

# Model 4046/4146 Primary Calibrators

## User's Guide

1980512, Revision C  
December 2006





# Model 4046/4146 Primary Calibrators

## User's Guide

1980512, Revision C  
December 2006

**SHIP/MAIL TO:**

TSI Incorporated  
500 Cardigan Road  
Shoreview, MN 55126-3996  
USA

**USA****Technical Support:**

(800) 874-2811/(651) 490-2811

**Fax:**

(651) 490-3824

**E-mail address:**

[answers@tsi.com](mailto:answers@tsi.com)

**Website:**

[www.tsi.com](http://www.tsi.com)

**INTERNATIONAL  
Technical Support:**

(+1) 651 490-2811

**Fax:**

(+1) 651 490-3824



**Copyright©**

TSI Incorporated / 2004-2006 / All rights reserved.

**Address**

TSI Incorporated, 500 Cardigan Road, Shoreview, MN 55126 USA

	<b>WARNING</b>
	TSI calibrators employ a heated platinum sensor. They should not be used in the presence of flammable or explosive gases or mixtures.

	<b>Caution</b>
	TSI calibrators are not medical devices under FDA 510k and in no situation should they be utilized for human respiration measurements.

**LIMITATION OF WARRANTY AND LIABILITY.** Seller warrants that this product, under normal use and service as described in the operator's manual, shall be free from defects in workmanship and material for a period of twenty-four (24) months, or the length of time specified in operator's manual, from the date of shipment to the customer. This limited warranty is subject to the following exclusions:

- a. Batteries and certain other components when indicated in specifications are warranted for a period of 90 days from the date of shipment to the customer.
- b. With respect to any repair services rendered, Seller warrants that the parts repaired or replaced will be free from defects in workmanship and material, under normal use, for a period of 90 days from the date of shipment to the customer.
- c. Seller does not provide any warranty on finished goods manufactured by others. Only the original manufacturer's warranty applies.
- d. Unless specifically authorized in a separate writing by Seller, Seller makes no warranty with respect to, and shall have no liability in connection with, any goods which are incorporated into other products or equipment by the Buyer. All goods returned under warranty shall be at the Buyer's risk of loss, Seller's factory prepaid, and will be returned at Seller's risk of loss, Buyer's factory prepaid.

The foregoing is IN LIEU OF all other warranties and is subject to the conditions and LIMITATIONS stated herein. NO OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR PARTICULAR PURPOSE OR MERCHANTABILITY IS MADE.

THE EXCLUSIVE REMEDY OF THE USER OR PURCHASER, AND THE LIMIT OF THE LIABILITY OF SELLER FOR ANY AND ALL LOSSES, INJURIES, OR DAMAGES IN CONNECTION WITH THIS PRODUCT (INCLUDING CLAIMS BASED ON CONTRACT, NEGLIGENCE, STRICT LIABILITY, OTHER TORT, OR OTHERWISE) SHALL BE THE RETURN OF THE PRODUCT TO THE FACTORY OR DESIGNATED LOCATION AND THE REFUND OF THE PURCHASE PRICE, OR, AT THE OPTION OF SELLER, THE REPAIR OR REPLACEMENT OF THE PRODUCT. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES. SELLER SHALL NOT BE RESPONSIBLE FOR INSTALLATION, DISMANTLING, REASSEMBLY OR REINSTALLATION COSTS OR CHARGES. NO ACTION, REGARDLESS OF FORM, MAY BE BROUGHT AGAINST THE SELLER MORE THAN ONE YEAR AFTER THE CAUSE OF ACTION HAS ACCRUED.

The purchaser and all users are deemed to have accepted the terms of this LIMITATION OF WARRANTY AND LIABILITY, which contains the complete and exclusive limited warranty of Seller. This LIMITATION OF WARRANTY AND LIABILITY may not be amended or modified nor may any of its terms be waived except by a writing signed by an authorized representative of Seller.

**Service Policy**

Knowing that inoperative or defective instruments are as detrimental to TSI as they are to our customers, our service policy is designed to give prompt attention to any problems. If any malfunction is discovered, please call TSI at 1-800-874-2811 or 1-651 490-2811 (International).

# CONTENTS

## CHAPTERS

<b>1</b>	<b>Unpacking and Parts Identification .....</b>	<b>1</b>
<b>2</b>	<b>Setting-Up .....</b>	<b>3</b>
	Assembly Instructions for the Calibrators.....	3
	Supplying Power.....	4
	Connecting Filter and Flow Tubes.....	4
<b>3</b>	<b>Operation.....</b>	<b>7</b>
	Overview.....	7
	ON/OFF Switch .....	7
	Flow Rate Measurement .....	7
	Setting Flow Rates and Calibrating Instruments .....	7
	Dampening Module .....	7
<b>4</b>	<b>Maintenance.....</b>	<b>9</b>
	Flow Sensor.....	9
	Re-certification.....	9
	Cases .....	9
	Storage .....	9
<b>5</b>	<b>Troubleshooting .....</b>	<b>11</b>

## APPENDIXES

<b>A</b>	<b>Specifications .....</b>	<b>13</b>
<b>B</b>	<b>Primary vs. Secondary Standard .....</b>	<b>15</b>



# Chapter 1

## Unpacking and Parts Identification

---

Carefully unpack the instrument and accessories from the shipping container. Check the individual parts against the list of components in Table 1. If any parts are missing or damaged, notify TSI immediately.

**Table 1. List of Components** (see figures 1-1 and 1-2)

<b>Qty</b>	<b>Item Description</b>	<b>Part/ Model</b>
1	Calibrator	4046 <i>or</i> 4146
1	Filter Model 4046: 22 mm 1S0 taper Model 4146: 63 mm HEPA filter with 0.375 inch barbed fittings	1602292 1602342
1	Tubing Kit Model 4046 with connectors and battery pack mounting lugs Model 4146 with connectors and battery pack mounting lugs	TK4000 TK4100
1	Battery Pack	4199
1	Soft Carrying Case Model 4046 Model 4146	1319403 1319404
1	Model 4046/4146 User's Guide	1980512
1	Dampening Module (Model 4146 only)	1040229

**Table 2. Optional Accessories**

<b>Qty</b>	<b>Item Description</b>	<b>Part/ Model</b>
1	AC Adapter 115 V, North America, ungrounded 100–240 V, NEMA 5-15 plug, grounded 100–240 V, Europlug, CEE 7/16, grounded 100–240 V, Great Britain, grounded, fused 100–240 V, Australia/NZ	2613033 8918-NA 8918-EC 8918-GB 8918-AT



**Figure 1-1 Model 4046 Components**

- |                             |                                 |
|-----------------------------|---------------------------------|
| 1. Calibrator               | 5. 6 AA-size Batteries          |
| 2. Soft-Sided Carrying Case | 6. Adapter                      |
| 3. Mounting Lugs            | 7. User's Guide                 |
| 4. Tubing                   | 8. High-Efficiency Inlet Filter |



**Figure 1-2 Model 4146 Components**

- |                             |                                 |
|-----------------------------|---------------------------------|
| 1. Calibrator               | 6. High-Efficiency Inlet Filter |
| 2. Soft-Sided Carrying Case | 7. User's Guide                 |
| 3. Mounting Lugs            | 8. Adapters                     |
| 4. Latex Tubing             | 9. Dampening Module             |
| 5. 6 AA-size Batteries      |                                 |

## Chapter 2

### Setting-Up

---

#### Assembly Instructions for the Calibrators

The calibrator can be quickly attached to the battery pack by screwing the mounting lugs into the threaded holes in the base of the calibrator. The lugs should then be placed over the receiving holes in the top of the battery pack and snapped gently into place. Insert the connector from the battery pack to the receptacle in the back of the calibrator. The calibrator is now ready to use.

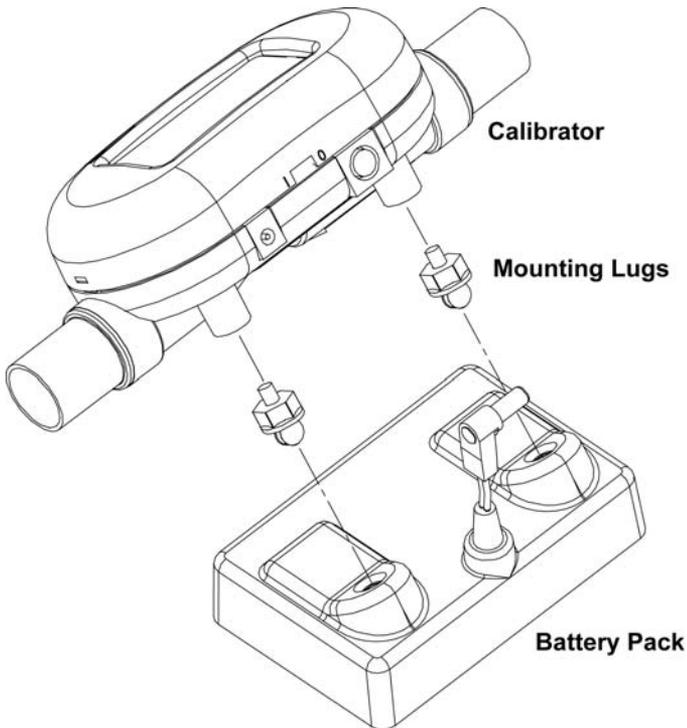


Figure 2-1 Calibrator Assembly

## Supplying Power

The calibrator can be powered in one of two ways: through the power jack using the supplied 4199 battery pack or using an optional AC adapter. The DC power input connector is shown below along with the power requirements.

Power Supply: 7.5 VDC  $\pm$  1.5 V, 300 mA maximum



## Connecting Filter and Flow Tubes

The Model 4046/4146 has a thermal sensor exposed to the air flow that must be protected from foreign matter and particles. TSI supplies a filter that should be connected to the inlet of the calibrator; however, any filter will work as long as it has a minimum efficiency of 99.9%.

	<b>Caution</b>
	Always use a filter on the inlet of the calibrator. Failure to filter the air flow may change the calibration and/or permanently damage the sensor.

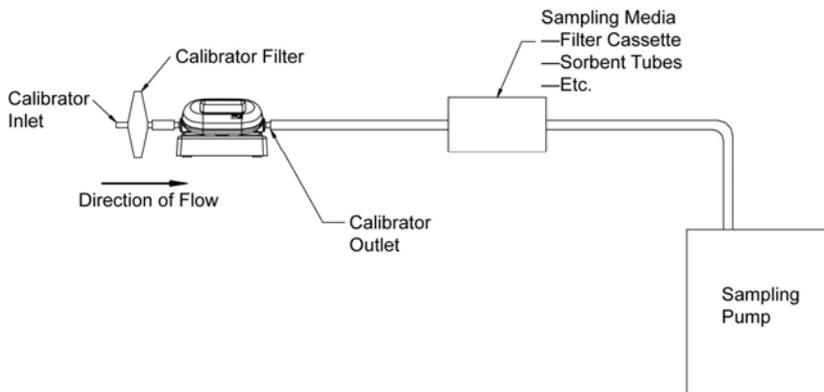
---

**Note:** Flow direction is identified by the large arrow printed on the bottom side of the calibrator and on the bottom of the battery pack.

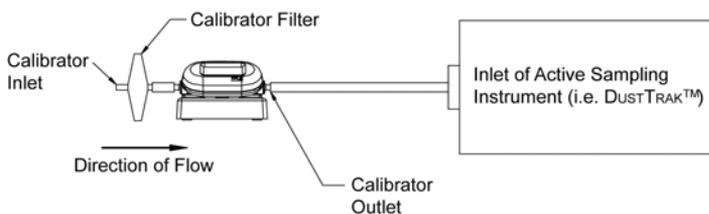
---

Attach the filter to the inlet of the calibrator using supplied tubing and/or adapters. Connecting a tube to the outlet of the calibrator will create back pressure. See Appendix A for calibrator accuracy specifications when operating at various pressures. In general, minimize back pressure on the calibrator by using shorter lengths of tubing to maintain highest level of accuracy.

① Sampling Pump with internal dampening chamber



② Active Sampling Instrument with internal dampening chamber



**Figure 2-2 Typical Setup Configurations**



**Figure 2-3 Typical Dampening Module Set Up**

Use the 6 in. (15 cm) tubing to connect the dampening chamber in line between the Model 4146 Calibrator and the instrument. For best results, position Dampening Module with openings to the side, off the work surface.

# Chapter 3

## Operation

---

### Overview

The Model 4046/4146 Calibrator measures volumetric flow rate inside the flow tube. All measurements made by the Models 4046/4146 are NIST traceable.

### ON/OFF Switch

Slide the switch to the ON position. The LCD displays volumetric flow in units of liters per minute (L/min).

### Flow Rate Measurement

Flow rate data will be displayed on the Model 4046/4146 through the LCD.

Volumetric flow is displayed in units of liters per minute (L/min).

### Setting Flow Rates and Calibrating Instruments

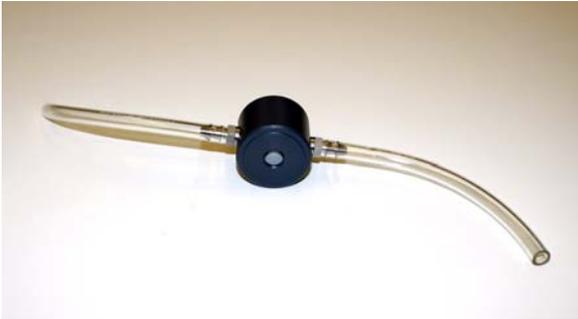
The Model 4046/4146 Calibrator may be used to set flow rates and calibrate sampling pumps or other instruments which draw an active flow sample. Be sure to follow all instrument manufacturer's flow setting and calibration procedures.

1. Start up the Model 4046/4146 Calibrator and let it warm up for 1 minute prior to setting any flow rates or conducting any calibrations.
2. Configure your sampling with the desired sampling media and sampling train to be used.
3. Connect the outlet of the Model 4046/4146 Calibrator to the inlet of the sample media (used with sampling pumps) or to the inlet of the active sampling instrument using the tubing supplied.
4. Follow the instrument manufacturer's flow setting and/or calibration procedures. The volumetric flow in units of liters per minute (L/min) will be continuously displayed on the LCD of the calibrator.

### Dampening Module

The Dampening Module is included for use with systems that do *not* have internal dampening chambers. The Dampening Module (P/N 1040229) can be added in line between the end of the sampling train and the Model 4146

calibrator. The Dampening Module reduces flow pulsation with insignificant affect on flow rate or back pressure.



**Figure 3-1 Dampening Module with Tubing Attached**

All diaphragm pumps produce flow pulsations during operation. Most commercially available 3 L/min and 5 L/min sampling pumps are designed with internal dampening chambers to minimize flow pulsations.

Some common air sampling instruments that may not have internal flow pulsation dampening chambers are listed below. Contact your instrument manufacturer if you have questions. This list is just an example and is not intended to be all inclusive.

- Low flow personal sampling pumps
- Confined space meters
- Photometers
- Optical Particle Counters (OPCs)
- Condensation Particle Counters (CPCs)
- Photo Ionization Detectors (PIDs)
- Flame Ionization Detectors (FIDs)

---

**Note:** The TSI DUSTTRAK™ and SIDEPAK™ Sampling Pumps contain internal dampening chambers. The Dampening Module is not needed to measure flow rates with these instruments.

The TSI SIDEPAK™ AM510 Personal Aerosol Monitor does not contain an internal dampening chamber. TSI recommends using the Dampening Module when using the Model 4146 Calibrator to measure AM510 flow rates.

---

# Chapter 4

## Maintenance

---

### Flow Sensor

Periodically inspect the flow sensor by looking into the outlet of the calibrator. Remove dust, particles and fibers from the sensor with clean, dry compressed air. The flow sensor may break if touched. ***Never run liquids through the calibrator and never touch the sensor with a brush.*** Dust or other deposits on the flow sensor will degrade the 4046/4146's flow accuracy.

	<b>Caution</b>
	The calibrator must be switched off for cleaning. Only use clean, dry, compressed air when attempting to remove contamination from the sensor.

### Re-certification

To maintain a high degree of confidence in the measurements made by the Model 4046/4146, TSI recommends that the instrument be returned to TSI every 12 months for re-certification. The calibrator will be recalibrated and returned with a certificate of calibration to US National Institute of Standards Technology (NIST) traceable standards.

### Cases

If the instrument case or storage case needs cleaning, wipe it off with a soft cloth dipped in isopropyl alcohol or mild detergent. Never submerge the calibrator or allow liquids to enter the flow tube.

### Storage

When storing the calibrator, always cover the ends of flow tubes with the caps provided to prevent dust or other foreign matter from entering the tube.



# Chapter 5

## Troubleshooting

---

---

Table 3 lists the symptoms, possible causes, and recommended solutions for common problems encountered with Model 4046/4146 Calibrators. If the symptom is not listed, or if none of the solutions solves the problem, please contact TSI Technical Support at 1-800-874-2811 or 651-490-2811.

**Table 3. Troubleshooting**

<b>Symptom</b>	<b>Possible Causes</b>	<b>Corrective Action</b>
No display.	Unit not switched on.	Switch on the unit.
	No power to instrument.	Check power connection.
Temperature reads high at low or zero flows.	Temperature sensor is being heated from the flow sensor.	The temperature value will track the actual air temperature once the flow rate through the calibrator exceeds 1 Std L/min.
Flow readings fluctuate greatly.	The flow is fluctuating.	Improve inlet conditions or increase display averaging time.
Display shows flows over-range with no flow passing through flow tube.	The sensor may be damaged or broken.	Return calibrator to TSI for service.



# Appendix A

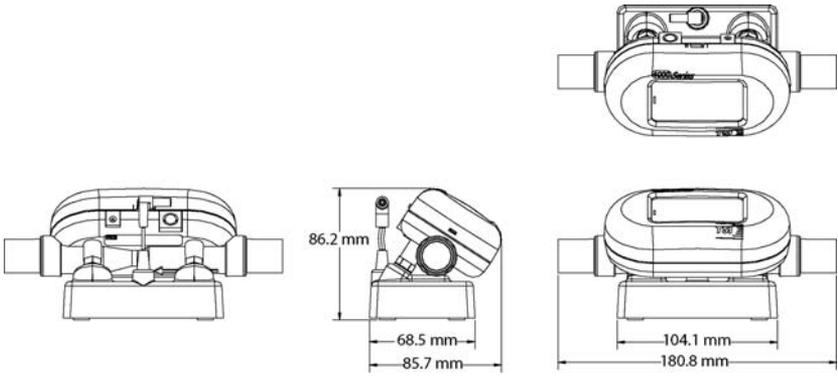
## Specifications

	Specifications*
<b>Flow Measurement</b> Measurement Range  Accuracy Air	Model 4046: 2.5 to 300 L/min Model 4146: 0.01 to 20 L/min  Model 4046: $\pm 2\%$ of reading or 0.05 std. L/min, whichever is greater Model 4146: $\pm 2\%$ of reading or 0.005 std. L/min, whichever is greater  at standard conditions (21.1°C and 101.3 kPa) See notes <b>1</b> through <b>5</b> below.
<b>Instrument Temp. Range</b> Operation, Ambient Storage, Ambient	0 to 50°C -20 to 60°C
<b>Physical Dimensions</b> External Dimensions  Tube Adapters (Inlet & Outlet)  Weight  Flow Body Material	Model 4046: 7.2 in. × 2.5 in. × 2.1 in. (18.3 cm × 6.4 cm × 5.3 cm) Model 4146: 5 in. × 2 in. × 1.25 in. (12.7 cm × 5 cm × 3.2 cm)  Model 4046: 3.0 Model 4046: 22 mm male ISO taper Model 4146: 0.375 inch O.D. straight  Model 4046: 1.2 lbs (0.5 kg) Model 4146: 1.7 lbs (0.8 kg)  Polycarbonate
<b>Warm-up Time</b>	1 min
<b>Power</b>	Battery pack 7.5 VDC $\pm$ 1.5 V, 300 mA maximum

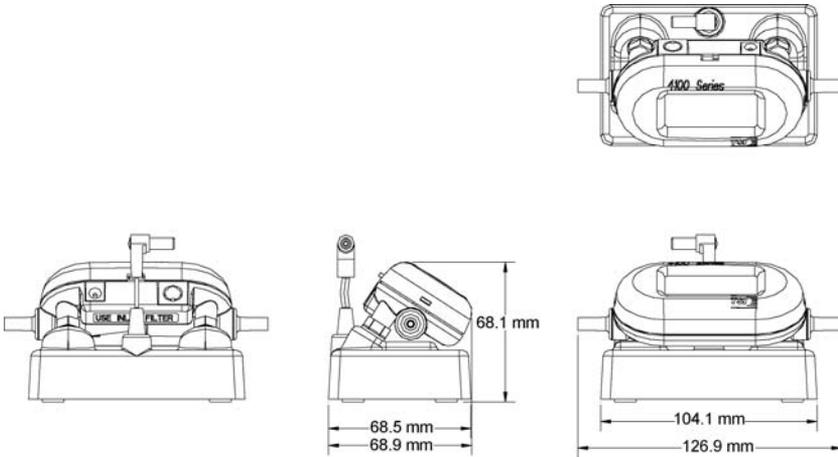
### Notes:

- Accuracy stated at standard conditions of 21.1°C and 101.3 kPa.
- Accuracy stated with air temperature and flow body temperature within  $\pm 10^\circ\text{C}$  of one another.
- Accuracy stated measuring dry air (less than 10% R.H.).
- Includes  $\pm 0.5\%$  of reading repeatability.
- Volumetric flow rate is calculated from the mass flow measurement. Add an additional 0.25% of reading to the flow accuracy to account for the uncertainty in measuring air temperature and pressure.

\*Specifications subject to change without notice.



**Figure A-1 Model 4046 Dimensions**



**Figure A-2 Model 4146 Dimensions**

## Appendix B

### **Primary vs. Secondary Standard**

---

---

By definition, a primary standard is one whose value is without relation or comparison to any other reference. There are three primary standards—mass, length, and time. There is no primary standard for air flow rate since the measurement is dependent on all three primary standards of mass, length, and time. Hence, all air flow calibrators are secondary standards in the strictest sense of the definition.

In the industrial hygiene arena, the terms “primary” and “secondary” have become generally accepted terms over time and should not be confused with actual primary and secondary standards as prescribed by the National Institute of Science and Technology (NIST). Some manufacturers of calibrators, by their own definition, refer to their products as “primary” standards referring to the manner they are applied and generally accepted for use in the industry. Other manufacturers adequately refer to their instruments as “calibrators”. There are no industry standards established for such designations based on the measurement technology being employed.

What is important is accuracy, repeatability, and regular, documented verification to a higher accepted standard such as NIST. Both primary and secondary calibrators must be verified on a regular basis and that testing recorded. Some guidelines recommend annual calibration to a higher accepted standard while others suggest as frequently as every 30 days or before a significant survey. It is important to have a certificate of traceability to NIST or other industry recognized testing organization indicating that an instrument has been calibrated against some mother device verified by NIST.



**TSI Incorporated**

**Headquarters—Tel:** +1 651 490 2811 **Toll Free:** 1 800 874 2811

**E-mail:** [answers@tsi.com](mailto:answers@tsi.com)

**UK Tel:** +44 1494 459200 **E-mail:** [tsiuk@tsi.com](mailto:tsiuk@tsi.com)

**France Tel:** +33 491 95 21 90 **E-mail:** [tsifrance@tsi.com](mailto:tsifrance@tsi.com)

**Germany Tel:** +49 241 523030 **E-mail:** [tsigmbh@tsi.com](mailto:tsigmbh@tsi.com)

**Sweden Tel:** +46 8 595 13230 **E-mail:** [tsiab@tsi.com](mailto:tsiab@tsi.com)

**India Tel:** +91 80 41132470 **E-mail:** [tsi-india@tsi.com](mailto:tsi-india@tsi.com)

**China Tel:** +86 10 8260 1595 **E-mail:** [tsibeijing@tsi.com](mailto:tsibeijing@tsi.com)

