Go Direct® Chloride Ion-Selective Electrode BNC

(Order Code GDX-CL-BNC)

The Go Direct Chloride Ion-Selective Electrode BNC is used to measure the concentration of chloride (Cl^-) ions in aqueous samples. It is designed to be used with the Vernier Go Direct Electrode Amplifier (order code GDX-EA). Chloride ions are found in freshwater samples as a result of water flowing over salt-containing minerals. These salts might include either sodium chloride (NaCl) or potassium chloride (KCl). The EPA maximum contamination level for chloride concentration in drinking water is 250 mg/L. The chloride ion concentration in seawater is approximately 19,400 mg/L—well below the upper limit of the Chloride ISE of 35,500 mg/L.

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

- Ion-Selective Electrode, packed in a storage bottle with a damp sponge
- 30 mL bottle of High Standard solution with SDS (1000 mg/L Cl^-)
- 30 mL bottle of Low Standard solution with SDS (10 mg/L Cl^-)
- 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 2, 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.

Note: Do not completely submerge the sensor. The BNC connection is not waterproof.

Preparing the Chloride 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. 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 Chloride ISE to stabilize. If you know the approximate concentrations of your samples, it is best to analyze them from lowest concentration to highest.

Specifications

Range (mV)	–1000 mV to +1000 mV
Range (concentration)	1 to 35,000 mg/L (or ppm)
Reproducibility (precision)	±30 mV
Interfering ions	CN^-, Br^-, I^-, OH^-, S^{2-}, NH_3
pH range	2–12 (no pH compensation)
Temperature range	0–80°C (no temperature compensation)
Electrode slope	–56 ±3 mV/decade at 25°C

Electrode resistance	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:

- CL-LST: Chloride Low Standard, 10 mg/L
- CL-HST: Chloride High Standard, 1000 mg/L

To prepare your own standard solutions, use the information in the following 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
Chloride High Standard	1000 mg/L as Cl–	1.648 g NaCl / 1 L solution
Chloride Low Standard	10 mg/L as Cl–	Dilute the High Standard by a factor of 100 (from 1000 mg/L to 10 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 the previous step with 900 mL of distilled water. Mix well.

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 Cl^- 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 1mg/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 Cl– standard	288 mV
10 mg/L Cl– standard	230 mV
1000 mg/L Cl–standard	114 mV
unknown sample	188 mV

$$S_m = -\frac{(230\text{ mV} - 114\text{ mV})}{2\text{ decades}} = -58\text{ mV/decade}$$

$$C = 10^{\wedge}[(188\text{ mV} - 288\text{ mV}) / -58\text{ mV/decade}] = 53\text{ mg/L } Cl^-$$

Troubleshooting

Sampling Freshwater Samples for Chloride Concentration

For best results, calibrate the Chloride ISE using the 10 mg/L and 1000 mg/L standards.

Measuring Chloride Concentration of Saltwater or Brackish Water

When measuring chloride concentration in seawater or brackish water, calibrate the Chloride ISE using the 1000 mg/L standard included with your Chloride ISE for one calibration point (or 1.806 parts per thousand, or ppt). For the second calibration point, prepare a standard that is 20,000 mg/L Cl^- by adding 32.96 g of solid NaCl to enough distilled water to prepare 1 L of solution:

$$\frac{2000\text{ mg }Cl^-}{1\text{ L}} \, \frac{1\text{ g }Cl^-}{1000\text{ mg }Cl^-} \times \frac{58\text{ g NaCl}}{355\text{ g }Cl^-} = 32.96\text{ g NaCl/L solution}$$

If you are calibrating in ppt, call this solution 36.13 ppt.

Determining Salinity of Saltwater or Brackish Water

Salinity is the total of all salts dissolved in water, expressed either as mg/L (equal to parts per million, ppm) or in parts per thousand (ppt). Seawater contains a fairly constant quantity of chloride ions. From your measurement of chloride ion concentration (in the previous section), salinity can be calculated using the following formula:

$$\text{Salinity (mg/L or ppm)} = 1.8066 \times [Cl^-\text{ concentration, mg/L}]$$

Using this formula, the salinity of saltwater is calculated to be:

$$\text{Salinity (mg/L or ppm)} = 1.8066 \times (19400\text{ mg/L}) = 35{,}000\text{ mg/L}$$

The level of salinity of seawater in parts per thousand, or ppt, would be:

$$\text{Salinity (ppt)} = 35000 / 1000 = 35\text{ ppt}$$

Using Ionic Strength Adjuster Solutions to Improve Accuracy

For optimal results at low concentrations of chloride ions, a standard method for taking measurements with the Chloride 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 Chloride 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.

Use an ISA with the Chloride ISE by adding 5.0 M $NaNO_3$ ISA solution (42.50 g $NaNO_3$ / 100 mL solution) to the Cl^- standard or to the solution being measured, in a ratio of 1 part of ISA (by volume) to 50 parts of the 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).

When the response of the Chloride ISE begins to slow, the membrane may need polishing. Cut a small piece (about 1 inch square) from a polishing strip. Wet the end of the electrode and the dull side of the polishing strip thoroughly with distilled water. Using only moderate pressure, polish the end of the electrode by gently rubbing it in a circular motion. This will remove the inactive layer of the membrane which impedes measurement. Rinse thoroughly with distilled water and recalibrate in the usual manner.

See general tips for using Ion Selective Electrodes at **www.vernier.com/til/665**

Repair Information

If you have followed the troubleshooting steps and are still having trouble with your Go Direct Chloride 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
Standard High Cl ISE Solution	CL-HST
Standard Low Cl ISE Solution	CL-LST
Storage Solution Bottles, pkg of 5	BTL

Warranty

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

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

Vernier

Vernier Science Education
13979 SW 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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