

# User Guide

Residual Chlorine  
Ion Selective  
Electrode



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This publication supersedes all previous publications on this subject.

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# Introduction

This user guide contains information on the preparation, operation and maintenance for the residual chlorine ion selective electrode (ISE). General analytical procedures, electrode characteristics and electrode theory are also included in this user guide. Residual chlorine electrodes measure all forms of total residual chlorine (free chlorine, hypochlorites and chlorine bound to nitrogenous compounds) in aqueous solutions quickly, simply, accurately and economically.

The measurement of residual chlorine in drinking water and wastewater using an ion selective electrode is an approved EPA method, EPA No. 330.5. This method permits rapid analysis to be done at the sampling site, eliminating erroneous low readings due to chlorine loss. Samples not measured immediately are subject to chlorine loss due to reaction with oxidizable species in the sample.

Measurements with the residual chlorine electrode require the addition of two reagents to the sample before measurement. The electrode has a slope of about +29 mV per decade change in concentration.

Technical Support Chemists can be consulted for assistance and troubleshooting advice. Within the United States call 1.800.225.1480 and outside the United States call 978.232.6000 or fax 978.232.6031. In Europe, the Middle East and Africa, contact your local authorized dealer. For the most current contact information, visit [www.thermo.com/contactwater](http://www.thermo.com/contactwater).

For the latest application and technical resources for Thermo Scientific Orion products, visit [www.thermo.com/waterapps](http://www.thermo.com/waterapps).

## **Residual Chlorine Solid State Combination ISE, Cat. No. 9770BNWP and 9770SC**

The residual chlorine combination electrode has the sensing and reference half-cells built into one electrode, which decreases the amount of required solutions and reduces waste. The residual chlorine combination electrode is available with a waterproof BNC connector, Cat. No. 9770BNWP, or a screw cap connector, Cat. No. 9770SC. Electrodes with a waterproof BNC connector can be used on any ISE or mV meter with a BNC connection. Electrodes with a screw cap connector require a separate cable.

# Required Equipment

1. Thermo Scientific Orion ISE meter, such as the 4-Star pH/ISE meter or 5-Star pH/ISE/DO/conductivity meter; equivalent ISE meter; or mV meter with a 0.1 mV resolution.
2. Thermo Scientific Orion residual chlorine electrode.
3. Magnetic stirrer or Thermo Scientific Orion stirrer probe, Cat. No. 096019. The stirrer probe can be used with 3-Star, 4-Star and 5-Star benchtop meters.
4. Volumetric flasks, graduated cylinders and beakers.
5. Storage bottles for calibration standards. Use 4 oz. amber glass wide-mouth packer bottles with screw on caps.
6. Distilled or deionized water.

To prepare standards and other chlorine solutions, distill an alkaline potassium permanganate solution to eliminate either free chlorine or chlorine demand from the water. Usually, a spatula of the potassium permanganate is adequate.

**Note:** *Water distilled from chlorinated tap water without alkaline permanganate will contain dissolved chlorine, which will yield erroneous results.*

7. 100 ppm as Cl<sub>2</sub> calibration standard, Cat. No. 977007.

The 100 ppm as Cl<sub>2</sub> calibration standard is actually a potassium iodate solution. Iodate is an oxidizing agent that reacts as if it were chlorine, but unlike chlorine it can be made into a stable solution for use as a calibration standard. For the best results, only use this standard as directed in this user guide.

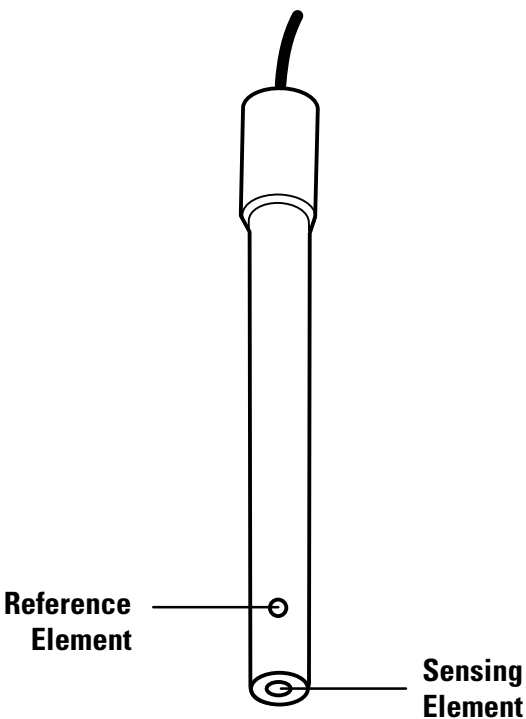
8. Acid reagent, Cat. No. 977011 – Adjusts the pH of the sample and standardizing solutions.
9. Iodide reagent, Cat. No. 977010 – Reacts to form free iodine.
10. Chlorine water (approximately 100 ppm as Cl<sub>2</sub>) – Dilute 1 mL of a 5 % hypochlorite solution (such as household bleach) to 500 mL with distilled water.

# Electrode Setup

## Residual Chlorine Electrode Preparation

Remove the protective shipping cap from the sensing element and save the cap for storage.

**Figure 1**  
**Residual Chlorine Electrode**



## Checking Electrode Operation (Slope)

These are general instructions that can be used with most meters to check the electrode operation. Refer to the meter user guide for more specific information.

This procedure measures electrode slope. Slope is defined as the change in millivolts observed with every tenfold change in concentration. Obtaining the slope value provides the best means for checking electrode operation.

**Note:** *Because the concentration of the chlorine water used in this procedure is only approximately known, do not use it as a calibration solution. Use it only for this procedure. Use the residual chlorine standard, Cat. No. 977007, for calibrations.*

1. If the electrode has been stored dry, prepare the electrode as described in the **Electrode Preparation** section.
2. Connect the electrode to a meter with a mV mode. Set the meter to the mV mode.
3. Add 100 mL of distilled water, 1 mL of iodide reagent, 1 mL of acid reagent and 1 mL of chlorine water to a 150 mL beaker. Gently stir the solution for two minutes and then stop stirring.
4. Rinse the electrode with distilled water and place the electrode into the solution prepared in step 3.
5. When a stable reading is displayed, record the electrode potential in millivolts.
6. Add 10 mL of chlorine water to the same beaker, gently stir the solution for two minutes and then stop stirring.
7. When a stable reading is displayed, record the electrode potential in millivolts.
8. There should be a 25 to 30 mV difference between the two millivolt readings when the solution temperature is between 20 to 25 °C. If the millivolt potential is not within this range, refer to the **Troubleshooting** section.



## Measurement Units

Chlorine concentration can be measured in moles per liter (M), parts per million (ppm) or any convenient concentration unit.

**Table 1**  
**Concentration Unit Conversion Factors**

Moles/Liter (M)	ppm
1.0	35500
$10^{-1}$	3550
$2.8 \times 10^{-2}$	1000
$10^{-2}$	355
$10^{-3}$	35.5
$10^{-4}$	3.55
$2.8 \times 10^{-5}$	1

## Sample Requirements

The epoxy body of the residual chlorine electrode is resistant to damage by aqueous solutions. The electrode may be used intermittently in solutions that contain methanol, benzene or acetone. Contact Technical Support for information on using the electrode for specific applications.

The solution temperature must be less than 50 °C.

## Measuring Hints

- Always wait at least two minutes for the iodide reagent, acid reagent and residual chlorine standard or sample to react before measuring or diluting the solution.
- Always rinse the electrode with distilled water between measurements and shake the electrode to remove the water and prevent sample carryover. Do not wipe or rub the electrode sensing element.
- Stir standards and samples during the two minute waiting period after the acid and iodide reagents are added.
- Do not stir standards and samples when the electrode is measuring the solutions.
- Always use freshly prepared standards for calibration.
- Store the calibration standards in 4 oz. amber glass wide-mouth packer bottles with screw-on caps.
- Measure samples as soon after collection as possible to avoid chlorine loss.
- Concentrated samples should be diluted before measurement.
- Make sure that the reference element on the electrode is fully immersed in the standard or sample.
- After immersing the electrode in a solution, check the electrode sensing surface for air bubbles and remove air bubbles by reimmersing the electrode in the solution and gently tapping it.
- Verify the electrode calibration every two hours by placing the electrode in a fresh aliquot of the least concentrated standard used for calibration. If the value has changed by more than 2%, recalibrate the electrode.

## Electrode Storage

Thoroughly rinse the electrode with deionized water and store the electrode dry.

For storage longer than one week, thoroughly rinse the electrode with deionized water and store the electrode dry with the protective shipping cap covering the sensing element.

## Electrode Maintenance

### Polishing the Residual Chlorine Electrode

The sensing surface of solid state electrodes can wear over time, which causes drift, poor reproducibility and loss of response in low level samples. The electrode can be restored by polishing the sensing surface with a polishing strip, Cat. No. 948201. The polishing strip can also be used if the sensing surface has been etched or chemically poisoned.

1. Cut off about an inch of the polishing strip.
2. Hold the electrode with the sensing surface facing up.
3. Place a few drops of distilled water on the sensing surface.
4. With the frosted side of the polishing strip facing down, use light finger pressure to place the polishing strip on top of the sensing surface.
5. Rotate the electrode for about 30 seconds.
6. Rinse the electrode with distilled water and soak the electrode in a 1 ppm or  $10^{-5}$  M chlorine standard for ten minutes.

# Analytical Techniques

A variety of analytical techniques are available to the analyst. The following is a description of these techniques.

**Direct Calibration** is a simple procedure for measuring a large number of samples. Only one meter reading is required for each sample. Calibration is performed using a series of standards prepared from a known potassium iodate solution. Iodate is used for standardization because chlorine and hypochlorite standards are difficult to prepare and are unstable. The standardizing solution is made from known amounts of iodate, iodide reagents, and acid reagent. The acid reagent produces the optimal pH for the oxidation/reduction reaction needed to form free iodine.

The concentration of the samples is determined by comparison to the standards. Samples are prepared by adding the iodide reagent and acid reagent. The chlorine in the samples reacts with iodide to form iodine, which is measured by the electrode. Accurate measurements require the proper ratio of iodide to sample chlorine concentration. The standard direct calibration procedure is used for samples in the range of 0.2 to 20 ppm chlorine. Samples above 20 ppm should be diluted before measurement.

**Low Level Calibration** is similar to the direct calibration technique. This method is recommended when the expected sample concentration is less than 0.2 ppm chlorine. A minimum three point calibration is recommended to compensate for the electrode's non-linear response at these concentrations. A special calibration standard preparation procedure is the best means of preparing low level calibration standards.

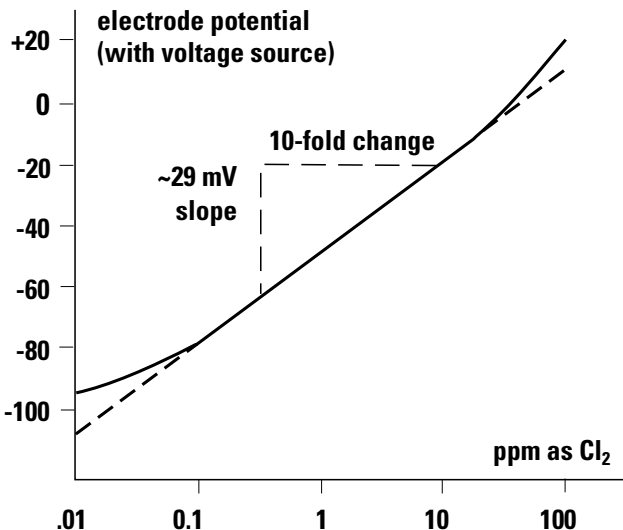
# Direct Calibration Technique

## Typical Direct Calibration Curve

In the direct calibration procedure, a calibration curve is constructed by measuring iodine produced by reaction between chlorine solutions and the iodide reagent in an acid medium. Electrode potentials developed in the iodine-containing solutions measured and plotted either in the meter memory or on semi-logarithmic paper (linear axis) against the chlorine concentration (logarithmic axis). The curve is linear between about 0.2 ppm and 20 ppm chlorine.

The direct calibration procedure is given for concentrations in the region of linear electrode response. Below about 0.2 ppm, the curve becomes non-linear because of iodine present in the iodide reagent. Low level procedures are given in a following section for measurements in the non-linear electrode region. If a blank correction is subtracted from the reading, a linear response curve is obtained. Above about 20 ppm, the background iodide level changes, and a non-linear response is seen. Samples above 20 ppm should be diluted before measurement. Samples may be measured without dilution if some inaccuracy is permissible. At 50 ppm chlorine, results will be about 20% higher and at 25 ppm, results will be about 8% higher.

**Figure 2**  
**Typical Electrode Response to Chlorine (Iodide and Acid Reagents Added to Solutions)**



## Direct Calibration Overview

The following direct measurement procedures are recommended for moderate level measurements. Samples must be in the linear range of the electrode – between 0.2 ppm and 20 ppm chlorine. A one point calibration is sufficient, although more points can be used. When using an ISE meter, sample concentrations can be read directly from the meter. When using a mV meter, a calibration curve can be prepared on semi-logarithmic graph paper, or a linear regression (against logarithmic concentration values) can be performed using a spreadsheet or graphing program.

## Direct Calibration Setup

1. Prepare the electrode as described in the **Electrode Preparation** section.
2. Connect the electrode to the meter.
3. Add 1 mL of the 100 ppm as Cl<sub>2</sub> standard, 1 mL of acid reagent and 1 mL of iodide reagent to a 150 mL beaker and stir the solution thoroughly. Let the solution stand for two minutes to allow for a complete reaction of the reagents.
4. Add 99 mL of distilled water and stir the solution thoroughly.
5. Store the prepared 1 ppm standard solution in an amber, stoppered storage bottle. Prepare a fresh solution daily. For the best results, prepare the 1 ppm standard solution every time you calibrate and verify the calibration.

**Note:** *To prepare standards and other chlorine solutions, distill an alkaline potassium permanganate solution to eliminate either free chlorine or chlorine demand from the water. Usually, a spatula of the potassium permanganate is adequate. Water distilled from chlorinated tap water without alkaline permanganate will contain dissolved chlorine, which will yield erroneous results.*

**Note:** *Always mix the acid reagent, iodide reagent and standard or sample and allow two minutes for the reaction to occur before diluting the solution with distilled water. The reaction between iodate and iodide in an acid solution is extremely slow after dilution is performed.*

## Direct Calibration Procedure Using a Meter with an ISE Mode

**Note:** See the meter user guide for more specific information.

1. Determine the electrode slope by performing the procedure in the **Checking Electrode Operation (Slope)** section.
2. Rinse the electrode with distilled water, blot it dry and place it into the amber storage bottle with the 1 ppm standard solution.
3. Wait for a stable reading and adjust the meter to display the value of the standard, as described in the meter user guide.
4. Set the meter to the slope value obtained from the **Checking Electrode Operation (Slope)** section.
5. Remove the electrode from the amber bottle, rinse the electrode with distilled water, blot it dry and seal the amber bottle with the stopper.
6. Add 100 mL of sample, 1 mL of acid reagent and 1 mL of iodide reagent to a clean 150 mL beaker and stir the solution thoroughly. Let the solution stand for two minutes to allow for a complete reaction of the reagents.
7. Rinse the electrode with distilled water, blot it dry and place it into the sample. The concentration of the sample will be displayed on the meter.

**Note:** For samples with a concentration above 20 ppm, dilute the sample so the concentration is between 0.2 and 20 ppm. Measure the diluted sample as described in the Direct Calibration Procedure Using a Meter with an ISE Mode section and multiply the concentration of the sample by the dilution factor.

## Direct Calibration Procedure Using a Meter with a mV Mode

**Note:** See the meter user guide for more specific information.

1. Determine the electrode slope by performing the procedure in the **Checking Electrode Operation (Slope)** section.
2. Set the meter to the mV mode.
3. Rinse the electrode with distilled water, blot it dry and place it into the amber storage bottle with the 1 ppm standard solution.
4. Wait for a stable reading and record the stable mV value and corresponding standard concentration.
5. Remove the electrode from the amber bottle, rinse the electrode with distilled water, blot it dry and seal the amber bottle with the stopper.
6.
  - a. Using semi-logarithmic graph paper, prepare a calibration curve by plotting the millivolt value on the linear axis and the standard concentration value on the logarithmic axis.
  - b. At the concentration value of 10 ppm, plot a mV value that is obtained by adding the slope value obtained from the **Checking Electrode Operation (Slope)** section to the mV value obtained from the 1 ppm standard solution.
  - c. Draw a straight line through the two points.  
See **Figure 3**.

**Note:** The slope is shown in the units of mV per decade and the graph is plotted across one decade of concentration.

7. Add 100 mL of sample, 1 mL of acid reagent and 1 mL of iodide reagent to a clean 150 mL beaker and stir the solution thoroughly. Let the solution stand for two minutes to allow for a complete reaction of the reagents.
8. Rinse the electrode with distilled water, blot it dry and place it into the beaker. When a stable reading is displayed, record the mV value.
9. Using the calibration curve prepared in step 6, determine the unknown concentration of the sample.

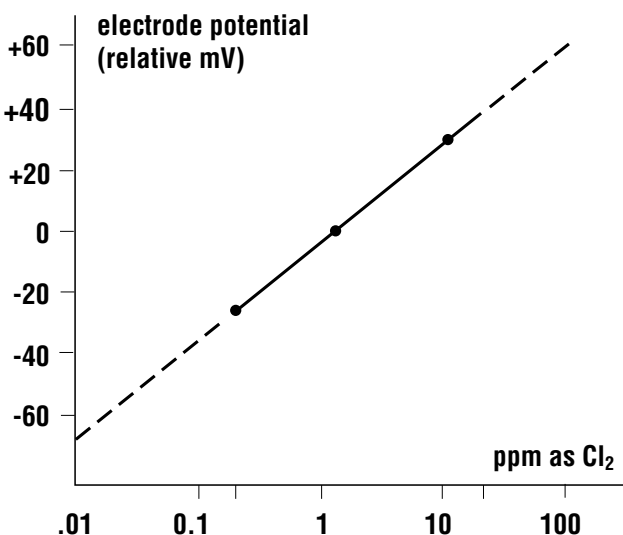


**Note:** For samples with a concentration above 20 ppm, dilute the sample so the concentration is between 0.2 and 20 ppm. Measure the diluted sample as described in the Direct Calibration Procedure Using a Meter with a mV Mode section and multiply the concentration of the sample by the dilution factor.

**Figure 3**

**Typical Plotted Calibration Curve**

Measurements are in the range of 0.2 to 20 ppm with an electrode slope of 29 mV/decade



# Low Level Calibration Technique

These procedures are for solutions that have a chlorine concentration of less than 0.2 ppm chlorine. Although electrode response deviates from a straight line below 0.2 ppm, measurements can be made by subtracting a blank correction from the apparent concentration reading from the specific in meter or the calibration curve.

Accurate results require that adequate time is allowed for electrode stabilization. Longer response time will be needed at low level measurements.

**Note:** *To prepare standards and other chlorine solutions, distill an alkaline potassium permanganate solution to eliminate either free chlorine or chlorine demand from the water. Usually, a spatula of the potassium permanganate is adequate. Water distilled from chlorinated tap water without alkaline permanganate will contain dissolved chlorine, which will yield erroneous results.*

**Note:** *Always mix the acid reagent, iodide reagent and standard or sample and allow two minutes for the reaction to occur before diluting the solution with distilled water. The reaction between iodate and iodide in an acid solution is extremely slow after dilution is performed.*

## Low Level Setup

1. Prepare the electrode as described in the **Electrode Preparation** section.
2. Connect the electrode to the meter.
3. Prepare a blank solution by adding 100 mL distilled water, 1 mL of iodide reagent and 1 mL of acid reagent to a clean 150 mL beaker and stir the solution thoroughly. Let the solution stand for two minutes to allow for a complete reaction of the reagents.

## Low Level Procedure Using a Meter with an ISE Mode

1. Rinse the electrode with distilled water, blot it dry and place it into the blank solution.
2. If a meter with an ISE mode and a blank correction setting is used, set the blank as described in the meter user guide.
3. Perform the procedure in the **Direct Calibration Procedure Using a Meter with an ISE Mode** section.
4. If a meter with an ISE mode and a blank correction setting is used, the meter will automatically correct the concentration of low level samples.

## Low Level Procedure Using a Meter with a mV Mode

1. Rinse the electrode with distilled water, blot it dry and place it into the blank solution.
2. If a meter with a mV mode is used, set the meter to the mV mode, wait for a stable reading and record the mV value.
3. Perform the procedure in the **Direct Calibration Procedure Using a Meter with a mV Mode** section.
4. If a meter with a mV mode is used, determine the chlorine concentration of low level samples by subtracting the blank concentration value:

$$C = C_s - C_b$$

C = corrected sample concentration

$C_b$  = blank concentration from graph

$C_s$  = sample concentration from graph

# Electrode Characteristics

## Electrode Response

The electrode potential plotted against concentration on semi-logarithmic paper results in a straight line with a slope of about 26 to 30 mV per decade change in concentration.

The time response of the electrode (the time required to reach 99% of the stable potential reading) varies from several seconds in concentrated solutions to several minutes near the limit of detection, after the reaction between the solution and the reagents is complete.

## Reproducibility

Reproducibility is limited by factors such as temperature fluctuations, drift and noise. Within the operating range of the electrode, reproducibility is independent of concentration. With hourly calibrations, direct electrode measurements reproducible to  $\pm 2\%$  can be obtained.

## Limits of Detection

At low levels, the electrode response is non-linear because of iodine present in the iodide reagent. For low levels, samples below 0.2 ppm chlorine, refer to the **Low Level Calibration** procedure. Allow longer stabilization time prior to reading meter to assure best results.

At high levels, above 20 ppm chlorine, the background iodide level changes and a non-linear electrode response is observed. Samples above 20 ppm should be diluted before measurement.

## Temperature Effects

The electrode slope is relatively independent of temperature, making it possible to calibrate with only one standard solution. However, because the calibration curve shifts by about 0.2 mV per degree C, the standardizing solution should be close to the temperature of samples. When measurements are made in the field, allow the standard solution used for calibration to reach the same temperature as the samples before calibration.

The electrode can be used at temperatures from 0 to 50 °C, provided that temperature equilibrium has occurred. For use at temperatures substantially different from room temperature, calibration standards should be at the same temperature as samples. The electrode must be used only intermittently at solution temperatures above 50 °C.

## Interferences

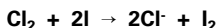
Strong oxidizing agents that can convert iodide to iodine (including iodate, bromine, cupric ion and manganese dioxide) interfere with ISE residual chlorine measurements. These are interferences in all iodometric ASTM methods.

Silver and mercuric ion concentrations must be below  $10^{-4}$  M (about 10 to 20 ppm) in the sample.

Chromate ions, an interference for the amperometric method, do not interfere with ISE residual chlorine measurements. Color and turbidity are not interferences.

## Theory of Operation

The electrode method is based on iodometric measurements of chlorine. An iodide reagent and an acid reagent are added to a sample, and the iodide reacts completely with the chlorine to form iodine.



The iodine concentration after reaction is equal to the chlorine concentration before reaction. Acid must be present for the conversion of chloramines to iodine.

The electrode contains a platinum (redox) sensing element and iodide-sensing reference element. The platinum element develops a potential that depends on the relative levels of iodine and iodide ion in solution.

$$E_1 = E_0 + (S/2) \log ([\text{I}_2] / [\text{I}^-])$$

$$E_1 = E_0 + (S \log [\text{I}_2] - S \log [\text{I}^-]) / 2$$

$E_1$  = potential developed by the platinum element

$E_0$  = a constant

$S$  = monovalent electrode slope (58 mV/decade at 25 °C)

$[\text{I}_2]$  = iodine concentration

$[\text{I}^-]$  = iodide concentration

The iodine-sensing element develops a potential that depends on the iodide level in solution.

$$E_2 = E_0' - S \log [\text{I}^-]$$

$E_2$  = potential developed by the iodide-sensing element

$E_0'$  and  $E_0''$  = constants

The meter measures the difference between the potentials developed by the two elements:

$$E_1 + E_2 = E_0'' - (S \log [I^-] / 2)$$

The combination of the platinum and the iodide-sensing elements measures the iodine concentration, which is equal to the total residual chlorine concentration before reaction with the iodide reagent.

One deviation from the theory of operation is important. The iodine formed by reaction combines with iodide ion to form the complex  $I_3^-$ . As long as iodide is in large excess over  $I_2$  is formed, iodide loss due to  $I_3^-$  formation is negligible. When this loss is not negligible, electrode response deviates from the linear response. Using the iodide reagent as directed, the total iodide concentration in samples and standardizing solutions is adequate to produce a linear response up to 20 ppm chlorine. Diluting more concentrated samples brings the level into the region of linear response.

# Troubleshooting

Follow a systematic procedure to isolate the problem. The measuring system can be divided into components for ease in troubleshooting: meter, electrode, sample/application, technique and voltage source.

## Meter

The meter is the easiest component to eliminate as a possible cause of error. Thermo Scientific Orion meters include an instrument checkout procedure and shorting cap for convenience in troubleshooting. Consult the meter user guide for directions.

The normal millivolt (mV) reading of the residual chlorine electrode is about 600 mV. Some meters may not be able to calibrate in the direct concentration (ISE) mode with mV readings this far from zero. If the meter will not calibrate, use a Thermo Scientific Orion ISE meter, such as the 4-Star pH/ISE meter or 5-Star pH/ISE/DO/conductivity meter, or use a mV meter with a 0.1 mV resolution.

## Electrode

1. Rinse the electrode thoroughly with distilled water.
2. Verify the electrode performance by performing the procedure in the **Checking Electrode Operation (Slope)** section.
3. If the electrode fails this procedure, review the **Measuring Hints** section. Clean the electrode thoroughly as directed in the **Electrode Maintenance** section.
4. Repeat the procedure in the **Checking Electrode Operation (Slope)** section.
5. If the electrode passes the procedure, but measurement problems persist, the sample may contain interferences or the technique may be in error.
6. Before replacing a faulty electrode, review this user guide and be sure to thoroughly clean the electrode; correctly prepare the electrode; use the acid and iodide reagents and correct standards; correctly measure the samples and review the **Troubleshooting Checklist** section.



## Sample/Application

The quality of results depends greatly upon the quality of the standards. Always prepare fresh standards when problems arise, it could save hours of frustrating troubleshooting! Errors may result from contamination of prepared standards, accuracy of dilution, quality of distilled water, or a mathematical error in calculating the concentrations.

The water used to prepare standards and samples must be free of chlorine and chlorine demand. Refer to the **Sample Requirements** section for instructions on the treatment of water.

The electrode and meter may operate with standards, but not with the sample. In this case, check the sample composition for interferences, incompatibilities or temperature effects. Refer to the **Sample Requirements, Temperature Effects** and **Interferences** sections.

## Technique

If trouble persists, review operating procedures. Review calibration and measurement sections to be sure proper technique has been followed. Verify that the expected concentration of the ion of interest is within the limit of detection of the electrode.

Check the method of analysis for compatibility with your sample. Direct measurement may not always be the method of choice. If working with low level samples, follow the procedure in the **Low Level Calibration** section.

## Voltage Source (U.S. Standard Connector Only)

The voltage source, Cat. No. 977001, is required for use with older residual chlorine electrodes that have a U.S. standard connector. The voltage standard offsets the electrode potential to give on-scale readings. Without the voltage source, electrode potentials of about 600 mV may be beyond the range of calibration for certain meters.

If using the voltage source, remove it from the electrode connector. Plug the pin-tip connector of the meter shorting strap into the voltage source. Connect the U.S. standard connector of the shorting strap to the sensing jack of the meter. Connect the pin-tip connector of the voltage source to the reference jack of the meter. Set the meter to the (absolute) millivolt mode. The potential reading should be approximately -600 mV. If the magnitude of the potential is less than 600 mV, replace the voltage source. The lifetime of the voltage source is one year.

## Troubleshooting Checklist

- Electrode is dirty –  
Refer to the **Electrode Maintenance** section for cleaning instructions.
- Sensing element is dirty or etched –  
Refer to the **Electrode Maintenance** section for cleaning instructions.
- Standards are contaminated or made incorrectly –  
Prepare fresh standards. Refer to the **Measurement Hints** and **Analytical Techniques** sections.
- Water used to make standards and dilute samples contaminated with free chlorine or chlorine demand –  
Distill an alkaline potassium permanganate solution to eliminate either chlorine from the water. Refer to the **Required Equipment** and **Analytical Techniques** sections.
- Acid and iodide reagents not used or used incorrectly –  
Acid and iodide reagents must be added to all standards and samples. Refer to the **Required Equipment** section for information on the acid and iodide reagents.
- Insufficient reaction with iodide reagent –  
Allow two minutes for the reaction to occur before diluting the standards and before measuring the sample.
- Oxidation of iodide or loss of iodine to air –  
Only stir the solutions to thoroughly mix them, do not stir the solutions while measuring them.
- Samples too concentrated (above 20 ppm) –  
Dilute samples with concentrations above 20 ppm before measurement and multiply the results by the dilution factor
- Samples and standards at different temperatures –  
Allow solutions to reach the same temperature.

- Air bubble on sensing element –  
Remove air bubble by reimmersing the electrode in solution.
- Electrode not properly connected to meter –  
Unplug and reconnect the electrode to the meter.
- Meter or stir plate not properly grounded –  
Check the meter and stir plate for proper grounding.
- Static electricity present –  
Wipe plastic parts on the meter with a detergent solution.
- Defective meter –  
Check the meter performance. See the meter user guide.

## **Assistance**

After troubleshooting all components of your measurement system, contact Technical Support. Within the United States call 1.800.225.1480 and outside the United States call 978.232.6000 or fax 978.232.6031. In Europe, the Middle East and Africa, contact your local authorized dealer. For the most current contact information, visit [www.thermo.com/contactwater](http://www.thermo.com/contactwater).

For the latest application and technical resources for Thermo Scientific Orion products, visit [www.thermo.com/waterapps](http://www.thermo.com/waterapps).

## **Warranty**

For the most current warranty information, visit [www.thermo.com/water](http://www.thermo.com/water).

# Ordering Information

<b>Cat. No.</b>	<b>Description</b>
9770BNWP	Residual chlorine combination electrode, waterproof BNC connector
9770SC	Residual chlorine combination electrode, screw cap connector
977007	100 ppm as Cl <sub>2</sub> residual chlorine standard, 475 mL bottle
977010	Iodide reagent, 5 x 50 mL bottles
977011	Acid reagent, 475 mL bottle
984201	Polishing strips

# Specifications

## Concentration Range

$3 \times 10^{-7}$  M to  $10^{-4}$  M (0.01 ppm to 20 ppm)

Higher concentrations may be read after dilution

## pH Range

0 to 14, samples are buffered to pH 4

## Temperature Range

0 to 50 °C continuous use, 50 to 100 °C intermittent use

## Electrode Resistance

Less than 1 megohms

## Reproducibility

± 2%

## Size

Body Diameter: 12 mm

Body Length: 110 mm

Cap Diameter: 16 mm

Cable Length: 1 meter (9770BNWP only)

*\* Specifications are subject to change without notice*

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**Thermo Fisher Scientific**

**Environmental Instruments**  
Water Analysis Instruments



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