Thermocouple
(Order Code TCA-BTA)

The Thermocouple is a simple and rugged sensor designed to measure temperature in the range of –200ºC to 1400ºC. Low cost and a wide temperature range make the Thermocouple a versatile temperature sensor. This sensor could be used for any of the following experiments:

- Study how the temperature inside a Bunsen burner flame varies with position.
- Compare the temperatures of different flames (candles *vs*. Bunsen burner).
- Check the calibration of ovens.
- Experimentally determine the melting point of copper, bismuth, or other solids.
- Measure the temperature of dry ice or liquid air.

Collecting Data with the Thermocouple

This sensor can be used with the following interfaces to collect data:

Here is the general procedure to follow when using the Thermocouple:

1. Connect the Thermocouple to the interface.
2. Start the data-collection software[1].
3. The software will identify the Thermocouple and load a default data-collection setup. You are now ready to collect data.

Data-Collection Software

This sensor can be used with an interface and the following data-collection software.

- **Logger *Pro* 3** This computer program is used with LabQuest, LabQuest Mini, LabPro, or Go!Link.
- **Logger *Pro* 2** This computer program is used with ULI or Serial Box Interface.
- **Logger Lite** This computer program is used with LabQuest, LabQuest Mini, LabPro, or Go!Link.
- **LabQuest App** This program is used when LabQuest is used as a standalone device.
- **EasyData App** This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2, LabPro, and Vernier EasyLink. We recommend version 2.0 or newer, which can be downloaded from the Vernier web site, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier web site, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **DataMate program** Use DataMate with LabPro or CBL 2 and TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators. See the LabPro and CBL 2 Guidebooks for instructions on transferring DataMate to the calculator.

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[1] If you are using Logger *Pro* 2 with either a ULI or SBI, the sensor will not auto-ID. Open an experiment file for the Thermocouple in the Probes & Sensors folder.

- **Data Pro** This program is used with LabPro and a Palm handheld.
- **LabVIEW** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

NOTE: This product is to be used for educational purposes only. It is not appropriate for industrial, medical, research, or commercial applications.

Specifications

Typical Accuracy[2]

0ºC to 900ºC	±2.2º
–200ºC to 0ºC	±5ºC
900ºC to 1400ºC	±15ºC
13-bit-resolution (SensorDAQ):	0.20ºC
12-bit-resolution (LabPro, LabQuest, LabQuest Mini, Go!Link, ULI, or SBI):	0.40ºC
10-bit-resolution(CBL 2:)	1.60ºC
Power:	11 mA @ 5 VDC

How the Thermocouple Works

Thermocouples make use of a property that occurs when two wires composed of dissimilar metals are joined at both ends. When one of the joined ends is heated, a continuous current is created and flows in a thermoelectric circuit. The small open-circuit voltage of this circuit (known as the Seebeck voltage) is a function of the junction temperature and the composition of the two metals. (The Vernier Thermocouple uses type-K thermocouple wire.) By measuring the voltage, the temperature at the joined end can be calculated.

Measuring the Seebeck voltage requires the connection of a voltmeter's leads to the thermocouple wires. This new junction creates an additional thermocouple. In order to compensate for this new thermocouple, we use a method called cold-junction compensation. This method requires that we know the temperature at the new junction. Traditionally, these junctions were held at 0ºC in an ice bath. The Vernier Thermocouple performs a direct measurement of the temperature of the reference junction with an integrated-circuit amplifier.

This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest, LabQuest Mini, LabPro, Go! Link, SensorDAQ, EasyLink, or CBL 2, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor.

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[2] The thermocouple wire is insulated by a high temperature glass which has a lower maximum temperature (704ºC, 1300ºF) than the wire itself (1400ºC, 2552ºF). Therefore, in use, place only the tip of the wire in the heat source and keep the insulation out of direct contact of the heat source.

Do I Need to Calibrate the Thermocouple?

Here are some things to consider in deciding whether or not to calibrate:

1. **For most circumstances, you do not need to calibrate this sensor.** Why? Your sensor has been custom calibrated by Vernier. This means that we have performed a very accurate factory calibration that is specific to each individual sensor. This unique calibration is stored on the sensor, and will be loaded by any of our data-collection programs that support auto-ID.

2. **Improved accuracy at very low temperatures (–200 to 0ºC)** You can get improved accuracy by loading a special low-temperature calibration:

   a. **Computers** With Logger *Pro* 3, after you have initially auto-identified the Thermocouple, you can choose Set up Sensors from the Experiment Menu. To access and select from the available sensor calibrations, click on the channel of the sensor you are using, and choose Calibrate. Then choose the second calibration, Thermocouple ^{o}C LO (for –200 to 0ºC).

   b. **LabQuest (standalone)** LabQuest App will identify the sensor automatically. Choose Sensor Setup from the Sensors menu. Select Thermocouple Low Range from the pull-down menu next to the channel to which the sensor is connected.

   c. **TI Graphing Calculators** Start DataMate, EasyData, or DataPro and the Thermocouple will be identified automatically. Select Setup on the Main screen. On the Setup screen, press the Enter key, then choose the calibration for low temperatures, THERMOCOUPLE (C LO).

   d. **Palm Powered handhelds** Start Data Pro. Tap New, or choose New from the Data Pro menu. The Thermocouple will be identified automatically. Tap Setup on the Main screen. On the Setup screen, tap the channel to which you connected the Thermocouple (e.g., CH1). From the drop-down list, select the Thermocouple (C LO) calibration (for low Temperatures).

3. **If you require very accurate temperature values, perform a new calibration.** This calibration is not necessary for most situations. But if you do wish to perform a two-point calibration, as provided for in all of our data-collection programs, follow this procedure:

   a. For the first calibration point place the thermocouple in a liquid of known temperature. When the voltage reading displayed by the data-collection program stabilizes, enter the known temperature value (e.g., 0ºC).

   b. For the second calibration point place the thermocouple in a liquid at a different known temperature. When the displayed voltage reading stabilizes, enter the known temperature value (e.g., ~100ºC).

Sample Activity: Using a Thermocouple to Measure Liquid Nitrogen and Liquid Oxygen Temperatures

Walter Rohr (Easton, PA) provided us with a great microscale method that uses liquid nitrogen (boiling point of N_2 = –196°C) to condense oxygen gas to a liquid (boiling point of O_2 = –183°C). The Thermocouple can be used to verify the different boiling temperatures of these
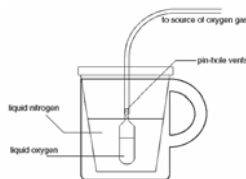
two liquids. The condenser is constructed using a piece of 5 mm plastic tubing and a 5 mL graduated Beral pipet. Cut the stem of the pipet to a length of about 2 cm. Insert the stem of the pipet bulb snugly into the plastic tubing. Use a straight pin or needle to make 4-5 small holes in the stem of the Beral pipet—these holes will provide a vent for excess oxygen gas. Connect the other end to a source of oxygen. This can be a demonstration tank of oxygen gas or a simple oxygen generator. The condenser does not require large amounts of gas; if you are using a demonstration tank of oxygen, release the gas at the slowest possible rate.

Place a Styrofoam cup into a coffee mug and fill it 3/4 full of liquid nitrogen. With the oxygen gas flowing, submerge the bulb of the pipet in the liquid nitrogen. In less than 10 minutes, the bulb of the Beral pipet should be more than half full of blue-colored liquid oxygen!

Use a pair of tongs to grip the neck of the pipet and lift it from the liquid nitrogen.
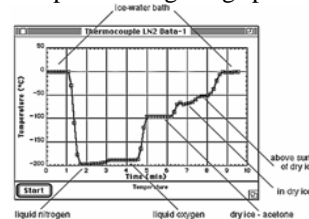
Quickly remove the plastic tubing by cutting the stem with a pair of scissors. Insert the probe wire into the liquid oxygen in the bulb and monitor its temperature. Students can easily see the difference between the boiling temperatures of the nitrogen and oxygen, –196°C and –188°C, respectively, in the sample data (77 K and 85 K, respectively).

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use.
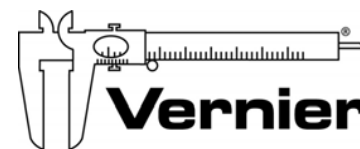
Measure. Analyze. Learn.™
Vernier Software & Technology
13979 S.W. Millikan Way • Beaverton, OR 97005-2886
Toll Free (888) 837-6437 • (503) 277-2299 • FAX (503) 277-2440
info@vernier.com • www.vernier.com

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