

ROY COOPER  
*Governor*  
DIONNE DELLA-GATTI  
*Secretary*  
MICHAEL A. ABRACZINSKAS  
*Director*



DAQ-13-001.1 Standard Operating Procedure (SOP)  
for the BGI TetraCal Flow Transfer Standards  
ECB RESPONSIBILITIES

Revision 0.0

1.0 Approval Sign Off-Sheet

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I certify that I have read and approve of the contents of the BGI TetraCal Flow Transfer Standards Standard Operating Procedure with an effective date of May 7, 2021.

**Director, Air Quality Division**

Mike Abraczinskas

Signature:  Date: 5/18/2021

**Ambient Monitoring Section Chief**

Patrick Butler

Signature:  Date: 5/18/2021

**Laboratory Analysis Branch Supervisor**

Jim Bowyer, Environmental Program Supervisor

Signature:  Date: 5/18/2021

**Projects and Procedures Branch Supervisor**

Joette Steger, Environmental Program Supervisor

Signature:  Date: 5/17/2021

**Primary SOP Author**

Travis Funderburk, Environmental Chemist

Signature:  Date: 5/17/2021

Disclaimer: This document, and any revision hereto, is intended solely as a reference guide to assist individuals in the operation of the instrument, related to the North Carolina Division of Air Quality's Ambient Monitoring Program.

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## 2.0 SCOPE AND PURPOSE

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This document is designed for the Electronics and Calibration Branch (ECB) Technicians operating the BGI TetraCal Flow Transfer Standards. The BGI TetraCal Flow Transfer Standards are used for but not limited to: audits, calibrations, verifications or testing of ambient monitoring equipment. This document shall provide procedures used to achieve uniformity and ensure highly accurate flow measurements.

## 3.0 EQUIPMENT CHECKS AND MATERIALS

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This section describes the equipment as well as materials that are required to complete the steps described in this document.

### 3.1 Instrument Description

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All BGI by Mesa Labs devices are based on the air flow measurement principle of the venturi. 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. Twice the flow rate yields four times the 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 essentially the actual 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 during the display of the 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 instrument provides an LCD indication of volumetric flow rate, standard flow rate, barometric pressure and ambient temperature, and filter temperature in some models. The unit is furnished with three auto ranging venturis and operates on either four AA alkaline batteries or a provided alternating current (AC) power module.



BGI TetraCal

### 3.1 Equipment and Material List

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- BGI TetraCal Flow Transfer Standard Kit
- E-log

### 3.2 Chemical and Material Checks

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This section is reserved. No special chemicals or materials are needed for this type of instrument. However, water, soap, lint free cloth are used in maintenance procedures.

### 3.3 Support Equipment Checks

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No support equipment is needed as the TetraCal is considered support instrumentation for the ambient monitoring network.

### 3.4 Initial Acceptance Testing

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Upon acceptance of a newly purchased or calibrated TetraCal, a designated ECB Technician will perform the following test procedures prior to putting the device into use:

- Open the boxed TetraCal and check for any damage during shipping. If damage is observed, contact the vendor and the shipping company to fill out the appropriate claims forms.
- Review the packing slip to verify the correct unit was sent from the manufacturer. If there is an issue, contact the vendor and reconcile these matters before moving forward.
- Find the certificate of calibration and review the entire document. Pay special attention to any unusual findings or notes from the certifying lab. Note: If any anomalies are found, contact the appropriate parties involved and rectify the issue of concern. Scan and file the certification of calibration (See Section 9.0 File Management) to the P: Drive at P:\Ambient\ECB\NIST Certification Devices.
- Use the Standard Operating Procedure DAQ-15-001.1 Verification of Ambient Monitoring Thermometers Version 0.0 and e-log to verify the temperature probe used with the TetraCal.
- Due to the complications in setting up a 3-point barometric pressure calibration it is acceptable to perform a 1-point pressure verification using a National Institute of Standards and Technology (NIST)-traceable barometer. Record the ambient pressure from the TetraCal and the NIST-traceable barometer in the designated section of the e-log.

## 4.0 SITE CHECKS

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This section is reserved. Site checks do not apply to this type of instrument.

## 5.0 DETAILED PROCEDURES

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This section covers the setup, important notes and operation of the TetraCal.

### 5.1 Setup for Operation

1. Remove the instrument from its carrying case. If the instrument is to be used in the laboratory, plug the power supply into a power source, otherwise it will operate from its AA batteries.
2. Plug the temperature probe into the port above the RS-232 port (data port).

3. Select a venturi for the flow range of interest. Each venturi is marked with a number indicating the range: 1 = 6 – 30 liters per minute (LPM), 2 = 1.2 – 6 LPM, 3 = 0.1 – 1.2 LPM.
4. Select a hose adapter for the venturi to match the tubing that will connect to the flow audit adapter. Be certain that the o-rings are lubricated and connect the adapter to the venturi.
5. With the serial and venturi numbers held right side up, insert the venturi into the hole in the top of the unit. Be certain that there is sufficient lubricant on the o-rings within the recess.
6. Power on the TetraCal, the instrument will automatically restart and auto range to the selected venturi. The display screen will appear as shown below:

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	%

TetraCal Display Screen

7. The ambient temperature (Ta) and the probe temperature (Tf) will display alternately in the screen.
8. Two flow rates (Qa and Qs) will be shown at the bottom. Volumetric flow (Qa) will be listed first. Standard flow (Qs) will be listed second. Always use the first flow listed; volumetric flow (Qa).

## 5.2 Important Notes about Using the TetraCal

1. When the unit is turned on, the venturi must have no air flowing through it. Every time the instrument is switched on, it will re-zero itself. If air is flowing through the venturi when the unit is turned on, that flow rate will be set as zero causing erroneous flow readings. Cover the venturi to restrict air flow while the unit is re-zeroing itself.
2. The control module must be level when switching on and when in use. 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.
3. In order to achieve the most precise measurements, the TetraCal must be in thermal equilibrium with the ambient environment of the sampler to be audited. To achieve this equilibrium, remove the TetraCal from its carrying case for at least 10 minutes prior to performing measurements. The unit should be placed in a shaded spot near the general area of the sampler. Additionally, if the TetraCal is subject to a temperature change of more than five degrees during use, equilibrium has not been met and the procedure should be restarted.
4. When the TetraCal is switched on using only battery power, XX % battery capacity remaining is displayed on the screen. It is not recommended to perform measurement if the battery power is less than 10% capacity. If the provided AC adaptor is utilized, the screen will indicate “DC In” and there is no run time limit. Note: Use of an AC power supply, other than the one provided, can cause severe damage to circuit components.
5. 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.
6. Do not attempt to repair the TetraCal as this is outside the scope of work assigned. Contact Mesa Labs for assistance.

## 6.0 OPERATION

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One of two procedures can be performed:

### 6.1 Procedure A.

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1. With the monitor not running, using the elastomeric tubing and flow audit adapter, connect the TetraCal to the monitor under assessment.
2. Switch on the TetraCal. Wait for the unit to finish the startup process.
3. Turn on the monitor's pump.
4. Once the monitor's flow rate stabilizes, the reading may be taken from the TetraCal.

### 6.2 Procedure B.

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1. Switch on the TetraCal. Wait for the unit to finish the startup process.
2. With the monitor running, using the elastomeric tubing and flow audit adapter, connect the TetraCal to the monitor. The flow resistance of the TetraCal may cause momentary instability in the monitor's flow control circuit.
3. Once the monitor's flow rate stabilizes, the reading may be taken from the TetraCal.

## 7.0 MAINTENANCE OF THE TETRACAL

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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 white or silver surface. If it is determined that cleaning is required, use the following procedure:

1. Rinse the entire venturi body in warm soapy water.
2. Any external deposits, which are not floated away, may be removed with a soft cloth.
3. 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.
4. Following cleaning, the venturi may be dried utilizing compressed air, or if not available, allowed to air dry.
5. Inspect the two o-rings on the venturi body. If any damage is observed, replace both.
6. Prior to reassembly, lubricate the o-rings with a wipe of grease.
7. There are two points which require careful lubrication. These points are the two o-rings at the top of each venturi to which the tubing adapter is attached and the four o-rings inside the socket into which the venturi is inserted. They should be sparingly lubricated with the tip of the finger.
8. Silicone grease seems to be the most successful all around lubricant.

The TetraCal is a NIST-traceable high-precision standard with a few moving parts. The calibration certificate received with the 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 device's measurement accuracy or general performance.

For these reasons, Mesa highly recommends returning the TetraCal to their calibration facility on an annual basis to ensure its measurement integrity. Recertification at Mesa Lab's facility includes any necessary repairs, with the exception of replacing the electronic boards, which will incur a fee. All TetraCals returned to the manufacturer for recertification will receive both a pre- and post-calibration.

## 8.0 DATA REVIEW

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Review certificates of calibration and the e-logs.

## 9.0 FILE MANAGEMENT

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The primary types of files to manage regarding the TetraCal include but are not limited to: certificates of calibration, e-logs and procurement documentation. These files are maintained on the P: Drive at P:\Ambient\ECB.

### 9.1 Certificates of Calibration

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The original certificate of calibration that comes with the units are kept on file at ECB. Scanned copies of these certificates are saved on the P drive at P:\Ambient\ECB\NIST Certification Devices for the appropriate current year.

## 10.0 FILE QUALITY ASSURANCE AND DATA HANDLING

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The primary types of files regarding file quality and data handling would include but are not limited to: certificates of calibration and e-logs. These files are maintained on the P: Drive at P:\Ambient\ECB\

## 11.0 TROUBLESHOOTING AND CORRECTIVE ACTIONS

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Follow section 7.0 MAINTENANCE OF THE TETRACAL before assuming the unit has malfunctioned. In the event the unit has truly malfunctioned contact Mesa Labs for assistance, any attempted repair will void any warranty.

## 12.0 REVISION HISTORY

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1. Revision 0 – [5/7/21] Original Publication

## 13.0 REFERENCES

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1. BGI by Mesa Labs TetraCal User Manual
2. NC DEQ-DAQ Standard Operating Procedure 2.49 Section 2: BGI TetraCal Standard Procedures for Operators Revision 2020
3. DAQ-14-001 Standard Operating Procedure (SOP) for Preparing SOPs for the NCDAQ
4. Quality Assurance Handbook for Air Pollution Measurement Systems Volume II Ambient Air Quality Monitoring Program January 2017



## 14.0 APPENDICES

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1. Appendix A – Example of Certificate of Calibration
2. Appendix B – Diagram and Specifications

## Appendix A: Example of Certificate of Calibration

Mesa Labs 10 Park Place Butler, NJ 07405  
NIST Traceable Calibration Facility, ISO 9001:2008 Registered



### CERTIFICATE OF CALIBRATION - NIST TRACEABILITY

(Refer to instruction manual for further details of calibration)

**TetraCal Serial Number:** 164425      **Date:** 12-Oct-20

**Calibration Technician :** Jan Oviedo

**Critical Venturi Flow Meter:** Max Uncertainty = 0.346%  
 Serial Number: 1A CEESI NVLAP NIST Data File 07BGI-0001  
 Serial Number: 2A CEESI NVLAP NIST Data File 07BGI-0003  
 Serial Number: 3A CEESI NVLAP NIST Data File 07BGI-0004  
 Serial Number: 4A CEESI NVLAP NIST Data File 07BGI-0002

**Room Temperature:** +/- 0.03°C from -5°C - 70°C      **Room Temperature:** 23.60 °C

NIST Traceability No. 518837

**Brand:** Telatemp      **Serial Number:** 300907  
**Std Cal Date:** 8-Jul-20      **Std Cal Due Date:** 8-Jul-21

**TetraCal :**

Ambient Temperature (set): 23.60 °C  
 Aux (filter) Temperature (set): 23.60 °C

#### Barometric Pressure and Absolute Pressure

Vaisala Model: PTB330(50-1100) Digital Accuracy: 0.03371%  
 Serial Number: C4310002  
**Std Cal Date:** 13-Mar-20      **Std Cal Due Date:** 13-Mar-21  
 Serial Number:  
**TetraCal :**  
 Barometric pressure (set): 753.5 mm of Hg

#### Results of Venturi Calibration

Flow Rate (Q) vs. Pressure Drop (ΔP).

Where: Q=Lpm, ΔP= Cm of H2O

Q1= 5.53865 ΔP ^ 0.51535      Overall Uncertainty: 0.35%  
 Q2= 1.17083 ΔP ^ 0.51927      Overall Uncertainty: 0.35%  
 Q3= 0.21538 ΔP ^ 0.54325      Overall Uncertainty: 0.35%

Date Placed In Service \_\_\_\_\_

(To be filled in by operator upon receipt)

Recommended Recalibration Date \_\_\_\_\_

(12 months from date placed in service)

Revised: August 2019  
Cal102-03T1 Rev C

**Mesa Labs 10 Park Place Butler, NJ 07405**  
 NIST Traceable Calibration Facility, ISO 9001:2008 Registered

Maximum allowable error at any flow rate is .75%.

VER. **3.41P**

Date	Technician
12-Oct-2020	Jan Oviedo

Serial No. **164425**

To Check a Tetra Cal					BP=	753.5	mm of Hg
6 - 30.00 Lpm							
Reading		CV					
Abs. P	Room	Qa	Qa				
Crit. Vent.	TEMP	Flow	TriCal				
mm of Hg		Lpm	Indicated	% Error			
165.75	23.6	6.47	6.49	0.33			
462.04	23.6	18.40	18.32	-0.44			Average %
728.14	23.6	29.11	29.23	0.40			0.10

To Check a Tetra Cal					BP=	754	mm of Hg
1.20 - 6.00 Lpm							
Reading		CV					
Abs. P	Room	Qa	Qa				
Crit. Vent.	TEMP	Flow	Tri Cal				
mm of Hg		Lpm	Indicated	% Error			
135.1	23.8	1.50	1.51	0.57			
315.4	23.8	3.57	3.56	-0.30			Average %
521.2	23.8	5.93	5.97	0.54			0.27

To Check a Tetra Cal					BP=	753.5	mm of Hg
0.10 - 1.20 Lpm							
Reading		CV					
Abs. P	Room	Qa	Qa				
Crit. Vent.	TEMP	Flow	TriCal				
mm of Hg		Lpm	Indicated	% Error			
235.2	24.0	0.428	0.426	-0.57			
474.65	24.0	0.895	0.892	-0.35			Average %
621.35	24.0	1.181	1.180	-0.09			-0.34

**Mesa Labs 10 Park Place Butler, NJ 07405**  
 NIST Traceable Calibration Facility, ISO 9001:2008 Registered

Pre-Recertification

Maximum allowable error at any flow rate is .75%.

VER. **3.41P**

Date	Technician
12-Oct-2020	Jan Oviedo

Serial No. **164425**

<b>To Check a Tetra Cal</b>					BP=	754	mm of Hg
<b>6 - 30.00 Lpm</b>							
Reading		CV		Qa			
Abs. P		Qa		TriCal			
Crit. Vent.	Room	Flow		Indicated	% Error		
mm of Hg	TEMP	Lpm					
167.11	23.6	6.52		6.52	-0.12		
457.32	23.6	18.20		17.98	-1.17		Average %
733.77	23.6	29.32		29.19	-0.42		-0.57

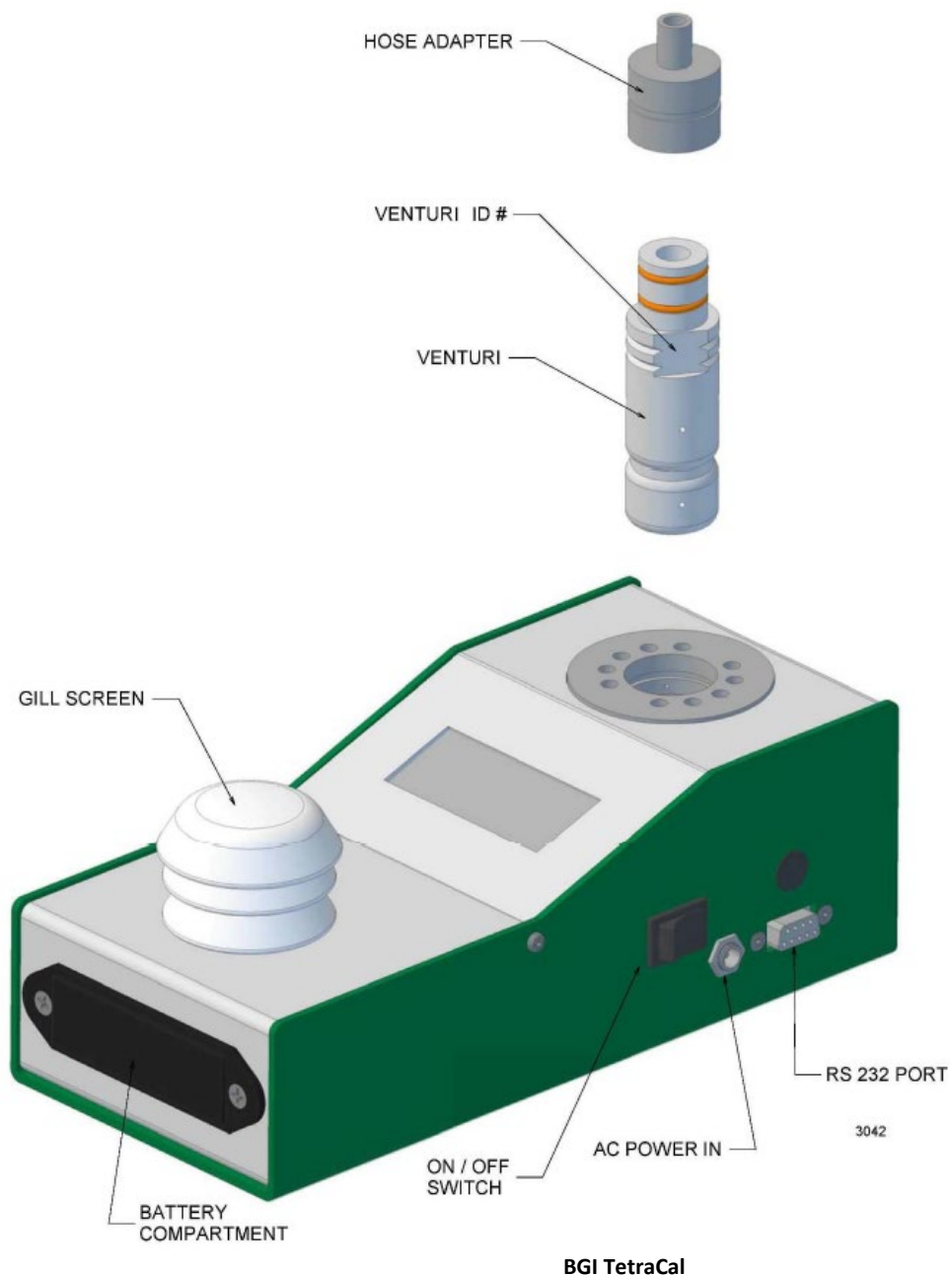
<b>To Check a Tetra Cal</b>					BP=	754	mm of Hg
<b>1.20 - 6.00 Lpm</b>							
Reading		CV		Qa			
Abs. P		Qa		Tri Cal			
Crit. Vent.	Room	Flow		Indicated	% Error		
mm of Hg	TEMP	Lpm					
135.0	23.8	1.50		1.51	0.66		
309.7	23.8	3.51		3.51	0.11		Average %
514.8	23.8	5.86		5.92	0.98		0.58

<b>To Check a Tetra Cal</b>					BP=	753.5	mm of Hg
<b>0.10 - 1.20 Lpm</b>							
Reading		CV		Qa			
Abs. P		Qa		TriCal			
Crit. Vent.	Room	Flow		Indicated	% Error		
mm of Hg	TEMP	Lpm					
235.62	23.9	0.429		0.427	-0.50		
464.55	23.9	0.875		0.866	-1.05		Average %
596.64	23.9	1.133		1.118	-1.28		-0.94

**As Received**

	DUT	Standard	Difference		Allowable	Condition
Pres <sub>AMB</sub> mmhg	754	754	0		1	In Tolerance
Temp <sub>AMB</sub> °C	23.8	23.6	0.2		1	In Tolerance
Temp <sub>Filter</sub> °C	23.7	23.6	0.1		1	In Tolerance

## Appendix B: Diagram and Specifications



### Specifications

TetraCal Flow Rate Range: 0.1 – 30 Lpm ( $\pm 1\%$ )  
TetraCal Ultra Flow Rate Range: 1 – 60 Lpm ( $\pm 1\%$ )  
Flow Accuracy: 0.75% of reading  
Temp. Operational Range:  $-30^{\circ}\text{C}$  to  $55^{\circ}\text{C}$

Temp. Reading Range: -30° C to 55° C

Temp. Accuracy: 0.5° C

Barometric Pressure Range: 400 to 800 mmHg

Barometric Pressure Accuracy: 5 mmHg

Dimensions of control module: 3.25 in. high ( 8.25 cm) X 3.125 in. wide ( 7.94 cm) X  
9 in. long ( 22.86 cm)

Height with venturi and hose adaptor: 6.30 in. (16.00 cm)

Weight w/ venture: 2.38 lbs (1.08 kg)

Carrying case dimensions: 15.75 in wide (40.00 cm) x 4.5 in high (11.43 cm) x  
12.25 in. thick (31.20 cm)

Weight complete with contents: 4.69 lbs (2.13 kg)

TetraCal/TetraCal Ultra Calibrator comes with the following:

TetraCal/TetraCal Ultra Calibrator

Power Supply

4 AA batteries

Venturi No. 1 (PN B2247)

Venturi No. 2 (PN B2248)

Venturi No. 3 (PN B2249)

1/4 inch hose adapter (PN A2253)

3/8 inch hose adapter (PN A2254)

1/2 inch hose adapter (PN A2255)

Fitted carrying case (PN B2271)

Calibration Certificate

Accessories/Parts:

Part No. Description

TC9 TetraCal O-ring kit

B2271 TetraCal carrying case

A2253 TetraCal 1/4" Adapter

A2254 TetraCal 3/8" Adapter

A2255 TetraCal 1/2" Adapter

TCIMP TetraCal IMPROVE Adapter Kit

B2247 #1 Venturi (Calibrate with TC5 or TC12)

B2248 #2 Venturi (Calibrate with TC5 or TC12)

B2249 #3 Venturi (Calibrate with TC5 or TC12)