



**Laboratory/Field Audit Calibrator**

***NIST Traceable – ISO 9001:2000***

**1 TO 30 Lpm**

***SENSIDYNE***<sup>®</sup>

Sensidyne, LP • 16333 Bay Vista Drive  
Clearwater, Florida 33760 USA

800-451-9444 • +1 727-530-3602 • +1 727-539-0550 [fax]

**web:** [www.sensidyne.com](http://www.sensidyne.com) • **e-mail:** [info@sensidyne.com](mailto:info@sensidyne.com)



**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.*

**Table of Contents.**

<b>Section</b>	<b>Topic</b>	<b>Page</b>
1.0	Quick Start	4
2.0	Introduction	4
3.0	Specifications	6
4.0	Principle of Operation	10
5.0	Instrument Set Up	10
6.0	Using the Calibrator	11
7.0	Software	13
8.0	Maintenance	13
9.0	Safety	13
10.0	Warranty	13
Appendix A	NIST Traceability	14
Appendix B	Lubrication	16
Appendix C	Volumetric and Mass (Standard) Flow	16

## 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

Note: The Deluxe Model includes both Venturis. The Low Flow Model includes only the #L Venturi and the High Flow Model includes only the #H Venturi.

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.

**Note:**

*A Venturi MUST be matched to a unit by serial number. Swapping a Venturi from one Challenger to another will cause accuracy loss.*

## 2.0 Introduction

The Challenger air flow calibrators are manufactured for Sensidyne, LP by BGI, Inc.

All Challenger calibrators are based on the air flow measurement principle of the Venturi<sup>1</sup>. Our calibrators are manufactured in an ISO 9000:2000 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 Ventura, which cover the flow rate range of 1 to 30 Lpm.



## Figure 1 – “Quick Start” Application of Challenger

### 3.0 Specifications

Flow rate range: 1 – 30 LPM ( $\pm 0.75\%$  or less) (Deluxe Model)  
1 – 6 LPM ( $\pm 0.75\%$  or less) (Low Flow Model)  
6 – 30 LPM ( $\pm 0.75\%$  or less) (High Flow Model)

Temp. operational range -30° C to 55° C  
Temp. reading range -30° C to 55° C ( $\pm .5^\circ$  C)  
Barometric pressure range 400 to 800 mm of Hg ( $\pm 5$ mm)  
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 w/ Venturi 7.4 oz (209 g)

One complete instrument comprises:

Quantity	Description	Catalog/Part No.
1	Challenger	811-9911-03
4	Installed AA batteries	Replacements obtained locally by user
1	Instruction Manual	Enclosed CD
1	Carrying Case	7013586
1	Software Disk	615-9901-01
1	Venturi H, 6-30 lpm	Contact Factory
1	Venturi L, 1-6 lpm	Contact Factory

Replacement supplies (not included with initial purchase).

1 Pkg. of 3

Venturi socket "O" rings

811-9913-01

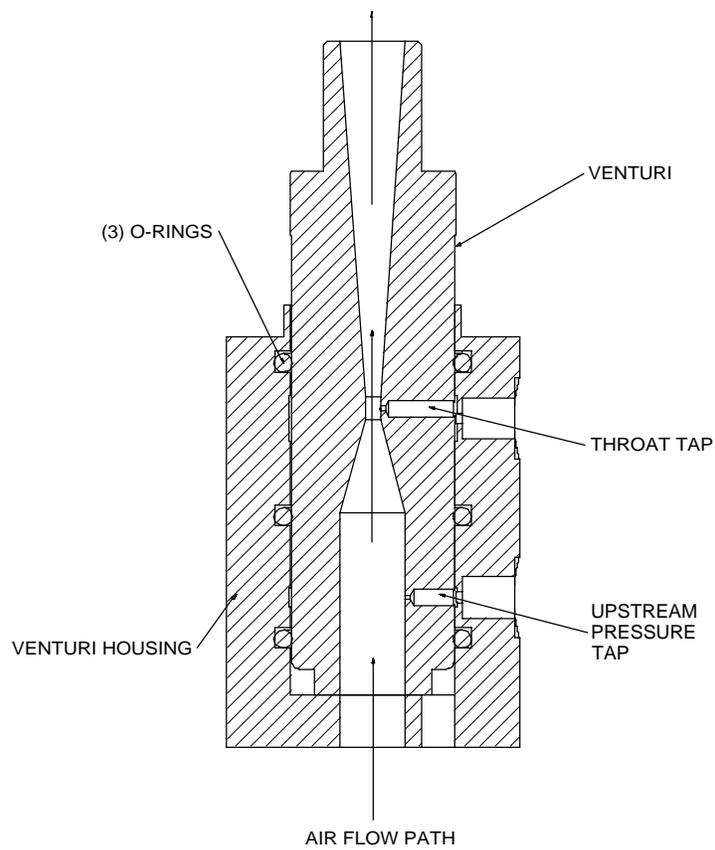


Figure 3 – Sectional View of Measuring Head

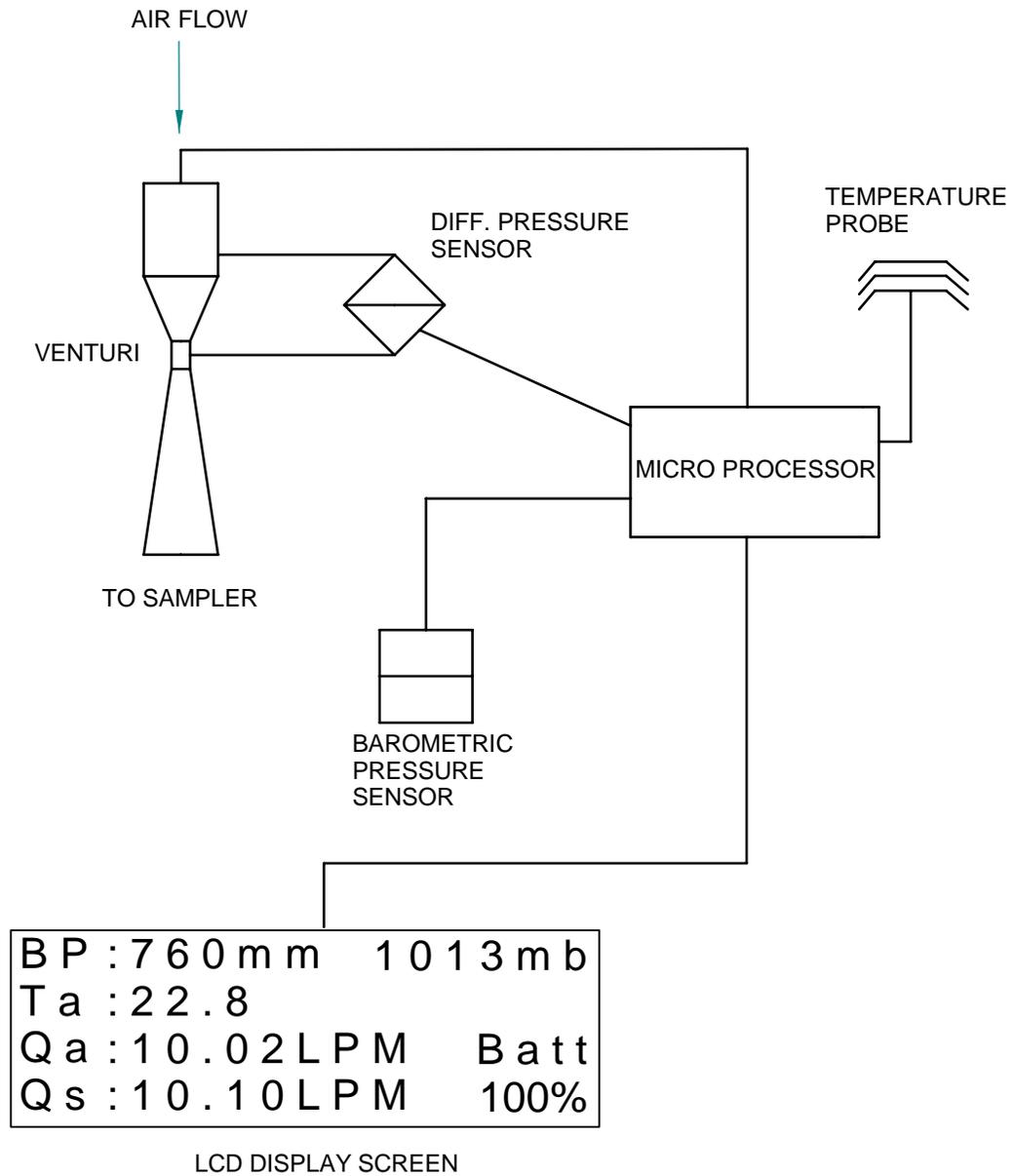


Figure 4- Schematic Diagram of Challenger

3061

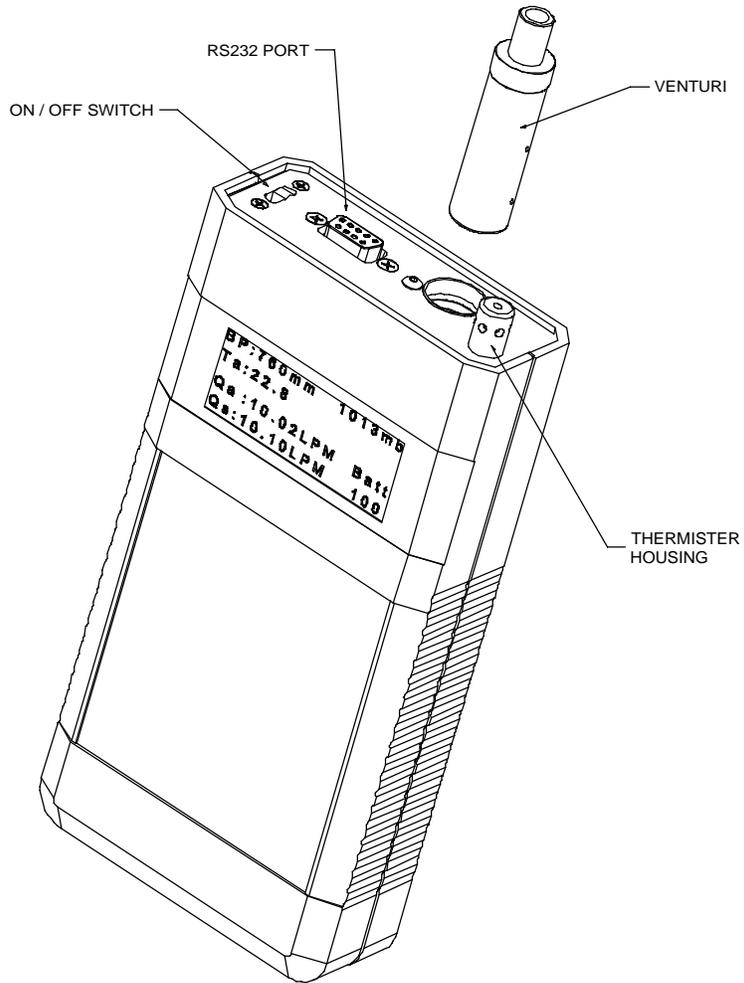


Figure 5 – Challenger Assembly

#### 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. As the flow rate through the Venturi increases, the pressure drop increases as the square root<sup>1</sup>. 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 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 2.500**  
**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 2.500**  
**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.

BP : 760 mm	1013 mb
Ta : 22.8	
Qa : 10.02 LPM	Batt
Qs : 10.10 LPM	100%

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 Venturi 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.
- D. Never use a Venturi in a Challenger if the serial numbers do not match. Venturi and Challenger are factory calibrated as a unit.

## **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

Software for the Challenger is subject to upgrade periodically. Contact Sensidyne to see if your unit may be upgradeable to the latest version.

## 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.

## 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

Sensidyne warrants this equipment to be free from defects in workmanship and material. We make no warranty, express or implied, except as set forth herein. Sensidyne's liability under this warranty extends for a period of one (1) year from the date of Sensidyne's shipment. It is expressly limited to repairing or replacing at the factory during this period and at Sensidyne'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.

Sensidyne 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, Sensidyne must be notified immediately upon arrival of the equipment. Return transportation charges are collect.

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 Sensidyne prior to returning parts or equipment for credit. Sensidyne makes engineering changes and improvements from time to time on instruments in its product line. 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, the factory 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 20C 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.

### **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.

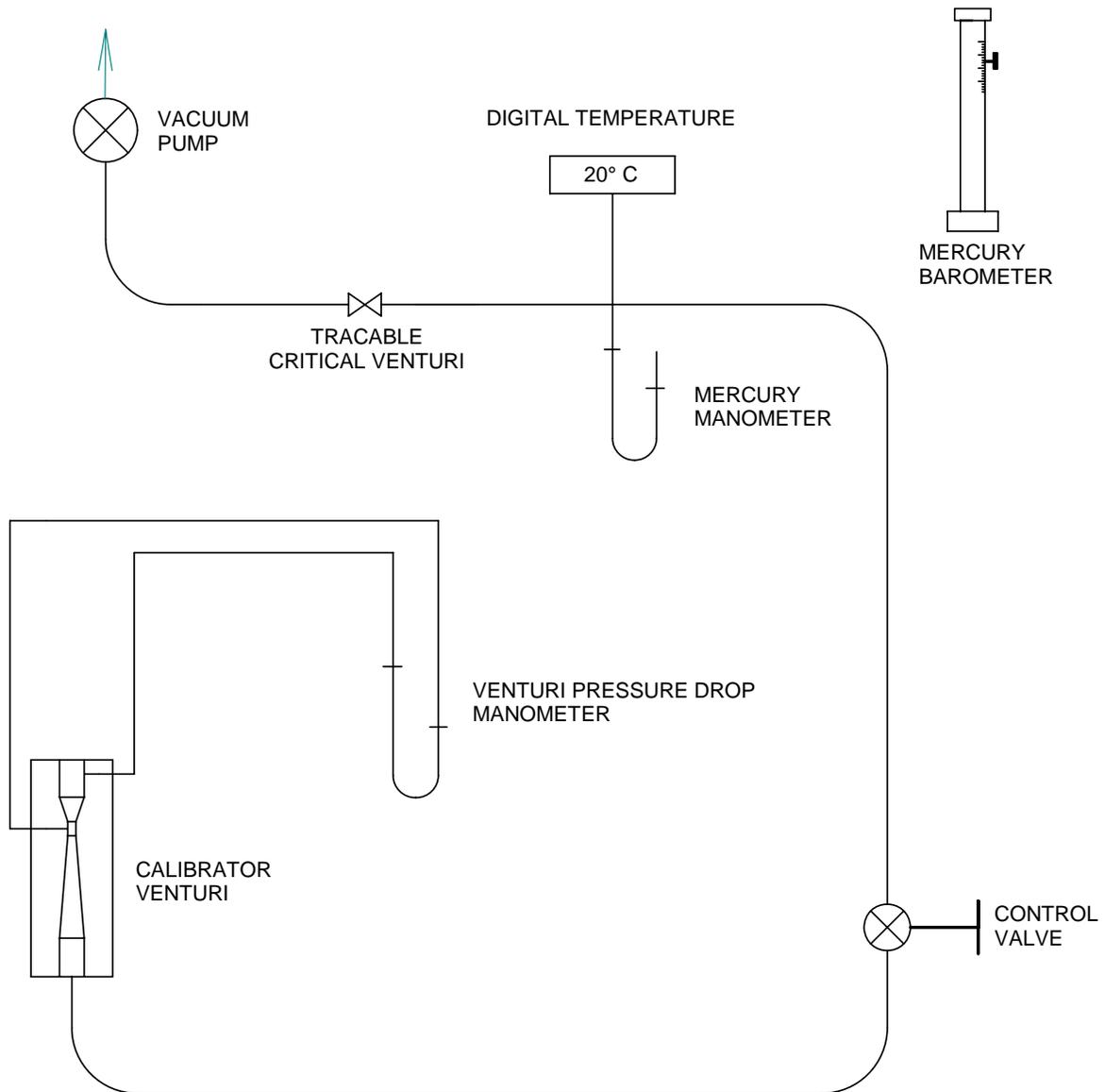


Figure A1- Schematic Diagram of Calibration Setup

2313

### 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

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<sub>2.5</sub>. *Electronic* meters usually read out in volumetric flow rate or **Q<sub>A</sub>**. Mass flow meters read out in **Q<sub>S</sub>**. The Challenger reads out in both.

EPA, for Politico Legal, reasons uses **Q<sub>S</sub>** known as **Standard** or **Mass** Air flow rate for reporting PM<sub>10</sub>. 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<sub>S</sub> it has come to be called **Mass flow**.

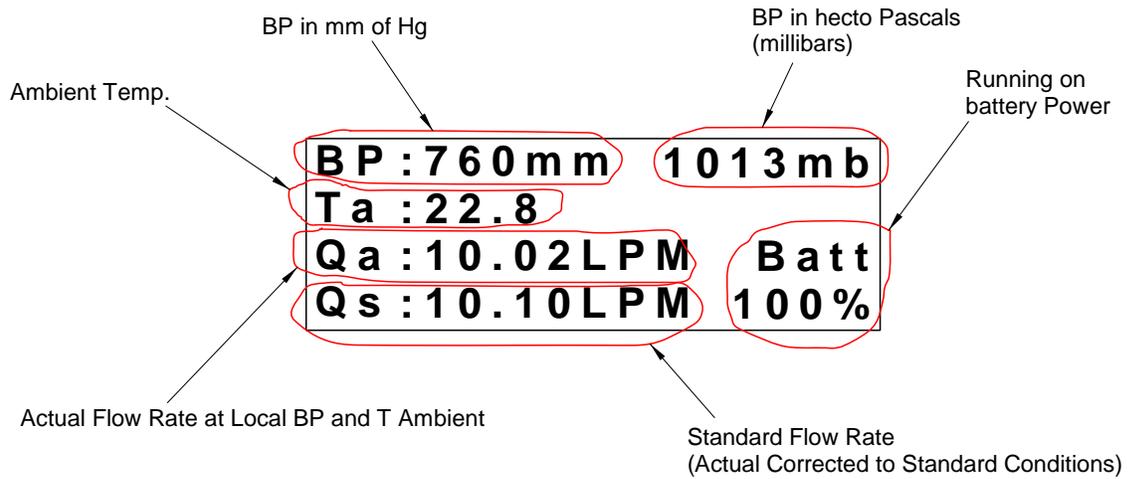
Throughout most of the world Q<sub>S</sub> is not usually referred to as mass flow and it is to a different standard. The conditions outside of the U.S. are **0 C** and 1013.25 mb.

The equations relating **Q<sub>A</sub>** and **Q<sub>S</sub>** are:

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

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

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



3064

## References

1. Fan Engineering, R. Jorgensen, ed. Buffalo Forge Co, Buffalo, NY. 6<sup>th</sup> 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. 4<sup>th</sup> Ed. 1990.

## Notes



***SENSIDYNE***<sup>®</sup>

Sensidyne, LP • 16333 Bay Vista Drive  
Clearwater, Florida 33760 USA  
800-451-9444 • +1 727-530-3602 • +1 727-539-0550 [fax]  
web: [www.sensidyne.com](http://www.sensidyne.com) • e-mail: [info@sensidyne.com](mailto:info@sensidyne.com)



ISO 9001:2000 Registered