Nitrate Ion-Selective Electrode BNC

(Order Code NO3-BNC)

The Vernier Nitrate Ion-Selective Electrode BNC is used to measure the concentration of nitrate (NO_3^-) ions in aqueous samples. It is designed to be used with the Vernier Electrode Amplifier (order code EA-BTA) or Vernier Go Wireless® Electrode Amplifier (order code GW-EA).

Inventory of Items Included with the Nitrate ISE

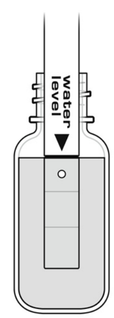
- Ion-Selective Electrode with BNC terminated end, packed with a storage bottle
- 30 mL bottle of High Standard solution with SDS (100 mg/L NO_3^--N)
- 30 mL bottle of Low Standard solution with SDS (1 mg/L NO_3^--N)
- Short-Term ISE Soaking Bottle

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.

Here is the general procedure to follow when using the Nitrate ISE to measure mV:
1. Connect the Nitrate ISE to a Vernier electrode amplifier.
2. Connect the electrode amplifier to the interface (if required).
3. Start the data-collection software.
4. The software will automatically load a default data-collection setup. Change the units to mV, if necessary. You are now ready to collect data.

Important: Do not fully submerge the sensor.

Preparing the Nitrate ISE for Use



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.

Collecting Data

1. Make sure the sensor is connected to a Vernier electrode amplifier.
2. Connect the electrode amplifier to the interface (if required).
3. Start the data-collection software. The software will automatically load a default data-collection setup. Change the units to mV, if necessary.
4. Remove the electrode from the soaking solution (high standard). Thoroughly rinse the lower section of the probe, especially around the tip, using distilled or deionized water. Blot dry with a paper towel.
5. 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.
6. 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.

How the Ion-Selective Electrode Works

Combination Ion-Selective Electrodes consist of an ion-specific (sensing) half-cell and a reference half-cell. The ion-specific half-cell produces a potential which is measured against the reference half-cell depending on the activity of the target ion in the measured sample. The ion activity and the potential reading change as the target ion concentration of the sample changes. The relationship between the potential measured with the ISE and the ion activity, and thereby the ion concentration in the sample, is described by the Nernst equation:

$$E = E_o - 2.303\frac{RT}{nF}\log(C + C_o)$$

E = measured potential (mV) between the ion-selective and the reference electrode
E_o = standard potential (mV) between the ion-selective and reference electrodes
R = Universal gas constant (R = 8.314 J mol^{-1} K^{-1})
T = Temperature in K (Kelvin), with T (K) = 273.15 + t °C where t is the temperature of the measured solution in °C.
F = Faraday constant (96485 C mol^{-1})
n = valence of the ion
C = concentration of ion to be measured
C_o = detection limit

Since R and F are constant, they will not change. The electrical charge of the ion (valence) to be measured is also known. Therefore, this equation can be simplified as:

$$E = E_o - S \bullet \log(C + C_o)$$

where $S = -2.303\frac{RT}{nF}$ is the ideal slope of the ISE.

The following table describes **ideal behavior**:

Ion Examples	n (valence of ion)	S (at 25 °C), mV/decade
Calcium (Ca^{2+})	+2	+29.58
Potassium (K^+), Ammonium (NH_4^+)	+1	+59.16
Nitrate (NO_3^-), Chloride (Cl^-)	–1	–59.16

Assuming C_0 is near zero, the equation can be rewritten as:

$$C = 10^{[(E - E_o) / S]}$$

allowing for the calculation of the ion concentration.

It is very important to note that this table reflects ideal behavior. Ion-selective electrodes have slopes that are typically lower than ideal. It is generally accepted that an ISE slope from 88–101% of ideal is allowable. The slope (S) is an indicator of ISE performance. If the slope changes significantly over time it may indicate that it is necessary to replace the ISE sensor tip.

Convert Potential to Concentration (Optional)

To measure the mV readings from an aqueous sample, calibration is not required. To convert mV readings to concentration (mg/L or ppm), you will use a modified version of the Nernst Equation:

$$C = 10^{[(E - E_o) / S_m]}$$

C = concentration of ion to be measured (mg/L or ppm)
E = measured potential of sample (mV)
E_o = measured potential (mV) at a C = 1 mg/L NO_3^--N concentration
S_m = measured electrode slope in mV/decade

The value of S_m, the measured electrode slope, is determined by measuring the potential of two standard solutions, and solving the equation below:

$$S_m = -[(\text{Low Standard} - \text{High Standard}) / \#\text{ of decades*}]$$

*A decade is defined as the factor of the difference between the two standard solutions. For example, the difference between a 1 mg/L standard and a 100 mg/L standard is 2 decades (a factor of 100 difference, or 1×10^2).

Example Calculation, converting mV to mg/L

For this example, the measured quantities are shown in the chart below:

Solution	Measured Potential
1 mg/L NO_3^--N standard	154 mV
100 mg/L NO_3^--N standard	44 mV
unknown sample	50 mV

$$S_m = -\frac{(154\text{ mV} - 44\text{ mV})}{2\text{ decades}} = -55\text{ mV/decade}$$

$$C = 10^{[(50\text{ mV} - 154\text{ mV}) / -55\text{ mV/decade}]} = 78\text{ ppm } NO_3^-\text{-N}$$

Units of Nitrate Concentration

Nitrate ion concentration is often expressed in units of mg/L of NO_3^- as N, or NO_3^--N, also known as "nitrate-nitrogen." This means that the concentration is expressed as nitrogen in the form of nitrate. The standards that are included with your Nitrate ISE have concentrations of 1 and 100 mg/L of NO_3^- as N. Here is the calculation for making a 100 mg/L NO_3^- as N standard starting with solid $NaNO_3$. Notice that the atomic weight of N, 14.0, is used instead of the atomic weight of NO_3^-, 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 (NO_3^- 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 NO_3^- instead of NO_3^- as N. To convert 100 mg/L NO_3^- as N to mg/L NO_3^-, perform this conversion:

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

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.

Specifications

Range (mV)	–450 mV to +1100 mV (EA-BTA) –1100 mV to +1100 mV (GW-EA)
Range (concentration)	1 to 14,000 mg/L (or ppm)
Reproducibility (precision)	±30 mV
Interfering ions	ClO_4^-, I^-, ClO_3^-, F^-
pH range	2.5–11 (no pH compensation)
Temperature range	0–40°C (no temperature compensation)
Electrode slope	–55 ±3 mV/decade at 25°C
Electrode resistance	0.1 to 5 MΩ
Minimum sample size	must be submerged 2.8 cm (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 NO_3^--N
NO3-HST: Nitrate High Standard, 100 mg/L NO_3^--N

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.

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

Nitrate ISE Replacement Membrane Modules

The sensor module of the Nitrate ISE has a PVC membrane with a limited life expectancy. This module (order code: NO3-MOD) 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 solutions 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 $(NH_4)_2SO_4$ ISA solution (26.42 g (NH_4) $2SO_4$ / 100 mL solution) to the NO_3^- 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).

Nitrate in the Environment

Nitrate ions, NO_3^-, 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, NH_3. Some ammonia is converted into ammonium ions, NH_4^+. Other bacterial action converts some of the ammonia and ammonium ions into nitrite ions, NO_2^-, and then into nitrate ions, NO_3^-.

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.

Related Products

- Ammonium Ion-Selective Electrode BNC: NH4-BNC
- Calcium Ion-Selective Electrode BNC: CA-BNC
- Chloride Ion-Selective Electrode BNC: CL-BNC
- Potassium Ion-Selective Electrode BNC: K-BNC
- Electrode Amplifier: EA-BTA
- Go Wireless Electrode Amplifier: GW-EA

Replacement Products

- Standard High Nitrate ISE Solution: NO3-HST
- Standard Low Nitrate ISE Solution: NO3-LST
- Nitrate Replacement Module: NO3-MOD

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