

SBA-5

CO₂ Gas Analyzer



Operation Manual

Version 2.03

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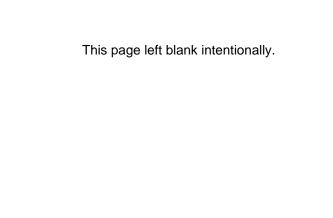


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Welcome

Thank you very much for purchasing our **SBA-5 CO₂ Gas Analyzer**. We greatly appreciate your business and we look forward to working with you and your team for many years to come.

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For applications where failure of this equipment to function correctly would lead to consequential damage, the equipment must be checked for correct operation and calibration at intervals appropriate to the circumstances. The PP Systems' equipment warranty is limited to replacement of defective components, and does not cover injury to persons or property or other consequential damage.

This manual is provided to help you install and operate the equipment. Every effort has been made to ensure that the information it contains is accurate and complete. PP Systems does not accept any liability for losses or damages resulting from the use of this information.

It is the operator's responsibility to review this information prior to installation and operation of the equipment. Otherwise, damage may be caused which is not covered under our normal warranty policy.

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User Registration

It is very important that ALL new customers register themselves with us to ensure that our user's list is kept up-to-date. If you are a PP Systems' user, please go to www.ppsystems.com and click on Customer Registration in the upper left hand corner.

Only **REGISTERED** users will be allowed access to the protected "Users" section of our web site. This section will contain important product information including hardware/software updates, application notes, newsletters, etc.

Thank you in advance for your cooperation.

Service & Warranty

PP Systems' equipment warranty is limited to replacement of defective components, and does not cover injury to persons or property or other consequential damage.

The equipment is covered under warranty for one complete year, parts and labor included. This, of course, is provided that the equipment is properly installed, operated and maintained in accordance with written instructions (i.e. Operator's Guide).

The warranty excludes all defects in equipment caused by incorrect installation, operation or maintenance, misuse, alteration, and/or accident.

If for some reason, a fault is covered under warranty, it is the responsibility of the customer to return the goods to PP Systems or an authorized agent for repair or replacement of the defective part(s).

Prior to returning equipment to PP Systems for service, you must first get in contact with our Service Manager (service@ppsystems.com) to request a case number for reference and tracking purposes.

Contact Information

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Unpacking and Storage of Your Equipment

Unpacking

It is extremely important that you check the contents of your equipment immediately upon receipt to ensure that your order is complete and that it has arrived safely. Please refer to the packing list to show all items that are included with your order. DO NOT DISCARD ANY OF THE PACKAGING MATERIAL UNTIL ALL OF THE ITEMS LISTED ARE ACCOUNTED FOR. WE RECOMMEND THAT YOU RETAIN THE ORIGINAL PACKING FOR FUTURE USE. If you suspect that any of the items listed on the packing list are not included or damaged, you must contact PP Systems or your authorized distributor immediately.

Introduction to this Operation Manual

In April 2017, a major revision was made to the SBA-5 that changed the microprocessor architecture and firmware that controls the operation of the product. The basic functionality, specifications, accuracy and commands were fundamentally unchanged. But there are few improvements and differences that were incorporated. If you have an SBA-5 purchased before April 2017, or with serial number lower than 5200, the SBA-5 CO2 Analyzer Operation Manual – Version 1.06 is the appropriate document to accurately describe your SBA-5.

For SBA-5 purchased after April 2017 with serial number 5200 and above, the **SBA-5 CO2 Analyzer Operation Manual – Version 2.00** (or higher) is the appropriate document to accurately describe your SBA-5.

Technical Specification

Analysis Method	Non-dispersive infrared, configured as an absolute
Analysis metriod	absorptiometer with microprocessor control of linearization.
	about the minute of the control of the care and the
CO₂ Measurement Ranges	0-1000 ppm (µmol mol ⁻¹) / 0.1%
CO2 monomone name	0-2000 ppm (µmol mol-1) / 0.2%
	0-5000 ppm (µmol mol-1) / 0.3%
	0-10000 ppm (µmol mol ⁻¹) / 1%
	0-20000 ppm (µmol mol ⁻¹) / 2%
	0-30000 ppm (µmol mol ⁻¹) / 3%
	0-50000 ppm (µmol mol ⁻¹) / 5%
	0-100000 ppm (µmol mol ⁻¹) / 10%
	, , , , , , , , , , , , , , , , , , ,
	Custom ranges up to 100,000 ppm upon request.
	Measurements are automatically corrected for temperature and
	pressure.
Pressure Compensation Range	60-115 kPa
Accuracy	<1% of span concentration over the calibrated range but limited
	by the accuracy of the calibration gas mixture.
Linearity	<1% throughout the range.
Stability	Automatic zero at regular intervals corrects for sample cell
	contamination, source and detector aging and pre-amplifier gain
	changes.
Calibration	Llogram and management of the service of
Warm-up Time	User programmable calibration (if required)
warm-up rime	Approximately 15 minutes. We recommend 30 minutes.
Sampling Rate	10 Hz. Sample data is averaged and output every 1.0 seconds.
Camping Nate	10 112. Cample data is averaged and output every 1.0 seconds.
Gas Flow Rate	Range: 100-1,000 cc/min (Maximum)
	We recommend 200-500 cc/min
Terminal Block	12 pin terminal block for system inputs and outputs.
101111111111111111111111111111111111111	
Analog Output	Dual 0-5V linear (CO ₂ and H ₂ O)
	4-20 mA (CO ₂ only)
Digital Interface	RS-232 (Terminal block)
	USB (Miniature 5 pin)
	Humidity Sensor Input
Sensor Input	1 sensor input channel (0-1V)
Power Supply	6-18 VDC
Power Consumption	~9 W (warm-up)
-	~1-3 W (normal operation and dependent on ambient
	temperature)
Electrical Connections	USB (Mini Type B), 12 pin pluggable terminal block, 2 pin power
	input and 0.1" header (12 pin)
Gas Connections	Three barbed fittings (inlet, exhaust and zero).
PCB Type	FR4
Operating Temperature Range	-20°C to +50°C
Relative Humidity Range	0-95% RH, non-condensing

Technical Specification (Continued)

Dimensions	12 cm (L) x 3.5 cm (H) x 7.5 cm (W) (SBA-5 PCB only) 13 cm (L) x 4.5 cm (H) x 8 cm (W) (SBA-5 with enclosure)
Weight	0.2 kg (SBA-5 PCB only) 0.4 kg (SBA-5 with enclosure)

PP Systems is continuously updating its products and reserves the right to amend product specifications without notice.

All brand/product names are trademarks of their respective owners.

Optional SBA-5 Accessories

PP Systems offers a range of optional accessories for use with the SBA-5 as follows:

Order Information		
Part Number	Description	
STD547	H ₂ O Sensor (SBA-5)	
	Solid state H ₂ O sensor for measurement of H ₂ O in addition to CO ₂ .	
	Range: 0-Dewpoint (mb)	
	Accuracy: < 2% RH	
10181-1	Miniature Rotary Sampling Pump (Schwarzer)	
STD509	Absorber Column	
STD007W	Sofnolime – CO ₂ scrubber for Auto-Zero	
AGA407/AGA408	Enclosure (including the SBA-5)	

To learn more about these optional accessories visit <u>www.ppsystems.com</u> or contact PP Systems directly.

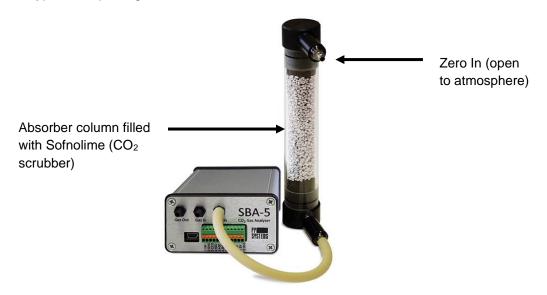
SBA-5 CO₂ Gas Analyzer with Optional Enclosure

As described on the previous page, the SBA-5 can be supplied complete with a rugged, aluminum enclosure if required. If purchased from PP Systems, the optional sampling pump and/or H₂O sensor can be housed and connected inside the enclosure.



Gas Connection

The sample gas connection is made to the "Gas In" port. After the gas passes through the CO₂ gas analyzer, it will exhaust from the "Gas Out" port. The "Zero In" gas port is used for the instrument "Auto-Zero" where CO₂ free gas is periodically flushed through the sample cell. (See Measurement Principle on page 12). Normally this is done using a CO₂ scrubber such as soda lime to remove CO₂ from the sample air. If required, PP Systems can supply an absorber column and soda lime for providing this function. See below for a typical setup using a zero column and CO₂ scrubber for Auto-Zero.



The absorber column supplied by PP Systems is used for instrument Auto-Zero. It includes two barbed gas fittings for use with 1/8" tubing. The column should always be in a vertical position for best results and to ensure that the air is properly scrubbed of CO₂.

Terminal Block on Enclosure

All electrical connections are made at the terminal block. It is clearly labelled on the front panel.

Pin Number	Name	Description
1	VIN	Power In 6-18 V
2	GND	Power and Signal Ground
3	CO2VOUT	CO₂ Analog Output Voltage
4	H2OVOUT	H₂O Analog Output Voltage
5	4-20OUT	4-20 mA Current Output
6	ZREQIN	Zero Request (momentarily ground to force a zero sequence)
7	SPAREIO	See Spare I/O Line on page 25.
8	GND	Power and Signal Ground
9	GND	Power and Signal Ground
10	TX	RS-232 TX to PC Serial Port D9-2
11	RX	RS-232 RX from PC Serial Port D9-3
12	GND	RS-232 Ground to PC Serial Port D9-5

Introduction and Overview

Measurement Principle

The SBA-5 OEM CO₂ Analyzer is a non-dispersive, infrared gas analyzer that features an "Auto-Zero" facility. Using infrared gas analysis techniques, we can readily determine CO₂ (Carbon Dioxide) concentrations to within a few ppm and instantaneous measurements are possible. Gases with di-atomic molecules such as CO₂ strongly absorbs photons in the infrared range. For CO₂, one region of strong absorption is 4.26 microns. A source (IR source) emitting strongly at this wavelength is a light bulb. If this is positioned at one end of a tube and at the other end is a sensor that is sensitive to photons at 4.26 microns, we have a simple infrared gas analyzer. As CO₂ is passed down the sample cell, it absorbs some of the infrared and the sensor reading decreases. The "Auto-Zero" feature, which occurs at regular intervals, allows for fast warm-up, adaptation to changing ambient conditions and excellent stability of the CO₂ signal. The action of auto-zeroing minimizes the effects on span (gas sensitivity) of sample cell contamination, source aging, changes in detector sensitivity and changes in pre-amplifier gain. By default and after system warm-up, the SBA-5 will perform "Auto-Zeros" every 20 minutes. The "Auto-Zero" interval can be changed by the user if required up to a maximum of 10,000 minutes. PP Systems highly recommends that the SBA-5 performs frequent "Auto-Zeros" to ensure accuracy and reliability of data.



SBA-5 CO₂ Gas Analyzer (PCB)

The above SBA-5 features a long optical bench for ranges up to 30000 ppm. A similar version SBA-5 can be supplied with a shorter optical bench for ranges greater than 30000 ppm up to 100000 ppm

The SBA-5 features automatic temperature and pressure compensation. It is supplied as a calibrated CO₂ optical bench (to a specified range) fitted to an FR4 type printed circuit board (PCB). All components are located on the board. For best results the SBA-5 should be packaged inside an enclosure for thermal stability. Also, normal operation requires a pump to flow the sample air through the analyzer and a zero gas for instrument Auto-Zero to ensure long term calibration and accuracy of the analyzer. These items can be supplied by the user or by PP Systems if required.

Powering up the SBA-5

The SBA-5 requires a 6-18V DC input to power up the analyzer. Power can be applied to 3 different connectors on the SBA-5 board (J2, J3 or J4). See below for appropriate connections to J2, J3 and J4.

Power Input connector (J2)

Connector on board is Molex 22-11-2022.

Pin Number	Name	Description
1	GND	Power and Signal Ground
2	VIN	Power In 6-18 V

Input/Output and RS-232Terminal Block (J3)

The terminal block connector is a Phoenix Contact 1881545 and the mating connector is a Phoenix Contact 1881422 pluggable push-in wire terminal block.

Pin Number	n Number Name Description	Description
1	VIN	Power In 6-18 V
2	GND	Power and Signal Ground
3	CO2VOUT	CO2 Analog Output Voltage
4	H2OVOUT	H2O Analog Output Voltage
5	4-20OUT	4-20 mA Current Output. See 4-20 mA Output on page 24.
6	ZREQIN	Zero Request (momentarily ground to force a zero sequence)
7	SPAREIO	See Spare I/O Line on page 24.
8	GND	Power and Signal Ground
9	GND	Power and Signal Ground
10	TX	RS-232 TX to PC Serial Port D9-2
11	RX	RS-232 RX from PC Serial Port D9-3
12	GND	RS-232 Ground to PC Serial Port D9-5

Input/Output Header (J4)

Standard 0.1" 12 pin double row male header. (These signals duplicate the signals on the terminal block).

Pin Number	Name	Description
1	VIN	Power In 6-18 V
2	GND	Power and Signal Ground
3	CO2VOUT	CO ₂ Analog Output Voltage
4	GND	Power and Signal Ground
5	H2OVOUT	H₂O Analog Output Voltage
6	GND	Power and Signal Ground
7	4-20OUT	4-20 mA Current Output. See 4-20 mA Output on page 24.
8	GND	Power and Signal Ground
9	ZREQIN	Zero Request (momentarily ground to force a zero sequence)
10	GND	Power and Signal Ground
11	SPAREIO	Spare I/O Line on page 25.
12	GND	Power and Signal Ground

Pump connector (J10)

The pump connector on the SBA-5 board is a Molex 22-11-2022. If you are using the sampling pump provided by PP Systems (Part No. 10181-1), the electrical connection is made to connector J10 on the board.

Pin Number	Name	Description
1	VIN	Power In 6-18 V
2	GND	Power and Signal Ground

<u>Please note</u>. For SBA-5 instruments shipped prior to April 2017 or with serial numbers below 5200 there is a different pump connector pin out. On these instruments please observe the positive and negative indicators on the PCB.

Status LED (D2)

There is an LED located at location D2 on the SBA-5 board to assist users with system troubleshooting:

D2	Represents the 'heartbeat' of the SBA-5. It flashes at 5 Hz indicating that the
	system is powered and operating properly. Refer to Mounting the SBA-5 on page
	18 for location of the LED.

Operation

Once the SBA-5 is connected to a proper power supply and immediately after it is powered up, there is a short pause and then the LED 'heartbeat' starts to flash. If the RS-232 or USB line is connected to a PC running a terminal program (i.e. Hyperterminal on older PC's, TeraTerm or Putty on more recent PC's), the following information is transmitted:

V,SBA5+nnnnn,x.xx,IRG5,mmmmm,y.yy

Where: nnnn= SBA-5 serial number

x.xx= SBA-5 firmware version number

mmmmm= IRGA-5 serial number

y.yy= IRGA-5 version number

(The IRGA-5 is a sub component of the SBA-5 with its own microprocessor and firmware)

The SBA-5 temperature is checked until it stabilizes near 55 °C with the following transmitted:

W, nn

Where: W=Warm up delay

nn= Temperature

This is then followed by an analyzer ZERO with the following transmitted:

Z, nn of 21

Where: Z= Zero

nn= the count up to 21

At count number 15, a click will be heard as the valve switches to measure mode. The remaining time is allowed for flushing out the sample cell.

SBA-5 Warm-up

We recommend allowing the SBA-5 to warm up for at least 30 minutes to ensure best operation. For the first 10-15 minutes, warm-up messages are output via digital lines (RS232 and USB). After approximately 15 minutes, CO₂ sensor data starts to get output via the digital lines. In approximately 30 minutes and after the system achieves thermal stability and records several good analyzer zeros, the SBA-5 should be stable and ready for use.

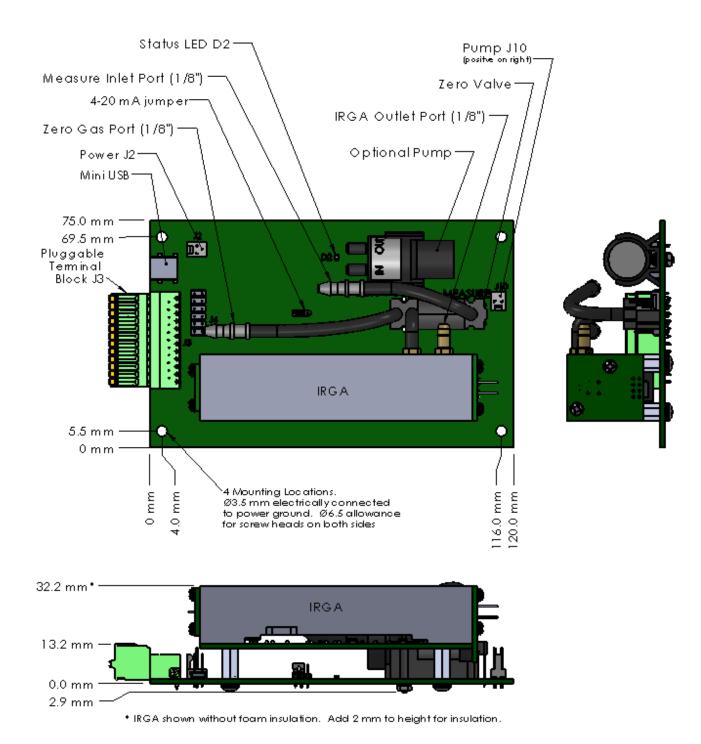
Installation

The SBA-5 is a high precision CO₂ analyzer designed for users that want to incorporate it into existing systems. For best results, we recommend building the SBA-5 into an enclosure to ensure good thermal stability. It can be used for use in monitoring/controlling CO₂ in greenhouses, environment control rooms, nurseries, IAQ, process control and industrial applications. Long term stability and accuracy is ensured as a result of our unique "Auto-Zero" technology.

A suitable sampling pump delivering sample air to the SBA-5 analyzer is also required for normal operation. PP Systems can supply an optional sampling pump (Part No. 10181-1) if required. The sampling pump is secured in place by a mounting clamp on the board and electrically connected to J10 and the pump voltage can be adjusted using software commands. We recommend a pump flow rate in the range of 200-500 cc/min for best results.

Mounting the SBA-5

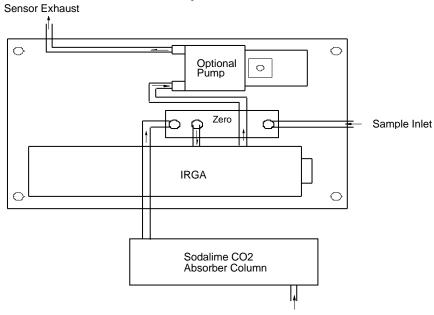
The following engineering diagram illustrates location of USB connector, terminal block, solenoid valve (for analyzer zero), LED, optional pump and mounting information.



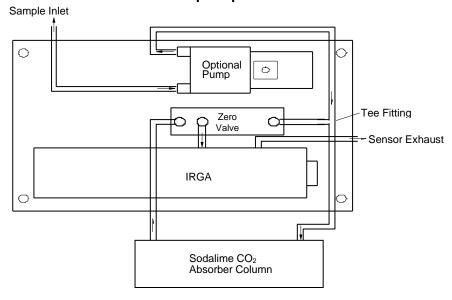
SBA-5 Gas Circuit

The following diagrams illustrate the gas circuit used by the SBA-5.

SBA-5 Plumbing with Pump Downstream



SBA-5 Plumbing with Pump Upstream



GAS Software

PP Systems Windows® based GAS ($\underline{\mathbf{G}}$ as $\underline{\mathbf{A}}$ nalysis $\underline{\mathbf{S}}$ oftware) software is available for displaying and logging CO₂ data from the SBA-5, and any additional information associated with it. No programming or command-line knowledge is required to utilize the GAS software. Connection between the SBA-5 and computer is via the USB interface. GAS will run on Windows XP and above.

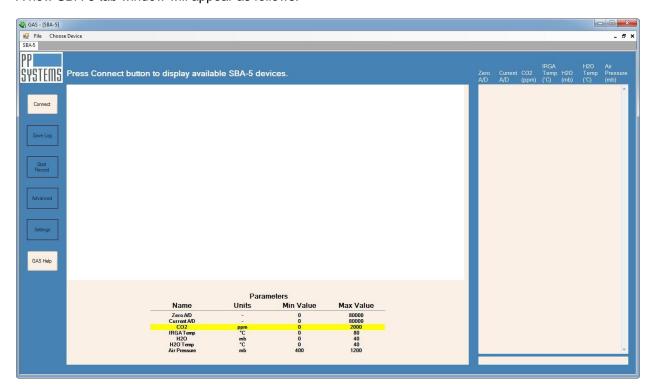
The GAS software is included on the flash drive that comes with each new instrument (Part No. 10182-1), under the "PC Utilities\GAS_v[x]" directory, where [x] is the version number. GAS is also available for download directly from our website (for registered users only). To install GAS, double click on "setup.exe". A number of standard installation windows will be shown to guide you through the installation process. Once GAS is installed, the following icon will appear on the desktop:



Double click this icon to start GAS. Next, click Choose Device and select SBA-5.



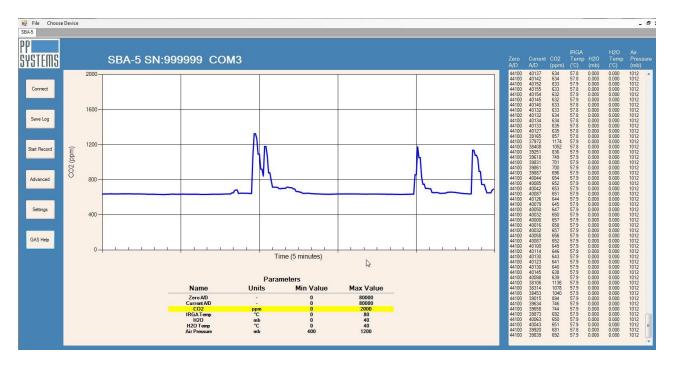
A new SBA-5 tab window will appear as follows:



Next, click the Connect button and a box will appear in the top left corner showing the available SBA-5 devices as below:



Select the SBA-5 that is connected and click OK. The main measurement screen will be displayed as follows:



Note: In the top left area, the device name (e.g., EGM-5, SBA-5 or WMA-5), serial number, and COM port are all displayed. Data is displayed both graphically and numerically. GAS gives the ability to log past data activity in a current session (Save Log) or record data (Start Record) for a time segment. Clicking the Advanced button will show a command-line window for sending commands directly to and from the SBA-5. The Settings button allows the user to modify the parameters' minimum and maximum values. Data is saved in comma-delimited .txt files. A graphical representation of each parameter can be seen by clicking the parameter name in the table below the graph. The highlighted parameter will be displayed on the graph. For more detailed information on the functionality of GAS, refer to "Gas Help" under the Help menu in the software.

SBA-5 Recalibration

If required, the SBA-5 can easily be recalibrated without having to return the instrument to PP Systems. You can perform a 1 point calibration using an accurate gas mixture. For greater accuracy, cylinder mixtures should be accurate to +/- 1% and traceable to NIST standards. Calibration accuracy is dependent on the accuracy of your gas mixture and accurate Zero (CO₂ free air). Therefore, it is critical that:

- Your calibration gas mixture is accurate
- The soda lime is fresh to ensure good Zero.
- The SBA-5 has been on for at least 30 minutes.
- The gas outlet port is unobstructed.

During calibration, the signal from the CO₂ detector is referenced against a gas of known CO₂ concentration. The SBA-5 calibration procedure uses two reference points:

- Zero CO₂ (generated from air that has been scrubbed through soda lime).
- Span Gas (a one point, user-defined CO₂ concentration, normally a cylinder of certified CO₂ composition). The rule of thumb is that you should use a gas concentration that is approximately the same concentration as your desired range. For instance, if you want to recalibrate to 5000 ppm then your gas mixture should be 5000 ppm (+/- 10%).

It is vital that both of these references are accurate.

Recalibration Procedure

- 1. Power up the SBA-5 and connect it to your computer and execute the GAS software and allow the SBA-5 to warm-up for approximately 30 minutes.
- 2. To avoid excess pressure in the SBA-5 sample cell and possible damage to the analyzer, you must connect the sample line with a "T" piece between the calibration gas mixture and the "Gas In" port on the SBA-5.
- 3. Start the flow of gas from your gas cylinder. The pressure regulator should be set to a very low pressure and there should be a slight flow excess gas venting from the open "T" Piece (approx. 250 ml/min). We recommend using a flow rate from the gas cylinder of approximately 200-500 ml/min.
- 4. In the GAS software, initiate a Zero by sending the Z" command. Do this by selecting the Advanced button in the GAS software to open the Advanced Command window. Then, in the Send Command text box, enter "Z", then select the Send button.
- 5. At completion of the Zero, monitor the CO_2 concentration that is being displayed and wait until it stabilizes. If it is reading the proper CO_2 concentration then there is no need to do anything. However, if the reading has stabilized and you are not near the concentration of your gas mixture you need to update the User Scale Factor by sending the appropriate "U" command. The new USF = (calibration gas concentration in ppm / reported gas concentration in ppm). For example, if the SBA-5 was reading 4950 ppm with the calibration gas of 5000 ppm, the USF = 5000/4950 = 1.010.
- 6. In the Send Command text box, enter the "U" command with the new USF. For example, enter "U1.010" in the text box and select the Send button. The CO₂ readings should immediately change to match the calibration gas concentration. (If desired, you can enter a "?" in the text box and select Send, then in the third row of the returned data, you can verify that the USF was changed to value you entered).

SBA-5 Communication

The SBA-5 is sold as an "OEM" unit designed to be built into users existing systems. Users may communicate with the SBA-5 via its RS-232 or USB port. By default, a sequence of output strings is generated by the SBA-5 on both the RS-232 port and the USB port which can be monitored by data loggers or a PC terminal emulation application such as HyperTerminal, TeraTerm or Putty. No additional commands are needed to utilize this default operating mode.

Additional functionality and optional configurations can be achieved by using two-way communication protocol between the SBA-5 and a PC. The PC can use any terminal emulation program such as HyperTerminal or custom software written by the user.

Further, PP Systems provides a free Windows-based program Gas Analysis Software (GAS) that can be installed on any PC to display and log SBA-5 data, and change settings using the commands described in the next sections.

In Windows XP computers, a serial communications program or terminal emulator was provided free by Microsoft called "HyperTerminal". In more recent version of Windows, Microsoft does not include a communication program. There are many free or inexpensive terminal emulator software packages that can be found including HyperAccess, TeraTerm, and Putty. Any of these programs would be appropriate to display the SBA-5 data and send the SBA-5 commands. If you have any questions, please feel free to get in touch with PP Systems.

RS-232 Connection and Setup

If you are using the RS-232 port on the SBA-5 CO₂ gas analyzer, use a standard D sub-miniature 9 pin female connector to connect to a PC serial port with three flying leads to the SBA-5 J3-10, 11, and 12, or purchase PP Systems part number STD533. The mating terminal block connector to the SBA-5 J3 is provided with every SBA-5.

The serial communications program (such as HyperTerminal) should be set with the following parameters:

Bits per second	19200
Data bits	8
Parity	N
Stop bits	1
Flow Control	None

USB Connection and Setup

The SBA-5 CO₂ gas analyzer data is also available on the USB port. In this mode, the SBA-5 is seen as a USB Communication Device Class device (CDC) and normally the appropriate Windows drivers will be loaded automatically by Windows on the first connection to a PC. Depending on the Windows version, the user may have to respond to Windows prompts to find the driver automatically and to load the driver. After successful driver installation, the SBA-5 will be seen as a COM port. Windows Device Manager is useful to determine which COM port (COM1-COM99) the Windows operating system assigned to the SBA-5.

(Note: In older SBA-5s manufactured prior to April 2017 and with serial number less than 5200, a special USB driver provided by PP Systems may be required to be manually installed. For these older SBA-5s, it is often easier to purchase and use a serial-to-USB adapter to eliminate the incompatibility issues with newer Windows versions.)

4-20 mA Output

The SBA-5 includes a circuit that generates 4-20mA output. The 4-20 mA output is available on the terminal block J3 at position 5 and also at the 0.1" header J4 at pin 7. The 4-20 mA circuit is powered by the SBA-5 main voltage input (J2-1, J3-1 or J4-1). A separate power source is not required and is not allowed. The 4-20 mA output is always a current source, and must be measured relative to SBA-5 ground at J2-2, J3-2, J4-2 (or one of the other grounds).

4-20 mA current can be directly measured with a mA current meter - connect J3-5 to positive, and J3-2 to negative. Many data loggers will require a shunt resistor to convert the 4-20 mA into a voltage (refer to your data logger technical manual for more information if required).

The 4-20 mA output is enabled or disabled using the 3 pin jumper J5 on the SBA-5 board. Refer to the picture under Mounting the SBA-5 on page 18. If the jumper is in the leftmost position connecting pins 1 and 2, then the 4-20 mA circuit is enabled. If the jumper is in the rightmost position connecting pins 2 and 3, then the 4-20 mA circuit is disabled (to save power). If there is no current output on the 4-20 mA pins, check that the jumper is in the correct position.

The SBA-5 main voltage input can be any voltage between about 6.5 V and 18 V. If only 6.5 V is supplied, then the 4-20 mA output will only be able to provide 20 mA output when the total resistance of the wire leads and the data logger shunt is 300 Ohms or less. For an 18 V supply, the output can drive up to about 900 Ohms at 20 mA.

Analog Output

Two analog outputs are provided on I/O header J4, one for CO_2 and another for H_2O . Both are 0-5V. The minimum (0V) and maximum (5V) readings can be user set with the "O" command for CO_2 or the "H" command for H_2O .

There are two modes of operation of the CO₂ analog output during an auto-zero. The default mode, and when the "J1" command is set, is for the analog output to hold at the last valid CO₂ reading before the auto-zero began until the auto-zero is complete. If the "J0" command is set, then the analog output tracks the actual CO₂ being measured during the auto-zero, so it will drop to near zero, then return once the measured gas is back in the IRGA. Please note that with SBA-5 firmware PC134-1 versions 1.00 through 1.06 the analog output tracks the actual CO₂ in the IRGA during the auto-zero period. If you prefer to

have the analog output hold to the last CO₂ value prior to the auto-zero period you should update the PC134-1 firmware to version 1.07.

Spare I/O Line

The spare I/O pin on the terminal block J3 and the I/O header CN4 can be set to different modes of operation. On power up or if a "J0" command is sent to the SBA-5, the spare I/O pin is a digital 0-5V output representing data valid. The line is 5V whenever the SBA-5 is measuring CO2 with no error conditions. It is 0V when the SBA-5 is warming up, zeroing or there is an error condition set. The pin can source only 3 mA of current at 5V.

If a "J1" command is sent to the SBA-5, the spare I/O pin is changed into a 0-1.0V analog input. In this mode, the output of the "M" measurement data line is modified to include the analog voltage of the spare I/O pin in millivolts just before the error status field.

Command Overview

To initiate a command, the USB port or RS232 port sends an ASCII character or string.

A single character command is acted on immediately when the character is received.

A string command is acted on after the command string terminator <CR> is received. The command can be sent with or without a checksum. If a checksum is sent, a "C" follows the checksum value.

For example,

Device sends command without checksum: S,11,1<CR>

Device sends command with checksum: S,11,1,043C<CR>

On successfully receiving a command string, the SBA5+ sends an acknowledgement by echoing back to all the ports the Command String and "OK", each terminated with a <CR> andlinefeed>.

A failure can be caused by:

- A string longer than 90 characters
- A delay of more than 15 seconds
- A bad checksum, if used.
- A command not recognized

Which will result in one of 4 error messages being sent;

- E, Command too Long\r\n
- E, Timed out\r\n
- E, Bad checksum\r\n
- E, Command not recognized\r\n

Note the command string is NOT echoed back on a failure.

Once a command is sent from the Device, another command must not be sent until the previous command has been acknowledged.

Command Summary

Axxx <cr></cr>	Time [minutes] between zero operations
Bxxx <cr></cr>	Averaging limit for CO ₂ running average.
Cxxx <cr></cr>	Number of digits to the right of the decimal point (Range: 0-2 integers). For example if you want to read out 2 decimal points such as 399.45 enter C2.
Dxxx <cr></cr>	Determines if there is a zero operation at warmup
Exxx <cr></cr>	Zero operation duration, argument is S, M, or L
Fxxx <cr></cr>	Measurement string format. 0 to 255 to enable individual outputs
H <min>,<max>CR</max></min>	Analog output H2OVOUT hardware scaling
Jxxx <cr></cr>	Sets the mode of the spare I/O pin. See Spare I/O Line on page 25.
Kxxx <cr></cr>	Turns source lamp on or off
Lxxx <cr></cr>	Low CO ₂ In [ppm] alarm.
М	Display a measurement.
N	Returns external board voltage and Spare I/O voltage
O <min>,<max>CR</max></min>	Analog output CO2VOUT hardware scaling
Pxxx <cr></cr>	Turns on-board pump on or off (if installed)
S,9,xxx <cr></cr>	Sets pump voltage from 0-100%
S,11,xxx <cr></cr>	Sets the measurement string output interval in seconds. 0.1-36000.
S,16, xxx <cr></cr>	CRC appended to each output string. 1 enables, 0 disables
S,21, xxx <cr></cr>	Sets the Time Constant of the running average filter. 0-100 sec, default 6 sec.
S, 23, xxx <cr></cr>	Silent Mode that disables automatic output strings for Zero messages, Warmup messages, and most Error messages. 1 enables Silent Mode, 0 disables. Default disabled.
Uxxx <cr></cr>	Sets the user scale factor (for user calibrations)
V	Returns the SBA-5 serial numbers and firmware version numbers
Wxxx <cr></cr>	Defines the measurement and zero ports on the solenoid valve.

Z	Perform a zero operation.
!	Turns measurement display off.
@	Turns measurement display on.
?	Display the SBA-5 configuration currently in use.
]	Restore the factory default configuration.

The following describes each command grouped by functional type.

Measurement Commands

М	Display a measurement
!	Turns measurement display off.
@	Turns measurement display on.
S,11,xxx <cr></cr>	Sets the measurement string output interval in seconds. 0.1-36000. Default is 1.0 sec. (Older SBA-5s had a fixed output interval of 1.6 sec)
S,16, xxx <cr></cr>	CRC appended to each output string. 1 enables, 0 disables. Default disabled.
S, 23, xxx <cr></cr>	Silent Mode that disables automatic output strings for Zero messages, Warmup messages, and most Error messages. 1 enables Silent Mode, 0 disables. Default disabled.

Measurement Command Response

Measurement format: M aaaaa bbbbb ccc.ccc dd.d ee.eeee ff.ffff gggg hh.h ii.i j

aaaaa	Zero A/D [counts], from last autozero sequence
bbbbb	Current A/D [counts]
ccc.cc	Measured CO2 [ppm],
dd.d	Average IRGA temperature [°C],
ee.e	Humidity [mbar], if humidity sensor is installed
ff.f	Humidity sensor temperature [°C], if humidity sensor is installed,
9999	Atmospheric pressure in IRGA [mbar],
hh.h	IRGA detector temperature [°C],

ii.i	IRGA source temperature [°C],
j	Status/Error code. Continuously displayed measurements do not display the j but instead display a text message .
	 No errors, measurements are valid aaaaa less than 25000 counts dd.d less than 5 °C from user specified temperature dd.d greater than 5 °C from user specified temperature ccc.ccc less than range from L command ee.eeee greater than 90 mbar Board voltage less than 4V IRGA source lamp not enabled IRGA Warming up Performing Zero Performing Simple Zero

Measurement String Format Command:

Fxxx <cr></cr>	Enables or disables individual measurement fields in the output measurement string. Range: 0-255 (integer). For each field desired in the output string, sum values from following list:
	aaaaa and bbbbb enabled with value =128,
	dd.d enabled with value =64,
	ee.eeee and ff.ffff enabled with value=32,
	gggg enabled with value=16,
	hh.h and ii.i enabled with value=08,
	<i>j</i> enabled with bit value=04.
	ccc.ccc is always present in output string.
	For example, when <i>value</i> is 212 (=128+64+16+4) the output string will be "M <i>aaaaa bbbbb ccc.ccc dd.d gggg j</i> "

Zero Valve Related Commands

Z	Perform a zero operation.
Dxxx <cr></cr>	Determines whether a zero operation is performed on completion of initial warmup or not. If not, then CO2 readings are computed with a previously stored zero reading that may produce inaccurate results. Recommended practice (and the default) is to perform a zero on power-up.

	Sending "D1" enables the power-up zero, and the string "Zpup=1" is shown in the configuration status (in response to a ? command). Sending "D0" disables the power-up zero, and the string "Zpup=0" is shown.
E <char>CR</char>	Zero operation duration. char: "S" = 21 second,
	"M" = 40 seconds,
	"L" = 90 seconds.
	Default is Short in which the autozero sequence is approximately 20 sec long. Longer duration zero cycles can be useful if the flow rate through the SBA-5 is lower than 100 ml/min or the measured gas concentration is above 10,000 ppm to insure fully purging measurement gas from the cell prior to recording a zero reading.
Axxx <cr></cr>	Time [minutes] between zero operations. <i>range</i> : 0-10000 (integer, but can be negative). Recommended maximum setting is 20 minutes. Longer time between zero cycles can reduce instrument accuracy.
	Sending the A command with any non-zero <i>value</i> will cause an immediate zero operation, followed by subsequent zero operations every <i>value</i> minutes. Normally, the SBA-5 performs a series of zero operations at power-up while the temperature is stabilizing. The time between these initial zero operations is a geometric progression starting at 2 minutes, then 4 minutes, then 8 minutes, etc. up to the maximum time between zeros as specified in the A command.
	It is possible, but not recommended, to disable these progressive zero operations during startup by setting the value in the A command to a negative number. For example, "A-10" will disable the progressive zeros if the configuration is saved with the X command, so that on the next power-up, the first timed zero occurs after 10 minutes (there still can be a power-up zero immediately after warm-up is complete, depending on the setting of the D command and Zpup).
	A0 disables all timed zeros and all progressive zeros. See D command to also disable the power-up zero. This is not a recommended setting.

Wxxx <cr></cr>	Defines which port of the zero valve has the zero CO2 gas, and which has the sample gas to be measured. W0 (Zdir=0) is default and means the zero gas is plumbed to the port on the zero solenoid valve closest to the green I/O connector, and the measurement port is the port furthest from the green I/O connector. W1 (Zdir=1) means the zero gas is plumbed to the port furthest from the I/O connector, and the measurement gas is at the port closest to the I/O connector. Valve definitions change immediately upon sending the command. The default port definitions are identified in silkscreen on the PCB. Note: In firmware V2.03 and earlier, the "W" command was a single character toggle-type command that changed the port state depending on what the current state was. In V2.04, it was changed to require a single argument 0 or
	current state was. In V2.04, it was changed to require a single argument 0 or 1.

CO2 Related Commands

Cyany CD:	you is the grouph or of digite to the gight of the designed point for any a
Cxxx <cr></cr>	xxx is the number of digits to the right of the decimal point for ccc.cc. range:
or	0-3 (integer).
Cxxx,yyy <cr></cr>	yyy is the number of digits to the right of the decimal point for humidity,
	pressure and temperature fields. <i>range</i> : 0-3 (integer).
Uxxx <cr></cr>	User Scale Factor. <i>range</i> : 0.1-10.0 (floating point). Default is 1.000. Scale factor applied to all reported CO2 values to allow user calibrations. There is no calibration 'routine', The user must calculate their desired scale factor from measurements and compute the USF = desired CO ₂ ppm / reported CO ₂ ppm. For example, if the SBA-5 reported 1995 ppm, when calibration gas of known 2000 ppm was sampled, then USF = 2000/1995 = 1.0025, and the command "U1.0025" would make the SBA-5 read 2000 ppm. User should set USF to 1.00 prior to performing recalibration measurements.
Lxxx <cr></cr>	Low CO ₂ In [ppm] alarm. <i>range</i> : 0-100000 (floating point). In typical environmental applications, a CO ₂ reading in measurement mode of less than 350 ppm indicates a problem with the autozero operation, such as the zero gas is not connected, the CO ₂ absorber is exhausted, or the zero valve is not operating. The Low CO ₂ Error helps identify those common problems before the abnormal readings can affect subsequent data. This value can be adjusted to suit a particular operating environment or can be eliminated completely by setting the <i>value</i> to 0.
S,21, xxx <cr></cr>	Time Constant of the exponential running average filter. Between 0 and 100 seconds, default 6 seconds. The time constant is the number of seconds to reach 63% of the final value in response to a step change in the raw CO2 readings. The time to reach 99% percent of the final value is 6.9 times Time Constant or 41 seconds for the default Time Constant of 6 sec. When the Time Constant value is set to 0, no running average is performed. (This command requires PC134-1 SBA-5

	Controller firmware V1.08 or higher. See release notes for PC134-1 V1.08 for more details.)
Bxxx <cr></cr>	Averaging limit for CO2 exponential running average filter. Default 6 ppm.
	Sets the Averaging Limit for the CO2 of the running average algorithm. If a new instrument reading differs from the current running average by more than the Averaging Limit value, a new running average is begun. Thus when the CO2 concentration is changing rapidly, the averaging is eliminated and the instrument can track changes at the basic instrument data rate of 1.0 seconds. When the Averaging Limit value is set to 0, no running average is performed. The default Averaging Limit value is 6 ppm. The running averaging is applied to displayed data and analog output signals.
O <min>,<max>CR</max></min>	Analog output CO2VOUT hardware scaling
	min is CO ₂ ppm represented by 0 volts, range: 0-100000 (integer),
	max is CO ₂ ppm represented by 5 volts, range: 0-100000 (integer).
H <min>,<max>CR</max></min>	Analog output H2OVOUT hardware scaling
	min is H ₂ O mbar represented by 0 volts, range: 0-40 (integer),
	max is H ₂ O mbar represented by 5 volts, range: 0-40 (integer).

Other Commands

"J0" sets the spare I/O to digital output representing data valid (default).
"J1" sets the spare I/O to be a 0-1.2V analog input. In this mode the output of the "M" line is modified to include the analog input voltage in millivolts with no decimal digits just before the error status field.
In firmware V2.02 and earlier, there was no J command, and spare I/O was used only for a data valid indication.
Turns source lamp on(1) or off(0). This is useful if the SBA-5 is kept powered 24/7, but the CO ₂ is only read occasionally (i.e. once per hour). By turning the lamp off when not in use, the life of the source lamp is extended.
Returns two voltage measurements, external board voltage and Spare I/O voltage
Turns the onboard pump from on or off, if one is installed. Sending "P0" turns pump off. Sending "P1" turns pump on.

S,9,xxx <cr></cr>	Set the pump power 0-100% when the optional on-board is installed. Default 50%.
Txxx <cr></cr>	Sets the control temperature of the IRGA thermostats in degrees C. Range is 27 to 60. Default is 55. This is useful for operation in low ambient temperature environments to save power. However, CO ₂ accuracy will be affected if the control temperature is changed from the factory setting.
V	Returns the SBA-5 serial numbers and firmware version numbers
?	Display the SBA-5 configuration currently in use (the volatile memory working area).
1	Restore the factory default configuration and calibration to the volatile memory working area.

Command Files

Any of the commands can be included in a text file created by a program such as Microsoft Notepad. This file can be downloaded to the SBA-5 by using the HyperTerminal menu item Transfer>Send Text File.... Command a zero operation before transferring the command file to ensure the maximum time until the next zero operation. Ensure that all lines including the last end with a carriage return and line feed (LF). Command files may include comments in the following format: ;commentCRLF.

The following additional serial communication setup parameters should be set in ASCII Setup>ASCII Sending when sending command files to the SBA-5:

- Do not send line ends with line feeds
- Do not echo typed characters locally
- Character delay: 10 milliseconds

Upgrading SBA-5 Firmware

From time to time, PP Systems will provide new features and functions to the SBA-5 operating characteristics. Firmware residing in non-volatile memory within the SBA-5 electronics can be upgraded in the field using a PC running custom PP Systems G5 Application Loader software and a USB connection to the SBA-5.

Use the following steps to upgrade the SBA-5 firmware:

- 1. Run Setup.exe in the folder "G5_App_Loader" on the SBA-5 flash drive. This will install the G5 Application Loader program.
- 2. Power up the SBA-5, and connect a USB cable from the SBA-5 to the PC.
- 3. Select "G5 App Loader" from either desktop icon or Start Menu item.
- 4. Select the COM port that Windows has assigned to the SBA-5. (All currently active COM ports are shown in the list box, you have to choose the right one for the SBA-5.)
- 5. In the Select Component list box, choose either SBA-5 or IRGA-5 depending on which component is being upgraded.
- 6. Select the Browse button to locate the correct upgrade file on the PC. The files will have the file extension .usr.

For the SBA-5 main controller the file is named: PC134-1SBAX XX.usr

For the IRGA-5 sub module the file is named: PC126-1IR5X_XX.usr

- 7. Select the Open button in Connect COM line and verify that the connection to the SBA-5 is complete and the status is 'Connected"
- 8. Select the Execute button on the Perform Upgrade line. It takes 1 to 4 minutes to upgrade the firmware and a message appears in the status box to inform whether or not the upgrade was successful.
- 9. Exit G5 App Loader. Disconnect USB cable. Power down SBA-5

Maintenance

Refer to Mounting the SBA-5 on page 18 for location of the pump (if applicable), infrared source and zero valve.

The SBA-5 is virtually maintenance free. If proper care is taken, the SBA-5 should last for many years. The user should make sure that the sample air is adequately filtered to protect the analyzer from dirt, dust, moisture, toxic gases, etc. In some PP Systems' products, PTFE hydrophobic membranes with 3 micron pore size (Millipore FSLW-14200) are mounted into 12.5 mm diameter in-line holders (Millipore SX00-001300). But any air filter with pore size of 25 micron or less would be adequate. The part number of the filter supplied by PP Systems is Part No. 10045-1.

Re-Order Information	
Part Number	Description
10045-1	Filter Assembly

Pump (Optional)

The optional sampling pump supplied by PP Systems and used with the SBA-5 is a miniature, rotary vane style pump. It is secured in place by a simple mounting clip and is electrically connected to the PCB at location J10 (2-pin header).



It operates from 1.0 - 5.0 VDC, which is generated by the SBA-5 controller board when powered. It is capable of delivering flow rates up to 500 cc/min flow. History has shown that this type of pump is rugged and very reliable and should last for many years. However, after prolonged use material from the vanes may build up within the pumps requiring cleaning.

Typically, the following symptoms are attributed to a worn or troubled pump:

- **Noise** a worn pump usually sounds rough or vibrates. It will also sound louder than a smooth running pump.
- **Temperature** the outer casing feels warm to the touch.

•

Re-Order Information		
Part Number	Description	
10181-1	Miniature Rotary Sampling Pump (Schwarzer)	

Removing a Pump

It is very easy to remove a pump for servicing. First, trace the electrical connection to the pump and disconnect the 2-pin connector from the SBA-5 board (J10).

The pump itself is secured to the board by a pump mounting bracket. Use caution when removing the pump from the bracket.

Servicing a Rotary Vane Pump

During prolonged operation, the vanes inside the pump will wear and deposit material inside the pump. Therefore, it is highly recommended that you clean the pump by flushing it through with isopropyl alcohol. The following procedure can be adopted:

1. Connect the pump to a 5V DC power source and fit a 30mm tube to the pump inlet. (The SBA-5 can be used to supply power via the pump electrical connector).

It is, however, essential that the flushing is performed with the pump to the side of the SBA-5 to avoid spillage onto the board.

2. Hold the pump above a beaker of isopropyl alcohol and dip the tube into the alcohol (see below). Run the pump to draw alcohol through it. A small roll of cotton wool in the inlet pipe can act as a filter for the re-circulating alcohol.



If the pump is seized, it may be freed by tapping it on the bench or by reversing the voltage to run it backwards. If this does not work, pump replacement is required.

3. Run alcohol through the pump for a minute or two to ensure that any material is removed. When finished, run the pump in air for at least 15 minutes to allow any residual alcohol to evaporate. Ideally, let the pump dry overnight before plumbing back up to the SBA-5. If the pump is reconnected prematurely, the soda lime in the absorber column will exhaust quicker than usual.

Absorber Column and CO₂ Scrubber (Optional)

The optional absorber column supplied by PP Systems is used for instrument Auto-Zero.



If you are using our absorber column we strongly recommend that you periodically inspect the following:

Gray Foam Filters

The two gray foam filters used inside the absorber column (top and bottom) will wear over time and should be inspected regularly and replaced when torn or reduced in size. The foam must be of an open celled type, such as packing foam.

Absorber Filters

Each black absorber end cap contains a white plastic filter disk. Generally these do not need to be replaced but should be checked periodically. However, they must be present to prevent any of the column contents being drawn with the gas stream causing damage to the instrument.

End Cap "O" Rings

Each black absorber end cap has two "O" rings, one that seals inside the plastic column and another that seals to the bulkhead gas fittings. All "O" Rings on the absorber column should periodically (every 3-4 weeks) receive a slight smear of silicone grease to aid ease of fitting, improve the seal and extend the life of the "O" rings and to keep them from cracking or breaking. Once sealed, end fittings should be checked to ensure that the O-rings are seated correctly in their groove and that they are not trapped or pinched resulting in system leaks.

Soda Lime (CO₂ Scrubber)

Soda Lime (Sofnolime) is supplied as white granules (1-2.5mm). We supply a self-indicating version of the soda lime that changes from white to violet when exhausted. However, given that most of our applications involve relatively low CO₂ concentrations the indicator is not so obvious and it does revert back to white when the instrument is not in use. Soda Lime cannot be regenerated and should be discarded when exhausted. Frequent replacement should not be required under normal circumstances. The amount of change is highly dependent on the "Auto-Zero" frequency, CO₂ concentration and flow rate. Under normal operating conditions, this desiccant is changed approximately 1 time per month.

At present, PP Systems supplies the following type of soda lime desiccant:

- Type: Sofnolime®, 1.0-2.5 mm, self-indicating (white to violet), 1 kg
- Manufacturer: Molecular Products. (<u>www.molecularproducts.com</u>)
- For the latest Material Safety Data Sheet, please visit www.molecularproducts.com and request the latest MSDS or contact PP Systems.

For the latest MSDS on alternative types of soda lime, please contact the manufacturer directly or contact PP Systems.

! CAUTION!

WASH YOUR HANDS AFTER HANDLING SODA LIME

MATERIAL SAFETY DATA FOR SODA LIME

CHEMICAL COMPOSITION				
CILINIOAL COMI COITION				
Components	% W/W			
Calcium Hydroxide	(Ca(OH)2) > 75.5%			
Sodium Hydroxide	(NaOH) < 3.5%			
Water	< 21.0%			
Indicator (Inorganic Salt)	< 0.2%			
PHYSICO-CHEMICAL DATA				
Form	Granules			
Color	White			
Odor	None			
Bulk Density	0.9 g/cm ³			
Solubility in Water	None			
pH in Water	12-14			
Incompatible Substances	Acids, Chloroform, Trichlorethylene			
Hazardous Decomposition				
Products	None			
PROTECTIVE MEASURES, S	TORAGE AND HANDLING			
Storage Conditions	Clean dry environment			
Preferred temperature range	0 - 35 °C. Store away from direct heat/sun.			
Protective Measures	Avoid inhaling dust. Wash hands after handling.			
Industrial Hygiene	Keep containers closed. Keep contents dry.			
	L			

MEASURES IN CASE OF ACCIDENTS AND FIRES		
Spillage	 Contain material. Sweep or vacuum up. Transfer solids to metal or plastic container for disposal. Wash down spillage with water. 	
Suit. Extinguishing Media	Water, CO ₂ , Powder, Foam, Halon.	
FIRST AID		
Inhalation	Remove from exposure. Obtain medical attention if discomfort persists.	
Skin Contact	 Drench with clean water. Obtain medical attention if skin becomes inflamed. 	
Eye Contact	Irrigate thoroughly with clean water.Obtain medical attention.	
Ingestion	 Wash out mouth thoroughly. Drink water. Obtain medical attention. 	
HAZARD LABELLING		
Transport Codes	None required.	
Hazard Classification	None.	

For the latest MSDS please visit the PP Systems web site or contact PP Systems directly.

Re-Order Information		
Part Number	Description	
STD509	Absorber Column with mountings	
41508-1	Gray Filter Foam	
STD007W	Sofnolime (white to violet), 1.0 kg	

Infrared Source

The infrared source should last for at least 2 years depending on use. The obvious sign of failure is that it is not flashing when the system is powered. It is preferable to return the instrument to PP Systems for full factory recalibration after changing a failed source lamp.

Zero Valve

If the Zero Valve requires replacement, please contact PP Systems. This part is soldered directly onto the circuit board. Proper care and instructions are required to avoid any accidental damage to the circuit board itself and to other components on the board.

User Notes