

Nitrate Ion-Selective Electrode

(Order Code NO3-BTA)



The Vernier Nitrate Ion-Selective Electrode is used to measure the concentration of nitrate (NO_3^-) ions in aqueous samples.

Inventory of Items Included with the Nitrate ISE

- Ion-Selective Electrode, packed with a storage bottle
- 30 mL bottle of High Standard solution with SDS (100 mg/L NO_3^-)
- 30 mL bottle of Low Standard solution with SDS (10 mg/L NO_3^-)
- Short-Term ISE Soaking Bottle

Collecting Data with the Nitrate ISE

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

- Vernier LabQuest[®] 2 or original LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro[®] with a computer or TI graphing calculator
- Vernier Go![®]Link
- Vernier EasyLink[®]
- Vernier SensorDAQ[®]
- CBL 2[™]
- TI-Nspire[™] Lab Cradle

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 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **LabQuest App** This program is used when LabQuest 2 or LabQuest is used as a standalone device.
- **DataQuest[™] Software for TI-Nspire[™]** This calculator application for the TI-Nspire can be used with the EasyLink or TI-Nspire Lab Cradle.
- **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 2.4 or newer, which can be downloaded from the Vernier website, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier website, 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.
- **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.

This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, Go! Link, SensorDAQ, TI-Nspire[™] Lab Cradle, 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.

NOTE: Vernier products are designed for educational use. Our products are not designed nor are they recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Preparing the Nitrate ISE for Use

Note: Follow this two-part process before taking measurements with your ISE.

Part I: Soak the Electrode

Soak the electrode in the High Standard solution (included with the ISE) for approximately 30 minutes. The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE. **Important:** Do not leave the ISE soaking for more than 24 hours. **Important:** If you plan to use the electrode outside the range of the standards provided, you will need to prepare your own standards and use those for soaking.

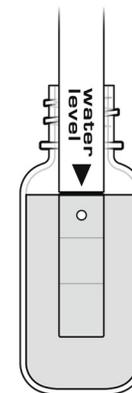
Note: If the ISE needs to be transported to the field during the soaking process, use the Short-Term ISE Soaking Bottle. Remove the cap from the bottle and fill it 3/4 full with High Standard. Slide the bottle's cap onto the ISE, insert it into the bottle, and tighten.

For long term storage, greater than 24 hours, make sure the sensor is stored in its storage bottle with the sponge slightly damp.

Part II: Calibrate the ISE

Calibrating the Nitrate ISE with a computer

1. Connect the Nitrate ISE to an interface, and connect the interface to your computer. Open Logger Pro 3.
2. Choose Calibrate from the Experiment menu and then click **Calibrate Now**.
3. **High Standard Calibration Point:** The Nitrate ISE should still be soaking in the High Standard. The ISE should not rest on the bottom of the container, and the



small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE.

4. Enter the concentration value of the High Standard (e.g., **100** for 100 mg/L) in the edit box.
5. After the voltage reading for Reading 1 stabilizes (~2 minutes), click .
6. **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE.
7. Enter the concentration value for the Low Standard (e.g., **1** for 1 mg/L).
8. After the voltage reading stabilizes, click .
9. To save the calibration to the sensor, follow the steps below:
 - a. Click the Calibration Storage tab at the top of the dialog box.
 - b. Click . Click .
 - c. Click  to continue. Click  to complete the process.

Calibrating the Nitrate ISE with LabQuest App

1. Connect the Nitrate ISE to LabQuest. Choose Calibrate from the Sensors menu and select Calibrate Now.
2. **High Standard Calibration Point:** The Nitrate ISE should still be soaking in the High Standard. The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE.
3. Enter the concentration of the High Standard (e.g., **100** for 100 mg/L) for Reading 1.
4. After the voltage reading stabilizes (~2 minutes), tap Keep.
5. **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE.
6. Enter the concentration of the Low Standard (e.g., **1** for 1 mg/L) for Reading 2.
7. After the voltage reading stabilizes, tap Keep.
8. To save the calibration to the sensor, follow the steps below:
 - a. Tap Storage.
 - b. Tap Save Calibration to Sensor. Tap OK.
 - c. Tap OK to complete the process.

Calibrating the Nitrate ISE with TI Graphing Calculators

Enter the calibration routine for your data-collection program. Consult the reference material for the calculator's program or app for the specific information concerning the calibration steps.

- **High Standard Calibration Point:** The Nitrate ISE should still be soaking in the High Standard. The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE. Enter the concentration of the High Standard (e.g., **100** for 100 mg/L).

- **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE. Enter the concentration of the Low Standard (e.g., **1** for 1 mg/L).

Collecting Data

1. Make sure the sensor is properly calibrated. If the meter has a reading of 1.0 mg/L and the sensor is not in a 1.0 mg/L solution, you need to calibrate. After calibration, rinse off the tip of the ISE and blot it dry with a paper towel.
2. Insert the tip of the ISE into the aqueous sample to be tested. **Important:** Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE. **Note:** Do not completely submerge the sensor. The handle is not waterproof.
3. Hold the ISE still until the reading stabilizes and record the displayed reading. **Note:** With some aqueous samples, especially those at high concentrations, it could take several minutes for the reading of the Nitrate ISE to stabilize. If you know the approximate concentrations of your samples, it is best to analyze them from lowest concentration to highest.

Using the Nitrate ISE with Other Vernier Sensors

Some combinations of sensors interfere with each other when placed in the same solution. The degree of interference depends on many factors. For more information, see www.vernier.com/til/638/

Storing the Ion-Selective Electrode

Proper care and storage are important for optimal longevity of your Nitrate ISE.

- Long-term storage of the ISE (longer than 24 hours): Moisten the sponge in the bottom of the long-term storage bottle with distilled water. When you finish using the ISE, rinse it off with distilled water and blot it dry with a paper towel. Loosen the lid of the long-term storage bottle and insert the ISE. **Note:** The tip of the ISE should NOT touch the sponge. Also, make sure the white reference mark is inside the bottle. Tighten the lid. This will keep the electrode in a humid environment, which prevents the reference junctions from completely drying out.
- Short-term wet storage (less than 24 hours): Fill the Short-Term ISE Soaking bottle 3/4 full with High Standard. Loosen the cap, insert the electrode into the bottle, and tighten.

How the Ion-Selective Electrode Works

The Vernier Nitrate Ion-Selective Electrode (ISE) is a membrane-based electrode that measures a specific ion (NO_3^-) in an aqueous solution. When the membrane of the electrode is in contact with a solution containing the specific ion, a voltage, dependent on the level of that ion in solution, develops at the membrane. The ISE is a combination style electrode. The voltage develops in relation to an internal Ag/AgCl reference electrode. The ISE measures for the specific ion concentration directly. Samples need to be aqueous to avoid contaminating or dissolving the membrane. The Vernier Nitrate Ion-Selective Electrode has a solid polymer membrane. The membrane is a porous plastic disk, permeable to the ion exchanger, but impermeable to water. It allows the sensing cell to contact the sample solution and separates the internal filling solution from the sample.

The voltage developed between the sensing and reference electrodes is a measure of the concentration of the reactive ion being measured. As the concentration of the ion reacting at the sensing electrode varies, so does the voltage measured between the two electrodes.

As described in the Nernst Equation, ISE response is a linear equation:

$$E = E_o + m(\ln a)$$

where E is the measured voltage, E_o is the standard potential for the combination of the two half cells, m is the slope, ln is the natural logarithm, and a is the activity of the measured ion species.

Assuming the ionic strength is fairly constant, the Nernst equation may be rewritten to describe the electrode response to the concentration, C, of the measured ion species:

$$E = E_o + m(\ln C)$$

Specifications

Range	1 to 10,000 mg/L (or ppm)
Reproducibility (precision)	$\pm 10\%$ of full scale (calibrated 10 to 1000 mg/L)
Interfering ions	ClO_4^- , I^- , ClO_3^- , CN^- , BF_4^-
pH range	2–11 (no pH compensation)
Temperature range	0–40°C (no temperature compensation)
Electrode slope	-56 ± 4 mV/decade at 25°C
Calibration voltages, typical	High (100 mg/L) 1.6 V, Low 2.4 V (1 mg/L)
Electrode resistance	1 to 4 M Ω
Minimum sample size	must be submerged 1.1 in

Maintaining and Replacing the ISE Standard Calibration Solutions

Having accurate standard solutions is essential for performing good calibrations. The two standard solutions that were included with your ISE can last a long time if you take care not to contaminate them. At some point, you will need to replenish your supply of standard solutions. Vernier sells replacement standards in 500 mL volumes. Order codes are:

NO3-LST: Nitrate Low Standard, 1 mg/L

NO3-HST: Nitrate High Standard, 100 mg/L

To prepare your own standard solutions, use the information in the table below.

Note: Use glassware designed for accurate volume measurements, such as volumetric flasks or graduated cylinders. All glassware must be very clean.

Standard Solution	Concentration (mg/L or ppm)	Preparation Method using High Quality Distilled Water
Nitrate (NO_3^-) ISE High Standard	100 mg/L NO_3 as N	0.607 g NaNO_3 / 1 L solution
Nitrate (NO_3^-) ISE Low Standard	1 mg/L NO_3 as N	Dilute the High Standard by a factor of 100 (from 100 mg/L to 1 mg/L).*

*Perform two serial dilutions as described below.

- Combine 100 mL of the High Standard with 900 mL of distilled water. Mix well.
- Combine 100 mL of the solution made in Step a with 900 mL of distilled water. Mix well.

Nitrate ISE Replacement Membrane Modules

The Nitrate ISE has a PVC membrane with a limited life expectancy. It is warranted to be free from defects for a period of twelve (12) months from the date of purchase; it is possible, however, that you may get somewhat longer use than the warranty period. If you start to notice a reduced response (e.g., distinctly different voltages or voltage ranges during calibration), it is probably time to replace the membrane module. **Important:** Do not order membrane modules far in advance of the time you will be using them; the process of degradation takes place even when they are stored on the shelf.

Using Ionic Strength Adjuster (ISA) Solution to Improve Accuracy

For optimal results at low concentrations of nitrate ions, a standard method for taking measurements with the Nitrate Ion-Selective Electrode (ISE) is to add ionic strength adjuster (ISA) solutions to each of your standard solutions and samples.

Adding an ISA ensures that the total ion activity in each solution being measured is nearly equal, regardless of the specific ion concentration. This is especially important when measuring very low concentrations of specific ions. The ISA contains no ions common to the Nitrate ISE itself. **Note:** The additions of ISA to samples or standards described below do not need to have a high level of accuracy—combining the ISA solution and sample solution counting drops using a disposable

Beral pipet works fine. The following are instructions for using ISA solutions with Vernier Ion-Selective Electrodes.

Use an ISA with the Nitrate ISE by adding 2.0 M (NH₄)₂SO₄ ISA solution (26.42 g (NH₄)₂SO₄ / 100 mL solution) to the NO₃⁻ standard or to the solution being measured, in a ratio of 1 part of ISA (by volume) to 50 parts of total solution (e.g., 1 mL of ISA to 50 mL of total solution, or 2 drops of ISA to 5 mL of total solution).

Using the Nitrate ISE

Nitrate ions, NO₃⁻, may be found in freshwater samples from a variety of sources. Sewage is often the primary source. Sometimes nitrates are present due to runoff from fertilized fields. Nitrates can also result from the runoff from cattle feedlots and barnyards. In all of these cases, as plant and animal organisms die, bacterial action breaks down the protein into ammonia, NH₃. Some ammonia is converted into ammonium ions, NH₄⁺. Other bacterial action converts some of the ammonia and ammonium ions into nitrite ions, NO₂⁻, and then into nitrate ions, NO₃⁻.

Units of Nitrate Concentration

Nitrate ion concentration is usually expressed in units of mg/L of NO₃⁻ as N, also known as “nitrate-nitrogen.” This means that the concentration of nitrate is expressed as if the nitrate were only in the form of nitrogen itself. The standards that are included with your Nitrate ISE have concentrations of 1 and 100 mg/L of NO₃⁻ as N. Here is the calculation for making a 100 mg/L NO₃⁻ as N standard starting with solid NaNO₃ (as shown in Table 1). Notice that the atomic weight of N, 14.0, is used instead of the atomic weight of NO₃⁻, 62.0.

$$\frac{100 \text{ mg N}}{1 \text{ L}} \times \frac{1 \text{ g N}}{1000 \text{ mg N}} \times \frac{85.0 \text{ g NaNO}_3}{14.0 \text{ g N}} = 0.607 \text{ g NaNO}_3 / \text{L solution}$$

Unpolluted waters usually have nitrate-nitrogen (NO₃⁻ as N) levels below 1 mg/L. Nitrate-nitrogen levels above 10 mg/L are considered unsafe for drinking water.

Test results are sometimes published in units of mg/L NO₃⁻ instead of NO₃⁻ as N. To convert 100 mg/L NO₃⁻ as N to mg/L NO₃⁻, you would perform this conversion:

$$\frac{100 \text{ mg N}}{1 \text{ L}} \times \frac{62.0 \text{ g NO}_3^-}{14.0 \text{ g N}} = 443 \text{ mg/L NO}_3^-$$

Sampling Freshwater Samples for Nitrate Concentration

For best results, calibrate the Nitrate ISE, using the 1 mg/L and 100 mg/L standards.

How Can I Have My ISE Read mV Output Instead of mg/L?

The amplification equation is: $V = 0.00727 * \text{mV} + 1.223$

Therefore, the reverse amplification equation, solving for mV, would be:

$$\text{mV} = 137.55 * V - 0.1682$$

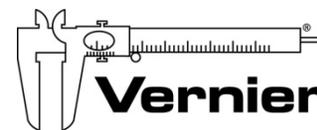
Warranty

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. ISE modules are covered by a one-year warranty.

Additional Vernier Ion-Selective Electrodes

Vernier sells Ion-Selective Electrodes that measure the concentration of ammonium (NH₄⁺), calcium (Ca²⁺), potassium (K⁺), and chloride (Cl⁻) ions in aqueous solutions. Order codes are:

- Ammonium Ion-Selective Electrode: NH4-BTA
- Calcium Ion-Selective Electrode: CA-BTA
- Chloride Ion-Selective Electrode: CL-BTA
- Potassium Ion-Selective Electrode: K-BTA



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