



Instructions **Including the** ***P Series***

Laboratory/Field Audit Calibrator

NIST Traceable – ISO 9001:2008

1 TO 30 Lpm (Model CH100)
30-450 ccm (Model CH050)

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Important Note

*If for any reason you are uncertain as to which Venturi is installed, recycle the I/O (off/on) switch. During boot up, the bottom line on the screen will read **SN XXXXXXL** which indicates that the 1-6 lpm range unit is installed. **SN XXXXXXH**, indicates that the 6-30 lpm range unit is installed.*

The low range version (30-450 ccm) has a single flow element and the above note does not apply.

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1.0 Quick Start

In order to put the instrument to immediate use as a Calibration/Audit device, follow these steps.

Step 1: Remove the instrument from its carrying case and turn it on.

Step 2: Install the correct Venturi for the flow rate range of interest.

#H 6-30 Lpm

#L 1.0-6 Lpm

The low flow unit has the flow element permanently installed.

Step 3: Provide tubing of the appropriate diameter to connect the Venturi to the instrument being audited/calibrated.

Step 4: With air flowing, you may now read the screen to determine volumetric flow rate, ambient temperature and barometric pressure.

For a diagram of the immediate application refer to Figure 1.

2.0 Introduction

All BGI calibrators are based on the air flow measurement principle of the Venturi the intermediate flow tube or the orifice¹. Our calibrators are developed by BGI and are manufactured in BGI's ISO 9001:2008 facility. The instruments provide an LCD indication of *Volumetric* and *Standard* flow rate, barometric pressure and ambient temperature. It operates on four AA alkaline energy cells (batteries). The electronics are all housed in the control module.

The instrument is furnished with two auto ranging Venturi, which cover the flow rate range of 1 to 30 Lpm. Or a single tube running in the intermediate flow range at 30 to 450 ccm.

In 2012 BGI introduced the **P Series** of flow calibrators. These instruments may be identified by a letter **P** in the boot up screen where the version number is displayed. The Version Number will be 3.0.0 or higher. They represent a complete revision of the Firmware to provide the user with advanced application utility. Throughout this manual additional sections have been labeled "**P Series**" and will apply to the newer instruments. All instruments returned for recalibration/repair will be upgraded to the P Series specification.



Figure 1 – “Quick Start” Application of Challenger

3.0 Specifications

Flow rate range: 1 – 30 Lpm (\pm 0.75% or less) – Model CH100
 30 - 450 ccm (\pm 1%) – Model CH050
 Temp. operational range -30° C to 55° C
 Temp. reading range -30° C to 55° C (\pm .5° C)
 Barometric pressure range 400 to 800 mm of Hg (\pm 5mm)
 533 to 1067 mb

Dimensions:

Control Module: 1.59 in. high (4.04 cm) X 3.90 in. wide (9.91 cm) X 7.70 in. long (19.61 cm)

Weight: 7.4 oz (209 g)

One complete instrument comprises:

Quantity	Description	Catalog/Part No.
1	Challenger	CH100 or CH100W (Ts=25 C) (Ts=0 C) CH100 or CH050 (P Series)
4	Installed AA batteries	Replacements obtained locally by user
1	Instruction Manual	Download PDF file from BGI website
1	Carrying Case	CH102
1	Software Disk	Download from BGI Website
1	Venturi H, 6-30 lpm	3048 (for CH100 only)
1	Venturi L, 1-6 lpm	3047 (for CH100 only)

Replacement supplies (not included with initial purchase).

1 Pkg. of 3	Venturi socket "O" rings	CH101 (for CH100 only)
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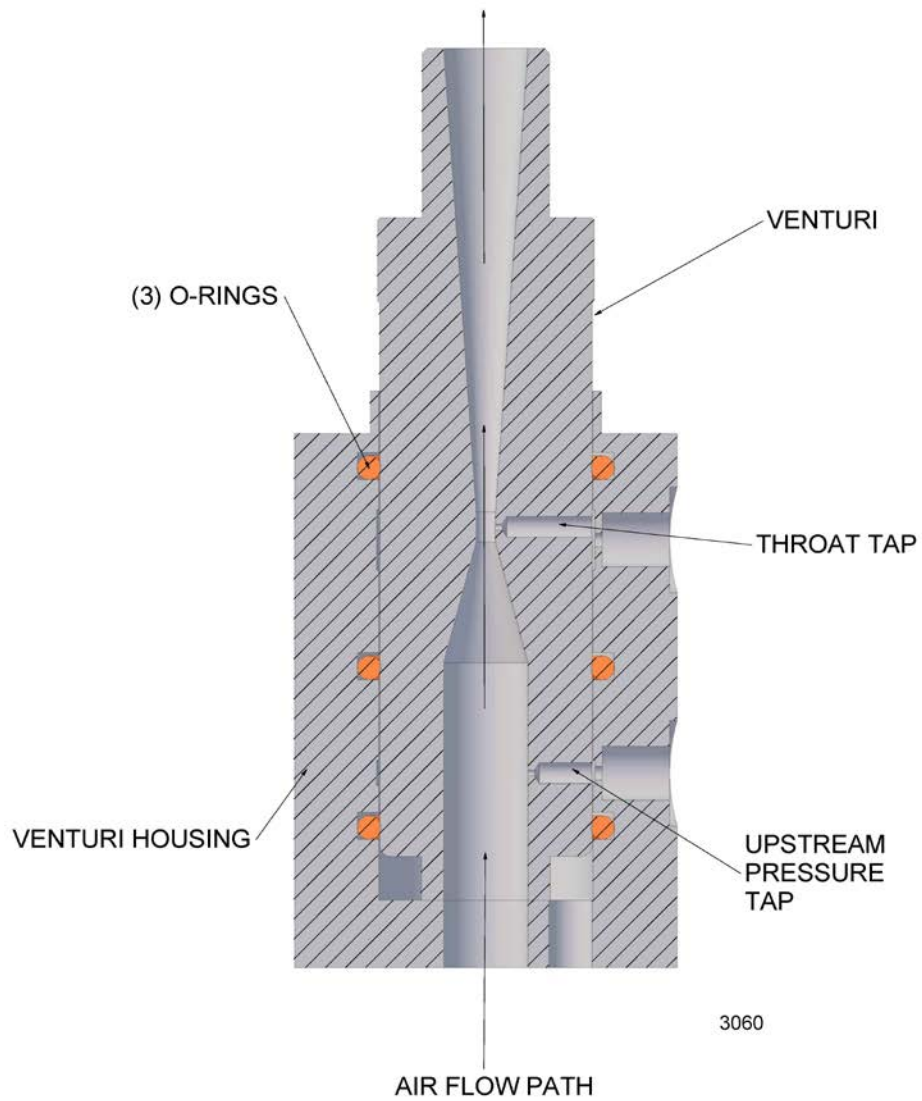


Figure 3 – Sectional View of CH100 Measuring Head

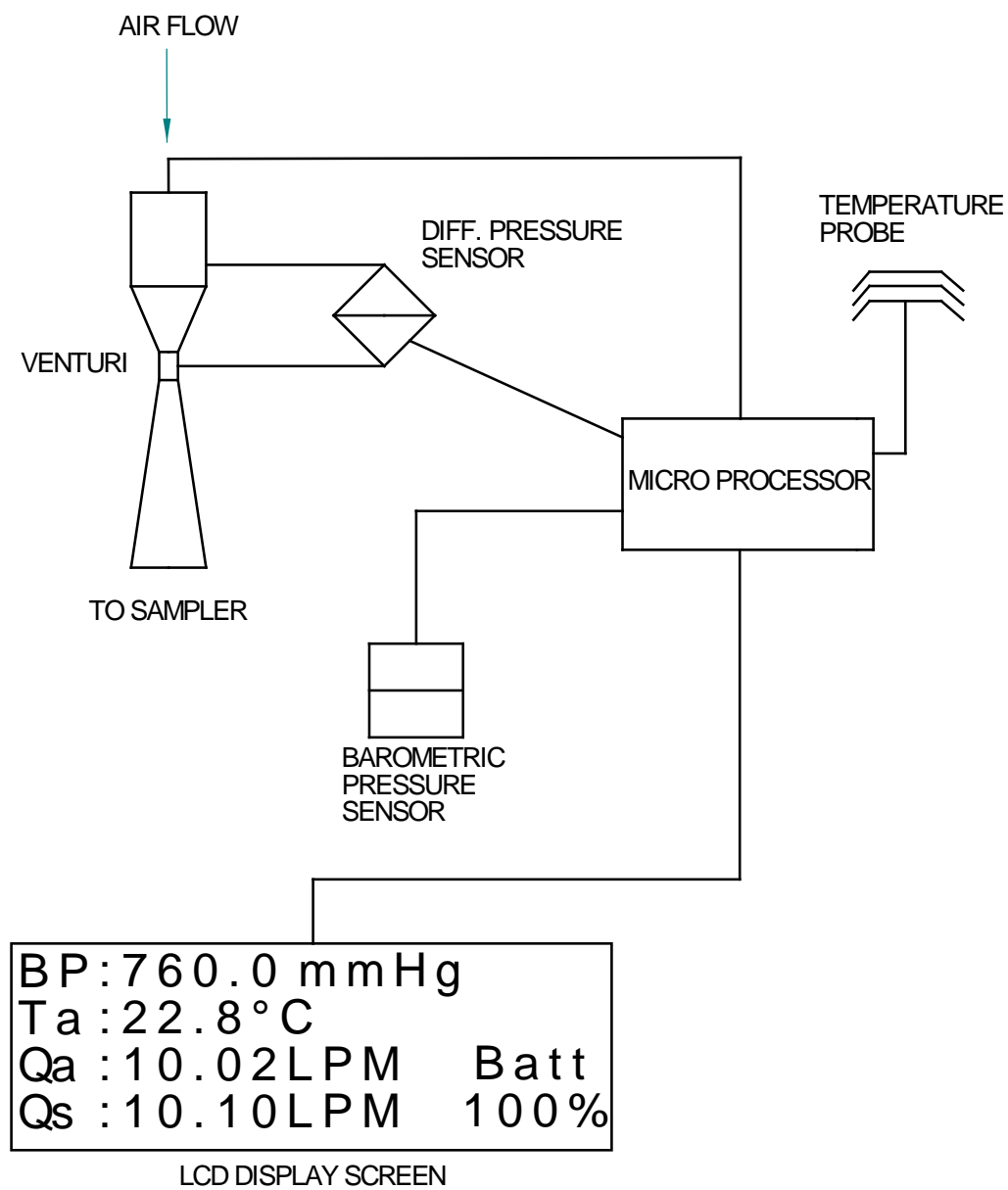


Figure 4- Schematic Diagram of Challenger

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Figure 5 – Challenger Assembly CH100

4.0 Principle of Operation

The calibrator measures volumetric flow rate by utilizing a pressure transducer to assess the pressure drop caused by air being drawn through a Venturi or a flow tube. As the flow rate through the Venturi or flow tube increases, the pressure drop increases as the square root¹. A four times increase in pressure drop yields twice the flow rate. A desirable feature of the Venturi is that most of the pressure drop created by the instrument is recovered in the expansion section of the Venturi. Therefore, measurements are made at nearly the true operating conditions of the sampler.

The signal from the pressure transducer is sent to the microprocessor where, it is combined, via an algorithm with information from the barometric pressure sensor and the ambient temperature sensor. To eliminate "fluttering" of the on screen display, of flow rate, the first 20 readings are averaged and then carried on as a rolling average. Barometric pressure and temperature are monitored and displayed on a continuous basis, when the instrument is switched on. A cutaway diagram of the Venturi measuring head is shown in figure 3 and a schematic diagram of the system is shown in Figure 4.

5.0 Instrument Set-up

Remove the instrument from its carrying case. The only control is an off/on switch on the end cap. Switch the instrument on and the screen will boot into the main idle display screen for whatever Venturi is installed. *If no Venturi is installed, or the low range is installed* then the boot screen will look like this:

The Challenger
Version X.XXX
SN000004-L

If the low range is installed no change will occur, to the screen. If the high range was installed or it is now installed, there will be a brief message:

VENTURI CHANGED

The boot screen will then have the following appearance:

The Challenger
Version X.XXX
SN000004-H

A Venturi is changed (installed) in the following manner. With the Venturi held vertically, plain end downwards (hose nipple up), plunge the Venturi into the hole in the top of the socket with a slight rotary motion. Be certain that there is sufficient lubricant on the "O" rings within the recess. (See appendix B about lubrication). At this point the instrument will automatically reboot and autorange to the selected Venturi.

B	P	:	7	6	0	.	0		m	m	H	g		
T	a	:	2	2	.	8		°	C					
Q	a	:	1	0	.	0	2	L	P	M	B	a	t	t
Q	s	:	1	0	.	0	0	L	P	M	1	0	0	%

Using a short length of elastomeric tubing, connect the sampler under test to the top of the Venturi and turn it on. The volumetric flow rate will now appear on the screen as shown above.

Important points to be noted concerning the utilization of the calibrator

- A. When starting the unit must have no air flowing through it.

Every time the instrument is switched on, it re-zeros itself. If air is flowing, that flow rate will be set as zero.

- B. In order to perform the most precise measurement audit, it is necessary for the device to be in thermal equilibrium with the ambient environment in which the sampler to be tested is located. The best procedure is to deploy the calibrator for 10 minutes prior to the test, in the vicinity of the sampler to be audited. Additionally, *if the calibrator is subject to a temperature change of more than five degrees, during use, it should be removed from the flowing air and rebooted.*
- C. When the calibrator is switched on *XX %* battery is displayed on the screen. So long as more than 10% is indicated, it is safe to proceed, in that, at least one hour of power is available. The test is now ready to be performed.

6.0 Using the calibrator

6.1 To perform an audit

One of two procedures should now be performed.

Procedure A. Turn *off* the sampler to be audited. Connect the calibrator to the inlet to the sampler with, user provided tubing. Turn *on* the calibrator, wait for the screen to finish the startup boot, *then* turn on the air sampler.

Procedure B. With the sampler to be audited *running*, when the calibrator screen has finished its startup boot, connect the measuring tube to the instrument under test

When using Procedure B, connecting tubing to a running pump, may cause momentary instability in the air samplers flow control circuit. Once the air samplers flow rate indicator stabilizes, the reading may be taken. A simple audit data format is shown in Table 1. This may be taken as a guide to designing a form suitable for your specific needs.

6.2 To perform a calibration.

The procedures and calculations for using the instrument to calibrate a sampler are the same as an audit, *except* that one should set the sampler to the exact flow rate required.

Table 1 Audit Data Format

Audited Instrument:

Make: _____ Model: _____ S/N: _____

Date: _____ Time: _____ Calibrator S/N: _____

Flow Rate – Lpm

Sampler: _____

% diff. = [(Calibrator-sampler)/ Calibrator]x100

Calibrator: _____

Allowed diff. = 4%; Pass _____ Fail _____

Ambient Temp. – C

Sampler: _____

Calibrator: _____

Allowed diff. = ± 2 C; Pass _____ Fail _____

Barometric Pressure – mm of Hg

Sampler: _____

Calibrator: _____

Allowed diff. = ± 10 mm; Pass _____ Fail _____

7.0 Software

In January 2008, the software for all BGI electronic calibrators was replaced by a completely new suite known as BGI Open. This suite has been revised and renamed to BGIOpenCal and can be downloaded at: http://www.bgiusa.com/cal/the_challenger.htm

8.0 Maintenance

Beyond battery replacement, the only part of the instrument requiring attention is the flow passage through the Venturi. After *long* periods of use, some atmospheric dust can coat the interior flow surfaces. The presence of such a deposit may be ascertained by viewing the interior of the Venturi under bright light; direct overhead sunlight being preferable. Glance into the interior, from either end, seeking any discoloration of the surface. If it is determined that cleaning is required, use the following procedure.

Rinse the entire Venturi body in warm soapy water. Any deposits, which are not floated away, may be removed externally with a soft cloth. If internal deposits are not removed by soaking, the best procedure is to immerse the unit in an ultrasonic bath containing soapy water. If an ultrasonic bath is not available, *judicious* use of a pipe cleaner is recommended. Following cleaning, the Venturi may be dried utilizing compressed air, or if not available, allowed to air dry.

The flow tube model (CH050) is fitted with an internal foam filter which will be replaced at its annual calibration.

9.0 Safety

There are no owner serviceable components in the instrument other than the Venturi socket "O" rings and the four AA batteries. These should only be replaced with good quality alkaline energy cells and should be promptly removed when expired, to prevent leakage and chemical damage to the electronic components. When the instrument is placed in long term storage (more than two months) always remove the batteries.

Even though there is no reason to disassemble the electronics box, should the need arise, always remove the batteries before proceeding further.

Adjustable potentiometers are contained within the electronic housing, which are factory set during calibration. If these are turned, the calibration will be lost and factory recalibration will be required.

10.0 Warranty Information

BGI warrants equipment of its manufacture and bearing its nameplate to be free from defects in workmanship and material. We make no warranty, express or implied, except as set forth herein. BGI's liability under this warranty extends for a period of one (1) year from the date of BGI's shipment. It is expressly limited to repairing or replacing at the factory during this period and at BGI's option, any device or part which shall within one year of delivery to the original purchaser, be returned to the factory, transportation prepaid and which on examination shall in fact be proved defective.

BGI assumes no liability for consequential damages of any kind. The purchaser, by acceptance of this equipment, shall assume all liability for consequences of its misuse by the purchaser, his employees or

others. This warranty will be void if the equipment is not handled, installed, or operated in accordance with our instructions. If damage occurs during transportation to the purchaser, BGI must be notified immediately upon arrival of the equipment. The Equipment will be returned via collect shipment.

A defective part in the meaning of this warranty shall not, when such part is capable of being repaired or replaced, constitute a reason for considering the complete equipment defective. Acknowledgment and approval must be received from BGI prior to returning parts or equipment for credit. BGI makes engineering changes and improvements from time to time on instruments of its manufacture. We are under no obligation to retrofit these improvements and/or changes into instruments which have already been purchased.

No representative of ours has the authority to change or modify this warranty in any respect.

Appendix A. NIST Traceability

A1.0 Introduction

NIST traceability for the calibrator is established with the use of devices which are of themselves traceable and for which, BGI holds current traceability certificates. Calibrations are performed under a set of ISO 9001:2000 procedures, subject to annual audit. During a flow rate calibration, the room temperature is established with an ASTM certified/traceable thermometer. Barometric pressure and absolute pressure are established with electronic manometers. These are backed by three Primary Standard Mercury Instruments/

A2.0 Flow Rate Calibration

A schematic diagram of an instrument undergoing flow rate calibration is shown in Figure 1A. Two traceable critical Venturi are utilized for this purpose. While the calibrator utilizes barometric pressure and ambient temperature to constantly display readings of volumetric flow rate, the initial Venturi calibration is performed and normalized to a base value. While any values are sufficient, "Engineering Standard Values" of 20° C and 760mm of Hg have been selected. Utilizing an Excel spreadsheet, the flow rate vs. pressure drop equation for each individual Venturi, under test, is determined. This equation is then installed in the individual units microprocessor. The flow tube model is calibrated using a Laminar Flow Element.

A3.0 Barometric Pressure Calibration

The barometric pressure sensor is set to match the actual current barometric pressure as determined by a Mercury barometer. A negative pressure of 150 mm of Hg is applied to the barometric pressure transducer and the output reading is adjusted to comply with BP – 150mm.

A4.0 Temperature Calibration

The Thermistor provided for measurement of ambient temperature is of a very high standard and are batch tested at the temperature extremes of –20° C and +55° C, utilizing an ASTM certified/traceable thermometer as a reference.

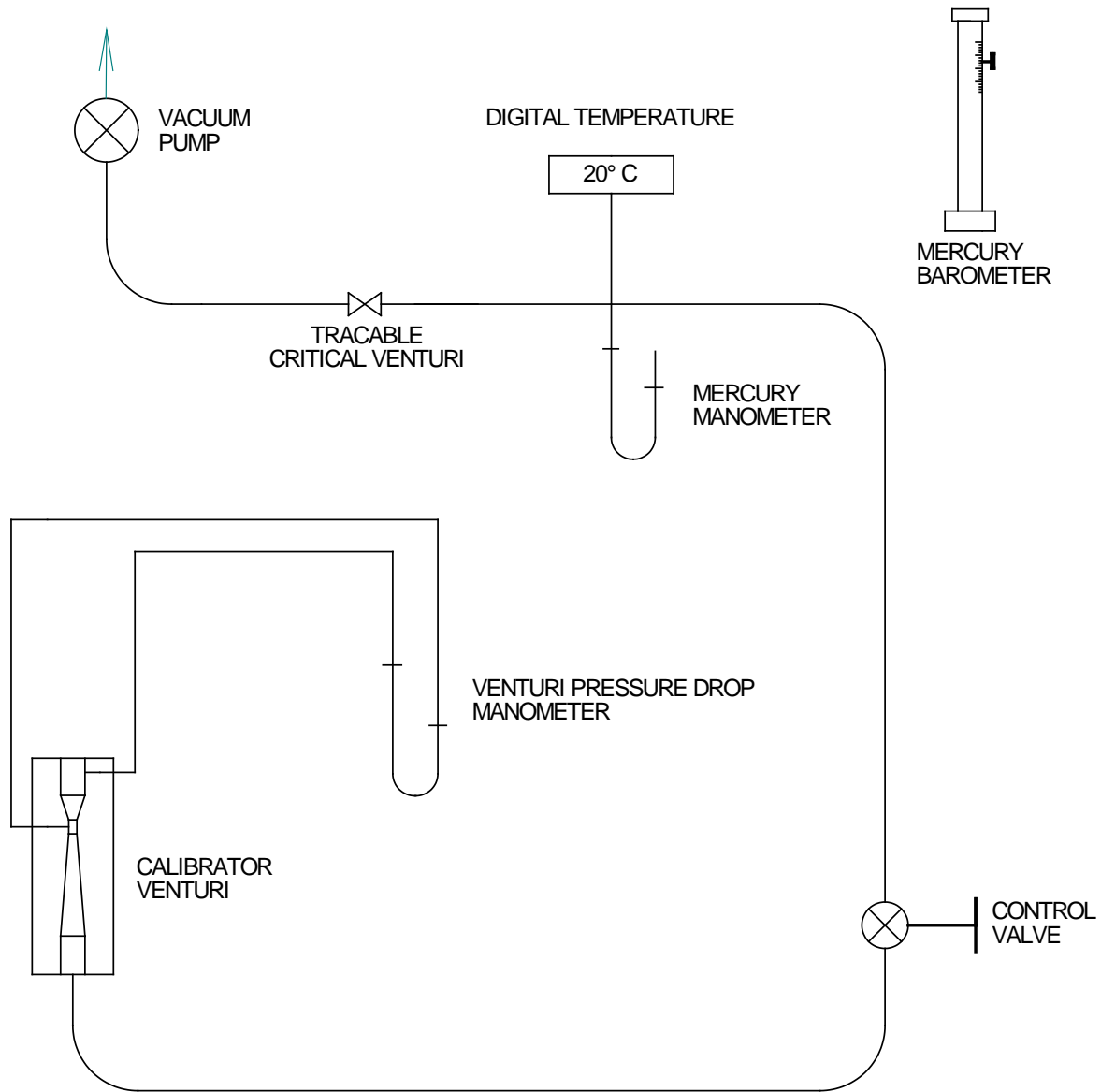


Figure A1- Schematic Diagram of Calibration Setup

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A5.0 Recalibration

Recalibration is immediately necessary if physical damage has occurred to such an extent that the instrument is rendered inoperable. In such cases, an instrument will be recalibrated as part of the repair procedure. There are no moving or wear parts in the instrument, therefore, barring physical damage, there is no reason for recalibration, except as required by ISO, company or regulatory requirements. These requirements are almost universally on a one-year basis, after being placed in service. Units received for recalibration will be thoroughly inspected and any requisite repairs will be performed prior to recalibration.

Appendix B. Lubrication (for CH100 only)

There is one point which requires careful lubrication it is the three "O" rings inside the socket into which the Venturi is inserted. They should be sparingly lubricated with the tip of the finger. General purpose automotive grease seems to be the most successful all around lubricant.

Appendix C. Volumetric and Mass (Standard) Flow.

There are two ways that practitioners of air sampling measure and talk about flow rate. Those doing compliance sampling for Industrial Hygiene/Occupational Health speak of **Volumetric** or **Actual** Air Flow rates. It is the volume of air at the existing pressure and temperature at the sampling site. The US EPA also specifies this type of measurement for $PM_{2.5}$. *Electronic* meters usually read out in volumetric flow rate or Q_A . Mass flow meters read out in Q_S . The Challenger reads out in both.

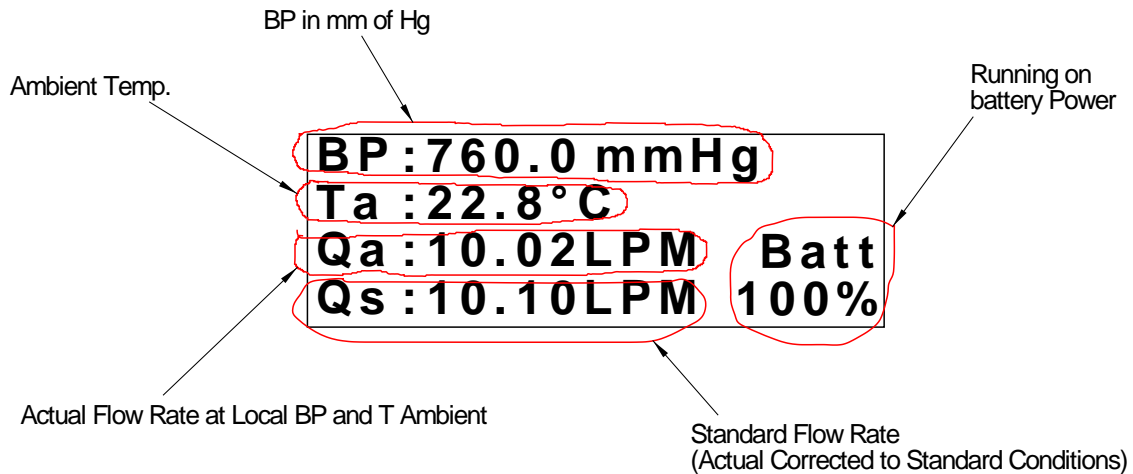
EPA, for Politico Legal, reasons uses Q_S known as **Standard** or **Mass** Air flow rate for reporting PM_{10} . This means that the flow rate is reported to **Standard** conditions. For the US EPA, these conditions are **25° C** and 1 atmosphere pressure. (1 Atmosphere = 760 mm of Hg = 29.92 in of Hg = 1013.25 millibars = 1013.25 hecto Pascals).

Because the mass of air flowing could be calculated from Q_S it has come to be called **Mass flow**. Throughout most of the world Q_S is not usually referred to as mass flow and it is to a different standard. The conditions outside of the U.S. are **0° C** and 1013.25 mb. The equations relating Q_A and Q_S are:

$$Q_S = Q_A * (BP_a/760)*(298.15/(T_a+273.15)) \text{ For U.S. applications when } T_s=25^\circ \text{ C and } BP_s=760 \text{ mm of Hg}$$

$$Q_S = Q_A * (BP_a/1013.25)*(273.15/(T_a + 273.15)) \text{ For world applications when } T_s=0^\circ \text{ C and } BP_s=1013.25 \text{ mb}$$

The screen which is the output of The Challenger is explained below:



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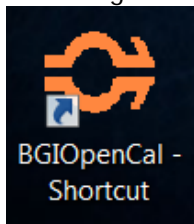
Appendix D. P Series Setup.

All calibrators with the **letter P** in the Version number of the start up screen are equipped with user selectable display parameters.

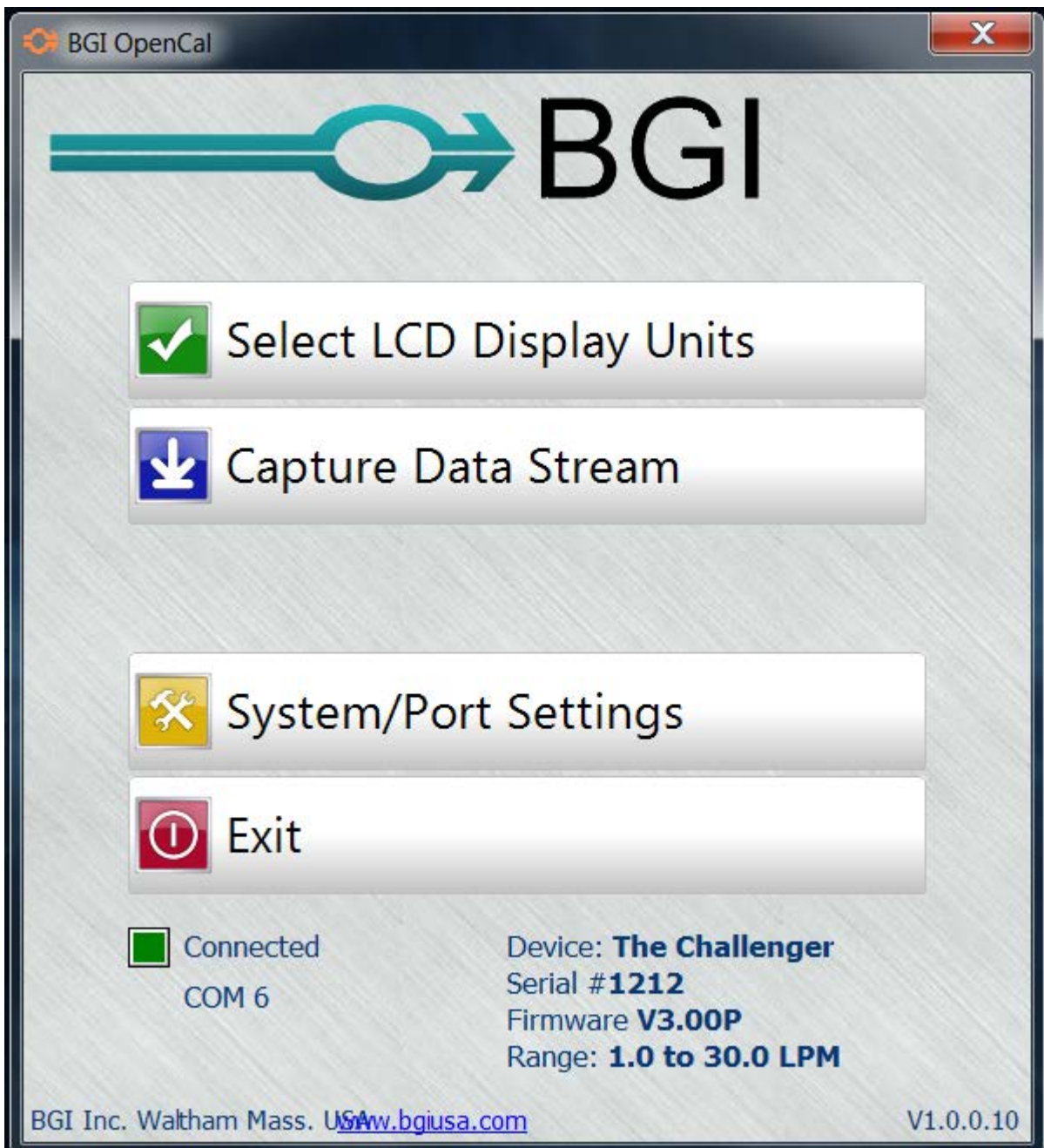
All units are shipped from the factory with the following default parameters installed:

B	P	:	7	6	0	.	0		m	m	H	g		
T	a	:	2	2	.	8		°	C					
Q	a	:	1	0	.	0	2	L	P	M	B	a	t	t
Q	s	:	1	0	.	0	0	L	P	M	1	0	0	%

A utility disc is shipped with every new/recalibrated/repared unit which will permit the selection of a wide range of measurement units. The Utility is known as [BGIOpenCal](#). It may be downloaded directly to your computer from the electronic version of this manual, or from the BGI web site on the page describing the calibrator. An icon will be created and displayed on your desktop:



Clicking on this icon will open a BGIOpenCal Set up screen. In order for the screen to be active your calibrator must be connected to your computer via a serial cable or in most cases today via a USB serial cable of good quality.



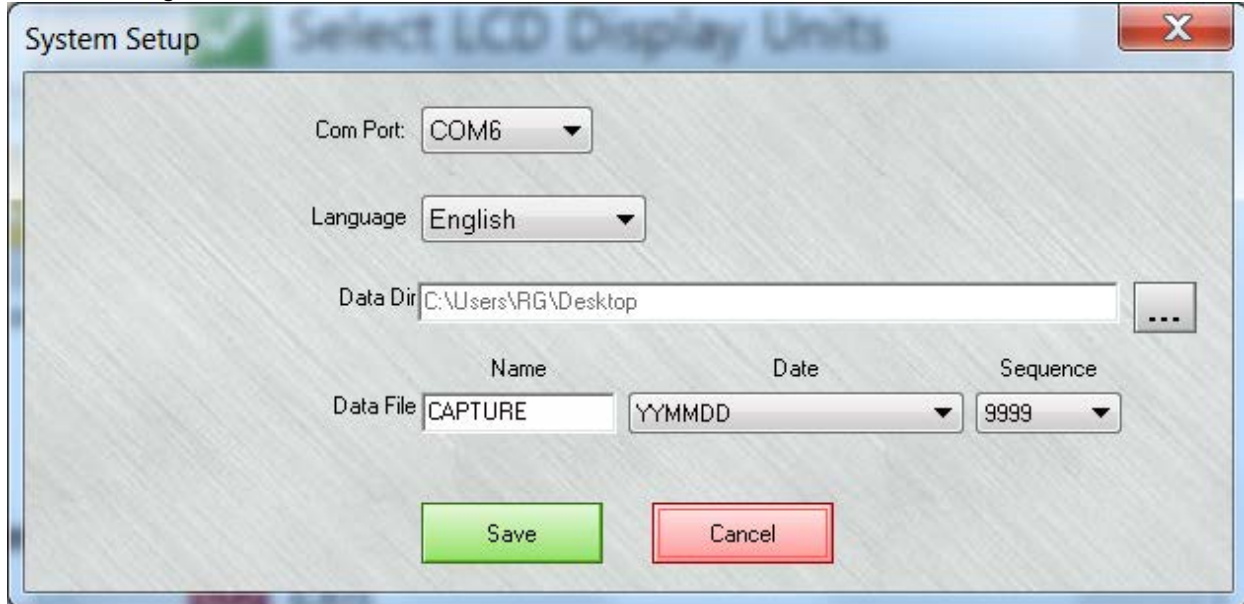
If the connection is successful, a green box and the number of the com port will be displayed. You will also see the details of your calibrator:



In the event that a com port is not automatically selected, select :



Click on it to go to:



If there is no com port displayed, set the cursor on the down arrow

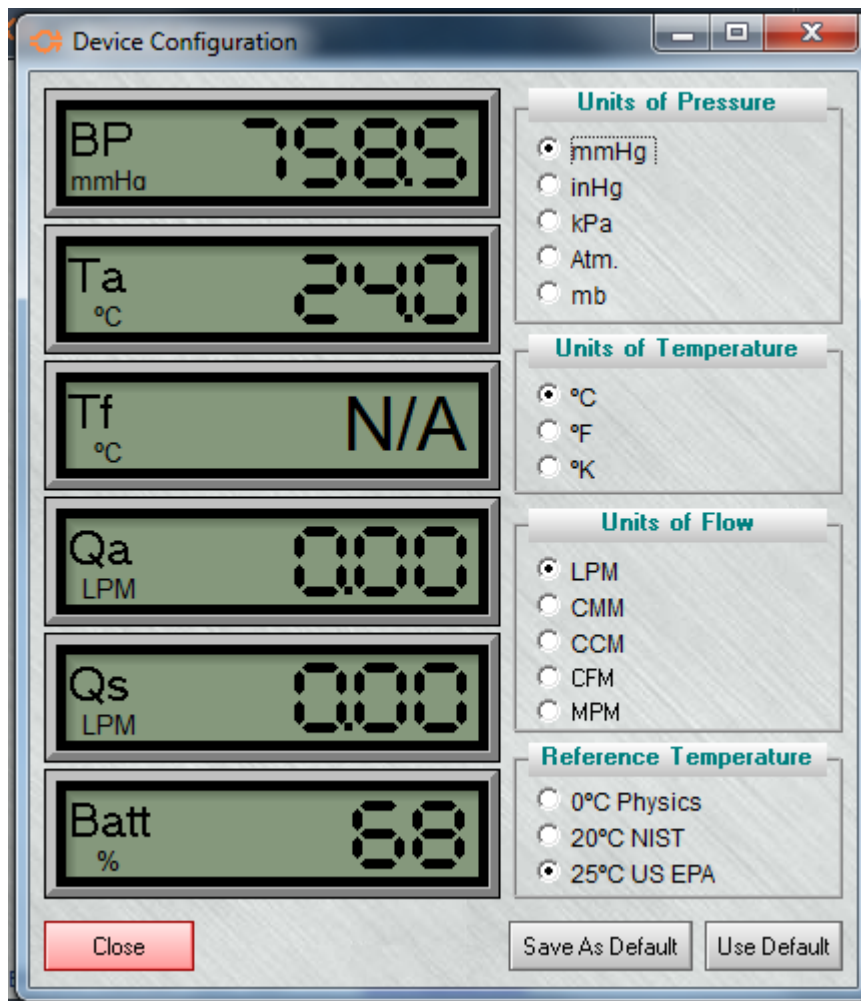


and a number will be displayed. Click on  and you are connected.

In the future when the same calibrator is connected to the same computer a port connection will be instantly established. You may now select:



Clicking on this icon will open the parameter selection area and permit a wide variety of measurement units to be displayed. The initial display will be the factory default values.



Five choices of units of pressure are available. In the order presented they are:

- mmHg - millimeters of Mercury
- inHg - inches of Mercury
- kPa - kilo Pascals
- Atm - Atmospheres
- mb - Millibars

At this point it is important to note that these parameters may all be changed while air is flowing through the instrument. This is a useful feature as it may aid the investigator to achieve a better "feel" for the most favorable units to utilize.

Three choices of units of Temperature are available:

- °C - Celsius
- °F - Fahrenheit
- °K - Kelvin

Five choices of flow rate units are available:

LPM - Liters per minute
CMM - Cubic meters per minute
CCM - Cubic centimeters per minute
CFM - Cubic Feet per minute
MPM - Moles per minute

The reference temperature is the "base" to which the Standard flow rate is presented. In the USA and other countries which directly utilize EPA guidelines (principally all of the Western hemisphere bar Canada) the Standard temperature is 25° C for PM 10. For the rest of the World the "base" is 0° C. Engineers and NIST use a base of 20° C when expressing Standard flow rate. At one time it was popular to refer to standard flow as mass flow. This was common but, incorrect and is rapidly fading.

A rectangular button with a light gray background and a thin border, containing the text "Save As Default" in a standard sans-serif font.

Once your selections have been made, press the  button and unplug the cable.

References

1. Fan Engineering, R. Jorgensen, ed. Buffalo Forge Co, Buffalo, NY. 6th Ed. 1961.
2. US EPA FRM 40 CFR Part 53, Federal Register, July 18, 1997.
3. Measurement Systems, E.O. Doebelin, McGraw-Hill Inc., New York, NY. 4th Ed. 1990.



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DECLARATION OF CONFORMITY

Manufacturer's Name: BGI Instruments

Manufacturer's Address: 58 Guinan St.

Waltham, MA 02451

Declares that the product:

Product: The Challenger

Model Number: N/A

Conforms to the following product specifications:

EN 55011:2007	European Industrial, scientific and medical (ISM) radio-frequency Equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement, Class A
EN61326-1:2006	Electrical Equipment for Measurement, Control and Laboratory use EMC Requirements
EN61000-4-2	Electrostatic Discharge
EN61000-4-3	Radiated Electromagnetic Fields

Revision History

Version 1.0.0	Created	April, 2007
Version 1.0.1	Changed screen notes	May, 2007
Version 1.1.1	Introduced BGI Open Software	January, 2008
Version 1.1.2	Added CE Declaration of Conformity	Dec, 2008
Version 1.1.3	Updated ISO Registration	March, 2009
Version 2.0.0	P Series Appendix	July, 2011
Version 2.1.0	Added model CH050	February 2012
Version 2.1.1	Updated some images to color	June 2013