Pressure Sensor

(Order Code PS-BTA or PS-DIN)

The Pressure Sensor can be used to monitor pressure changes in gas-law experiments in chemistry and physics, such as Boyle's law (pressure vs. volume) and Gay-Lussac's law (pressure vs. absolute temperature). You can determine the value of absolute zero on the Celsius temperature scale. The Pressure Sensor can also be used to monitor reaction rates as a gas is produced in a chemical reaction. Vapor pressure of various liquids and solutions can be monitored and you can show the relationship between vapor pressure and absolute temperature. Biology teachers can use the Pressure Sensor to monitor changes in the partial pressure of oxygen or carbon dioxide gases in an enclosed atmosphere.

The Pressure Sensor can be used with any of the following laboratory interfaces available from Vernier:

- Vernier LabPro™ (for use with computers or TI Graphing Calculators)
- Texas Instruments CBL™ 2 or CBL System
- Universal Lab Interface (ULI)
- Serial Box Interface
- MultiPurpose Lab Interface (MPLI)

Inventory of Items Included with the Pressure Sensor

Included with your Pressure Sensor are accessories for performing vapor pressure experiments or pressure-temperature experiments. Check to be sure that each of these items is included:

- two taperd valve connectors inserted into a No. 5 stopper
- one tapered valve connector inserted into a No. 1 stopper
- one two-way valve
- two Luer-lock connectors (white) connected to either end of a piece of plastic tubing
- one 20-mL syringe
- two transpiration tubing clamps (white)

How the Pressure Sensor Works

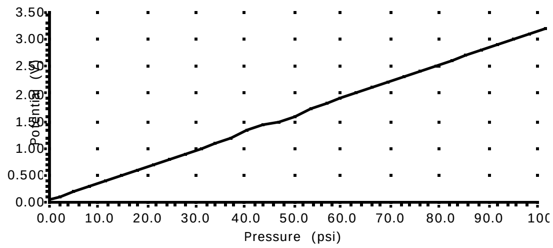
The heart of this circuit is the SenSym SCX100ANC. It has a membrane which flexes as pressure changes. This sensor is set up for absolute pressure measurement, so one side of the membrane is a vacuum. The sensor produces an output voltage which varies in a linear way with absolute pressure. It includes special circuitry to minimize errors caused by changes in temperature. The 100 in the part number indicates that the range of this sensor is 0 to 100 psi. The "A" in the part number indicates that it measures absolute pressure.

Pressure Units

Pressure can be measured in many different units. We quote values here in several of the units shown below. Some equivalent values for 1 atmosphere are:

1 atmosphere	= 760 mm of Hg
	= 101.325 kilopascals
	= 29.92 in. of Hg (at 0°C)
	= 1.013 bar
	= 14.696 psi

We provide an amplifier circuit that conditions the signal from the SCX100 sensor. With this circuit, the output voltage from the Pressure Sensor will be linear with respect to pressure with 0.00 volts corresponding to a complete vacuum, 0.454 volts corresponding to 14.7 psi (one atmosphere), and 3.09 volts corresponding to 100 psi. The output voltage increases 0.031 volts for each psi increase. This allows the sensor to cover the range of 0 to 100 psi (6.8 atm).



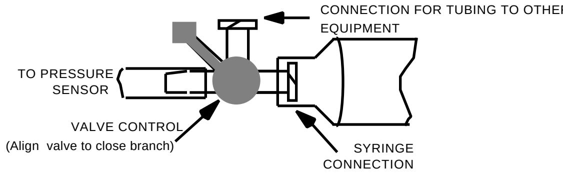
The SCX100ANC pressure sensor is fairly durable, but it is designed only for use with non corrosive gases such as air, helium, nitrogen, etc. Do not get it wet.

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

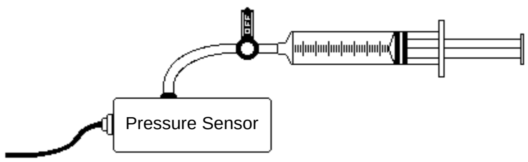
If you purchased the PS-BTA, you will find a DIN to BTA adapter in the box with your sensor. Use the adapter to connect the sensor to a LabPro, CBL 2 or CBL.

Using the 3-way Valve and Rubber-Stopper Apparatus

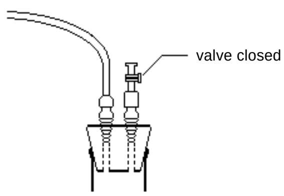
There is a plastic tube on the Pressure Sensor running from a port inside the box to a three-way valve on the outside of the box. The two openings (or stems) on the three-way valve have a small threaded end called a *luer lock.* You may attach plastic or rubber tubing to one of the ports using the supplied adapter (already mounted on extra tubing). The adapter accepts tubing with an inside diameter of 0.125 inches (3.2 mm), and commonly available 3/16-inch plastic tubing can be connected to it. You can also attach the 20-mL plastic syringe included with the Pressure Sensor *directly* to this stem (see figure at the bottom of the page). The other port (pointing upward in the figures below) of the three-way valve opens to the atmosphere and can serve as a pressure release. As you set up your experiments, you can always return the pressure to atmospheric pressure by opening this side stem. When the blue control (or “off”) handle is aligned with one of the stems, it closes off this stem. Note: Since the side stem also has a luer lock, it is possible to connect the syringe or the adapter with tubing in this side position.



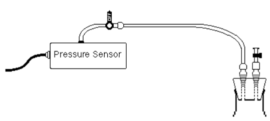
To perform pressure-volume (Boyle's law) experiments, connect the plastic syringe to one of the valve stems with a *gentle* 1/2 turn. Close the stem that leads into the Pressure Sensor box using the blue control handle, and set the syringe to any volume setting you like. Then close the open stem (see the figure below). The pressure inside the syringe is now equal to atmospheric pressure at the volume you selected. You are now set to collect pressure-volume data. Further details on performing Boyle's law experiments are provided later in this booklet.



The white, threaded adapter end of the long piece of plastic tubing can also be connected to one of the valve stems with a full turn. The other end can be connected to the shorter stem on the two-way stopper included with your Pressure Sensor, as



shown here. For example, when doing a pressure-temperature experiment, the tubing apparatus can be connected to the rubber stopper which is in turn inserted into the neck of a 125-mL Erlenmeyer flask:



This provides a constant-volume gas sample. Directions for collecting pressure-temperature data or vapor pressure data are described later in this document.

Calibration

There are several ways to handle calibration with this sensor. In some cases, the circuit can be used without calibration. Often you are interested in only relative pressures, and you can use the raw voltage output of the Pressure Sensor. With the Pressure Sensor as shipped, voltage is proportional to pressure. In most cases, you can simply load the appropriate calibration file that was included on your laboratory interfacing program from Vernier. This calibration will be satisfactory for most experiments using the Pressure Sensor.

For the very best results, you can calibrate this unit yourself using one of the methods described below. You will need to know the local air pressure, and/or have a reliable pressure measurement instrument.

Two-Point Calibration

This is the calibration procedure we use with all of our sensors. You simply do a two-point calibration as described in the program manual using two different pressures, both measured with another pressure gauge. One pressure is easy to get in this case simply use atmospheric pressure as measured by a barometer. For the other pressure, you can:

- Use the syringe provided with the Pressure Sensor to produce a pressure very near zero. We have found that this method works very well. Connect the syringe to the Pressure Sensor and open the unused stem of the three-way valve by aligning the blue valve control with the stem that leads into the Pressure Sensor box. Push the plunger on the syringe all the way in and close the unused stem leading to the atmosphere by aligning the blue valve control with it. To produce near zero pressure, pull the plunger out to the 20-cc position. If your syringe and valve have a tight seal, the pressure will be <0.01 atm, and you can call it zero for calibration.
- Apply pressure with a pump, measuring it at the same time with a pressure gauge.

Whatever method you use, the input should be named "Pressure," and appropriate units should be entered as part of the calibration.

One-Point Calibration

This calibration method uses the predetermined sensitivity of the Pressure Sensor to simulate a two-point calibration. It cannot be used if you have changed the gain potentiometer inside the box. Follow the instructions on the screen and in your program manual to begin calibration. The input should be named "Pressure" and appropriate units should be entered. For the first of the two calibration points, open the unused stem of the three-way valve to expose the Pressure Sensor port to atmospheric pressure. Do this by aligning the blue valve control with the stem leading to the inside of the Pressure Sensor. Read a laboratory barometer and enter its pressure reading as the known pressure. Also, note the voltage reading.

For the second point, close the unused stem by aligning the blue valve control with it. Blow on the tubing connected to the three-way valve of the Pressure Sensor, so that the voltage reported increases. Now press the ENTER key, while noting the voltage. Take this as the second calibration point and calculate the change in voltage between the two calibration points. Calculate what the pressure was using the known sensitivity of the Pressure Sensor. Use the equation:

Pressure (in. psi) = first pressure reading + voltage change / 0.031 volts/psi.

If you use different pressure units, make the appropriate conversion. This calculation gives you the pressure at the second calibration point. It uses the known sensitivity of the unit.

Adjusting the Pressure Sensor

There is an offset potentiometer that you can use to increase or decrease the output signal. In normal use, you will never need to make this adjustment! This potentiometer can be adjusted without opening the box. Place a small jeweler's screwdriver through the hole in the end of the box and you will notice a slotted screw that can be turned. This is a 15-turn potentiometer, so the adjustment can be made very gradually. One way to adjust the calibration of the Pressure Sensor is to adjust this potentiometer. There is also a gain control potentiometer inside the box. Adjusting this potentiometer requires opening the box, and is not recommended for normal use. When this unit is shipped, we set the gain potentiometer in the fully clockwise position. This sets the gain at its lowest value. This potentiometer can be turned counter-clockwise to increase the sensitivity. The maximum sensitivity is about 290 mV per psi. If you adjust the potentiometers, test the response of the unit by attaching a plastic tube to the input port, and blow and suck on it. Make sure that the voltage increases when you blow on the tube and decreases when you suck on the tube.

A complete schematic of the Pressure Sensor is available. Contact Vernier.

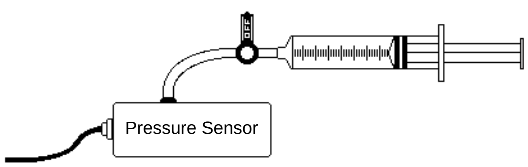
Specifications

- Sensing element: SenSym SCX100ANC
- Pressure range (as shipped): 0 to 6.8 atm (0 to 100 psi)
- Maximum pressure that the sensor can tolerate without permanent damage:
  10.2 atm or 150 psi
- Sensitivity (as shipped, minimum) 454 mV/atm or 31 mV /psi
  (with gain adjusted to maximum) 4.2 V/atm or 290 mV /psi
- Resolution (as shipped) using a 12-bit, 5 volt A/D converter (ULI II, Serial Box):
  0.00275 atm
- Resolution (as shipped)using a 10-bit, 5 volt A/D converter (CBL, original ULI):
  0.011 atm
- Combined linearity and hysteresis: typical ±0.1% full scale, maximum ±0.5% full scale
- Response time: 100 microseconds

Suggested Experiments

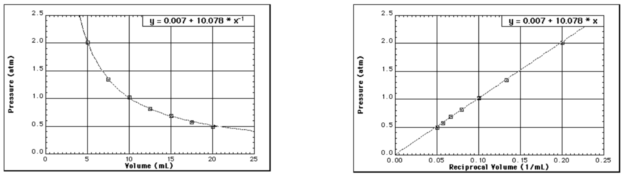
Boyle’s Law (Pressure vs. Volume)

Boyle’s law is a classic physics/chemistry concept that can be easily demonstrated using the Pressure Sensor. One easy way to do this is to use the plastic syringe included with the Pressure Sensor. Connect the plastic syringe to one of the valve stems with a *gentle* 1/2 turn. Close the stem that leads into the Pressure Sensor box using the blue control handle and set the syringe to any volume setting you like. Then close the open stem.



The pressure inside the syringe is now equal to atmospheric pressure at the volume you selected. You are now set to collect pressure-volume data. Take data as you change the volume. The syringe is marked in volume units (cc or mL). You can both increase and decrease the volume. This experiment is detailed in our *Chemistry with*

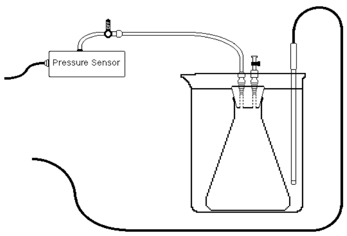
Computers and *Chemistry with CBL* lab manuals. Sample data collected with this sensor and the syringe are graphed below:

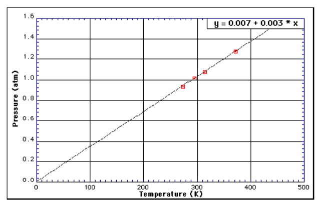


Sample Boyle's Law Graphs

Gay-Lussac’s Law (Pressure vs. Absolute Temperature)

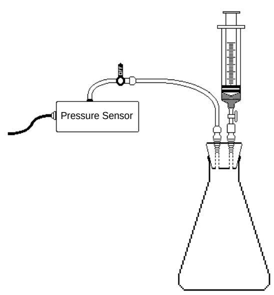
Gay-Lussac’s law states that if the volume remains constant, the pressure of a container of a gas is directly proportional to its absolute temperature. The white, threaded adapter end of the long piece of plastic tubing can be connected to one of the valve stems with a full turn. The other end can be connected to the rubber stopper apparatus (included with your Pressure Sensor), which is in turn inserted into a 125-mL Erlenmeyer flask. This provides a constant-volume gas sample.





Temperature data can be collected using a temperature probe, along with the Pressure Sensor. Place the flask in water baths of different temperatures. Take data on how the pressure changes with temperature changes. Remember that all temperatures should be measured using the Kelvin temperature scale. Using the same apparatus, pressure and temperature data may be extrapolated to determine a Celsius temperature value for absolute zero. Details for this experiment are included in our *Chemistry with Computers* and *Chemistry with CBL* lab manuals.

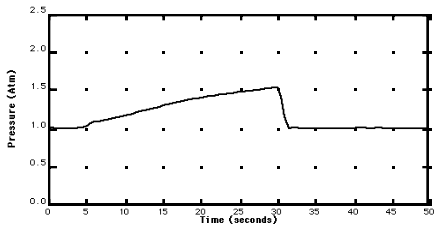
Vapor Pressure Measurements



The Pressure Sensor can be used along with the pressure sensor accessories to collect vapor pressure data. The Pressure Sensor is connected to short stem that protrudes from the rubber stopper. Draw 2-3 mL of the liquid to be vaporized up into the syringe. With the two-way valve closed, screw the syringe onto the two-way valve, as shown above. Once the system is closed and you have begun monitoring pressure, open the two-way valve, squirt the liquid into the 125-mL Erlenmeyer flask and close the valve. Vapor pressure data can easily be collected using any of our interfaces and data collection programs. Gently swirl the flask. Once the system equilibrates, the flask can be placed in water baths of varying temperature to investigate the relationship between vapor pressure and temperature (a temperature probe can be connected to the second port of the interface). Details for this experiment are included in our *Chemistry with Computers* and *Chemistry with CBL* lab manuals.

Studying Chemical Reactions by Monitoring Pressure

Many chemical reactions produce gases that can cause a pressure increase in a sealed container. The pressure change can be used as a way of monitoring the rate of reaction. You can change concentrations or temperatures, or add catalysts, to see how the reaction rate changes. As a very simple example, the graph below was made using the Pressure Sensor to monitor the reaction of Alka-Seltzer® and water. We made a hole in the top of a plastic 35-mm film container. We then ran a tube from the Pressure Sensor through the hole and sealed it with silicone sealant. We then placed a piece of an Alka-Seltzer tablet and 10 mL of water in the container and sealed it. The graph below shows the pressure increase as the reaction takes place. Note the sudden drop in pressure when the lid of the container pops off.



Using the Pressure Sensor to Monitor the Rate of Reaction

Pressure in Liquids

If you measure the pressure at the end of a long plastic tube forced underwater, you can indirectly measure depth. Connect the tubing to the input port of the Pressure Sensor and then put the end of the tube under water. The pressure reading will increase 0.0965 atmospheres for every meter below the surface of the water. If you use different pressure units, you will need to make the appropriate conversion.

Note: If you measure depth in this way, the depth you are measuring is to the top of the air, which extends up the tube for a short distance. If this measurement error bothers you, you can simply calibrate your depth measurement system when the end of the tube is at known depths and automatically correct for this.

Using the Pressure Sensor with a Computer

This sensor can be used with a Macintosh or PC computer and any of the following lab interfaces: LabPro, Universal Lab Interface, or Serial Box Interface. Follow these general procedures to use the Pressure Sensor with a computer:

1. Connect the Pressure Sensor to the appropriate port on the interface.
2. Start the data collection software on the computer. If you are using a Power Macintosh or Windows computer, run the Logger *Pro*™ software. If you are using an older Macintosh, DOS, or Windows 3.1 computer, run the Data Logger program.
3. Open an experiment file in the Logger *Pro* or Data Logger folder, and you are ready to collect data.

Using the Pressure Sensor with TI Graphing Calculators

This sensor can be used with a TI Graphing Calculator and any of the following lab interfaces: LabPro, CBL 2, or CBL. Follow these general procedures to use the Pressure Sensor with a graphing calculator:

1. Load a data-collection program onto your calculator:
   - LabPro or CBL 2: Use the DataMate program. This program can be transferred directly from LabPro or CBL 2 to the TI Graphing Calculator. Use the calculator-to-calculator link cable to connect the two devices. Put the calculator into the Receive mode, and then press the Transfer button on the interface.
   - Original CBL: Vernier has several programs that support this sensor and other sensors. When using the Pressure Sensor with the original CBL, we recommend the CHEMBIO or the PHYSICS program. This program is available free on our web site at www.vernier.com. Our programs can also be obtained on disk. (Contact us for more information.) Load the program into a calculator using TI-GRAPH LINK.
2. Use the calculator-to-calculator link cable to connect the interface to the TI Graphing Calculator using the I/O ports located on each unit. Be sure to push both plugs in firmly.
3. Connect the Pressure Sensor to any of the analog ports on the interface. In most cases, channel CH 1 is used.
4. Start the data-collection program and you are ready to collect data.

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