Battery cover removal

Option: Remote Electronics for High Line or Gas Temperatures

Some applications involve operating temperatures outside the standard Alicat device specifications. A solution using remote electronics is available. (This option is not applicable for liquid devices.)

The flow body's components are minimized to only the required sensors. The flow data is sent to the microprocessor electronics up to 6 feet away from the sensor package.

Relocating the sensitive electronics allows for installation of the flow body in ambient temperatures as high as 85° Celsius with gas temperatures under 100°Celsius.

In these applications we recommend our custom gauge calibration at a gas temperature of up to 70°Celsius. This will reduce zero shift errors that occur when actual gas flow temperatures deviate substantially from the gas calibration temperature.

This configuration is also used in integrations that require a compact flow package at the installation point.

Option: Remote Panel Display

Our Remote Display option offers the flexibility of using Alicat's display with units that are embedded inside processes or instrument enclosures.

The Remote Display retains all of the same features as our standard display.

The Remote Display is ideal for:

- OEMs Remote Panel Mounting
- Gas Panels
- Leak Detection Systems
- Embedded Systems
- Fuel Cell Test Stations
- Artificial Environments

Accessory: BB9 Multi-Drop Box

The **BB9 Multi-Drop Box** makes it convenient to wire multiple flow and/or pressure devices to a single RS-232 or RS-485 port. ***Now available with a USB interface!***

The Multi-Drop Box has nine 8 pin mini-DIN ports available. The ports are to be used with a standard double ended 8 pin mini-DIN (DC-62) style cable going from the box to each flow or pressure device.

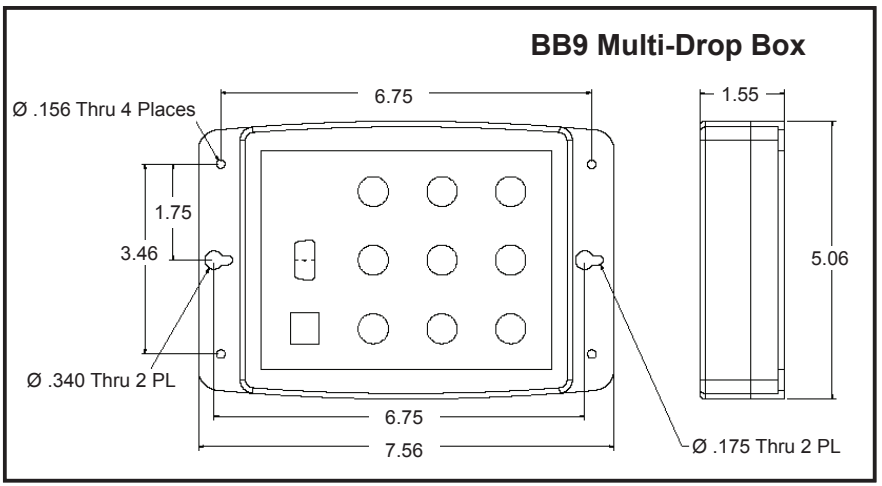
A single DB9 D-SUB type connector (COM PORT) connects, using the included cable, to the serial connector on a PC or laptop.

All of the flow and/or pressure devices are powered via a terminal block on the front of the box.

If more than nine devices will be required, additional Multi-Drop Boxes can be daisy chained together with a double ended 8 pin mini-DIN cable plugged into any receptacle on both boxes.

BB9 Power Supply for Large Valve Controllers: The PS24VHC (Power Supply 24Vdc High Current) is a 6.5Amp 24Vdc power supply designed for running multiple large controllers on a BB9.

The 6.5Amp power supply can run as many as 8 large valve controllers, which makes it ideal for the BB9 and multiple large valve (or small valve / large valve combination) controllers on a BB9.



Accessory: Flow Vision™ SC Software

Flow Vision™ SC is an intuitive software interface to help your test cycles run smoother and shorten your engineering time!

Flow Vision™ SC lets you connect to and communicate with multiple Alicat units simultaneously. Now you can view virtual displays, control tabs, charts and data lines from every connected Alicat device on the same screen.

Flow Vision™ SC supports all RS-232 and RS-485 Serial communication functions, including: **gas selection, tareing, set-point control, valve tuning and flow averaging.**

Session Saving: Save and reload your configuration data with confidence.

Script Building: Create scripts to adjust a controller's set-point value at variable specified time intervals.

Charting: Chart as many parameters as you want off as many devices as you want, with color coding, zooming, and printing functionality.

Alarms: Create software alarms that will notify you of given parameter conditions.

Data Capture & Logging: Capture and log data to either a .csv file or a .txt file. Improved Data Logging and Data Log File Splitting for easy to manage data.

Accessory: Flow Vision™ MX Software

Alicat's New Flow Vision™ MX software gives you an easy way to do GAS BLENDING using Alicat Mass Flow Controllers and your own PC.

Flow Vision™ MX software is a simple way to connect up to six Alicat mass flow controllers and create your own gas mix concentrations.

Using our inexpensive ***BB9-USB*** and a single USB connection you can:

- **Create** your own gas blends
- **Adjust** flow rates
- **Save** your specific blend formulas.

All the controllers can be powered through the BB9-USB with a single power supply.

Just connect your unique gases to each controller, select the gas type either locally on the controller or through Flow Vision™ MX, manifold the flow outputs and create your gas mix.

Accessories

Part Number	Description
FLOWVISIONSC	Flow Vision™ SC software for interface with all Alicat instruments
FLOWVISIONMX	Flow Vision™ MX software for gas blending
BB9	9 position Multi-Drop Box
BB9-I	9 position Multi-Drop Box, Industrial connectors
PVPS24U	Universal 100-240 VAC to 24 Volt DC Power Supply Adapter
PS24VHC	High current power supply for BB9 use with Large Valve Controllers
PCASE	Industrial carry and storage case for portable meters/gauges
DC-61	8 Pin Male Mini-DIN connector cable, single ended, 6 foot length
DC-251	8 Pin Male Mini-DIN connector cable, single ended, 25 foot length
DC-301	8 Pin Male Mini-DIN connector cable, single ended, 30 foot length
DC-501	8 Pin Male Mini-DIN connector cable, single ended, 50 foot length
DC-751	8 Pin Male Mini-DIN connector cable, single ended, 75 foot length
DC-6RT	8 Pin Male Right Angle Mini-Din Cable, single ended, 6 foot length
DC-62	8 Pin Male Mini-DIN connector cable, double ended, 6 foot length
DC-252	8 Pin Male Mini-DIN connector cable, double ended, 25 foot length
DC-502	8 Pin Male Mini-DIN connector cable, double ended, 50 foot length
DC-602	8 Pin Male Mini-DIN connector cable, double ended, 60 foot length
MD8DB9	8 Pin Male Mini-DIN to DB9 Female Adapter, 6 foot length
DBC-251	DB15 cable, single ended, 25 foot length
510199	DB9 cable, double-ended female, 3 meter length
IC10	Industrial cable, 6 Pin, single ended, 10 foot length
IC10-18G	18 gauge industrial cable, 6 Pin, single ended, 10 foot length
IC20	Industrial cable, 6 Pin, single ended, 20 foot length
IC24-18G	18 gauge industrial cable, 6 Pin, single ended, 24 foot length
IC50	Industrial cable, 6 Pin, single ended, 50 foot length
IC-102	Industrial cable, 6 pin double ended, 10 foot length
USB-RS232	RS-232 to USB Converter
REMOTE	Remote Electronics with Display
RD	Remote Panel Mount Display

Accessories

MNPT to Compression Fittings	
10-32 - 1/8”	SS-200-1-0157
10-32 - 1/4”	SS-400-1-0256
1/8” - 1/8”	SS-200-1-2
1/8” - 1/4”	SS-400-1-2
1/8” - 3/8”	SS-600-1-2
1/8” - 1/2”	SS-810-1-2
1/8” - 3mm	SS-3M0-1-2
1/8” - 4mm	SS-4M0-1-2
1/8” - 6mm	SS-6M0-1-2
1/8” - 8mm	SS-8M0-1-2
1/8” - 12mm	SS-12M0-1-2
1/4” - 1/8”	SS-200-1-4
1/4” - 1/4”	SS-400-1-4
1/4” - 3/8”	SS-600-1-4
1/4” - 1/2”	SS-810-1-4
1/4” - 3mm	SS-3M0-1-4
1/4” - 4mm	SS-4M0-1-4
1/4” - 6mm	SS-6M0-1-4
1/4” - 8mm	SS-8M0-1-4
1/4” - 12mm	SS-12M0-1-4
1/2” - 1/8”	SS-200-1-8
1/2” - 1/4”	SS-400-1-8
1/2” - 3/8”	SS-600-1-8
1/2” - 1/2”	SS-810-1-8
1/2” - 3/4”	SS-1210-1-8
1/2” - 6mm	SS-6M0-1-8
1/2” - 8mm	SS-8M0-1-8
1/2” - 12mm	SS-12M0-1-8
1/2” - 16mm	SS-16M0-1-8
3/4” - 1/4”	SS-400-1-12
3/4” - 1/2”	SS-810-1-12
3/4” - 3/4”	SS-1210-1-12
3/4” - 12mm	SS-12M0-1-12
3/4” - 16mm	SS-16M0-1-12

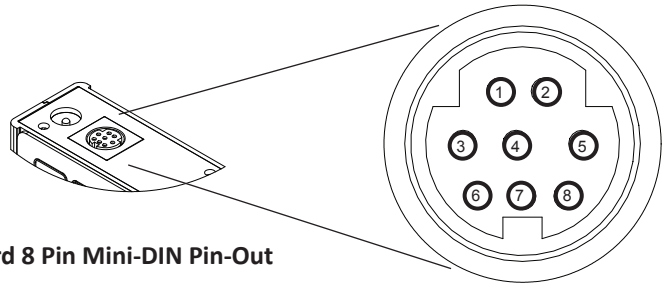
Filters & Elements FNPT-MNPT	
10-32 5µ	510053
10-32 20µ	510054
1/8” 20µ	ILF-1/8-20
1/4” 40µ	ILF-1/4-40
1/2” 40µ	ILF-1/2-40*
3/4” 40µ	ILF-3/4-40*
20µ element	ILFE20
40µ element	ILFE40
40µ element	ILFE40L*

Filters & Elements FNPT-FNPT*	
10-32 5µ	CF-303-20-316
*requires MNPT to MNPT coupler to interface with Alicat flow bodies	

10-32 Male UNF to 1/8 FNPT Adapter
410133
Male M5 (10-32) Buna-N O-ring face seal to 1/8”Female NPT

Eight Pin Mini-DIN Connector Pin-Outs

If your Alicat Instrument was ordered with the standard Eight Pin Mini-DIN connection, please be sure to reference the following pin-out diagram.



Standard 8 Pin Mini-DIN Pin-Out

Pin	Function	Mini-DIN cable color
1	Inactive or 4-20mA Primary Output Signal	Black
2	Static 5.12 Vdc or Secondary Analog Output (4-20mA, 5Vdc, 10Vdc) or Basic Alarm	Brown
3	RS-232 Input Signal	Red
4	Analog Input Signal	Orange
5	RS-232 Output Signal	Yellow
6	0-5 Vdc (or 0-10 Vdc) Output Signal	Green
7	Power In (as described above)	Blue
8	Ground (common for power, communications and signals)	Purple

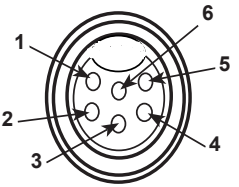
Note: The above pin-out is applicable to all the flow meters and controllers with the Mini-DIN connector. The availability of different output signals depends on the options ordered. **Underlined Items** in the above table are optional configurations that are noted on the unit's calibration sheet.

Locking Industrial Connector Pin-Outs

If your Alicat Instrument was ordered with a Six Pin Locking Industrial connection, please be sure to reference the following pin-out diagram.

A locking industrial connector is standard on all CSA/ATEX approved devices. It is also available as an option on all other Alicat instruments.

Pin	Function	Cable Color
1	Power In (+)	Red
2	RS-232TX / RS-485 +	Blue
3	RS-232RX / RS-485 -	White
4	Remote Tare Meters (Ground to Tare) Analog Set-Point Input (Controllers)	Green
5	Ground (common for power, communications and signals)	Black
6	Signal Out (Voltage or Current as ordered)	Brown

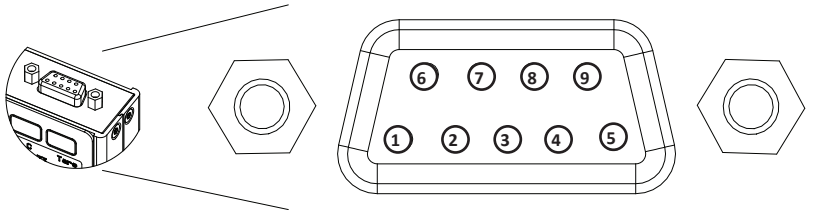


Six-pin Industrial Connector

Note: The above pin-out is applicable to all the flow meters and controllers ordered with the industrial connector. The availability of different output signals depends on the flow meter options ordered.

DB9 Pin-Outs

If your Alicat instrument was ordered with a DB9 connection, please reference the following pin-out diagram.



Standard DB9 Pin-Out Female Connector

Pin	Function
1	Inactive or optional 4-20mA Primary Output Signal
2	Static 5.12 Vdc or Secondary Analog Output (4-20mA, 5Vdc, 10Vdc) or Basic Alarm
3	Serial RS-232RX or RS-485 -
4	Analog Input Signal [4-20mA, 5Vdc, or 10Vdc] (short to ground for remote tare function on non-controllers)
5	Serial RS-232TX or RS-485 +
6	0-5 Vdc (or 0-10 Vdc) Output Signal
7	Power In (+Vdc)
8	Ground (common for power, communications and signals)
9	Ground
Note: The above pin-out is applicable to all the flow meters and controllers with the **DB9** connector. The availability of different output signals depends on the options ordered. **Underlined Items** in the above table are optional configurations that are noted on the unit's calibration sheet.	

STOP **Do not connect RS-485 to RS-232 units. Check part number or contact factory to verify RS-485 functionality.**

Due to variance in cable manufacturing, please identify proper wiring/pins via continuity check & color when using bare cut multi-strand cables.

PROFIBUS Pin-Outs

If your Alicat Instrument was ordered with a PROFIBUS connection, please be sure to reference the following pin-out diagram.

Power and Signal Connections:

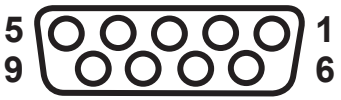
Connect to the device using two DB9 connectors.

The female top connection is PROFIBUS.

The male connection on the side is power and RS-232 or RS-485.

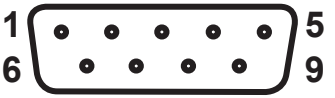
Pin out diagrams for all PROFIBUS enabled Alicat devices are shown below.

TOP

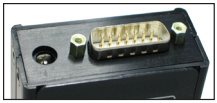


1. NC
2. OPT GND
3. DP
4. RTS
5. DGD
6. VP
7. OPT 7 to 30VDC
8. DN
9. NC

SIDE



1. NC
2. RS232RX
3. RS232TX
4. NC
5. GND
6. NC
7. 7 to 30VDC
8. GND
9. NC

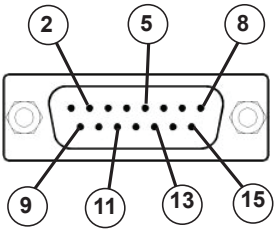


DB15 Pin-Outs

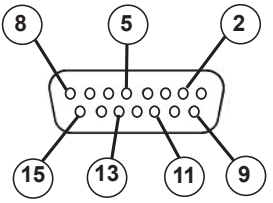
If your instrument was ordered with a DB15 connection, be sure to check the Calibration Label on the device and reference the appropriate pin-out diagram.

The following pin-out chart describes the safest and generally compatible arrangement when connecting a non-Alicat DB15 wire to a **DB15** equipped Alicat. Not all features may be available between brands, but the common denominators are featured in our DB15 offerings, along with some options for customization.

DB15 – Pin-Out Alicat Style



Male Connector Front View



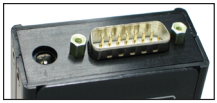
Female Connector Front View

Pin Number	Function
1	Ground
2	Primary Analog Signal Output
3	Ground
4	N/C
5	Power Supply (+Vdc)
6	N/C
7	N/C
8	Analog Tare (meters — when grounded) Analog Set-Point Input (controllers)
9	Power Supply Common
10	Ground
11	Secondary Analog Signal Output / fixed 5.12Vdc
12	N/C
13	RS-232 RX (receive) or RS-485 –
14	Ground
15	RS-232 TX (send) or RS-485 +

Check your device's calibration certificate and user manual for the actual electrical input/output requirements, as all instruments are custom configured to some extent.

NOTE: Pins 1, 3, 9, 10, and 14 are connected together inside of the device and are common grounding points.

N/C = Not Connected/Open (can be used for custom pin assignments – please consult factory).

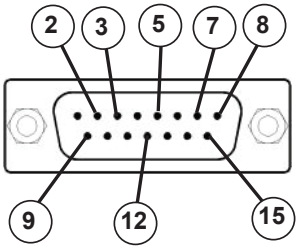


DB15 Pin-Outs

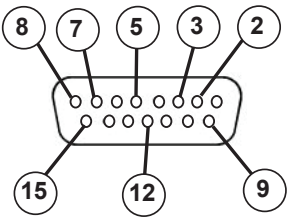
If your instrument was ordered with a DB15 connection, be sure to check the Calibration Label on the device and reference the appropriate pin-out diagram.

The following pin-out chart describes the safest and generally compatible arrangement when connecting a non-Alicat DB15 wire to a **DB15A** equipped Alicat. Not all features may be available between brands, but the common denominators are featured in our DB15 offerings, along with some options for customization.

DB15A – Pin-Out "Aalborg" Style



Male Connector Front View



Female Connector Front View

Pin Number	Function
1	Ground
2	Primary Analog Signal Output
3	Analog Tare (meters — when grounded)* Analog Set-Point Input (controllers)*
4	Ground
5	Power Supply Common
6	Ground
7	Power Supply (+Vdc)
8	RS-232 Tx (send) / RS-485, A (-) [receive]
9	Ground
10	N/C
11	N/C
12	Secondary Analog Signal Output / fixed 5.12Vdc*
13	N/C
14	N/C
15	RS-232 Rx (receive) / RS-485, A (+) [send]

Check your device's calibration certificate and user manual for the actual electrical input/output requirements, as all instruments are custom configured to some extent.

* Added to allow for full use of features on Alicat devices, may not be present on host wiring

NOTE: Pins 1, 4, 5, 6, and 9 are connected together inside of the device and are common grounding points.

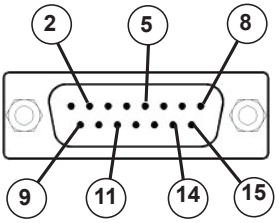
N/C = Not Connected/Open (can be used for custom pin assignments – please consult factory).

DB15 Pin-Outs

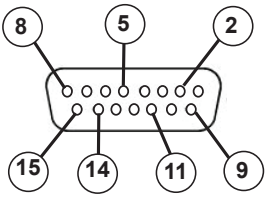
If your instrument was ordered with a DB15 connection, be sure to check the Calibration Label on the device and reference the appropriate pin-out diagram.

The following pin-out chart describes the safest and generally compatible arrangement when connecting a non-Alicat DB15 wire to a **DB15B** equipped Alicat. Not all features may be available between brands, but the common denominators are featured in our DB15 offerings, along with some options for customization.

DB15B – Pin-Out "Brooks" Style



Male Connector Front View



Female Connector Front View

Pin Number	Function
1	Ground
2	Primary Analog Signal Output
3	N/C
4	N/C
5	Power Supply (+Vdc)
6	N/C
7	N/C
8	Analog Tare (meters — when grounded) Analog Set-Point Input (controllers)
9	Power Supply Common
10	Ground
11	Secondary Analog Signal Output / fixed 5.12Vdc
12	N/C
13	N/C
14	RS-232 RX (receive) or RS-485 –
15	RS-232 TX (send) or RS-485 +

Check your device's calibration certificate and user manual for the actual electrical input/output requirements, as all instruments are custom configured to some extent.

NOTE: Pins 1, 9, and 10 are connected together inside of the device and are common grounding points.

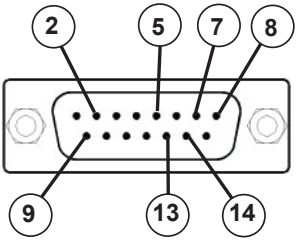
N/C = Not Connected/Open (can be used for custom pin assignments – please consult factory).

DB15 Pin-Outs

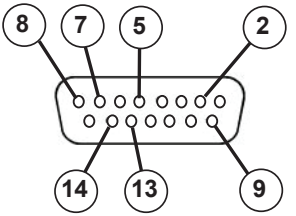
If your instrument was ordered with a DB15 connection, be sure to check the Calibration Label on the device and reference the appropriate pin-out diagram.

The following pin-out chart describes the safest and generally compatible arrangement when connecting a non-Alicat DB15 wire to a **DB15K** equipped Alicat. Not all features may be available between brands, but the common denominators are featured in our DB15 offerings, along with some options for customization.

DB15K – Pin-Out "MKS" Style



Male Connector Front View



Female Connector Front View

Pin Number	Function
1	N/C
2	Primary Analog Signal Output
3	N/C
4	N/C
5	Power Supply Common
6	N/C
7	Power Supply (+Vdc)
8	Analog Tare (meters — when grounded) Analog Set-Point Input (controllers)
9	Secondary Analog Signal Output / fixed 5.12Vdc *
10	N/C
11	Ground
12	Ground
13	RS-232 RX (receive) or RS-485 – *
14	RS-232 TX (send) or RS-485 + *
15	Ground

Check your device's calibration certificate and user manual for the actual electrical input/output requirements, as all instruments are custom configured to some extent.

NOTE: Pins 5, 11, 12 and 15 are connected together inside of the device and are common grounding points.

N/C = Not Connected/Open (can be used for custom pin assignments – please consult factory).

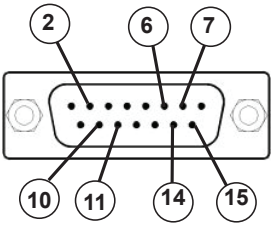
***** Added to allow for full use of features on Alicat devices, may not be present on host wiring.

DB15 Pin-Outs

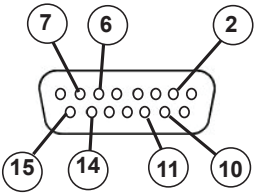
If your instrument was ordered with a DB15 connection, be sure to check the Calibration Label on the device and reference the appropriate pin-out diagram.

The following pin-out chart describes the safest and generally compatible arrangement when connecting a non-Alicat DB15 wire to a **DB15H** equipped Alicat. Not all features may be available between brands, but the common denominators are featured in our DB15 offerings, along with some options for customization.

DB15H – Pin-Out "Hastings H" Style



Male Connector Front View



Female Connector Front View

Pin Number	Function
1	N/C
2	RS-232 RX (receive) or RS-485 – *
3	N/C
4	N/C
5	Ground
6	Primary Analog Signal Output
7	Power Supply Common
8	N/C
9	N/C
10	Secondary Analog Signal Output / fixed 5.12Vdc *
11	Power Supply (+Vdc)
12	Ground
13	N/C
14	Analog Tare (meters — when grounded) Analog Set-Point Input (controllers)
15	RS-232 TX (send) or RS-485 + *

Check your device's calibration certificate and user manual for the actual electrical input/output requirements, as all instruments are custom configured to some extent.

NOTE: Pins 5, 7 and 12 are connected together inside of the device and are common grounding points.

N/C = Not Connected/Open (can be used for custom pin assignments – please consult factory).

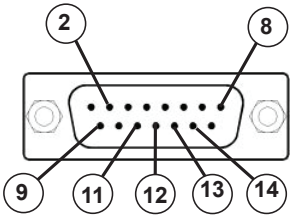
***** Added to allow for full use of features on Alicat devices, may not be present on host wiring.

DB15 Pin-Outs

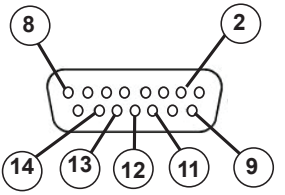
If your instrument was ordered with a DB15 connection, be sure to check the Calibration Label on the device and reference the appropriate pin-out diagram.

The following pin-out chart describes the safest and generally compatible arrangement when connecting a non-Alicat DB15 wire to a **DB15S** equipped Alicat. Not all features may be available between brands, but the common denominators are featured in our DB15 offerings, along with some options for customization.

DB15S – Pin-Out "Sierra" Style



Male Connector Front View



Female Connector Front View

Pin Number	Function
1	Ground
2	Primary Analog Signal Output
3	N/C
4	N/C
5	Ground
6	N/C
7	N/C
8	Analog Tare (meters — when grounded) Analog Set-Point Input (controllers)
9	Power Supply Common
10	Ground
11	Secondary Analog Signal Output / fixed 5.12Vdc *
12	RS-232 RX (receive) or RS-485 – *
13	Power Supply (+Vdc)
14	RS-232 TX (send) or RS-485 + *
15	Ground

Check your device's calibration certificate and user manual for the actual electrical input/output requirements, as all instruments are custom configured to some extent.

NOTE: Pins 1, 5, 9, 10 and 15 are connected together inside of the device and are common grounding points.

N/C = Not Connected/Open (can be used for custom pin assignments – please consult factory).

***** Added to allow for full use of features on Alicat devices, may not be present on host wiring.

Additional Information for Alicat CSA and ATEX Approved Devices

See the following page for Special Conditions regarding the use of these units!

II 3 G

C US

EEx nA IIC T4

Class I, Div. 2 Group A, B, C and D T4

24 Vdc, 0.800A max

Class I, Zone 2 AEx nA IIC T4

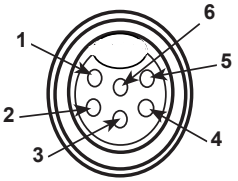
WARNINGS:

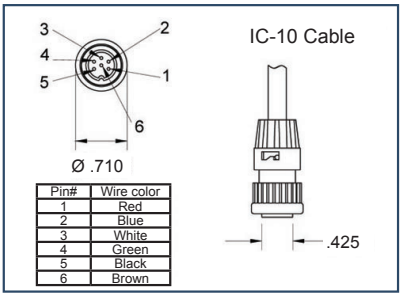
EXPLOSION HAZARD – DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS AREA IS KNOWN TO BE NON-HAZARDOUS.

EXPLOSION HAZARD – SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2.

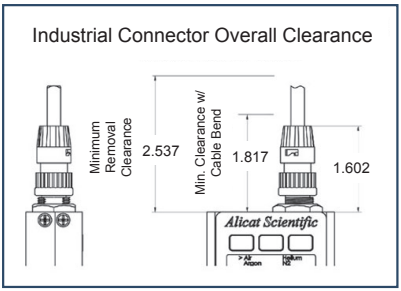
All Alicat CSA / ATEX approved devices are equipped with a locking 6 pin industrial connector. The power and signal connections are shown below.

Pin	Function	Cable Color
1	Power In (+)	Red
2	RS-232TX / RS-485 +	Blue
3	RS-232RX / RS-485 –	White
4	Analog Input Signal	Green
5	Ground (common for power, communications and signals)	Black
6	Signal Out (Voltage or Current as ordered)	Brown





IC-10 Locking Industrial Cable



Clearance Requirements for Industrial Connector

USE of Alicat instruments (M, MS, MC, MCS, MCR, MCRS, P, PS, PC, PCS, PCR and PCRS product families only) in Class 1 Division 2 applications.

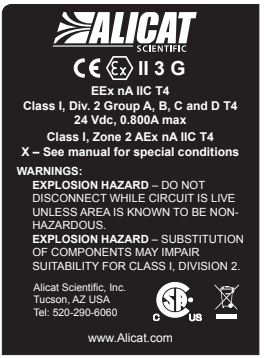
CSA certifies the use of this product for general use as well as use in hazardous locations as defined by Class 1 Division 2 Group A, B, C and D T4.

CSA certification is indicated by the product label as shown below and not by the statements in this, or any accompanying documentation.

Special Conditions:

To comply with CSA certification the following information is included in the product literature:

- When equipment is properly labeled, it is suitable in Class I, Division 2, Group A, B, C and D, T4
  - Tamb. -40°C to +50°C
- Electrical Rating 24Vdc, 0.800A max
- Instruments shall be powered by a CSA certified, UL listed, Class II external power supply suitable for the application
- Instruments shall be housed in an enclosure with a minimum IP54 rating or location providing equivalent protection
- Instrument's final approval shall be provided by the local authority having jurisdiction



USE of Alicat instruments (M, MS, MC, MCS, MCR, MCRS, P, PS, PC, PCS, PCR and PCRS product families only) in applications requiring ATEX Certification.

Properly labeled Alicat instruments comply to the following ATEX standard:

II 3 G EEx nA IIC T4 (-40°C ≤ Ta ≤ +50°C)

The examination certificate was issued by the CSA in accordance with accepted practices and procedures. This confirms compliance with the European ATEX Directive or Group II Category 3G equipment.

ATEX certification is indicated by the product label as shown above and not by the statements in this, or any accompanying documentation.

Special Conditions:

- Properly labeled equipment is only certified for use in ambient temperatures in the range of -40°C to +50°C only
- Electrical Rating 24Vdc, 0.800A max
- Instruments shall be powered by a CSA certified, UL listed, Class II external power supply suitable for the application
- Instruments shall be housed in an enclosure with a minimum IP54 rating or location providing equivalent protection
- Instrument's final approval shall be provided by the local authority having jurisdiction