User's Guide to Advanced Serial Programming

Contents

Introduction

The Alicat Scientific Inc. Advanced Serial Programming Guide is intended to be a roadmap and tool for users who are interfacing with Alicat Flow and Pressure products via RS-232 / RS-485. From sending a setpoint or querying a device for data, to performing field calibrations, this manual is intended to provide a clear and concise guide to the manner in which Alicat devices interface over RS-232 / RS-485.

Alicat's RS-232 / RS-485 communication is a multi-drop interface wherein up to 26 different Alicat devices can be communicated with over a single com port on a laptop or PC. Each Alicat device on a multi-drop connection will have a unique letter ID between A and Z. An Alicat device that has an "@" symbol as its device ID is in streaming mode. An Alicat device with a letter ID is in polling mode. For the purposes of writing to registers or making adjustments to devices as described in this manual, it is best to have the device in question set to polling mode. Communication with multiple devices on a single COM port will be disrupted if any of those devices are in streaming mode.

This manual is divided into three primary sections. The first section covers the full list of available commands for the normal operation of Alicat devices and includes definitions of all error codes and commands.

The second section covers the 16 bit register definitions that control the basic operations of the Alicat devices (WARNING changing register values can alter and impair the operation of your device, please consult the factory if you have any questions about appropriate register definitions and your ability to use them for your needs.)

The third section covers basic field calibration procedures for adjusting the calibration of Alicat devices in the field or by Metrology departments, please note that field calibration invalidates the existing NIST traceable calibration certification.

RS-232 / RS-485 Commands Line

Below is an example of the data line that will be returned from a device being communicated with through RS-232 / RS-485, and an explanation of what each section of the output means.

A	+087.59	+024.41	+0000.0	+0000.0	0000.0	000000.0	Air	HLD
Device ID	Absolute pressure	Temperature	Volumetric flow rate	Mass flow rate	Set-point	Totalized flow	Gas	Status code

Quick Reference of RS-232 / RS-485 Commands

Command Codes

*@=A – Sets device identifier to A, sets device to Polling mode (applies to all connected devices).
A – Returns data frame
A[#] – Sends new setpoint
A$$G[#] – Changes gas selection
A$$V – Volumetric tare
A$$P – Pressure tare
A$$T – Resets TOTalizer
A$$H – Holds valve at present value
A$$C – Cancels valve hold
A$$L – Locks display
A$$U – Unlocks display
A$$A – Arms controller display
A$$R[#] – Reads contents of register
A$$W[#]=[value] – Writes value to register

Error Codes

ADC – Analog to Digital Conversion error
EXH – Valve Exhaust
HLD – Valve HOLD active
LCK – Display LOCK active
MOV – Mass flow Overage
POV – Pressure Overage
TOV – Temperature Overage
VOV – Volumetric flow Overage
OVR – Totalizer Overage

Query Codes

A??D* - Queries Data frame (ranges)
A??M* - Queries Manufacturer info
A??G* - Queries Gas list

RS-232 / RS-485 Commands, Error Codes and Uses

All of the following commands should be prefaced with the unit ID of the device you wish to send the command to (e.g. *A*$$V would tare the volumetric flow rate for unit *A*).

<u>Set Point</u>

0<Carriage Return> = 0% of device's full scale range
64000<Carriage Return> = 100% of device's full scale range
65535<Carriage Return> = 100% of device's full scale range, plus the device's 2.4% over range.

<u>Direct Value Set Point</u>

S25.2<Carriage Return> = Set Point of 25.2
S100<Carriage Return> = Set Point of 100

<u>Tares</u>

$$P<Carriage Return> = Tare Pressure
$$V<Carriage Return> = Tare Volumetric Flow
$$T<Carriage Return> = Tare Totalizer

<u>Gas Select</u>

??G*<Carriage Return> = Retrieves Gas Table of Device
$$G<Carriage Return> = Returns Data Line Specifying Gas
$$G0<Carriage Return> = Sets Gas of Device to AIR
$$G1<Carriage Return> = Sets Gas of Device to ARGON
$$G..<Carriage Return> = Set Gas of Device to Gas from Gas Table

<u>Read/Write Commands</u>

See the Reading and Writing Registers Section for detailed instructions.
$$R...<Carriage Return> = Read Command, used to read registers of the device.
$$W...<Carriage Return> = Write Command, used to write registers of the device.

<u>Front Panel Lockout</u>

$$L<Carriage Return> = Lock Front Panel Buttons
$$U<Carriage Return> = Unlock Front Panel Buttons

<u>Controller Valve Overrides</u>

On a Single Valve controller
$$H<Carriage Return> = Valve maintains current position
$$E<Carriage Return> = No effect.
$$C<Carriage Return> = Resume normal PID control

On a Dual Valve Controller
$$H<Carriage Return> = Both valves closed
$$E<Carriage Return> = Exhaust valve open inlet valve closed.
$$C<Carriage Return> = Resume normal PID control

Device Information Commands

??M*<Carriage Return> = Retrieves Manufacturer Data of Device
??D*<Carriage Return> = Returns Detailed Information About the Device’s Data Line Output

COMPOSER™ Commands

Creating and Deleting Gas Mixtures with COMPOSER™ using RS-232 or RS-485

Note: All commands must be prefixed with the unit ID if the unit is not in streaming mode. You may create and store up to 20 gas mixtures containing up to five constituent gases each. The constituent gases must be chosen from the existing list of gases installed on the device (which may vary model to model). Please see page 28for lists of gases and their corresponding gas numbers.

Create a Gas Mixture
To create a gas mixture, enter a single-line command according to the following formula:

[Unit ID]GM [Gas Name] [Gas Mix Number] [Percent 1] [Gas Number 1] [Percent 2] [Gas Number 2] …

Notes: Do not type the brackets. There should be only one space between all items. Any percentages less than 1, should have a leading zero before the decimal (i.e. 0.25 for .25%). Trailing zeros are not necessary but they are allowed to help visualize the percentages on screen (as in the example). The sum of all percentages must be 100.00 otherwise an error will occur.

Here is an example of a three gas mixture for a new gas called “MyMix1” (50% O2, 49.5% Helium, and .5% Neon), stored in user location #236, where the unit ID of the device is “A”:

A GM MyMix1 236 50.00 11 49.50 7 0.50 10 <ENTER>

Gas Name: Name your mixture using a maximum of 6 characters.

Gas Mix Number: COMPOSER™ user mixes have Alicat gas numbers between 236 and 255. You can assign any number in this range to your new mixture. If another mixture with the same number exists, it will be overwritten, even if that gas is currently selected on the unit. If you enter a 0 here, the new mix will be assigned the next available number between 236 and 255.

Percent 1: The percentage of the first constituent gas. The percentage of each constituent must be between 0.01 and 99.99. Values entered beyond two decimal points will be rounded to the nearest 0.01%.

Gas Number 1: The Alicat gas number of the first constituent gas.

Percent 2: The percentage of the first constituent gas. Values entered beyond two decimal points will be rounded to the nearest 0.01%.

Gas Number 2: The Alicat gas number of the first constituent gas.

Additional Gases: (Optional) The above pattern of [Percent] + [Gas Number] may be repeated for additional constituent gases up to a total of 5 constituents. The sum of all percentages must be 100.00.

On success, the unit ID (if set) is returned followed by a space. The number of the gas mixture is then returned, followed by the percentages and names of each constituent in the mix. If the gas is not successfully mixed, a "?" is returned.

Delete a Gas Mixture
To delete a gas mixture, enter: [Unit ID]GD [Gas Number]: The number of the COMPOSER™ user mixture you wish to delete from the unit

Only COMPOSER™ user mixtures can be deleted with this command.

On success, the unit ID (if set) is returned followed by a space and the number of the gas deleted. If the gas is not successfully deleted, a "?" is returned.

Basic Serial Command Information

Case Sensitivity

Alicat devices are case *insensitive*, in other words your device will treat the inputs **a** and **A** the same. All identifiers will be capitalized in this document.

Device Identifier

Alicat devices are given an alphabetical identifier. Typically, this identifier is factory set to 'A', although certain devices may use other letters, from A to Z. Other commonly used identifiers are 'L', 'M', 'H', and 'R'. To communicate with the device via RS-232 / RS-485, the identifier must be used. If the device has a display, the identifier can be found by pressing the 'menu' button, followed by the **RS-232 / RS-485 Comm** button. Under the **RS-232 / RS4-85 Comm** menu, find the **Unit ID** option, which will list the identifier of the device. If the device does not have a display, the identifier can be set to 'A' by entering ***@=A <Carriage Return>**. This "*@" command will write the unit ID to every device connected on the RS-232 / RS-485 line. If you are assigning unit ID's via this command, ensure that only the device you wish to assign an ID to is connected on the RS-232 / RS-485 line.. The identifier of the device can also be determined through Register 17.

If the identifier of the device is known, and needs to be changed, a similar command format to the one above can be used, substituting the command '(Identifier)' for the '*', which should look like **Z@=A<Carriage Return>**.

RS-232 / RS-485 Interface

RS-232 / RS-485 is the traditional name for a series of standards for serial binary data and control signals. In this case it specifically refers to the command line interface, using ASCII input that communicates with Alicat devices, which allows for the adjustment of registers to troubleshoot issues or customize the device for specific applications. RS-232 / RS-485 communications also allows for data acquisition from all Alicat devices, as well as automation of control.

Communication software is required to communicate via RS-232 / RS-485. Some users chose to write their own, but in most cases users will make use of a previously created application.

These applications include:

- **Alicat's Serial Terminal** application, which requires Microsoft's .NET Compact Framework to run. It is free, and will allow for full RS-232 / RS-485 communication. It is already configured for use with Alicat devices, and requires no further configuration. http://www.alicat.com/support/software/

- **Flow Vision SC**, an RS-232 / RS-485 communication application. It contains a Graphical User Interface (GUI) which provides automatic configuration, session saving for easy configuration and experiment setup reloads, data capturing and logging (including a graphing tool), simple and advanced script building for automating meter and control command sequences, software alarms, and support for multiple devices.
  http://www.alicat.com/products/accessories-and-software/flow-vision-software/
- **HyperTerminal**, which refers to a group of programs that were included with Windows from the release of Windows 95 until the release of Windows XP. Any editions of Windows released after Windows XP do not include HyperTerminal. HyperTerminal requires configuration to be used with Alicat devices, and if using an edition after Windows XP, a copy must be obtained from any of the various sources on the internet. Instructions for configuring HyperTerminal for use with Alicat devices are present in the device manual.
- **LabVIEW** (short for Laboratory Virtual Instrument Engineering Workbench), is a system design and development environment, which is commonly used for data acquisition, instrument control, and industrial automation. LabVIEW is not produced by Alicat, and requires configuration to work with our devices. Though we are not affiliated with National Instruments, we do attempt to provide support for using LabVIEW as an interface with our devices.
  http://www.alicat.com/support/software/
  http://www.ni.com/labview/buy/

Reading/Writing Registers

Reading a Register

The **Device Identifier** section can be referenced for further information on finding the identifier if it is not known. To read a register, begin by typing the identifier of the device, followed by **$$R**, and enter the numerical designation of the register to be queried. The full command to read register 20 on a device identified as **A**, should be

"**A$$R20<Carriage Return>**"

The device will respond with a data line output of the value in the register, as below:

"**A 020 = 9239**" Note that the value will can be any number between 0 and 65535, and will differ based on which register is queried.

Writing a Register

Writing a value to a register is performed in much the same way as reading a register. Begin by typing the identifier of the device, followed by **$$W**, and enter the numerical designation of the register you wish to write to, followed by an equal sign, and the value you wish to change the register to. This can be a value between 0 and 65535. The full command to write a value to register 20 on a device identified as **A**, should be

"**A$$W20=1047<Carriage Return>"**

The device will respond with a data line output confirming the new value in the register, as below:

"A 020 = 1047" Note that this value will be equal to whatever value that was written into the register if the command is entered correctly.

When attempting to read/write a register, if no response occurs, the command was not executed by the device. This can occur for several reasons such as the command was not received, was mistyped, RS-232 / RS-485 communication has failed, the command refers to an unimplemented or inappropriate register, or the value was unacceptable for the register. If the device does not respond, check the syntax and formatting of the command, and resend it.

Register Functionality

Due to space constraints a single register can hold multiple functionality settings. This results in needing to sum multiple values in a single register to obtain the desired result in functionality from the register. As an example, **Register 46** holds information for both the Gas Select table and Dead Band Settings.

Register Definitions

This section covers commonly referenced registers, including tables for typical values and their meanings, as well as explanations of their uses, and information for altering them to customize the device for a specific application. The commands for reading and writing to registers are covered on the previous page.

When adjusting the registers covered in the following section, it is best to follow these simple guidelines:

1) Read the value in the register you wish to change
2) Record this value for your records
3) Determine the change to the existing register value that you wish to implement, by consulting the register definition.
4) Add or subtract the adjustment from the existing value.
5) Write the sum of step 4 into the register

Important Notes: Each register will have **a given value already set in it**, based on the specifications of the device at its time of manufacture. Many of the values listed below for each register must be added to or subtracted from the current value in order to effect a correct change.
Do not assume that the register has a starting value of zero and work from there. Before making any changes, determine the current value of the register to be adjusted, and notate it, so that if the alteration to the register does not have the desired effect, the device can be reset to its previous state.

In some cases, it may be best to use the tables below to determine how the device is configured currently, and make alterations from there.

Each table under each separate register heading has different effects, and can be used with any value from either table.

The values from some tables can be added together to enable multiple functions. However for some registers, this is not the case, and only one selection must be made from each table.

Example: Register 17 has two distinct tables, **Baud Rate**, and **Device Identifier**. This means that any of the values from the first table, **Baud Rate**, can be used with any of the values from the **Device Identifier** table. The device can support many different configurations, ranging from choosing a Baud Rate of 38,400 and an identifier of 'B', which is a value of 16899, to choosing a baud rate of 2,400 and an identifier of 'Z', which is a value of 23040.

Some Registers have even more tables, and may need one table adjusted while the others remain the same. In these cases, it is important to determine which variables must remain the same from each available table, and only change the variable related to the specific table(s). Refer to Register 20 – Output Definitions (Page 16) for more in-depth examples.

Register 16 - Meter Functions

This register governs the device functions The **Function Enables** table defines what functionalities are enabled on the device. A typical mass device would have all of these function enables set, excepting the liquid correction enable, which is only used on liquid devices.

WARNING: Removing the any of the values from the Function Enables table will adversely affect the operation of the device. Include all given values (except Liquid Correction on non-liquid devices) on the table. If a function is not needed, use the Display and RS-232 / RS-485 Disables table to hide this data instead.

The **Display and RS-232 / RS-485 Disable** table defines what data will be displayed, or transmitted over RS-232 / RS-485. In a typical mass device, none of the values in this table would be used. Typically, this table would be used in cases when a user wanted to minimize the data output from the device, by toggling off data that they don't require for their application, in order to reduce the size of the data stream.

Display and RS-232 / RS-485 Disables		Function Enables	
32768	**= Don't Show Mass**	**128**	**= Mass Flow**
16384	**= Don't Show Gas**	**64**	**= Gas Select**
		32	**= Liquid Correction**
1024	**= Don't Show Volumetric**	**4**	**= Volumetric Flow**
512	**= Don't Show Temperature**	**2**	**= Temperature**
256	**= Don't Show Pressure**	**1**	**= Pressure**

Example: A user wishes to take a mass meter, and disable volumetric flow from displaying or streaming, while leaving the function enabled. The user does not want to invert their inputs or outputs.

Step 1: Refer to the **Display and RS-232 / RS-485 Disable** table. The user wants Volumetric Flow Display disabled. To disable Volumetric Flow Display, a value of **1024** would be added to the register.

NOTE: This table only disables features. To leave all data outputs enabled, you will not select anything from this table. This table is only for disabling functions. A value of 0 from this table means all basic data outputs of a device will be enabled.

Step 2: Refer to the **Function Enables** table. To enable Mass Flow, Gas Select, Volumetric Flow, Temperature and Pressure functions, the table shows values of **128, 64, 4, 2, 1**.

Step 3: Add the values found in steps 1 and 2 for a value of **1223.** Writing this value to register 16 will result in a device with Mass Flow, Gas Select, Volumetric Flow, Temperature, and Pressure enabled and Volumetric Flow Display disabled.

Register 17 - Device ID and RS-232F/RS-485H Settings

This register governs the device's baud rate and device identifier. Devices are factory configured to an identifier of A by default. To make any changes to registers, first put the device into polling mode. To change the identifier without being previously aware current identifier, use the command **'*@=(Identifier)<Carriage Return>'**, where the identifier is any letter from A – Z. This will also put the device into polling mode.

The **Baud Rate** table allows the user to raise or lower the baud rate of the device in order to allow for communication. Older computers or specific serial ports may require higher or lower baud rates than the 19,200 that the device typically is given at the factory. If a baud rate higher than 38,400 is required, contact the manufacturer for assistance.

To determine a value for the **Identifier** table, it is easiest start with a value of 65 * 256 = 16640, which equals **A**. To change the identifier, increase the base by 1. For example, 66 * 256 = 16896, which equals **B**, continuing until **Z**, which equals 23040 = 90 * 256.

To return the device to streaming mode, use the command **'@=@'**.

Device Identification and RS-232F/RS-485H Settings

Baud Rate		**Device Identifier**	
3	**= 38,400**	**A**	**= 16640**
2	**= 19,200**	**B**	**= 16896**
1	**= 9,600**	**…**	
0	**= 2,400**	**Z**	**= 23040**

Examples:	**'@'**	**RS-232F/RS-485H streaming device**
	'A' - 'Z'	**RS-232F/RS-485H addressed device**

Example, a user desires a device with a baud rate of 19,200 and an identifier of B.

Step 1: Refer to the **Device Identifier** table. An identifier of B requires a value of **16896**.

Step 2: Refer to the **Baud Rate** table. A Baud Rate of 19,200 requires a value of **2**.

Step 3: Add the values found in steps 1 and 2 for a value of **16898**. Writing this value to register 17 will result in a device with identifier **B** and a Baud Rate of 19,200.

Register 18 - Power-up Settings

This register governs the settings of the device upon power-up. These settings include limiting functionality accessible through the Front Panel buttons, changing what screen displays on power up, or stopping certain selections, such as gas selection, or set point.

The **Power-up Options** table contains options that control the operation of the device when it is powered on. These options are not all mutually exclusive. Some can be used in tandem to achieve combined effects.

32768 – The default setting for the device. Selecting this option allows all normal functions, including, but not limited to, saving the set point, and gas select, and using all Front Panel buttons. It specifically allows the device to **store a given set point** (either given via RS 232 or locally) to the EEPROM, causing the device to stay at that set point even if depowered and powered again.

16384 – **Front Panel Lock**. This option disables the use of the front panel buttons to protect the current settings on the device from being changed. While the menus of the device will still be accessible, no options are able to be altered without removing the lock.

4096 – **Display Totalizer Screen.** This option sets the device to show the **Totalizer** screen on power up. Only available if the Totalizer adder was included on the device at the time of manufacture.

2048 – **Do not save new Gas Selection**. This option will cause the device to only store a gas selection made through **RS 232 or the front panel** until the device is depowered and repowered, at which point it will reset to the default gas selection chosen before this option was enabled.

1024 – **Save Main Screen buttons**. This option, when selected, will cause the last data output selected by front panel button to remain on the screen after the device was depowered and repowered.

0 – **Set Point Reset.** This option causes the device to reset its set point to zero upon being depowered and repowered. This eliminates any previously given set points, including the $$H (Hold) command. This will also cause the device to display the **Main** screen on startup, while still remembering any gas selections made. The device will **not** save the main screen button selections.

The **Power-up Tare Delay** table allows the device to operate with a delay of up to 25.4 seconds before it will tare the flow it displays upon startup. If left at 0, the device will not tare upon power-up. Any value between 1 and 254 will add a tenth of a second of delay, and cause the device to perform an automatic tare after that delay from powering up the device.

<u>Power-up Options</u>
32768 = Automatically save new RS-232 / RS-485/local set points to EEPROM. (Standard)
16384 = FP buttons locked (Mode, Main Tare, & Gas Main buttons not affected).
4096 = Display Totalizer screen on power-up if totalizer active else Main screen.
2048 = Do NOT save new RS-232 / RS-485/FP gas selection to EEPROM.
1024 = Save Main screen (M,V,P,T) buttons to EEPROM when they change.
0 = Read setpoint only on power-up (do not save to EEPROM), FP buttons unlocked, valve hard-zero startup allowed on setpoint zero & $$H override, display Main screen, save gas selection to EEPROM, and do NOT save main screen buttons.

<u>Power-up Tare Delay (tenths of seconds)</u>
255 = No Tare
254 = 25.4 seconds delay
. . .
1 = 0.1 delay
0 = No Tare

Example, a user desires a device with default **Power-up Options** and a **Power-up Tare** with a delay of 2 seconds.

Step 1: Refer to the **Power-up Options** table. The default option requires a value of **32768**.

Step 2: Refer to the **Power-up Tare Delay** table. Activating the power-up tare and giving it a delay of 2 seconds requires a value of **20**.

Step 3: Add the values found in steps 1 and 2 for a value of **32788**. Writing this value to register 18 will result in a device with default power up options, with a tare that will occur 2 seconds after power-up.

Register 19 - Tare Settings

This register governs the settings for taring the device, ranging from enabling taring on the display to setting an automatic tare delay for Mass Flow Controllers. It also contains the option to change the set point display to a percentage of full scale instead of flow range.

The **Display Tare Select** table allows the device to be tared through the use of a button on the front panel of the display, as well as selecting what reading to tare.

The **Remote Tare Select** table allows a Flow Meter (not a controller) to be given an analog signal through the set point pin of the connector to tare a chosen variable from the list. If no value is selected, then remote taring is not enabled. **This option is not available on a Controller.**

The **Auto Tare Delay** table allows the device to add a delay period before it automatically tares. This can range from 0 seconds to 25.5 seconds, and can only be used on controllers. This delay is typically set to 11, or 1.1 seconds, except in the case of extremely low flow controllers, with ranges of 50 SCCM and below.

The **Special: RS-232 / RS-485 Option** table specifically enables the device to show the totalizer timer and/or the percentage of valve drive currently being used in the RS-232 / RS-485 data line. The valve drive percentage option is only available on controllers.

Display Tare Select		Remote Tare Select		Auto Tare Delay (tenths of seconds)	
8192	**= Volumetric**	**768**	**= Totalizer**	**255**	**= 25.5 seconds delay**
4096	**= Pressure**	**512**	**= Volumetric**	**. . .**	
0	**= No Display Tare**	**256**	**= Pressure**	**0**	**= 0.0 delay**
		0	**= No Remote Tare**		

Special: RS-232 / RS-485 Option

16384 = Display totalizer timer on data frame.

32768 = Display valve drive value in percent.

Example, a user desires a controller device with volumetric **Display Tare Select** and an **Auto Tare** Delay of 2 seconds, while outputting valve drive percentage.

Step 1: Refer to the **Display Tare Select** table. The volumetric tare select value is **8192**.

Step 2: Refer to the **Auto Tare Delay** table. To set the delay to 2 seconds, a value of **20** is also required.

Step 3: Refer to the **Special: RS-232 Option** table. Setting the valve drive output requires a value of **32768.**

Step 4: Add the values found in steps 1,2 and 3 for a value of **40980**. Writing this value to register 18 will result in a device with a volumetric display tare, a set point displayed in percent, and an auto tare delay of 2 seconds.

Register 20 - Output Definitions

This register governs a wide variety of features, from controller options such as set point types and auto tare enabling, to what variable the device is controlling, to the analog and current output of the device. This register is more complex and involved than any of the others listed, and requires great care when altering values in it. Each table requires only one selection, and some have two possible options, depending on the value entered.

The **Controller Options** table specifies the setpoint input method. The four selectable options for setpoint input method in this register are Analog, Serial, Current, and Front Display

The **Controller Select** table governs which variable a given controller will attempt to control when given a set point. Mass and volumetric flow, as well as pressure, are available. **Be aware that changing a controller from Mass/Volume to Pressure may require adjustment of the control terms of the device. Refer to the manufacturer with any questions.**

The **PWM Channels Select** table governs outputs, primary and secondary, current or analog. Be aware that changing from one type of output to another, i.e. 0-5V to 1-5V or 0-5V to 4-20mA, cannot be done in the field, and must be adjusted at the factory. Adjustments to track different variables within a given output type are able to be done through this register, such as changing 0-5V from tracking Mass Flow to Pressure.

Controller Options		Else (if the value on the left is not included)
16384	**= Analog Set point**	**RS-232 / RS-485 Set point**
8192	**= Auto Tare**	**No Auto Tare**
4096	**= 4-20 mA Set point**	**0-5V Set point**
2048	**= Local (Front Panel) Setpoint**	**Analog or RS-232 / RS-485**

Controller Select	
1024	**= Mass Flow**
768	**= Volumetric Flow**
256	**= Pressure**
0	**= No Controller**

PWM Channels Select

Main	Secondary	1-5V Range
11	**176**	**= Mass Flow**
10	**160**	**= Volumetric Flow**
9	**144**	**= Temperature**
8	**128**	**= Pressure**
		0-2.5-5V Bidirectional Range
15	**240**	**= Mass Flow**
14	**224**	**= Volumetric Flow**
13	**208**	**= Temperature**
12	**192**	**= Pressure**
		0-5V Range (externally convertible to 0-10V or 4-20mA)
7	**112**	**= Mass Flow**
6	**96**	**= Volumetric Flow**
5	**80**	**= Temperature**
4	**64**	**= Pressure**
		FIXED / Default
3	**48**	**Reserved**
2	**32**	**Reserved**
1	**16**	**= 5.12V Secondary / Main Out**
0	**0**	**= 0.00V Secondary / Main Out**

Example, a user desires a controller device with an analog set point, which controls volumetric flow, and has a primary output of 0-5V which tracks volumetric flow, and a secondary output of 0-5V which tracks pressure.

Step 1: Refer to the **Controller Options** table. The Analog Set Point value is **16384**. Controller devices should always receive Auto Tare, which is a value of **8192**.

Step 2: Refer to the **Controller Select** table. To control volumetric flow, the value is **768**.

Step 3: Refer to the **PWM Channels Select** table. To set the Main (or Primary) output to track volumetric flow, the value is in the first column, which is **6**. To set the Secondary output to track pressure, the value is in the second column, which is **64**.

Step 4: Add the values found in steps 1, 2 and 3 for a value of **17222**. Writing this value to register 20 will result in a device which has an analog set point, which controls volumetric flow, has a primary output of 0-5V which tracks volumetric flow, and a secondary output of 0-5V which tracks pressure.

NOTE: The **Registers 21, 22 and 23** govern the **PID control terms** of the device. The values of the registers directly represent these parameters. Altering these will directly effect the operation and control of the device. Consult the **primary device manual** for tuning instructions, or for more advanced information, **contact the manufacturer**.

Register 21 - Proportional Control Variable

Register 22 - Differential Control Variable

Register 23 - Integral Control Variable

Register 24 - Set Point

This register governs the set point of a controller device, to order the device to open or close it's valve. Any number can be used in this register, from a range of 0 to 64000, which is 100% of the full scale of the device.

Value	% of Full Scale
64000	**= 100**
48000	**= 75**
32000	**= 50**
16000	**= 25**
0	**= 0**

Register 26 – Volumetric Flow Gain

This register governs the flow gain of the device and can be any value between 0 and 65535. Adjusting will increase or decrease data output of the volumetric flow, by varying the software amplification of the device's sensor output. This register has a linear relationship to the reading of volumetric flow on the device. Adjustment toward the upper end of the register's value limit (65535) will raise the flow reading of the device. Adjustment toward the lower end (0), will decrease it. This register is primarily adjusted if the user needs to recalibrate their device in the field because it is not reading accurately.

Note: Great care should be taken to notate what the device's original value in register 26 is before making any adjustments, as any changes to register 26 can affect the device's accuracy.

Note: In most cases, the flow gain of a device falls into a predetermined range. If the user's device requires a value in register 26 below 2000 or above 48000, it is possible that the device may need troubleshooting and repair. Contact the factory about the issue before attempting to recalibrate the device.

Value	Gain
65535	**= 2.9999**
49152	**= 2.5**
32768	**= 2.0**
16384	**= 1.5**
0	**= 1.0**

Register 33 – Pressure Offset

This register can be any value between 0 and 65535. It is used to adjust the absolute pressure reading of the device, to bring it into agreement with the current barometric pressure. If the barometric pressure reading of the device is reading off from an accurate barometric pressure standard, this register can be adjusted to bring the device back into agreement. Raising the value in this register will lower the pressure reading.This register is very sensitive, so it should not be necessary to adjust this address by a great amount to bring the device into agreement.

Note: If the variance between the device's barometric pressure reading and the accurate barometric standard is more than +/-0.5 PSIA, the device is considered be grossly out of specification, may be damaged, and should be returned to the factory for evaluation instead of being adjusted in the field.

Register 41 – Temperature Offset

This register can be any value between 0 and 65535. Typically, this register should be approximately 35000. It is used to adjust the current temperature reading of the device. Handling or powering the device for long periods of time will cause the temperature reading to shift. To get an accurate reading against an accurate temperature standard, ensure that the device is not powered or handled, and is left in the same environment as the temperature standard for long enough to ensure that they are both equilibrated before checking the temperature. The sensor is very sensitive and can shift easily in these conditions. Changes in the value of the register are 128 counts per 1 °C. Raising the value in the register will lower the temperature reading.

Note: If the variance between the device's temperature reading and the accurate temperature standard is more than +/-2.0 °C, the device is considered to be grossly out of specification, may be damaged, and should be returned to the factory for evaluation instead of being adjusted in the field.

Register 42 - STP

Register 42 contains the definition of the STP that a given Mass flow device is using to calculate mass flow. The default value in register 42 is 32768, and this stands for a 160 PSIA scale unit set to an STP of 25° C and 1 atm.

Here are some common STP's and their equivalent value in Register 42 for basic changing of STP over RS-232 / RS-485:

Pressure Scale	Standard Temperature	Standard Pressure	Register 42
160 PSIA	25 C	1 atm	32768
160 PSIA	21 C	1 atm	32328
160 PSIA	0 C	1 atm	30020
160 PSIA	70 F (21.11 C)	1 atm	32340
160 PSIA	20 C	1 atm	32218
60 PSIA (Whisper)	25 C	1 atm	12288
60 PSIA (Whisper)	21 C	1 atm	12123
60 PSIA (Whisper)	0 C	1 atm	11258
60 PSIA (Whisper)	70 F (21.11 C)	1 atm	12128
60 PSIA (Whisper)	20 C	1 atm	12082

Please note that register 42 can adversely effect mass flow readings if used incorrectly. Units with differing mass and volumetric flow ranges may have significantly different values in register 42. Please consult factory if you have questions or discrepancies regarding register 42.

Register 46 – Gas Select / Deadband

This register controls both gas selection and the display dead band settings. Please see page 28 for lists of gases and their corresponding gas numbers.

Register 46: Gas Select

Values between 0-255 are used to represent gasses from the selection available in the unit. 0-29 are the standard gasses included on units prior to Composer software being added. Additional gasses are available if the unit has Composer software. To determine the value for a particular gas, use of the ??G* command will return all gasses in the unit, as well as their number.

The Zero Dead Band function is added to whatever gas selection value is set. Zero Dead Band will cause the display to ignore flow readings below a certain percentage of full scale flow, allowing noise to be eliminated for ease of interpreting the visible reading. This can be set anywhere between 0% and 6.375%.

Note: Mass Controllers will have Zero Dead Band set to 0% by default. Using a value other than 0% could allow the unit to control to a set-point while the display evidences no flow.

The default value for mass flow meters, as well as all pressure units is .25%

As an example, to set a device's gas select to Helium with a dead band of .25% of full scale, you would:

Step 1: Look in the Main Gas Table and find the desired gas, **Helium**, this corresponds to a register value of **7**.

Step 2: Look at the Zero Band table and find the desired .25%, this corresponds to a value of **2560**.

Step 3: Add the values from Step 1 and 2, which will give a result of **2567.** Writing this value to register 46 will change the gas of the device to **Helium**, while also setting the zero dead band of the device to **.25%**.

Main Gas Table

0 = Air	10 = Ne Neon	20 = C-25 75Ar+25CO2
1 = Ar Argon	11 = O2 Oxygen	21 = C-10 90Ar+10CO2
2 = CH4 Methane	12 = C3H8 Propane	22 = C-8 92Ar+8CO2
3 = CO Carbon Monoxide	13 = n-C4H10 norm-Butane	23 = C-2 98Ar+2CO2
4 = CO2 Carbon Dioxide	14 = C2H2 Acetylene	24 = C-75 75CO2+25Ar
5 = C2H6 Ethane	15 = C2H4 Ethylene	25 = HE-75 75Ar+25He
6 = H2 Hydrogen	16 = i-C4H10 iso-Butane	26 = He-25 75HE+25Ar
7 = He Helium	17 = Krypton	27 = A1025 He A-1025
8 = N2 Nitrogen	18 = Xe Xenon	28 = Star29 Stargon® CS
9 = N2O Nitrous Oxide	19 = SF6 S Hexafluoride	29 = P-5 95Ar+5CH4

Note: Alicat instruments manufactured before the addition of the COMPOSER feature include only those gases listed in the Main Gas Table. For COMPOSER equipped instruments, please see page 28 for complete lists of gases and their corresponding gas numbers.

Register 46: Deadband

LCD P,V,M Zero Band

0	**= 0.000% Full Scale**
256	**= 0.025**
512	**= 0.050**
. . .	
5120	**= 0.500**
. . .	
10240	**= 1.000**
. . .	
65280	**= 6.375% Full Scale**

Register 47 - Pressure & Volumetric Flow Averaging (Geometric Running Average)

This register governs the averaging of both the pressure reading of the device, and the volumetric flow of the device. Each can be adjusted individually depending upon the application's requirements. Typical values that are used for this register include **257**, which refers to the minimum averaging available for both pressure and volumetric flow, **383**, which refers to 50% averaging on volumetric flow, and **511**, which refers to 100% averaging on volumetric flow. In most cases, averaging is not needed for pressure readings, and should be left at its minimum value. For maximum averaging, write **65535** to the register, which will raise both volumetric and pressure averaging to their maximum.

Values of 1 to 256 for additional averaging on pressure and vflow.

Initialize to 257 (256 + 1) for minimum geometric running averaging on both.

Pressure	VFlow	GRA	
256	**1**	**= 1**	**minimum geometric running averaging**
512	**2**	**= 2**	
. . .	**. . .**	**. . .**	
65280	**255**	**= 255**	

Register 53 – Controller Valve Offset

Dual-valve pressure controllers have a unique relationship with this register. The value in this register must end in an odd number in order to enable dual-valve control, and the device must be depowered and repowered between each adjustment to register 53. Contact the factory with any questions regarding these settings with dual-valve pressure controllers.

Back-pressure controllers and negative gauge controllers can sometimes have a unique relationship with this address as well, causing it's operation to be inverted. Contact the factory if questions or problems arise regarding this.

This register controls how quickly a controller's valve opens from a zero set-point, by adjusting the amount of voltage that the valve drive starts with (voltage offset) to reduce the amount of lag before the valve actually begins to control the selected variable. All controllers will have a value set in this register between 0 and 65535. A higher value in this register will cause the valve to open with less delay, but may have problematic effects with overshoot when initially opening the valve from a closed state. A lower value will cause there to be a lag time (potentially siginifcant) before the valve actually opens and begins controlling.

This value is factory-set using default pressure conditions based on the flow rate of the valve. Any controller should already have a value in this register, typically anywhere between 15000 and 30000, depending on the flow rate and the presence of any specified pressure conditions.

To make adjustments to these settings:

Increasing response speed

1. Place the unit in whatever conditions it will be in when in use. Ensure the device has a 0% set-point, and that the inlet pressure is set to the pressure for use.
2. Give the device a very small set-point, 1-2% of full scale. Observe the unit, to see how long it takes to register a flow reading.
3. If this is longer than desired, increase the value in register 53 by 1000, and try again. Larger increments of change will return a shorter delay. If the flow reading overshoots the set-point badly, the value in register 53 is too high, and should be reduced.

Decreasing response speed (removing overshoot issues)

1. Place the unit in whatever conditions it will be in when in use. Ensure the device has a 0% set-point, and that the inlet pressure is set to the pressure for use.
2. Give the device a very small set-point, 1-2% of full scale. Observe the unit, to see how long it takes to register a flow reading.
3. If the device is overshooting the set-point objectionably, reduce the value in register 53 by 1000, and try step 2 again. Larger increments of change will reduce the overshoot more. If the flow reading stops showing a flow reading immediately, the value in register 53 is too low, and should be increased.

Register 85 - PID Loop Select

This register governs the control algorithm selection for the device. In most cases, the device will be set to PD. In pressure controllers, or other high-accuracy controllers, PD2I may be used.

2 = PD2I - Should be used for dual-valve controllers. May be used for high-performance flow controllers operating with precisely defined pressure conditions. May also be used for flow-through pressure controllers.

1 = PD - Normally selected control algorithm. This is generally going to provide good, stable control on single valve devices and is easier to tune.

Note: Dual valve devices also need the value of 32768 added to register 85 to ensure proper functionality.

Register 91 – Streaming speed

This register governs the communication speed while the unit is in streaming mode. The device can be set to streaming mode by setting the device identifier to "@" either through the display or using a serial command. The device will constantly send a data frame over serial without waiting for a serial command. In order to maximize streaming speed remove any data not of interest from the data stream, this is done by editing register 16.

1	=	1ms (Minimum)
50	=	50ms (Default)
65535	=	65.535 seconds (Maximum)

Register 92 - Batch totalizer set point

This feature requires a controller equipped with a totalizer (optional). The batch totalizer set point allows the unit to flow a predetermined amount before stopping flow. If the device has a zero in this register its set point will be disabled and the device will operate without this feature.

Assuming the device is ranged to 100.0sccm with a matching totalizer (default) and the desired flow amount is 50.5cc setting this register to 50.5 will allow the unit to flow at the preset flow rate until the device has flowed the desired amount. Once this flow amount is reached the device will override valve control shutting the valve.

Field Calibration of Alicat Flow Meters

Experience has shown that most users of Alicat Scientific flow meters treat these instruments with care. This means that recalibration is normally a simple matter of checking the flow against a standard and adjusting the flow gain so that it matches an accurate standard.

Before attempting to recalibrate the device, it is necessary to check that the reading of the absolute pressure and temperature sensors are within specifications. If the temperature or pressure requires adjustment, adjust them prior to adjustment of the flow gain.

Step 1: Establishing Serial Communications

There are a number of options for how to establish RS-232 / RS-485 communications with the Alicat device. See the '**RS-232 / RS-485 Interface**' section for details. If the user wishes to interface via HyperTerminal, the instructions for setting up communications are included in the device manual. Communications can also easily be established via Alicat's Serial Terminal, or Flow Vision SC.

Type *@=A<Carriage Return> to poll the flow meter. The computer should respond with a single line of information.

After the address has been set to A, type "A" followed by hitting the <Carriage Return> key to see a line of current data.

Step 2: Temperature

To check the temperature, the meter should be left in the same environment as the temperature standard for long enough to ensure the meter and the standard are both equilibrated. The temperature sensors are quite sensitive and can easily change temperature if the flow bodies are handled or held. Make sure it has not been handled prior to comparing the displayed temperature to the standard.

The temperature reading on the meter display should be equal to the standard within +/- 2.0°C. **If it is grossly out of specification, the device may have been damaged and should be returned to the factory for evaluation.**

Once the device is in the conditions listed above, continue through the communications application.

*Refer to the '**Register 41 – Temperature Offset**' (page 19) section for more detailed information.

1. Type A$$R41<Carriage Return>. The computer responds with A 41=XXXXX where the X's denote the numerical value in register 41. **Write this value down so that register 41 can be returned to the factory settings if necessary.**
2. The value in register 41 will need to be changed in order to make the reading match the temperature standard within 0.5°C.

   Note: Changes are 128 counts per °C. Increasing the value in register 41 will lower the temperature. Decreasing the value will raise it.

3. Type A$$W41=XXXXX where the X's denote the new value to be attempted.
4. Type **A<Carriage Return>** to poll the device and compare the temperature reading with the temperature standard. (The temperature is the second piece of data in the line.)

Step 3: Absolute Pressure

To check the absolute pressure, the meter should be checked against an accurate barometric standard. Make sure the environment in which the meter being checked resides is still and not affected by stray air currents, as from forced air heaters or air conditioners.

The absolute pressure reading on the meter display should be equal to the standard within +/-0.5 PSIA. **If it is grossly out of specification, the device may have been damaged and should be returned to the factory for evaluation.**

Once the device is in the conditions listed above, continue through the communications application.

*Refer to the '**Register 33 – Pressure Offset**' (page 19) section for more detailed information.

1. Type A$$R33<Carriage Return>. The computer responds with A 33=XXXXX where the X's denote the numerical value in register 33. **Write this value down so that register 33 can be returned to the factory settings if necessary.**
2. The value in register 33 will need to be changed in order to make the reading match the barometric standard.

   Note: Increasing the value in 33 will reduce the pressure reading. The scale is fairly sensitive, so a large change should not be necessary.
3. Type A$$W33=XXXXX<Carriage Return>, where the X's denote the new value. The computer should respond with A 33=XXXXX with the new value.
4. Type A<Carriage Return> to poll the device and compare the absolute pressure reading with the barometric standard. (The pressure is the first piece of data in the line.)

Step 4: Flow

To check the flow, the meter should be checked against an accurate mass flow standard. Prior to checking against the standard, several things should be noted:

Be sure that the meter is set for the gas flowing through the standard.

Be sure that the standard is set for the gas flowing through it.

Be sure that the standard is correcting to standard conditions of 25°C and 14.695 PSIA

Be sure that the meter is powered by an appropriate AC/DC adapter.

Be sure there are NO leaks between the meter and the standard.

Be sure to perform a valid tare on the meter prior to the flow check. See the manual for instructions on accurately taring the meter.

Once the device in the conditions listed above, continue through the communications application

*Refer to the '**Register 26 – Volumetric Flow Gain** (page 18) section for more detailed information

Check the flow reading at 25% of full scale, 50% of full scale, and 100% of full scale. All should match the flow standard within 1% of the full scale of the device (full scale / 100). If the meter is within +/-1.0% of the full scale range of the device, the flow gain should be adjusted as described below.

If the gain cannot be adjusted such that all of the above points fall within 1% against the standard, the meter may be fouled or the differential pressure sensor may be damaged and the meter may need to be returned to the factory for cleaning/evaluation. The most common cause of non-linearity is nonlaminar flow which is often caused by debris or corrosion.

To adjust the flow gain:

1. Type A$$R2 <Carriage Return>. The device should respond with A 26=XXXXX, where the X's denote the numerical value in register 26. Perform a linear interpolation to determine what value is required to match the desired gain. This can also be approached by the trial and error method if necessary.
2. Set the flow to full scale by the flow standard and adjust register 26 as follows until the flow reading matches the flow standard.
3. Enter the new value to register 26. For example, to try a gain of 2, type A$$W26=XXXXX<Carriage Return> where the X's denote the numerical value.
4. The computer will respond to the new value by confirming that A 26=32768. To see the effect of the change, type A<Carriage Return> to poll the device. Do this several times and take an average if necessary. **It is good practice to tare the meter at zero flow between gain adjustments.**
5. Once register 26 is set to a value that brings the device within +/-1.0% of full scale check readings at half and quarter scale to make sure they still match the standard. These devices are generally quite linear, and the readings should fall in within 1% of the full scale of the device.

Alicat Select 5.0 Preloaded Gases

Note: Alicat instruments manufactured before the addition of the COMPOSER feature include only those gases listed in the Main Gas Table (page 21). For COMPOSER equipped instruments, please reference the lists below for gases and their corresponding gas numbers.

Alicat Gas Select™ 5.0 Preloaded Gases

PURE NON-CORROSIVE GASES

Gas Number	Short Name	Long Name
14	C2H2	Acetylene
0	Air	Air
1	Ar	Argon
16	i-C4H10	i-Butane
13	n-C4H10	n-Butane
4	CO2	Carbon Dioxide
3	CO	Carbon Monoxide
60	D2	Deuterium
5	C2H6	Ethane
15	C2H4	Ethylene (Ethene)
7	He	Helium
6	H2	Hydrogen
17	Kr	Krypton
2	CH4	Methane
10	Ne	Neon
8	N2	Nitrogen
9	N2O	Nitrous Oxide
11	O2	Oxygen
12	C3H8	Propane
19	SF6	Sulfur Hexafluoride
18	Xe	Xenon

BREATHING GASES

Gas Number	Short Name	Long Name
164	EAN-32	32% O2 / 68% N2
165	EAN	36% O2 / 64% N2
166	EAN-40	40% O2 / 60% N2
167	HeOx-20	20% O2 / 80% He
168	HeOx-21	21% O2 / 79% He
169	HeOx-30	30% O2 / 70% He
170	HeOx-40	40% O2 / 60% He
171	HeOx-50	50% O2 / 50% He
172	HeOx-60	60% O2 / 40% He
173	HeOx-80	80% O2 / 20% He
174	HeOx-99	99% O2 / 1% He
175	EA-40	Enriched Air-40% O2
176	EA-60	Enriched Air-60% O2
177	EA-80	Enriched Air-80% O2
178	Metabol	Metabolic Exhalant (16% O2/ 78.04% N2 / 5% CO2 / 0.96% Ar)

CHROMATOGRAPHY GASES

Gas Number	Short Name	Long Name
29	P-5	5% CH4 / 95% Ar
206	P-10	10% CH4 90% Ar

WELDING GASES

Gas Number	Short Name	Long Name
23	C-2	2% CO2 / 98% Ar
22	C-8	8% CO2 / 92% Ar
21	C-10	10% CO2 / 90% Ar
140	C-15	15% CO2 / 85% Ar
141	C-20	20% CO2 / 80% Ar
20	C-25	25% CO2 / 75% Ar
142	C-50	50% CO2 / 50% Ar
24	C-75	75% CO2 / 25% Ar
25	He-25	25% He / 75% Ar
143	He-50	50% He / 50% Ar
26	He-75	75% He / 25% Ar
144	He-90	90% He / 10% Ar
27	A1025	90% He / 7.5% Ar / 2.5% CO2
28	Star29	Stargon CS 90% Ar / 8% CO2 / 2% O2

PURE CORROSIVES*

Gas Number	Short Name	Long Name
32	NH3	Ammonia
80	1Butene	Butylene (1-Butene)
81	cButene	Cis-Butene (cis-2-butene)
82	iButene	Iso-Butene
83	tButene	Trans-Butene
84	COS	Carbonyl Sulfide
33	Cl2	Chlorine
85	CH3OCH3	Dimethylether
34	H2S	Hydrogen Sulfide (H2S)
31	NF3	NF3 (Nitrogen Trifluoride)
30	NO	NO (Nitric Oxide)
36	C3H6	Propylene (Propylene)
86	SiH4	Silane (SiH4)
35	SO2	Sulfur Dioxide

*Pure Corrosive gases are only available on S-Series instruments that are compatible with these gases.
Gas numbers 33 and 35 are not available on controllers.

BIOREACTOR GASES

Gas Number	Short Name	Long Name
145	Bio-5M	5% CH4 / 95% CO2
146	Bio-10M	10% CH4 / 90% CO2
147	Bio-15M	15% CH4 / 85% CO2
148	Bio-20M	20% CH4 / 80% CO2
149	Bio-25M	25% CH4 / 75% CO2
150	Bio-30M	30% CH4 / 70% CO2
151	Bio-35M	35% CH4 / 65% CO2
152	Bio-40M	40% CH4 / 60% CO2
153	Bio-45M	45% CH4 / 55% CO2
154	Bio-50M	50% CH4 / 50% CO2
155	Bio-55M	55% CH4 / 45% CO2
156	Bio-60M	60% CH4 /40% CO2
157	Bio-65M	65% CH4 /35% CO2
158	Bio-70M	70% CH4 / 30% CO2
159	Bio-75M	75% CH4 / 25% CO2
160	Bio-80M	80% CH4 / 20% CO2
161	Bio-85M	85% CH4 / 15% CO2
162	Bio-90M	90% CH4 / 10% CO2
163	Bio-95M	95% CH4 / 5% CO2

LASER GASES

Gas Number	Short Name	Long Name
179	LG-4.5	4.5% CO2 / 13.5% N2 / 82% He
180	LG-6	6% CO2 / 14% N2 / 80% He
181	LG-7	7% CO2 / 14% N2 / 79% He
182	LG-9	9% CO2 / 15% N2 / 76% He
183	HeNe-9	9% Ne / 91% He
184	LG-9.4	9.4% CO2 / 19.25% N2 / 71.35% He

O2 CONCENTRATOR GASES

Gas Number	Short Name	Long Name
197	OCG-89	89% O2 / 7% N2 / 4% Ar
198	OCG-93	93% O2 / 3% N2 / 4% Ar
199	OCG-95	95% O2 / 1% N2 / 4% Ar

REFRIGERANTS*

Gas Number	Short Name	Long Name
100	R-11	Trichlorofluoromethane
101	R-115	Chloropentafluoroethane
102	R-116	Hexafluoroethane
103	R-124	Chlorotetrafluoroethane
104	R-125	Pentafluoroethane
105	R-134A	Tetrafluoroethane
106	R-14	Tetrafluoromethane
107	R-142b	Chlorodifluoroethane
108	R-143a	Trifluoroethane
109	R-152a	Difluoroethane
110	R-22	Difluoromonochloromethane
111	R-23	Trifluoromethane
112	R-32	Difluoromethane
113	RC-318	Octafluorocyclobutane
114	R-404A	44% R-125 / 4% R-134A / 52% R-143A
115	R-407C	23% R-32 / 25% R-125 / 52% R-134A
116	R-410A	50% R-32 / 50% R-125
117	R-507A	50% R-125 / 50% R-143A

*Refrigerant gases are only available on S-Series instruments that are compatible with these gases.

FUEL GASES

Gas Number	Short Name	Long Name
185	Syn Gas-1	40% H2 + 29% CO + 20% CO2 + 11% CH4
186	Syn Gas-2	64% H2 + 28% CO + 1% CO2 + 7% CH4
187	Syn Gas-3	70% H2 + 4% CO + 25% CO2 + 1% CH4
188	Syn Gas-4	83%H2+14%CO+3%CH4
189	Nat Gas-1	93% CH4 / 3% C2H6 / 1% C3H8 / 2% N2 / 1% CO2
190	Nat Gas-2	95% CH4 / 3% C2H6 / 1% N2 / 1% CO2
191	Nat Gas-3	95.2% CH4 / 2.5% C2H6 / 0.2% C3H8 / 0.1% C4H10 / 1.3% N2 / 0.7% CO2
192	Coal Gas	50% H2 / 35% CH4 / 10% CO / 5% C2H4
193	Endo	75% H2 + 25% N2
194	HHO	66.67% H2 / 33.33% O2
195	HD-5	LPG 96.1% C3H8 / 1.5% C2H6 / 0.4% C3H6 / 1.9% n-C4H10
196	HD-10	LPG 85% C3H8 / 10% C3H6 / 5% n-C4H10

STACK GASES

Gas Number	Short Name	Long Name
200	FG-1	2.5% O2 / 10.8% CO2 / 85.7% N2 / 1% Ar
201	FG-2	2.9% O2 / 14% CO2 / 82.1% N2 / 1% Ar
202	FG-3	3.7% O2 / 15% CO2 / 80.3% N2 / 1% Ar
203	FG-4	7% O2 / 12% CO2 / 80% N2 / 1% Ar
204	FG-5	10% O2 / 9.5% CO2 / 79.5% N2 / 1% Ar
205	FG-6	13% O2 / 7% CO2 / 79% N2 / 1% Ar