PRIMARY CALIBRATORS
MODEL 4046/4146

USER'S GUIDE

P/N 1980512, REVISION F
MARCH 2016

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WARNING

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

Caution

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

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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 contact your nearest sales office or representative, or call TSI's Customer Service department at (800) 874-2811 (USA) or (001 651) 490-2811 (International) or visit www.tsi.com.

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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)

Qty	Item Description	Part/ Model
1	Calibrator	4046 *or* 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

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

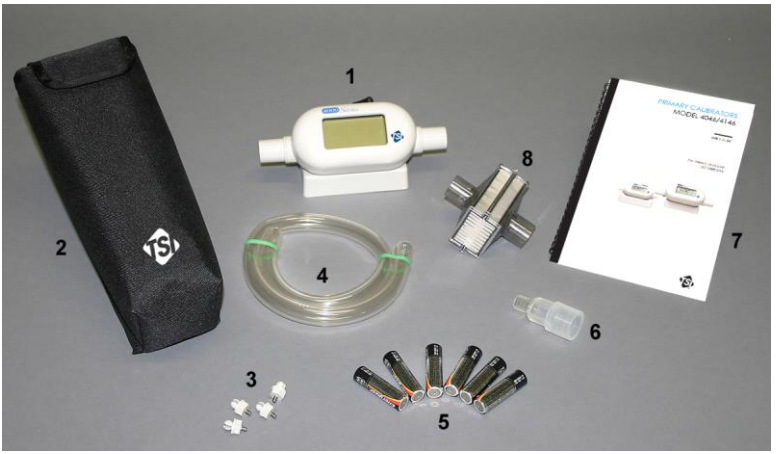

Figure 1-1 Model 4046 Components

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

Figure 1-2 Model 4146 Components

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

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.

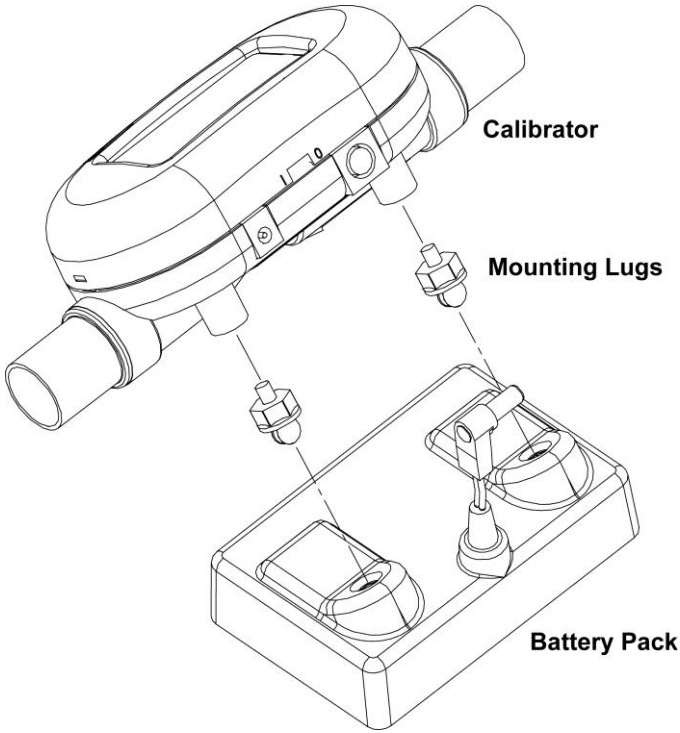

Figure 2-1 Calibrator Assembly

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 ± 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%.

	Caution
	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.

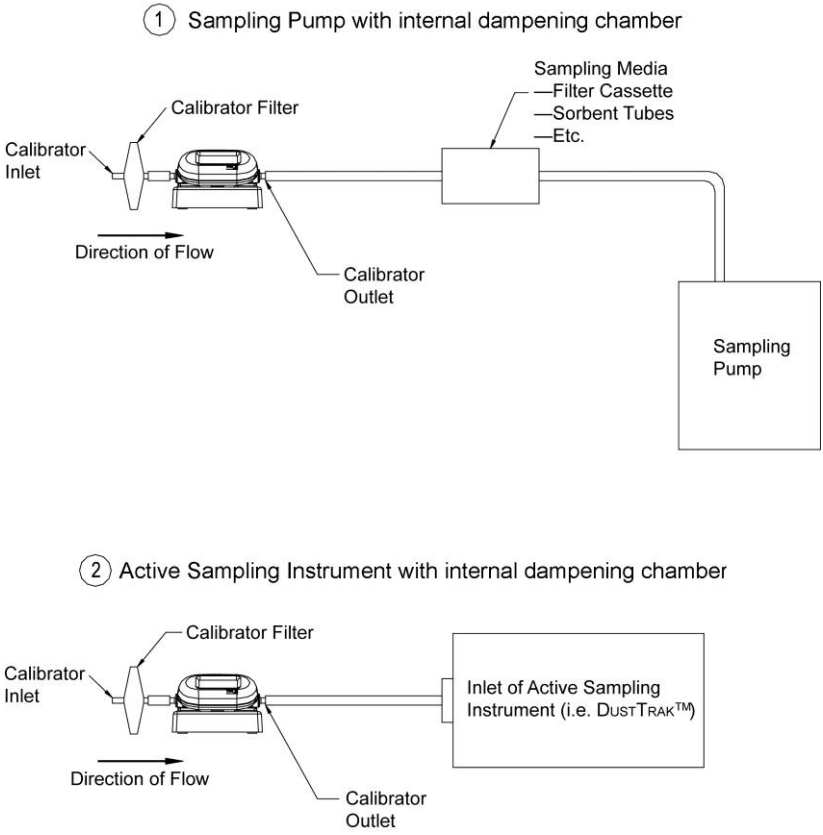

Figure 2-2 Typical Setup Configurations

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.

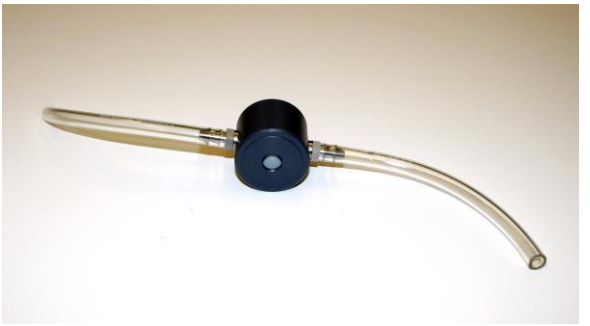

Figure 3-1 Dampening Module with Tubing Attached

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.

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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.

Caution

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.

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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

Symptom	Possible Causes	Corrective Action
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.

Technical Contacts

- If you have any difficulty installing the Model 4046/4146, or if you have technical or application questions about this instrument, contact an applications engineer at TSI Incorporated, (651) 490-2811 or contact answers@tsi.com.

- If the Model 4046/4146 fails, or if you are returning it for service, visit our website at http://rma.tsi.com or contact TSI at:

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Appendix A

Specifications

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

Notes:

1 Accuracy stated at standard conditions of 21.1°C and 101.3 kPa.

2 Accuracy stated with air temperature and flow body temperature within ±10°C of one another.

3 Accuracy stated measuring dry air (less than 10% R.H.).

4 Includes ±0.5% of reading repeatability.

5 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.

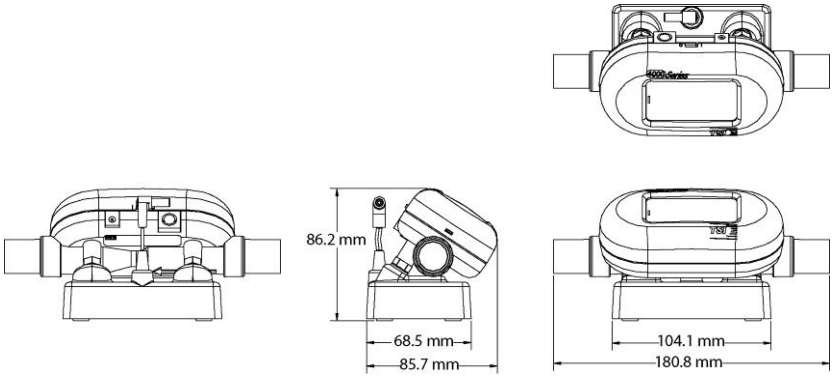

Figure A-1 Model 4046 Dimensions

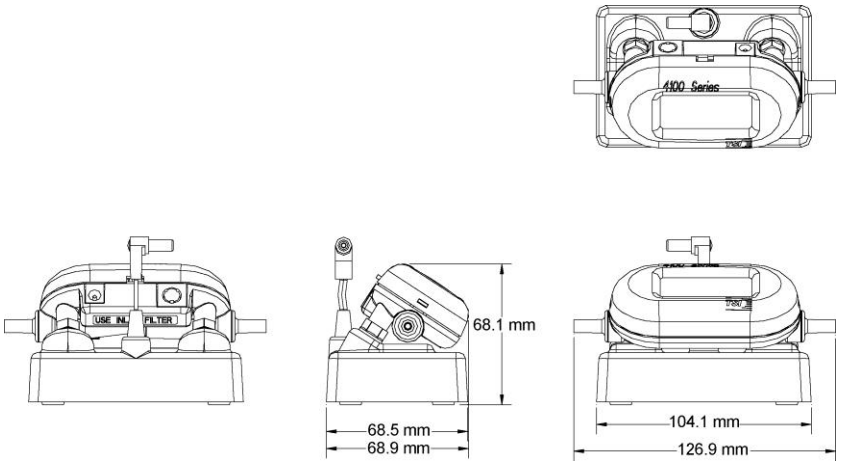

Figure A-2 Model 4146 Dimensions

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.

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