Go Direct® Nitrate Ion-Selective Electrode BNC

(Order Code GDX-NO3-BNC)

The Go Direct Nitrate Ion-Selective Electrode BNC is used to measure the potential (mV) and calculate the concentration of nitrate (NO_3^-) ions in aqueous samples. It is designed to be used with the Go Direct Ion-Selective Electrode Amplifier (order code GDX-ISEA).

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.

What's Included

- Go Direct Nitrate 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^-)
- 30 mL bottle of Low Standard solution with SDS (1 mg/L NO_3^-)
- Short-Term ISE Soaking Bottle

Using the Product

To prepare the electrode to make measurements, follow this procedure:

- Connect the Ion-Selective Electrode BNC to the Go Direct Ion-Selective Electrode Amplifier. Push the BNC connector of the electrode onto the connector on the amplifier, then turn the BNC connector about one-half turn clockwise.
- Connect the amplifier to your computer, Chromebook™, LabQuest®, or mobile device and run the data-collection software. Change the sensor channel to the appropriate ion or Potential, if necessary.
- Your ISE needs to be prepared before use. This includes a 30-minute soak in the High Standard solution.
- 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 and calibration.
- The ISE should not rest on the bottom of the container.
- The small white reference contacts near the tip of the electrode should be immersed.
- Make sure no air bubbles are trapped below the ISE.
- Do not leave the ISE soaking for more than 24 hours.
- Do not completely submerge the sensor. The BNC connection is not waterproof.

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. Remove the storage bottle 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.
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.
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.

Note: Readings are reported in mV by default. If you choose to change the sensor channel to nitrate concentration, you may want to calibrate the sensor. If you wish to convert the mV reading to concentration manually, refer to the How the Sensor Works section of this user manual.

Calibration

A calibration is stored on each Go Direct Ion-Selective Electrode Amplifier before it is shipped that is appropriate for an electrode. As the electrode's membrane ages, this factory calibration may become inadequate. For best results, we recommend performing a two-point calibration.

Note: 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 and calibration. Standards should be two decades apart (e.g., 5 mg/L and 500 mg/L).

For additional calibration information, see **www.vernier.com/til/4011**

Specifications

Range (mV)	–1000 mV to +1000 mV (GDX-ISEA)
Range	1 to 14,000 mg/L (or ppm)
Reproducibility (precision)	±30 mV
Interfering ions	ClO_4^-, I^-, ClO_3^-, CN^-, F^-
pH range	2–11 (no pH compensation)
Temperature range	0 to 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)

Care and Maintenance

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.

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.

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 thefollowing table. **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 Na NO_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.

Replacement Modules

The Go Direct Nitrate Ion-Selective Electrode BNC 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, 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.

How the Sensor 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 that 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:

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

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:

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

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	160 mV
100 mg/L NO_3^-–N standard	44 mV
unknown sample	50 mV

$$S_m = -\frac{(160\text{ mV} - 44\text{ mV})}{2\text{ decades}} = -58\text{ mV/decade}$$

$$C = 10^{\wedge}[(50\text{ mV} - 160\text{ mV}) / -58\text{ mV/decade}] = 79\text{ ppm } NO_3^-\text{–N}$$

Units of Concentration

Nitrate ion concentration is usually expressed in units of mg/L of NO_3^- 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 NO_3^- as N. Here is the calculation for making a 100 mg/L NO_3^- as N standard starting with solid $NaNO_3$ (as shown in Table 1). Notice that the atomic weight of N, 14.0, is used instead of the atomic weight of NO_3^-, 62.0.

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

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^-, you would perform this conversion:

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

Troubleshooting

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^-.

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 $(NH_4)_2SO_4$ 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).

For additional troubleshooting and FAQs, see **www.vernier.com/til/665**

Repair Information

If you have followed the troubleshooting steps and are still having trouble with your Go Direct Nitrate Ion-Selective Electrode BNC, contact Vernier Technical Support at support@vernier.com or call 888-837-6437. Support specialists will work with you to determine if the unit needs to be sent in for repair. At that time, a Return Merchandise Authorization (RMA) number will be issued and instructions will be communicated on how to return the unit for repair.

Accessories/Replacements

Item	Order Code
Storage Solution Bottles, pkg of 5	BTL
Standard High Nitrate ISE Solution	NO3-HST
Standard Low Nitrate ISE Solution	NO3-LST
Nitrate Replacement Module	NO3-MOD
Go Direct Ion-Selective Electrode Amplifier	GDX-ISEA

Warranty

Warranty information for this product can be found on the Support tab at **www.vernier.com/gdx-no3-bnc**

General warranty information can be found at **www.vernier.com/warranty**

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