



EPA FRM Compatible Field Audit Calibrator

NIST Traceable – ISO 9001:2008

deltaCal Manual

Models

DC1: 1.5 – 19.5 LPM

DC100: 10 – 60 LPM

DC200: 0.8 – 3.5 LPM



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MK101-13 Rev. B

Table of Contents

Section	Topic	Page
1.0	Quick Start	3
2.0	Introduction	3
3.0	Specifications	5
4.0	Principle of Operation	9
5.0	Instrument Set Up	9
6.0	Using the deltaCal®	12
7.0	Software	14
8.0	Maintenance and Recalibration	14
9.0	Safety	14
10.0	Warranty	15
Appendix A	Qs/Qa Relationship	16
Appendix B	Note on Instrument Versions	17
Appendix C	Changing Display Units Using deltaCal	18

1.0 Quick Start

Step 1: Remove the deltaCal® from its carrying case and place the control module in position it will be used during measurement. Turn on the deltaCal®.

Step 2: Remove the inlet head from your FRM sampler, but leave the 12 inch downtube in place.

Step 3: Install the deltaCal® measuring head on the 12 inch downtube in place of the inlet. If the instrument to be audited is not already running, start it now.

Step 4: You may now read the deltaCal® screen to determine volumetric flow rate, ambient temperature and barometric pressure.

Step 5: Shut off the audited unit, open the filter cassette holder and remove the cassette. The filter temperature probe will now be visible. Plug the hand held temperature probe provided with the deltaCal® into the control module. Hold the tip of the probe within 1 cm. of the filter temperature probe, without touching it. Ensure that direct sunlight does not fall on either sensor. You may now audit filter temperature.

For a diagram of the immediate application refer to Figure 1 on following page. For further information on these steps, refer to Section 6.

2.0 Introduction

The BGI deltaCal® is an EPA FRM compatible flow audit device using a venturi. The deltaCal® is manufactured in Mesa Labs' ISO 9001-2008 facility. This calibrator features a LCD display of volumetric and standard flow rate, barometric pressure, ambient temperature. It operates on either four AA batteries or AC power. The electronics are all housed in the control module.

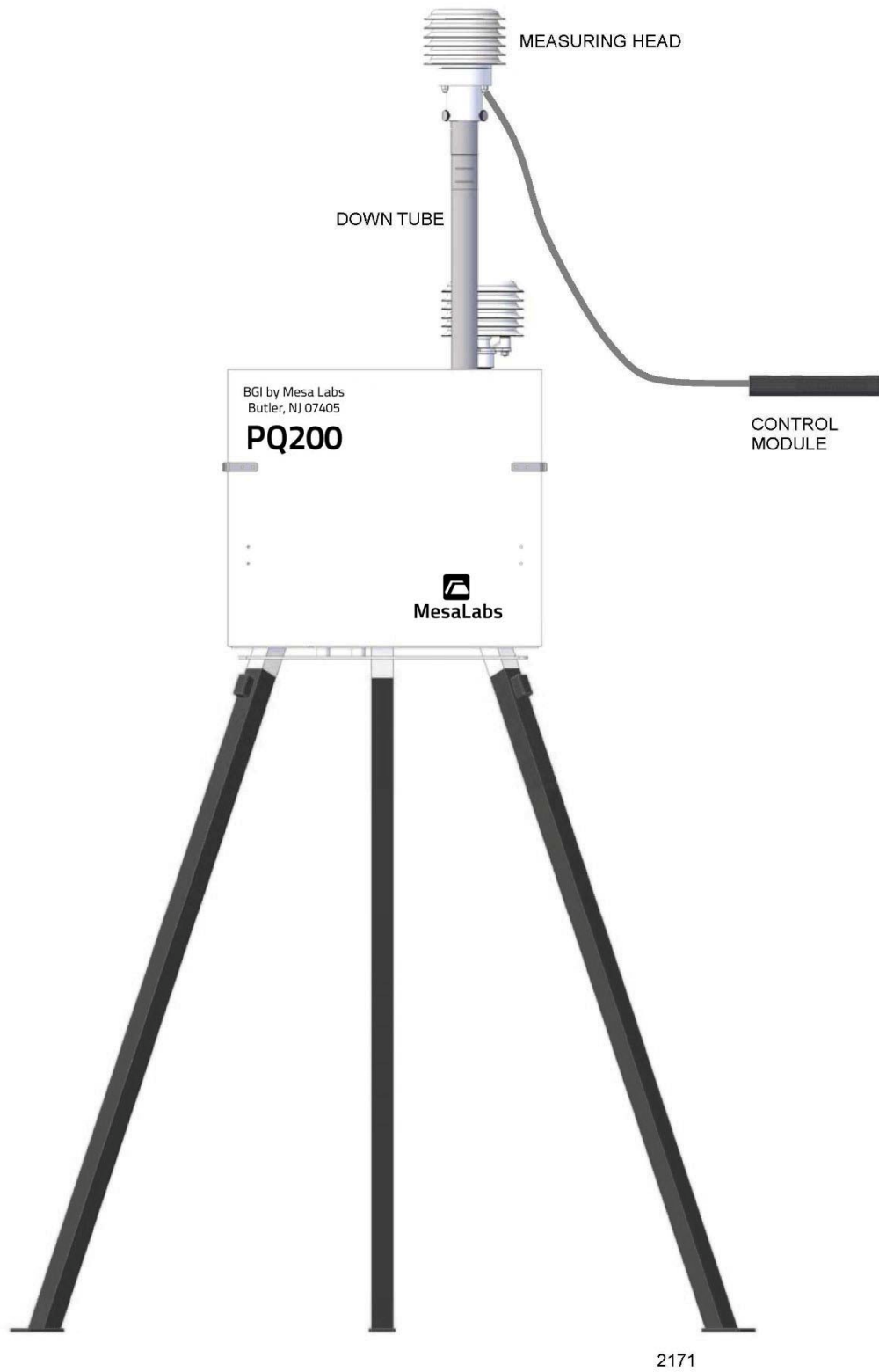


Figure 1 – Installation of deltaCal® on an FRM

3.0 Specifications

Flow Rate Range	
DC1 model:	1.5 – 19.5 LPM
DC100 model:	10 – 60 LPM
DC200 model:	0.8 – 3.5 LPM
Flow Accuracy	0.75% of reading
Temp. Operational Range	-30° C to 55° C
Temp. Reading Range	-30° C to 55° C ($\pm .5^\circ$ C)
Temp. Accuracy	0.5° C
Barometric Pressure Accuracy	5 mmHg
Barometric Pressure Range	400 to 800 mm of Hg (± 5 mm)
Dimensions:	
Measuring Head	5" OD (12.7 cm) X 10" high (25.4 cm)
Control Module	8" (20.3 cm) X 4" (10.15 cm) X 1.7" thick (4.32 cm)
Combined weight	2.2 lbs (1 kg)
Hand held temp probe	
Length of cable	33" (83.8 cm)
Length of probe	5" (12.7 cm)
Carrying case:	
Dimensions	18" (45.7 cm) X 13" (33 cm) X 7" thick (17.8 cm)
Weight complete with contents	5.5 lbs (2.5 kg)

Your deltaCal comes with the following:

- deltaCal® calibrator
- Temperature Probe
- Power Supply
- 4 AA batteries
- Fitted Hard Carrying Case
- Calibration Certificate

The layout of the deltaCal carrying case is shown in Figure 2 on the following page.

Accessories/Parts

Part No.	Description
DC3	delta/tetraCal Power Supply Kit
188125	deltaCal 3/8" Hose Barb Adapter
188126	deltaCal 5/16" Hos Barb Adapter
DC14	deltaCal Flow Rate Upgrade 1.5-19.5 LPM
CA9030	deltaCal Carrying Case
DC7	deltaCal Venturi Thumb Screw
188166	deltaCal O-Ring Kit
10248	deltaCal Rad Shield Replacement Kit



Figure 2 – deltaCal® Carrying Case

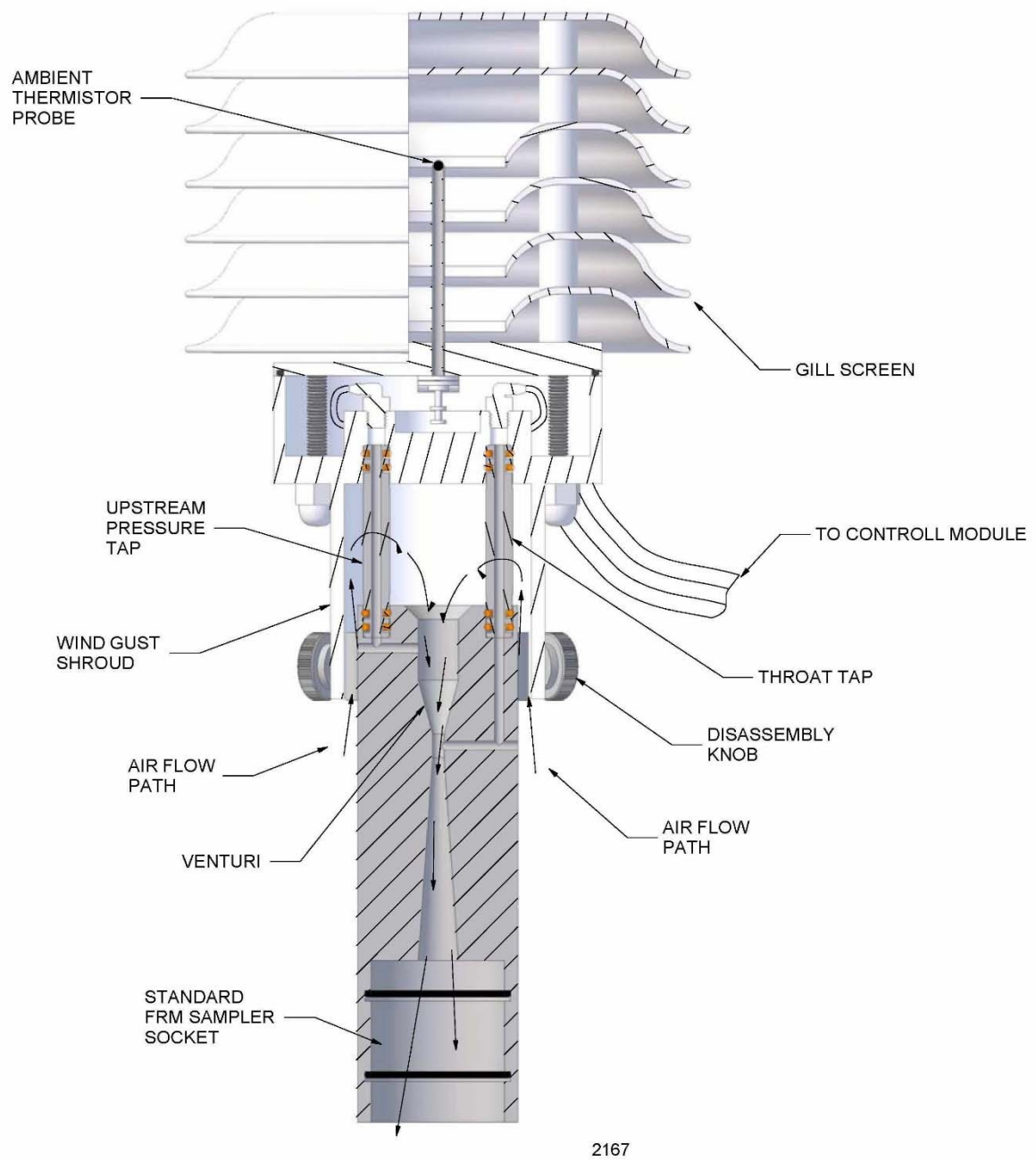


Figure 3 – Sectional View of Flow Measuring Head

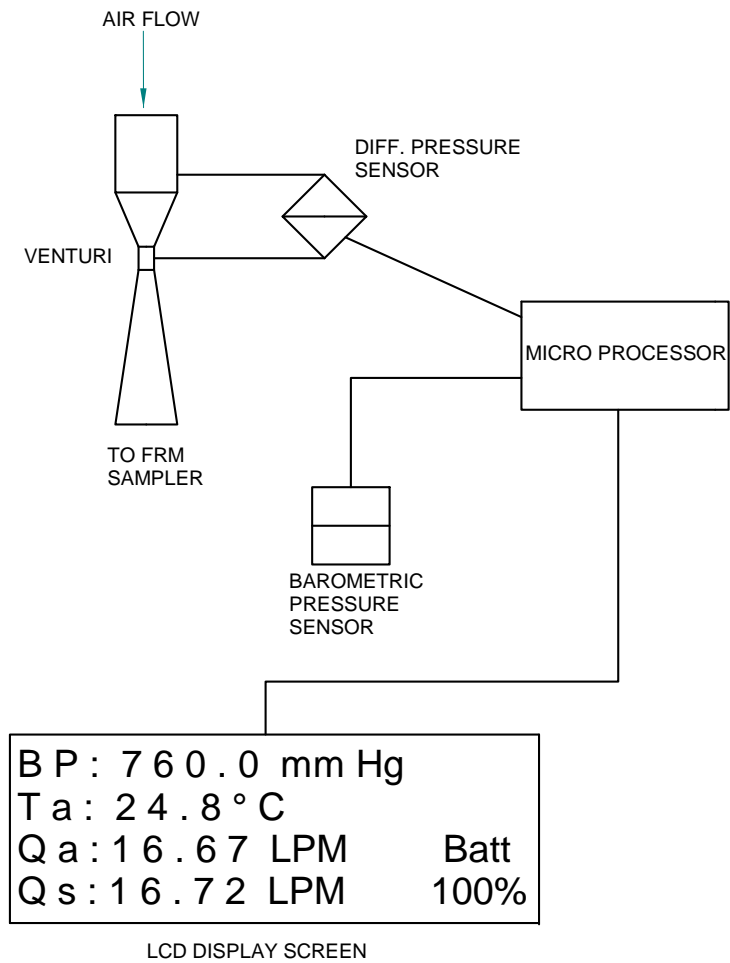


Figure 4 – Schematic Diagram of deltaCal®

4.0 Principle of Operation

The deltaCal[®] measures volumetric flow rate by utilizing a pressure transducer to assess the pressure drop caused by air being drawn through a venturi. As the flow rate through the venturi increases the pressure drop increases as the square root. Twice the flow rate yields a four times increase in pressure drop. 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 which incorporates the barometric pressure and ambient temperature to calculate a standardized flow rate. To eliminate fluttering of the on screen display of volumetric 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. The included temperature probe may be used for the purpose of auditing an FRM sampler's filter temperature. The temperature of the probe is displayed on the screen when it is plugged into the module. A cutaway diagram of the 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 and plug in the filter temperature probe to the labeled port provided in the end panel (Figure 5).

Important points to be noted concerning the utilization of the deltaCal

- A. The measuring head 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. When turning on the control module, the control module must be in the position in which it is going to be used, either horizontal or vertical. The case houses the pressure transducers, which are subject to the force of gravity. Positional changes can give rise to minor errors. This effect applies to all devices containing pressure transducers.
- C. In order to perform the most precise measurement audit, the deltaCal[®] must be in thermal equilibrium with the ambient environment of the sampler to be audited. To achieve this equilibrium, remove the deltaCal[®] from its carrying case for at least 10 minutes prior to the audit in the vicinity of the sampler. Additionally, if the deltaCal[®] is subject to a temperature change of more than five degrees during use, it should be rebooted.

When the deltaCal[®] is switched on and no external power is being utilized *XX*% battery capacity remaining is displayed on the screen. So long as more than 10% is indicated, you may perform your audit as at least one hour of power is available. If the provided AC adaptor is utilized, the screen will indicate "DC In" and there is no limit to the run time. Note: Use of an AC power supply, other than the one provided, can cause severe damage to circuit components.

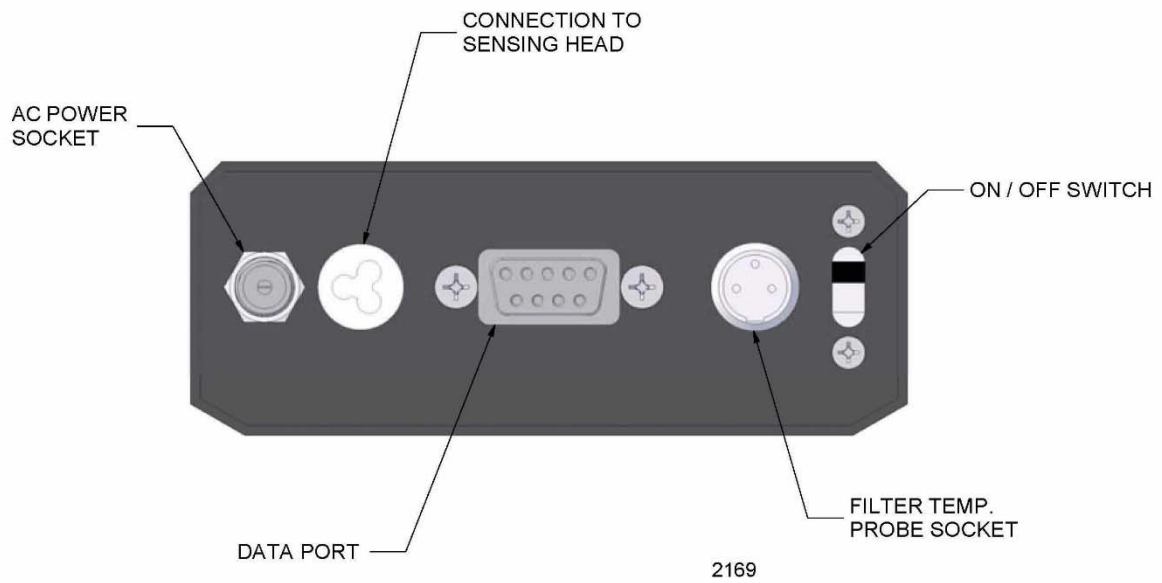


Figure 5 – deltaCal® Control Panel

Table 1 Audit Data Format

Audited Instrument:

Make: _____ Model: _____ S/N: _____

Date: _____ Time: _____ deltaCal® S/N: _____

Flow Rate – Lpm

Sampler: _____

% diff. = $[(\text{deltaCal}^{\text{®}} - \text{sampler}) / \text{deltaCal}^{\text{®}}] \times 100$

DeltaCal®: _____

Allowed diff. = 4%; Pass _____ Fail _____

Ambient Temp. – C

Sampler: _____

DeltaCal®: _____

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

Barometric Pressure – mm of Hg

Sampler: _____

DeltaCal®: _____

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

Stop sampler, open filter holder, remove cassette and hold tip of Temp. Probe adjacent to samplers Filter Temp. Probe *without touching it*.

Filter Temp. C

Sampler: _____

DeltaCal®: _____

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

6.0 Using the deltaCal®

6.1 To perform an audit

One of two procedures should now be performed.

Procedure A Turn off the sampler to be audited. Remove the louvered inlet. Leave the 12 inch downtube in place. Install the deltaCal measuring head onto the top of the 12-inch downtube. Turn on the deltaCal®, wait for the screen to finish the start-up boot, and then turn on the air sampler.

Procedure B With the sampler to be audited running, remove the louvered inlet. When the screen has finished its start-up boot, install the measuring head onto the 12 inch down tube.

The flow resistance of the deltaCal® head may cause momentary instability in the air samplers flow control circuit. Once the air sampler's main screen flow rate indicator stabilizes, the reading may be taken. A sample audit data format is shown in Table 1.

Once the dynamic reading of flow rate is completed, the air sampler pump may be shut down per manufacturer's instructions and the filter temperature sensor may be audited. Open the filter cassette clamping mechanism and remove the cassette. You can now view the filter temperature sensor. Hold the probe of the deltaCal® filter temperature sensor within 1 cm. of the sampler's sensor without actually touching it. Shield both sensors from direct sunlight. Read both the samplers indicated filter temperature and the deltaCal®'s probe temperature and record them.

It should be noted that some brands of sequential samplers may require minor disassembly to gain access to the filter temperature sensor.

6.2 To perform a calibration.

The procedures and calculations for using the deltaCal® to calibrate a sampler are the same as an audit, except the flow rate tolerance of is $\pm 2\%$ rather than $\pm 4\%$ as allowed for an audit. While full EPA procedures are carefully spelled out in the Federal Reference Method in 40 CFR 50 Appendices J and L, it is important to note that the flow rate should be calibrated at the operational point and 10% above and below that point, as indicated in Table 2.

Table 2 EPA FRM Calibration Points

		$\pm 2\%$
Standard Flow Rate – Lpm	16.67	16.34 – 17.00
10% Below Standard – Lpm	15.00	14.7 – 15.30
10% Above Standard – Lpm	18.30	17.97 – 18.71

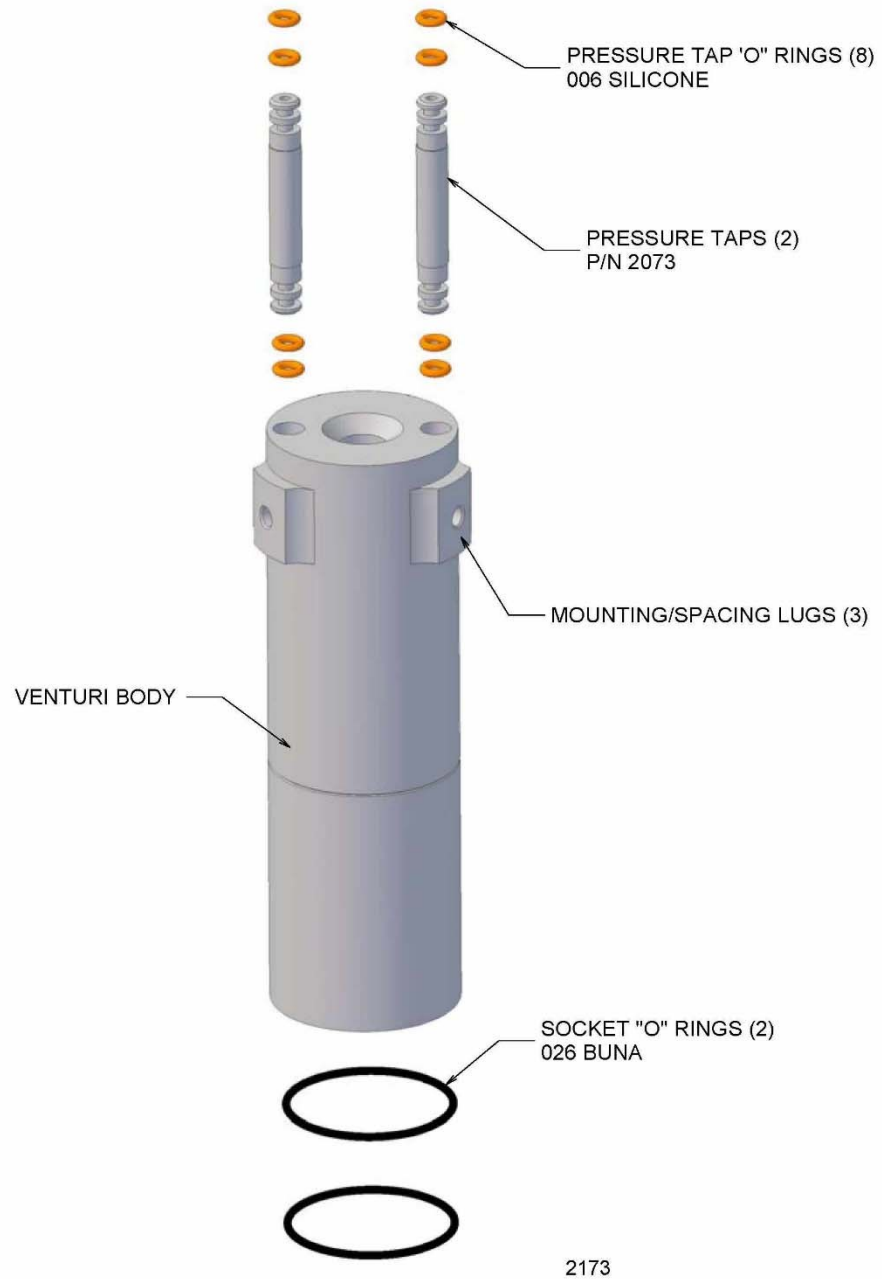


Figure 6 – Salient Details of Venturi Body

7.0 Software

All BGI calibrators are designed to operate with the OpenCal software. The software allows the user to change the display units for flow, temperature, and pressure. You can also view and save a real-time data stream. For further information on changing the display units of your calibrator, refer to Appendix B. <http://bgi.mesalabs.com/software/>

8.0 Maintenance and Recalibration

8.1 User 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. Holding the instrument in the inverted position, glance into the interior, seeking any discoloration of the white or silver surface. If it is determined that cleaning is required, refer to Figure 3.

Remove the three knurled thumbscrews from the side of the measuring head and set aside. Grasp the body of the instrument, under the shoulder, in one hand and the venturi in the other. Gently pull the two sections apart. *Avoid any pulling force to the Gill Screen.* Set aside the upper section of the measuring head with the Gill screen attached and you are left with the venturi body shown in Figure 7. Rinse the entire venturi body in warm soapy water. Any external deposits, which are not floated away, may be removed 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. Be especially certain to blow all liquid out of the pressure taps and their attendant passages.

Inspect the silicone rubber o-rings on each pressure tap. If any damage is observed, replace all four. Prior to reassembly, lubricate the o-rings with a wipe of light grease. Prior to reinstalling the venturi into the body of the instrument, note that there is only one rotational position in which both the pressure taps *and* the three screw holes on the body can be aligned. Hence, incorrect assembly is impossible. Having ascertained the correct rotational position for reassembly, gently insert the venturi section into the recess, until the tips for the pressure taps bottom. Rotate the venturi section gently back and forth (clockwise/counterclockwise) until the tips of the pressure taps go into the recesses provided. Slide the venturi longitudinally, back and forth until the three screw holes line up and reinstall the three thumb screws, hand tight.

The two o-rings in the socket of the instrument, which fits over the 12 inch downtube, during calibration procedures, should be frequently inspected for wear and tearing. They should be replaced at the first sign of wear and always kept lightly greased for ease of use.

8.2. Factory Recertification

Your deltaCal is a NIST-traceable high-precision standard with few moving parts. The calibration certificate you received with your unit is valid for one year from the date of certification. Environmental factors, product wear, drift of sensors or inadvertent damage may adversely affect your deltaCal's measurement accuracy or general performance. For these reasons, Mesa highly recommends that you return your deltaCal to our manufacturing and calibration facility in Butler, NJ to ensure its measurement integrity.

Recertification at our facility include any necessary repairs, with the exception of replacing the electronic boards, which will incur a fee. All deltaCals returned to our facility for recertification will receive both a pre- and post-calibration.

9.0 Safety

The four AA batteries 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 over two months, always remove the batteries.

Do not substitute other power supplies. Use only the unit provided, or severe electrical problems could occur. Even though there is no reason to disassemble the electronics box, should the need arise, always unplug the line current power supply and remove the batteries.

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.

The filter temperature probe has a range of -50° to $+50^{\circ}$ C with an accuracy indicated on the traceability certificate. We recommend that the probe should only be used within the normal EPA range of -30° to 40° C. The tip of the probe will be irreparably damaged if it is applied to surfaces above 50° C. Under no circumstances should it be inserted into any area, which might cause damage to the probe or that the probe might cause damage to.

10.0 Warranty Information

Mesa Labs 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. Mesa's liability under this warranty extends for a period of one (1) year from the date of product's shipment. Mesa Labs warrants service performed on equipment at our factory for a period of ninety (90) days and spare parts for a period of sixty (60) days. During these periods, the warranty is expressly limited to repairing or replacing any device or part returned to the factory and proven defective upon evaluation. These warranty periods will not be extended under any circumstances.

Mesa 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, its employees, or others. Purchaser is responsible for all damages resulting from field repairs and installation of equipment and parts. This warranty will be void if the equipment is not handled, transported, installed, or operated in accordance with our instructions. If damage occurs during transportation to the purchaser, Mesa must be notified immediately upon arrival of the equipment.

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 Mesa prior to returning parts or equipment for credit. To obtain a Return Merchandise Authorization (RMA), contact csbutler@mesalabs.com with details of the warranty or service claim. Purchaser is responsible for return shipment of equipment to the factory for warranty and non-warranty repairs. Mesa Labs will provide ground shipment to the purchaser for warranty repairs. All shipments from Mesa Labs will be handled by FedEx, unless otherwise requested. If the purchaser elects to use a third party freight forwarder or another shipping carrier, the purchaser is thereby responsible for the shipment.

Mesa Labs periodically makes engineering changes and improvements on instruments of its manufacture. We are under no obligation to retrofit these improvements and/or changes into instruments which have already been purchased.

For refund of new products, equipment must be in a new and unused condition. A restocking fee of 30% of the product's value will be charged for returns after thirty (30) days. Mesa Labs will not accept any returns after ninety (90) days.

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

Appendix A. Qs/Qa Relationship

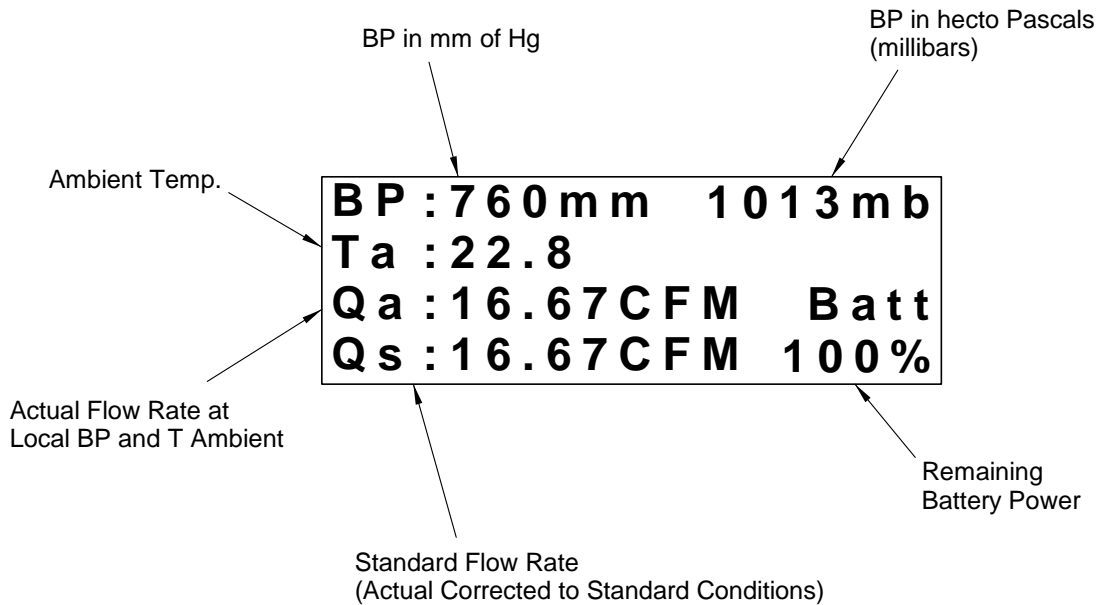
U.S. EPA uses Q_s , known as standard air flow rate, for reporting PM_{10} . This means that the flow rate is reported to Standard conditions. For the U.S. EPA, these conditions are 25° C and 1 atmosphere pressure. (1 atmosphere = 760 mm of Hg = 29.92 in of Hg = 1013.25 millibars = 1013.25 hecto Pascals).

The standard conditions outside of the U.S. are 0° C and 1013.25 mb.
 Q_s is calculated using the following equations:

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

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

Your HiVolCal® performs this calculation to provide Q_s , Q_a , T_a , and BP on a continuous basis. At the same time, the two most popular Barometric pressure units (mm of Hg and millibars or hecto Pascals) are also provided. This results in the following screen:



3138

Remember, Q_s is always set to sea level conditions, but the Standard temperature is always factory set to either 25° C (US EPA, Canada and other countries using US EPA conditions) or 0° C. If the Firmware version contains the letter W (for world) the temperature base is 0° C.

Appendix B. Note on instrument versions

Instruments with version numbers beginning with 2.4.X have a different venturi than previous versions. These units are further identified by a groove running around the venturi body. The flow rate range has been shifted from the original 2-20 lpm to 1.5 to 19.5 lpm. to accommodate a revived interest in Dichotomous particulate samplers.

Instruments with version 2.5.X and higher include will display both volumetric and standardized flow. To change the standardizing temperature, use the OpenCal software according to the instructions in Appendix B.

Instruments with version 4.00 and higher include two internally stored power curves for greater accuracy over full specification range.

Appendix C. Changing display units using OpenCal

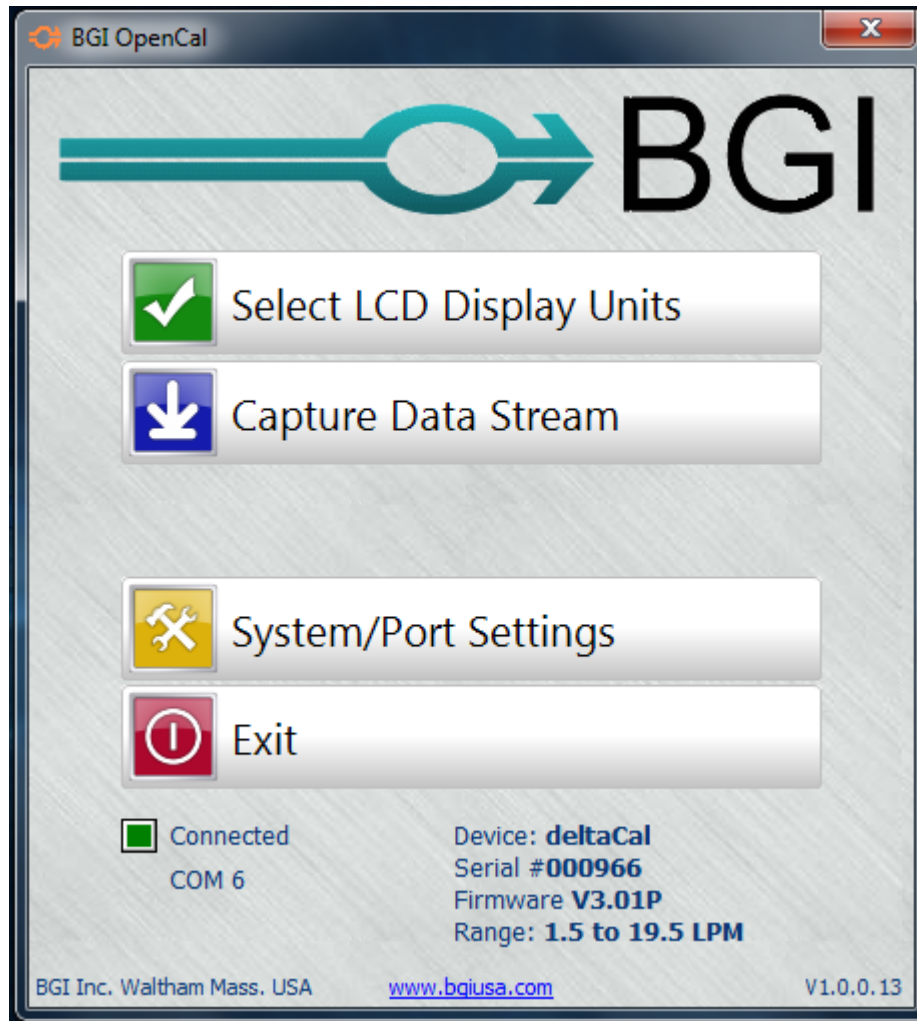
All calibrators with the letter P in the Version number of the start up screen are equipped with user selectable display parameters.

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

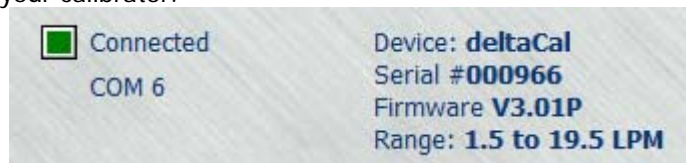
B	P	:	7	6	0	.	0		m	m	H	g
T	a	:	2	4	.	8	°	C				
Q	a	:	1	6	.	6	7	L	P	M		B a t t
Q	s	:	1	6	.	7	2	L	P	M		1 0 0 %

To change these measurement units, the BGI OpenCal software may be downloaded at bgi.mesalabs.com/software.

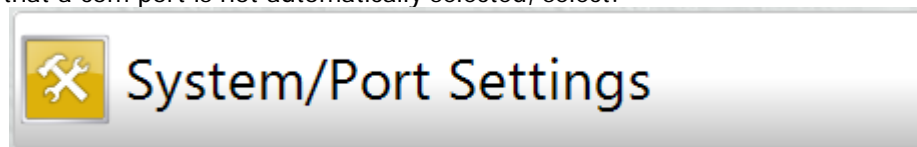
After you have downloaded this software, connect your deltaCal to your computer with either an RS-232 serial cable or a USB-serial adapter prior to opening the software



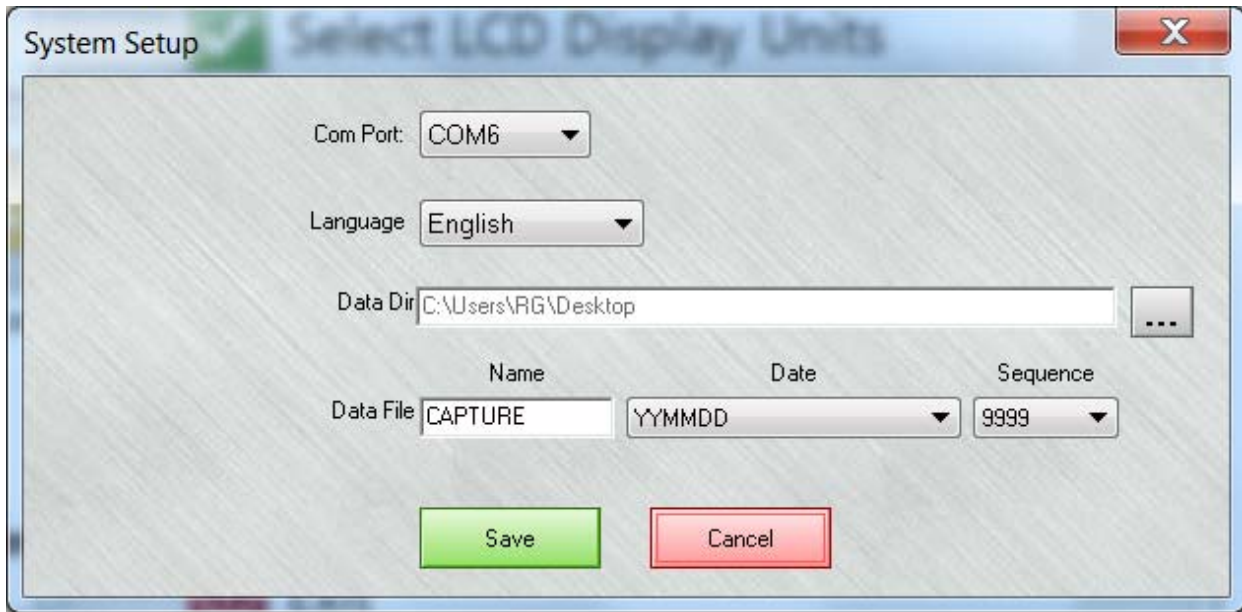
If the connection is successful, a green box and the number of the com port will be displayed. You will also see the details of your calibrator.



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



Click on it to go to:

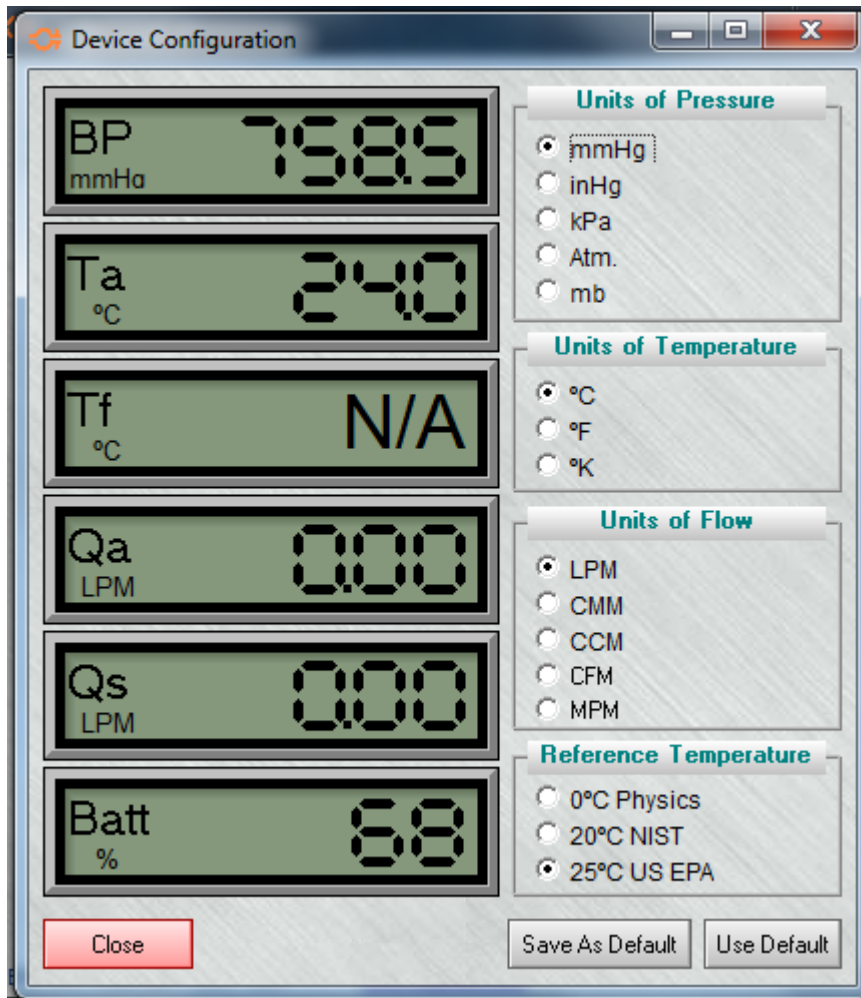


If there is no com port displayed, set the cursor on the down arrow to select the correct com port. Save this setting before exiting this screen.

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.



The reference temperature is the "base" to which the Standard flow rate is presented. Choose the reference temperature that is appropriate for reporting standardized flow to your local air monitoring agency. In the USA and countries that follow the US EPA regulations, this temperature is 25°C. .

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