Operating Manual

16 Series
Portable Calibration Unit

Innovative Flow and Pressure Solutions

NIST

Limited Lifetime Warranty

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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.

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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.

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Portable Calibration Unit

Thank you for purchasing an Alicat Scientific Portable Calibration Unit (PCU). Please take the time to find and read the information contained in this manual. This will help to ensure that you get the best possible service from your instrument.

The Alicat Scientific Portable Calibration Unit (PCU) is designed to accurately measure gas flow rates of common gases with three separate flow meters with ranges determined by the end user's needs.

The laminar flow, differential pressure flow meters housed in the PCU are accurate and exceptionally repeatable devices, making the PCU an excellent portable secondary standard for field flowmeter calibration.

The PCU's three separate displays allow you to monitor Temperature, Absolute Pressure, Volume Flow Rate, and Mass Flow Rate simultaneously. The PCU is also equipped with an RS-232 output port that can be connected to a computer or other data-logging device.

The Alicat PCU is designed for CLEAN, DRY, NON-CORROSIVE gases.

Connecting the PCU

The inlet and outlet connections to the PCU are located below the displays for their respective flow ranges (Figure 1).

Inlet connections are located on the left and the outlet connections are located on the right (Figure 1.)

The connections are either 1/8", 1/4", 3/8" or 1/2" push-connect style tubing fittings with each fitting corresponding to a single flow range. Use appropriately sized plastic tubing to connect the flow source to the corresponding inlet fitting. If necessary, connect the corresponding outlet fitting to the original source destination with proper tubing.

CAUTION: If the outlet fittings are not connected to your piping, the gas being measured will vent to atmosphere at the outlet fittings! Use protective eyewear!

Never Vent Flammable Gases To Atmosphere!

POWER

The PCU is designed to operate on either two 9 Volt Alkaline batteries or via a 9-20VDC power supply running at a minimum 100mA. The batteries should operate the PCU for 8 hours under normal usage.

If the batteries drop below 7 volts, the replace battery light will come on and the batteries should be replaced or alternate power should be applied.

When the replace battery light is on the accuracy of the meters' readings cannot be guaranteed.

Application

Maximum operating line pressure is 145 PSIG (1000 kPa).

> **Caution:** *Exceeding the maximum specified line pressure may cause permanent damage to the solid-state differential pressure transducer.*

If the line pressure is higher than 145 PSIG (1000 kPa), a pressure regulator should be used upstream from the flow meter to reduce the pressure to 145 PSIG (1000 kPa) or less if possible. Although the meter's operation is uni-directional, reversing the flow direction will inflict no damage as long as the maximum specified limits are not exceeded.

> **Note:** *Avoid installations (such as snap acting solenoid valves upstream) that apply instantaneous high pressure to the meter as permanent damage to the differential pressure sensor could result. This damage is not covered under warranty!*

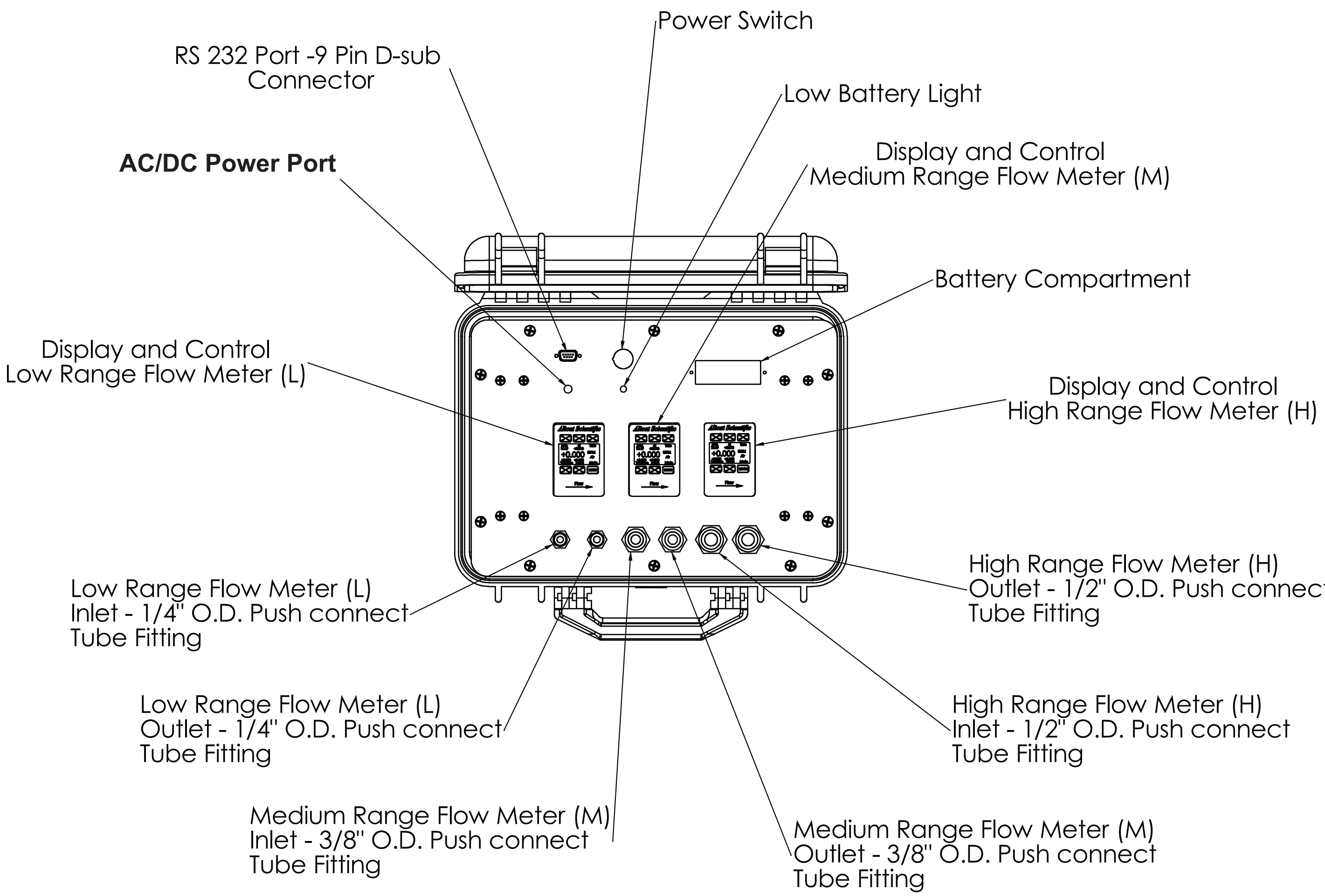

Figure 1. PCU Controls and Connections

Note: Inlet and Outlet connection diameters may vary, depending on how the PCU is configured.

Operating the PCU

The meter for each flow range on the PCU is controlled by its own set of Display/Control electronics located above the inlet and outlet ports of each flow range. The PCU meters can have several screen “modes” depending on how the device is ordered. All PCU meters have a default Main Mode, Select Menu Mode, a Gas Select Mode (the Gas Select Mode may not be available on meters calibrated for a custom gas or blend), a Communication Select Mode, a Manufacturuer Data Mode and a Miscellaneous Mode. In addition, your device may have been ordered with the optional Totalizing Mode (page 27). The device defaults to Main Mode as soon as power is applied to the PCU.

Main Mode

The main mode screen defaults on power up with the mass flow on the primary display. The following parameters are displayed in the main mode as shown in Figure 2.

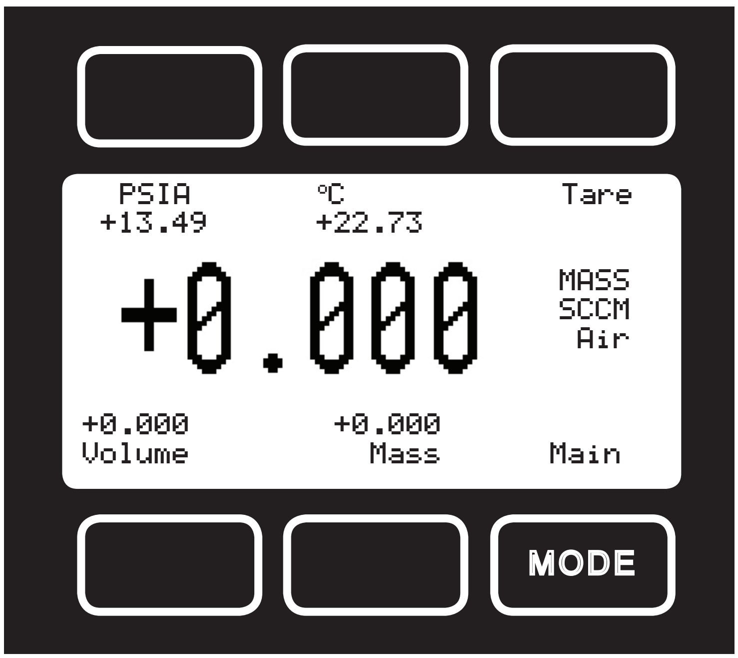

Figure 2. Main Mode Display

The “MODE” button in the lower right hand corner toggles the display between the Main display and the Select Menu display.

Tare – Pushing the dynamically labeled “Tare” button in the upper right hand corner tares the flow meter and provides it with a reference point for zero flow. This is a simple but important step in obtaining accurate measurements. It is good practice to “zero” the flow meter each time it is powered up. If the flow reading varies significantly from zero after an initial tare, give the unit a minute or so to warm up and re-zero it.

If possible, zero the unit near the expected operating pressure by positively blocking the flow downstream of the flow meter prior to pushing the “Tare” button. Zeroing the unit while there is any flow will directly affect the accuracy by providing a false zero point. If in doubt about whether a zero flow condition exists, remove the unit from the line and positively block both ports before pressing the “Tare” button. If the unit reads a significant negative value when removed from the line and blocked, it is a good indication that it was given a false zero. It is better to zero the unit at atmospheric pressure and a confirmed no flow conditions than to give it a false zero under line pressure.

Once zeroed the PCU can now be used to check the calibration of other mass flow meters. Providing there are no leaks in the lines, the PCU can be used to check another mass flow meter either upstream or downstream of the PCU.

Note: The PCU cannot be used to directly check volumetric flow meters (such as rotameters) because the density of the gas changes with the pressure drop present in all systems.

Gas Absolute Pressure: The PCU flow meters utilize an absolute pressure sensor to measure the line pressure of the gas flow being monitored. This sensor references hard vacuum and accurately reads line pressure both above and below local atmospheric pressure. This parameter is located in the upper left corner of the display under the dynamic label “PSIA”. This parameter can be moved to the primary display by pushing the button just above the dynamic label (top left). The engineering unit associated with absolute pressure is pounds per square inch absolute (PSIA). This can be converted to gage pressure (psig = the reading obtained by a pressure gauge that reads zero at atmospheric pressure) by simply subtracting local atmospheric pressure from the absolute pressure reading:

PSIG = PSIA – (Local Atmospheric Pressure)

The flow meters use the absolute pressure of the gas in the calculation of the mass flow rate. For working in metric units, note that 1 PSI = 6.89 kPa.

Gas Temperature: The PCU flow meters also utilize a temperature sensor to measure the line temperature of the gas flow being monitored. The temperature is displayed in engineering units of degrees Celsius (°C). The flow meters use the temperature of the gas in the calculation of the mass flow rate. This parameter is located in the upper middle portion of the display under “°C”. This parameter can be moved to the primary display by pushing the top center button above “°C”.

Volumetric Flow Rate: The volumetric flow rate is determined using the Flow Measurement Operating Principle described elsewhere in this manual. This parameter is located in the lower left corner of the display over “Volume”. This parameter can be moved to the primary display by pushing the “Volume” button (lower left). In order to get an accurate volumetric flow rate, the gas being measured must be selected (see Gas Select Mode). 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 ratio between the two gases viscosities.

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 portion of the display over “Mass”. This parameter can be moved to the primary display by pushing the button located below “Mass” (bottom center). The meter uses the measured temperature and the measured absolute pressure to calculate what the flow rate would be if the gas pressure was at 1 atmosphere and the gas temperature was 25°C. This allows a solid reference point for comparing one flow to another.

Flashing Error Message: 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.

Select Menu Mode

Pushing "Mode" once will bring up the "Select Menu" display. Push the button nearest your selection to go to the corresponding screen. Push "Mode" again to return to the Main Mode display. (**Note:** *If your meter was ordered with Totalizing Mode option (page 26), pushing the "Mode" button once will bring up the "Totalizing Mode" display. Pushing "Mode" a second time will bring up the "Select Menu" display.)*

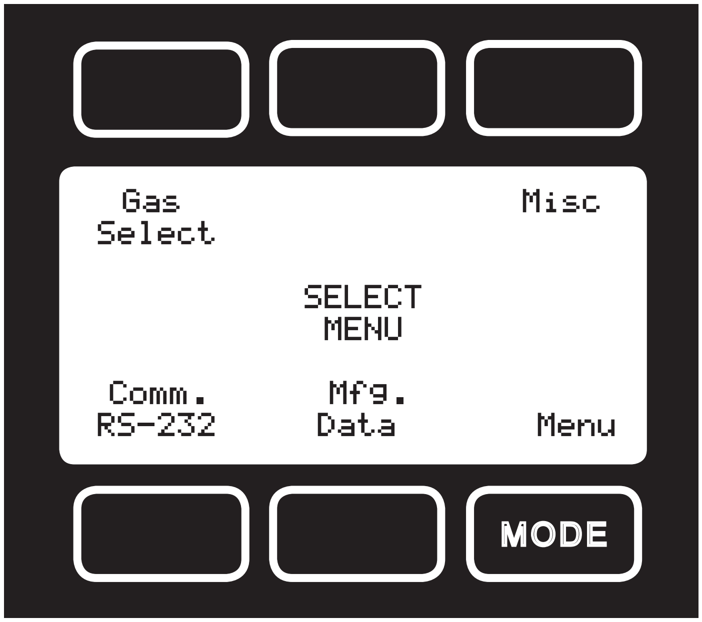

Figure 3. Select Menu Display

Gas Select Mode

The gas select mode is accessed by pressing the button above "Gas Select" on the Select Menu display. The screen will appear as shown in Figure 4 below.

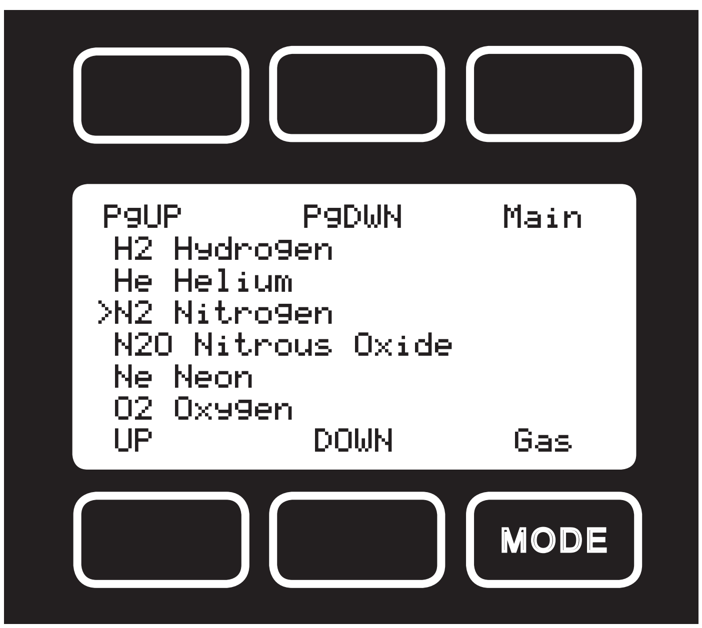

Figure 4. Gas Select Display

The selected gas is displayed on the default main mode screen as shown in Figure 2, and is indicated by the arrow in the Gas Select Mode screen in Figure 4. To change the selected gas, use the buttons under "UP" and "DOWN" or above "PgUP" and "PgDWN" to position the arrow in front of the desired gas. When the mode is cycled back to the Main Mode, the selected gas will be displayed on the main screen. (**Note:** *Gas Select Mode may not be available for units ordered for use with a custom gas or blend.)*

Communication Select

The Communication Select mode is accessed by pressing the button below "Comm. RS-232" on the Select Menu display. The screen will appear as shown in Figure 5 below.

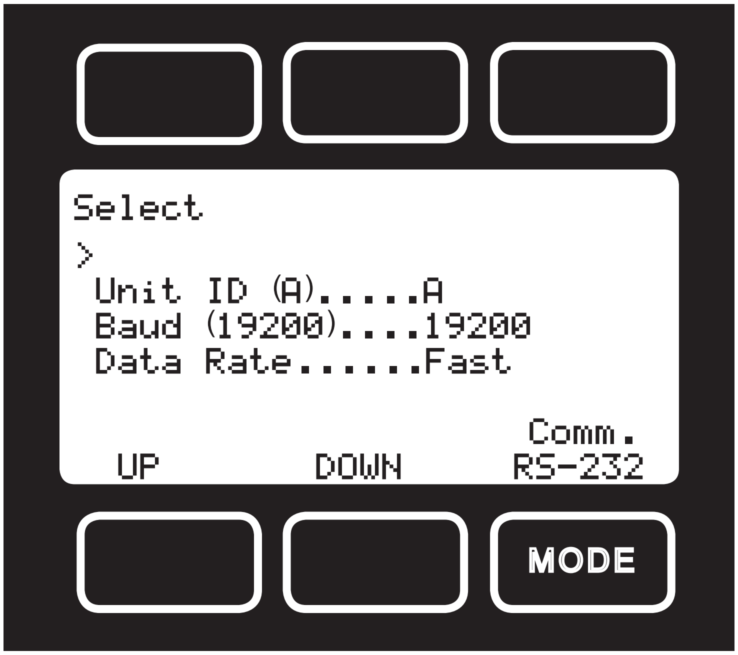

Figure 5. Communication Select Display

Unit ID – Valid unit identifiers are letters A-Z and @ (see **Note** below). This identifier allows the user to assign a unique address to each device so that multiple units can be connected to a single RS-232 port on a computer. The Communication Select Mode allows you to view and/or change a unit's unique address. To change the unit ID address, press the "Select" button in the upper left corner of the display until the cursor arrow is in front of the word "Unit ID". Then, using the UP and DOWN buttons at the bottom of the display, change the unit ID to the desired letter. ***Any ID change will take effect when the Communication Select Screen is exited by pushing the MODE or Main button.***

Note: When the symbol @ is selected as the unit ID, the device will go into streaming mode when the Communication Select Mode is exited by pushing the MODE or Main button. See the RS-232 Communications chapter in this manual for information about the streaming mode.

Baud – The baud rate (bits per second) determines the rate at which data is passed back and forth between the instrument and the computer. Both devices must send/receive at the same baud rate in order for the devices to communicate via RS-232. The default baud rate for these devices is 19200 baud, sometimes referred to as 19.2K baud. To change the baud rate in the Communication Select Mode, press the "Select" button in the upper left corner of the display until the cursor arrow is in front of the word "Baud". Then, using the UP and DOWN buttons at the bottom of the display, select the required baud rate to match your computer or PLC. The choices are 38400, 19200, 9600, or 2400 baud. ***Any baud rate change will not take effect until power to the unit is cycled.***

Data Rate – Changing the Data Rate affects the rate at which the instrument dumps its data in the streaming mode. Slow is ½ the Fast rate. The speed of the Fast rate is determined by the selected baud rate. It is sometimes desirable to reduce the data rate if the communication speed bogs down the computer's processor (as is not uncommon in older laptops), or to reduce the size of data files collected in the streaming mode. To change the data rate in the Communication Select Mode, press the "Select" button in the upper left corner of the display until the cursor arrow is in front of the word "Data Rate". Then, using the UP and DOWN buttons at the bottom of the display, select either Fast or Slow. ***Any data rate change will be effective immediately upon changing the value between Fast and Slow.***

Manufacturer Data

“Manufacturer Data” is accessed by pressing the “Mfg. Data” button on the Select Menu display (Figure 3). The “Mfg 1” display shows the name and telephone number of the manufacturer. The“Mfg 2” display shows important information about your flow meter including the model number, serial number, and date of manufacture.

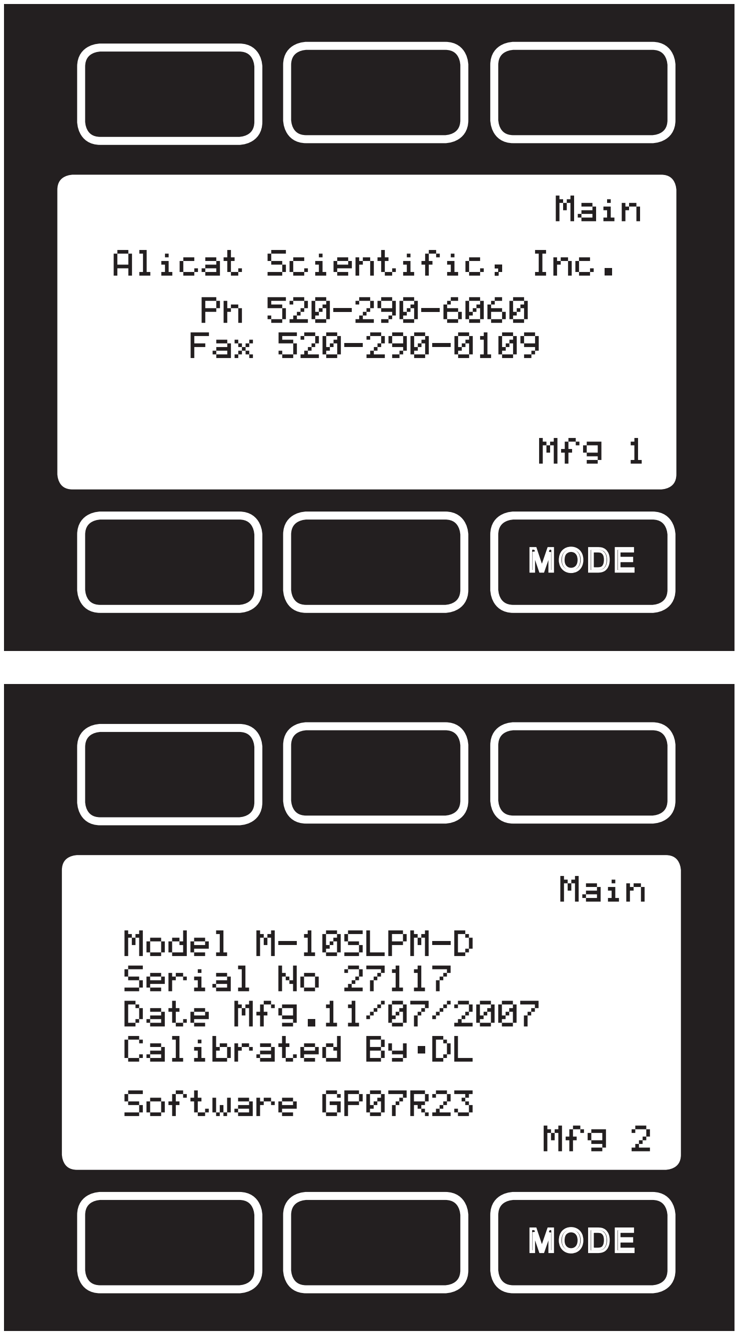

Figure 6. Manufacturer Data Displays

Miscellaneous Mode

The Miscellaneous mode is accessed by pressing the button above the “Misc” label in the upper right hand corner of the Select Menu display. The screen will appear as shown in Figure 7. Push the button above “Select” to move the cursor even with the item you wish to adjust. Then use the “UP” and “DOWN” buttons to make the adjustment.

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

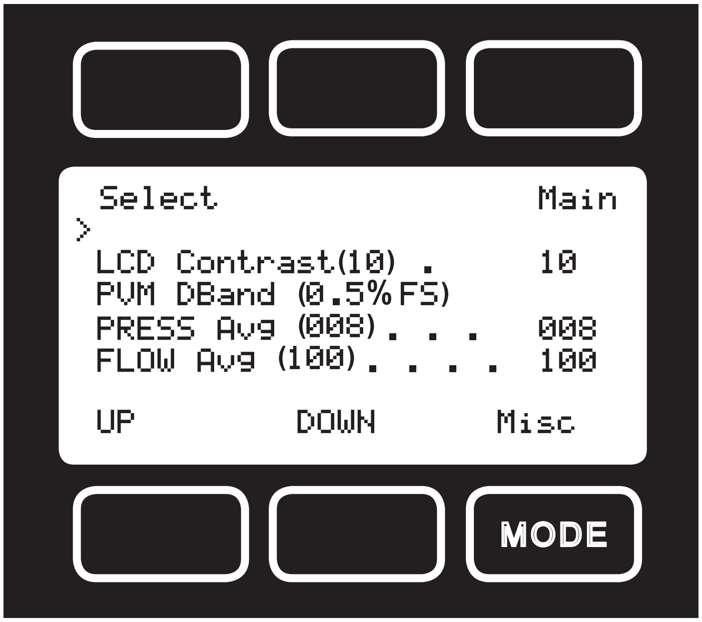

Figure 7. Miscellaneous Display

LCD Contrast: The Liquid Crystal Display Contrast can be adjusted between 0 and 30 with zero being the lightest contrast and 30 being the darkest contrast. To change the contrast, press the “Select” button in the upper left hand corner of the display until the cursor arrow is in front of the words “LCD Contrast (X)”. Then using the UP and DOWN buttons at the bottom of the display, change the contrast value as desired. The change is immediate and the effect can be monitored as the value is changed.

Display Zero Deadband: Zero deadband refers to a value below which the display simply 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 actually exist, especially in high noise (electrical) environments. This display deadband does not affect the analog or digital signal outputs — there is no zero deadband on the output signals. The display zero deadband can be adjusted between 0 and 3.2% of the Full Scale (FS) of the sensor. PVM refers to Pressure, Volumetric Flow and Mass Flow, the three parameters to which the deadband applies. To adjust the display zero deadband, press the “Select” button in the upper left hand corner of the display until the cursor arrow is in front of the words “PVM DBand (X %F.S.)”. Then using the UP and DOWN buttons at the bottom of the display, change the display zero deadband value as desired.

Pressure Averaging: It is sometimes advantageous to apply an averaging factor to the pressure output (and display) to make it easier to read and interpret rapidly fluctuating pressures. Pressure averaging can be adjusted between 1 (no averaging) and 256 (maximum averaging). This is a geometric running average where the number between 1 and 256 can be considered very roughly equivalent to the response time constant in milliseconds. This can be very effective at “smoothing” high frequency process oscillations such as those caused by diaphragm pumps. To adjust the pressure averaging, press the “Select” button in the upper left hand corner of the display until the cursor arrow is in front of the words “PRESS Avg (XXX)”. Then using the UP and DOWN buttons at the bottom of the display, change the pressure averaging value as desired.

Flow Averaging: It is sometimes advantageous to apply an averaging factor to the flow output (and display) to make it easier to read and interpret rapidly fluctuating flows. Flow averaging can be adjusted between 1 (no averaging) and 256 (maximum averaging). This is a geometric running average where the number between 1 and 256 can be considered very roughly equivalent to the response time constant in milliseconds. This can be very effective at “smoothing” high frequency process oscillations such as those caused by diaphragm pumps. To adjust the flow averaging, press the “Select” button in the upper left hand corner of the display until the cursor arrow is in front of the words “FLOW Avg (XXX)”. Then using the UP and DOWN buttons at the bottom of the display, change the flow averaging value as desired.

RS-232 Output and Input

Connect the male RS-232 DB9 port (See Fig. 1) of the PCU to the serial port of your computer or data logger. This will normally require a female/female DB9 cable (included).

One of the most common ways to access the RS-232 output from your PCU is through a simple terminal program. Open your Hyperterminal RS-232 terminal program (installed under the “Accessories” menu on all Microsoft Windows operating systems). Select “Properties” from the file menu. Click on the “Configure” button under the “Connect To” tab. Be sure the program is set for: 19200 baud and an 8-N-1-None (8 Data Bits, No Parity, 1 Stop Bit, and no Flow Control) protocol. Under the “Settings” tab, make sure the Terminal Emulation is set to ANSI. Click on the “ASCII Setup” button and be sure the “Send Line Ends with Line Feeds” Box is not checked, and that the “Append Line Feeds to Incoming Lines” box is checked. Those settings not mentioned here are normally okay in the default position. Type L M or H to read data for the desired range.

When the queried the window will fill with 6 columns of data representing the range (L=Low, M=Medium, H=High), absolute pressure, temperature, volumetric flow, mass flow, and selected gas respectively. Pressure units are PSIA, temperature units are Degrees C, volumetric flow units are Liters Per Minute, and mass flow units are Standard Liters Per Minute. The Low range is 0-2 SLPM, the Medium range is 0-50 SLPM, and the High range is 0-1000 SLPM.

```
L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
```

PCU Mass Flow Meter Data Format
(Low Range)

RS-232 Output and Input

Configuring HyperTerminal®:

1. Open your HyperTerminal® RS-232 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 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. Type L M or H to read data for the desired range.
7. 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 communcation select menu, select @ as identifier and exit the screen). If data still does not appear, check all the connections and com port assignments.

Tare –Tareing (or zeroing) the flow meter provides it with a reference point for zero flow. This is a simple but important step in obtaining accurate measurements. It is good practice to "zero" the flow meter each time it is powered up. A unit may be Tared by following the instructions on page 10 or it may be Tared via RS-232 input.

To send a Tare command via RS-232, enter the following strings:

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

Collecting Data:

The RS-232 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 17.

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

When the queried the window will fill with 6 columns of data representing the range (L=Low, M=Medium, H=High), absolute pressure, temperature, volumetric flow, mass flow, and selected gas respectively. Pressure units are PSIA, temperature units are Degrees C, volumetric flow units are Liters Per Minute, and mass flow units are Standard Liters Per Minute. The Low range is 0-2 SLPM, the Medium range is 0-50 SLPM, and the High range is 0-1000 SLPM.

```
L +014.70 +025.00 +02.004 +02.004 AIR
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L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
L +014.70 +025.00 +02.004 +02.004 AIR
```

PCU Mass Flow Meter Data Format
(Low Range)

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

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 meter 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>

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 PCU Gas Flow Meters 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:

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

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 π, 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 9). 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 PCU internally compensates for this change.

Other Gases: PCU 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 standard 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)

PCU Flow Meters reference 25ºC and14.696 PSIA (101.32kPa) - unless ordered otherwise. Refer to the calibration sheet to confirm the reference point.

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 recently incorporated the latest data sets from NIST (including their REFPROP 7 data) in our products' built-in gas property models. Be aware that calibrators that you may be spot checking against may be using 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.
Recharge the battery.

Flow reading is approximately fixed either near zero or near full scale regardless of actual line flow.
Differential pressure sensor may be damaged. Avoid installations that can subject sensor to pressure drops in excess of 10 PSID. A common cause of this problem is instantaneous application of high-pressure gas as from a snap acting solenoid valve upstream of the meter. Damage due to excessive pressure differential is not covered by warranty.

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.

Meter reads negative flow when there is a confirmed no flow condition.
This is an indication of an improper tare. If the meter is tared while there is flow, that flow is accepted as zero flow. When an actual zero flow condition exists, the meter will read a negative flow. Simply re-tare at the confirmed zero flow condition. Also note that while the meter is intended for positive flow, it will read negative flow with reasonable accuracy (it is not calibrated for bi-directional flow) and no damage will result.

Meter does not agree with another meter I have in line.
Volumetric meters will often not agree with one another when put in series because they 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. PCU 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.

Flow flutters or is jumpy.
The meters are very fast and will pick up any actual flow fluctuations such as from a diaphragm pump, etc. Also, inspect the inside of the upstream connection for debris such a Teflon tape shreds. Note: PCU meters feature a programmable geometric running average (GRA) that can aid in allowing a rapidly fluctuating flow to be read.

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.

RS-232 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 communications select screen for current meter readings). Close HyperTerminal® and reopen it. Reboot your PC.

Slower response than specified.
PCU meters feature an RS-232 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. If you require the fastest possible response time, please consult the factory for written instructions on adjusting the GRA.

Jumps to zero at low flow.
PCU meters feature an RS-232 programmable zero deadband. The factory setting is usually 0.5% of full scale. This can be adjusted via RS-232 programming between NONE and 6.375% of full scale. Contact the factory for more information.

Discrepancies between old and new units.
Please see “Standard Gas Data Tables” explanation on page 21.

Maintenance and Recalibration

General: The PCU requires minimal maintenance. It has 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 meters are designed to measure CLEAN, DRY, NON-CORROSIVE gases. A 20 micron filter (50 micron for 50 LPM and up) mounted upstream of the meter 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. Providing that the CLEAN, DRY, and NON-CORROSIVE mantra is observed, this periodic recalibration is sufficient. A label located on the control panel of the device lists the recalibration due date. The device should be returned to the factory for recalibration near the listed due date. Before calling to schedule a recalibration, please note the serial number of the device. The Serial Number, Model Number, and Date of Manufacture are also available on the Manufacture Data 2 screen (page 11).

Cleaning: The PCU requires no periodic cleaning. The outside of the case can be washed as necessary. The control panel and displays may be cleaned with a soft dry rag. Avoid excess moisture or solvents.

For repairs, recalibrations, or recycling of this product, contact:

Alicat Scientific, Inc.
2045 N Forbes Blvd. Bldg.103
Tucson, Arizona 85745
USA
Ph. 520-290-6060
Fax 520-290-0109
email: info@alicatscientific.com
Web site: www.alicatscientific.com

Technical Data for the Alicat Portable Calibration Unit (PCU)

The following specifications are for the standard configuration of the device. Please contact us or visit www.alicatscientific.com for customization details, application notes, etc.

Basic Specification	PCU Meters	Description
Accuracy	± (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	Measure and Control
Typical Response Time	10	Milliseconds (Adjustable)
Standard Conditions (STP)	25º C & 14.696PSIA	Mass Reference Conditions
Operating Temperature	−10 to + 50	º Celsius
Zero Shift	0.02%	Full Scale / º Celsius / Atm
Span Shift	0.02%	Full Scale / º Celsius / Atm
Humidity Range	0 to 100%	Non – Condensing
Flow Rate	128% Measurable	Full Scale
Maximum Pressure	145	PSIG
Input /Output Signal Standard	RS-232 Serial & 0-5Vdc	
Input / Output Secondary	0-5 Vdc; 0-10Vdc;4-20mA	Pressure, Temperature or Flow
Warm-up Time	< 1	Second
Wetted Materials	303 & 302 Stainless Steel, Viton®, Silicone RTV (Rubber), Glass Reinforced Nylon, Aluminum, Silicon, Glass.	

Standard Full Scale Flow Ranges		
0.5SCCM	100SCCM	50SLPM
1SCCM	500SCCM	100SLPM
2SCCM	1SLPM	250SLPM
5SCCM	2SLPM	500SLPM
10SCCM	5SLPM	1000SLPM
20SCCM	10SLPM	1500SLPM
50SCCM	20SLPM	

No charge for alternate full scale ranges to increase accuracy (e.g. 2.5SLPM) or alternate units of measure (e.g. 133SCFH).

Full Scale range applies for all 30 gases and mixtures in the calibration table.

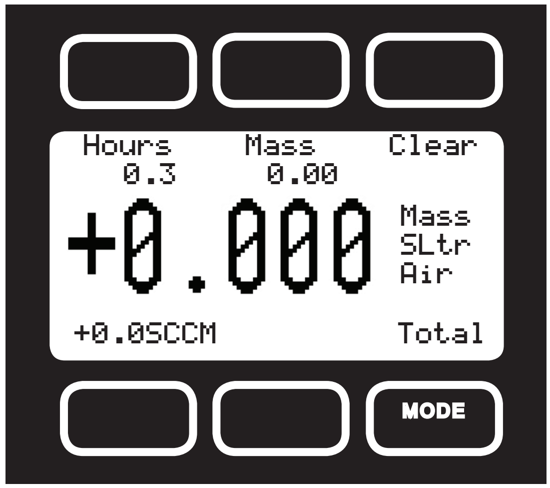
Standard Pressure Drop Across the Device in PSID	
Full Scale Flow	
0.5SCCM to 1SCCM	1.0
2SCCM to 50SCCM,	1.0
100SCCM to 500SCCM	1.0
1SLPM	1.0
5SLPM	1.0
10SLPM	1.0
20SLPM	1.0
50SLPM	2.0
100SLPM	2.5
250SLPM	4.0
500SLPM	5.5
1000SLPM	6.0
1500SLPM	9.0

Flow Conversion Table:

	CCM	CCH	LPM	LPH	CFM	CFH
CFH	0.0021	0.00003	2.1189	0.035	60.0	1.0
CFM	0.000035	0.0000005	0.035	0.00059	1.0	0.0166
LPH	0.06	0.001	60.0	1.0	1699.0	28.316
LPM	0.001	0.000017	1.0	0.0166	28.316	0.4719
CCH	60.0	1.0	60000.0	1000.0	1699011.0	28317.0
CCM	1.0	0.0167	1000.0	16.667	28317.0	471.947

Option: Totalizing Mode Screen

PCU Meters 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 meter or controller since the last time the totalizer was cleared. The Totalizing Mode screen shown below is accessed by pushing the “MODE” button until the label over it reads “Total”. *If your meter is ordered with Totalizing Mode option, pushing the “Mode” button once will bring up the “Totalizing Mode” display. Pushing “Mode” a second time will bring up the “Select Menu” display. Pushing it a third time will return you to the Main Mode Sreen.*



Counter – The counter can have as many as six digdits. At the time of order, the customer must specify the resolution of the count. This directly affects the maximum count. For instance, if a resolution 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 resolution, 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.

Hours.–.The display will show elapsed time since the last reset in 0.1 hour increments. The maximum measurable elapsed time is 6553.5 hours (about nine months). The hours count resets when the “clear” button is pushed, an RS-232 clear is executed or on loss of power

Clear – The counter can be reset to zero at any time by pushing the dynamically labeled “Clear” button located above the upper right side of the display. To clear the counter via RS-232, establish serial communication with the meter or controller as described in the RS-232 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>)