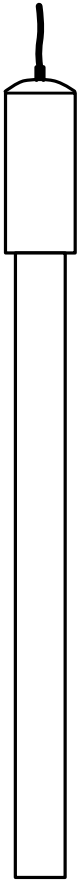
Cl_2

Orion 97-70

Orion Residual Chlorine Electrode

INSTRUCTION MANUAL



Analyze • Detect • Measure • Control™

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GENERAL INFORMATION

Introduction

The Orion 97-70 Residual Chlorine Electrode allows total residual chlorine to be measured quickly and accurately. All forms of total residual chlorine are measured: free chlorine, hypochlorites, and chlorine bound to nitrogenous compounds. This electrode method is EPA approved for drinking water and wastewater (EPA No. 330.5).

The method permits rapid analyses to be done at the sampling site, eliminating erroneous low readings due to Cl_2 loss. (Samples not measured immediately are subject to chlorine loss due to reaction with oxidizable species in the sample).

This electrode method requires the addition of two reagents to the sample before measurement. The electrode has a slope of about + 29 mV per decade increase in concentration.

Packing List

Electrode — With protective cap on tip

Voltage Source — Packed under styrofoam box (with U.S. Standard electrode only, Orion 977000)

Iodide Reagent (50 mL bottle)

Orion 97-70 Instruction Manual

Warranty Card

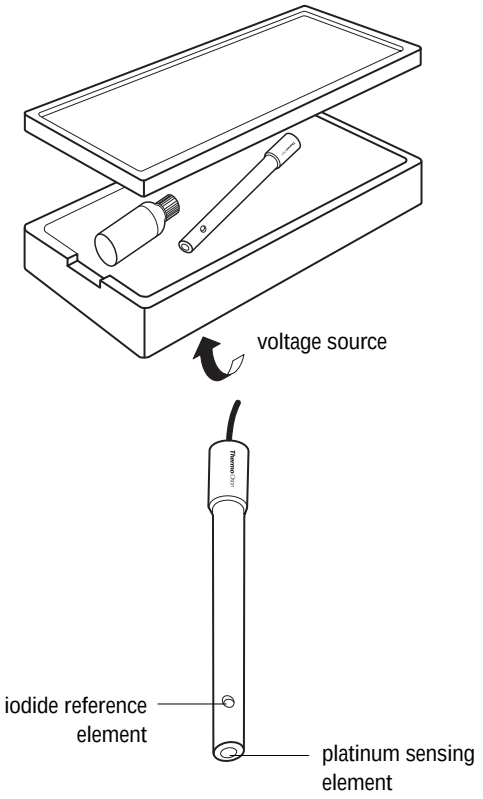

Figure 1: Orion 97-70 Total Residual Chlorine Electrode

Required Equipment

Meter

ISE meters, such as Orion EA940, 920A, 720A, 710A or 290A, offering direct concentration readout for specific ions are the easiest to use. If unavailable, use a pH/mV meter with readability to 0.1 mV, such as Orion 420A, 520A, or 525A.

Reference Electrode

None required.

Magnetic Stirrer

Micro-stir bars are recommended for small volume measurements.

Graph Paper

4-cycle semi-logarithmic paper for preparing calibration curves (for use with digital pH/mV laboratory meters)

Polishing Strips (Orion 948201)

To polish sensing and reference elements.

Voltage Source (Orion 977001)

Supplied with the U.S. Standard electrode, (voltage source located under styrofoam box). Offsets electrode potential to give on-scale readings. (Without voltage source, electrode potentials of about + 600 mV may be beyond the range of the calibration control of certain meters.)

Storage Bottle

4 oz. Amber glass wide-mouth packer bottle with screw on cap. Used to store standardizing solution.

Required Solutions

Distilled or Deionized Water

To prepare standards and solutions, distill an alkaline potassium permanganate solution to eliminate either free chlorine or chlorine demand from water. A spatula full of the potassium permanganate will suffice.

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

Standard Solutions	Orion
Residual Chlorine Standard — Potassium iodate solution, 100 ppm as Cl_2 (Iodate is an oxidizing agent that reacts as if it were chlorine,but unlike chlorine, can be made into stable solutions for use as standardizing solutions). For best results, use this standard only as directed in this manual.	977007
Acid Reagent — Adjusts the pH of the sample and standardizing solutions	977011
Iodide Reagent — Reacts to form free iodine	977010
Chlorine water (approximately 100 ppm as Cl_2). Dilute 1 mL of 5% hypochlorite solution (e.g., Clorox) to 500 mL with distilled water	Customer prepared

BEFORE USING THE ELECTRODE

Electrode Preparation

- Remove the rubber cap covering the electrode tip.
- If using an electrode with a U.S. Standard connector, attach the pin-tip connector to the voltage source (Orion 977001). Plug the pin-tip connector of the voltage source into the reference jack of the meter and plug the U.S. Standard connector of the electrode into the sensing jack of the meter.
- If using an electrode with a BNC Connector and an Orion meter, slide connector into input while pushing in and turning clockwise to lock into position.

NOTE: Most meters with BNC Connectors have sufficient mV span to work without the voltage source.

Checking Electrode Operation (Slope)

These are general instructions which can be used with most meters to check electrode operation. See individual meter instruction manuals for 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 standardizing solution. Use only for the slope check. Use the Residual Chlorine Standard (Orion 977007) for calibration only.***

- Prepare electrodes as described under **Electrode Preparation**. Non-Orion Meters may require special adapters. Consult your meter instruction manual.
- Place 100 mL distilled water in a 150 mL beaker. Add 1 mL iodide reagent and 1 mL acid reagent.
- Add 1 mL chlorine water to beaker and stir gently for two minutes to allow complete reaction. Set the function switch of the meter to the mV mode.
- Rinse electrode and place in solution prepared in step 3 with the reference element submerged. Do not stir. When a stable mV reading is displayed, record the electrode potential in millivolts.
- Add 10 mL chlorine water to the beaker. Stir gently for two minutes to allow complete reaction, then stop stirring.
- When a stable mV reading is displayed, record the electrode potential in millivolts.
- The difference between the first and second potential reading is defined as the slope of the electrode. The slope should be in the range of 26-30 mV/decade. If the difference in potential is not within this range, refer to **Troubleshooting Section**.

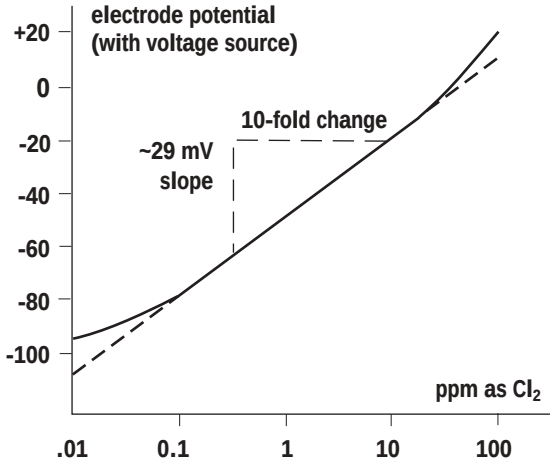

Figure 2: Typical Electrode Response to Chlorine (Iodide and Acid Reagents Added to Solutions)

The curve was 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 are plotted on the linear axis of semilogarithmic graph paper against chlorine concentration (Cl_2) on the logarithmic axis. The curve is linear between about 0.2 ppm and 20 ppm Cl_2.

Below about 0.2 ppm, the curve becomes non-linear because of iodine present in the iodide reagent. If a blank correction (see **Low-level Measurement**) is subtracted from the reading, a linear response curve is obtained (dashed line). 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 Cl_2, results will be about 20% high; at 25 ppm, results will be about 8% high.

Helpful Information

Units of Measurement

Total residual chlorine is conveniently measured in units of ppm as Cl_2 (mg as Cl_2/L). Other units such as moles per liter or grains per gallon can be used.

Sample Requirements

The epoxy electrode body is resistant to attack by inorganic solutions. The electrode may be used intermittently in solutions containing methanol, benzene, or acetone. Consult Thermo Electron's Technical Service Chemists for use of electrode in specific applications.

Temperature must be less than 100 °C.

Measuring Hints

- Always allow two minutes for sample, iodide reagent, and acid reagent to react before measuring.
- Always allow about two minutes for iodide reagent, acid reagent, and residual chlorine standard to react before diluting.
- Always rinse electrode with deionized water after measurement. Blot electrode dry with a clean, dry tissue after each measurement to prevent solution carryover.
- Store the 1 ppm standardizing solution in 4-oz. Amber glass, wide-mouth packer bottle with screw-on cap. Verify calibration every two hours by inserting the electrode into the bottle.
- Prepare 1 ppm standardizing solution fresh daily.
- Do not stir during measurement.
- Measure samples as soon after collection as possible to avoid chlorine loss.
- If electrode becomes sluggish and drifty, it may be coated with a deposit. Soak electrode in a mild laboratory detergent and water mixture for approximately 10 minutes. Rinse well. If electrode does not respond to cleaning, or if the electrode has been exposed to mercury ions, polish the elements with Orion Polishing Strips (Orion 948201).

  To polish: cut off a one-inch length of paper and wet the frosted side. Using a circular motion, polish the sensing and reference elements for about 30 seconds each. Rinse and soak in distilled water for about five minutes before use.
- For best reproducibility, prepare standards and samples using the same time interval for the reaction (e.g., two minutes).
- 1 ppm KIO_3 acts as Cl_2. It is not recommended to use any other solution.
- When using a meter without a voltage source and an error occurs during calibration, scroll value onto display.
- Make sure that the reference element on the electrode is immersed into the sample.

ANALYTICAL PROCEDURES

Direct Calibration

A simple procedure for measuring a large number of samples. Only one meter reading is required for each sample. Calibration is performed with a residual chlorine standardizing solution prepared from a known potassium iodate solution. Iodate is used for standardization because chlorine or 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.

Samples are prepared for measurement by adding iodide reagent and acid reagent. Chlorine in the samples reacts with iodide to form iodine, which is, in turn, measured by the electrode.

Accurate measurement requires the proper ratio of iodide to sample chlorine concentration. The standard procedure given below is used for samples in the range of 0.2 to 20 ppm Cl_2. Samples above 20 ppm Cl_2 should be diluted before measurement.

For Samples Between 0.2 and 20 ppm

Setup (1 ppm standardizing solution)

1. Remove the rubber cap covering the electrode tip.
2. Connect electrodes to the meter.
3. Pipet 1 mL residual chlorine standard (100 ppm as Cl_2), 1 mL acid reagent, and 1 mL iodide reagent into a 150 mL beaker. Use only 1 mL of each solution, and do not add water. Mix thoroughly and allow to stand for two minutes to allow complete reaction.
4. Add 99 mL distilled water and mix thoroughly.
5. Store this 1 ppm standardizing solution in the brown, stoppered storage bottle for calibration. Prepare a fresh solution every day. For best results, prepare a 1 ppm standardizing solution each time you calibrate and check calibration.

NOTE: Always mix the three reagents and allow two minutes for reaction before diluting with distilled water. The reaction between iodate and iodide in an acid solution is extremely slow after dilution.

Using a Meter with Direct Concentration Readout

See individual meter instruction manuals for more specific information.

1. Rinse electrode with deionized water, blot dry, and place in bottle containing 1 ppm standardizing solution.
2. Set the slope on the meter to the slope value determined in the daily slope check.
3. Wait for a stable reading, then calibrate the meter to display the value of the standard (1 ppm) as described in the meter instruction manual.
4. Remove electrode from solution and blot dry. Replace cap on storage bottle.
5. Transfer 100 mL sample to a 150 mL beaker. Add 1 mL of acid reagent and 1 mL of iodide reagent. Mix thoroughly and let stand for about two minutes to allow complete reaction.
6. Place electrode in sample so that the reference element is submerged. Read chlorine concentration in ppm directly from the mater.

Using a Meter with Millivolt Readout Only

1. Adjust the meter to measure mV.

2. Rinse electrode with deionized water, blot dry, and place in bottle containing 1 ppm standardizing solution.

3. Wait for a stable reading to be displayed and record the mV value.

4. Using a semilogarithmic graph paper, prepare a calibration curve by plotting the millivolt value on the linear axis and the standard concentration value on the logarithmic axis.

5. Plot a second point on the graph as follows:

   At the concentration value of 10 ppm: Plot a mV value which is obtained by adding the slope value obtained in the daily slope check to the mV value obtained from the 1 ppm standardizing solution.

   Draw a line through the two points (see **Figure 3**).

   NOTE: Slope value is mV/decade and you are plotting across 1 dec of concentration.

6. Remove the electrode from the solution. Blot dry. Replace the cap on the storage bottle.

7. Transfer 100 mL sample to a 150 mL beaker. Add 1 mL of iodide reagent and 1 mL of acid reagent. Mix thoroughly and let stand for about two minutes to allow complete reaction.

8. Place the reference electrode in the sample so that the reference element is submerged. Record the mV reading. Determine the total residual chlorine level in the sample from the calibration curve.

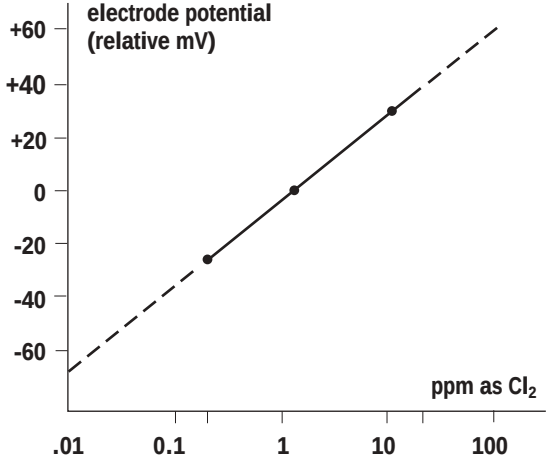

Figure 3: Plotting a Calibration Curve for Measurements in the Range 0.2 to 20 ppm for an Electrode Slope of 29 mV/Decade

Low-Level Measurement

This procedure is for samples below 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.

Setup

1. Prepare a blank: Take 100 mL of the distilled water used to prepare all solutions. Add 1 mL of iodide reagent and 1 mL of acid reagent. Mix thoroughly and let stand for two minutes to allow complete reaction.

2. Rinse electrodes with deionized water, blot dry and place in solution prepared in step 1.

   If using a meter with direct concentration readout capability and blank correction: Set blank according to meter instruction manual.

   If using a meter with a millivolt readout only: Record the mV value in the blank solution.

Measurement

Use direct calibration procedure for your meter type.

For meters with millivolt readout only: Determine the chlorine concentration by subtracting the blank correction:

$$C = C_s - C_b$$

where:
C_b = blank concentration from graph
C_s = sample concentration from graph

For Samples Above 20 ppm

Dilute samples so that the concentration will be between 0.2 and 20 ppm. Measure the diluted sample as described under direct calibration procedure for your meter type and multiply concentration by the dilution factor.

Electrode Storage

Rinse electrode and store dry.

TROUBLESHOOTING

Troubleshooting Checklist

Symptom	Possible Causes
Off-scale or Over-range reading	Defective meter
	Electrodes not plugged in properly
	Voltage source not used (where required)
	Voltage source faulty
Noisy or unstable readings (readings	Defective meter
	Meter or stirrer not grounded
Drift (Reading slowly changing in one direction)	Insufficient reaction with iodide reagent
	Oxidation of iodide or loss of iodine to air
	Sensing or reference element dirty or etched
	Stirring during measurement
	Residual chlorine standard added to sample
"Wrong Answer"	Sample too concentrated (above 20 ppm)
	Standardizing solution oxidized
	Electrode malfunction (all measurements are 1 ppm)
	Incorrect sign
	Distilled water contaminated
	Dilution error (samples above 20 ppm)

Troubleshooting Checklist

Solution
Perform meter checkout procedure
Unplug electrode and reset
Attach voltage source to pin-tip electrode connector
Check voltage source
Perform meter checkout procedure (See meter instruction manual)
Check meter and stirrer for grounding
Allow two minutes for reaction before diluting standards or before measuring sample
Stir solutions only to mix thoroughly
Clean sensing element (see **Measuring Hints**)
Stir solutions only to mix; do not stir during measurement
Add only iodide and acid reagent to sample
Dilute samples above 20 ppm before measurement
Prepare fresh standardizing solution daily
Check electrode slope (see **Checking Electrode Operation**)
Be sure to note sign of millivolt reading correctly
Prepare fresh distilled water
Multiply result by correct dilution factor

Troubleshooting Guide

The most important principle in troubleshooting is to isolate the components of the system and check each in turn. The components of the system are: 1) Meter, 2) Electrodes, 3) Voltage Source, 4) Standard, 5) Water, and 6) Sample.

Meter

The meter is the easiest component to eliminate as a possible cause of error. Orion meters are provided with an instrument checkout procedure in the instruction manual and a shorting strap for convenience in troubleshooting. Consult the manual for complete instructions and verify that the instrument operates as indicated and is stable in all steps.

Electrodes

1. Rinse electrodes thoroughly with distilled water.
2. Check electrode operation (slope).
3. If electrode fails this procedure, polish the chlorine electrode as directed in **Measuring Hints**.
4. Repeat step 2, **Checking Electrode Operation**
5. If the stability and slope check out properly but measurement problems persist, the sample may contain interferences or complexing agents, or the technique may be in error. See **Standard**, **Water**, and **Sample sections**.
6. Before replacing a "faulty" electrode, or if another electrode is not available for test purposes, review the instruction manual and be sure to:
   - Clean the electrode thoroughly
   - Prepare the electrode properly
   - Use proper solutions and standards
   - Measure correctly
   - Allow two minutes reaction time
   - Review Troubleshooting Checklist
   - Check voltage source

Voltage Source

Remove the voltage source 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. Turn the meter function switch 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 (Orion 977001). The lifetime of the voltage source is about one year.

Standard

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! Error may result from contamination of prepared standards, accuracy of dilution, quality of distilled water, or a mathematical error in calculating the concentrations.

Water

The water used to prepare standards and samples must be free of chlorine or chlorine demand. See **Required Solutions** for treatment of distilled or deionized water.

Sample

If the electrodes work properly in standards but not in sample, look for possible interferences, complexing agents, or substances which could affect response or physically damage the sensing electrode or the reference electrode. If possible, determine the composition of the samples and check for problems. See **Sample Requirements**, and **Interferences**.

Assistance

After troubleshooting all components of your measurement system, contact The Technical Edge℠ for Orion products. Within the United States call 1.800.225.1480, 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.

For the most current warranty information, visit www.thermo.com.

ELECTRODE CHARACTERISTICS

Electrode response

The electrode potential plotted against concentration on semilogarithmic paper results in a straight line with a slope of about 26-30 mV per decade. See **Figure 2**.

The electrode shows 95% response to a step change in concentration in less than one minute after the reaction between sample and iodide reagent is complete.

Reproducibility

Reproducibility is limited by factors such as temperature fluctuations, drift and noise. Within the electrode operating range, reproducibility is independent of concentration. With calibration every hour, direct electrode measurement reproducible to ± 2% can be obtained.

Temperature Effects

The electrode slope is independent of temperature, making it possible to calibrate with only one standardizing 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 bottle of standardizing solution to come to sample temperature before calibration.

The electrode can be used at temperatures from 0-100 °C, provided that temperature equilibrium has occurred. For use at temperatures substantially different from room temperature, equilibrium times of up to one hour are recommended. The electrode must be used only intermittently at solution temperatures above 80 °C.

Interferences

Strong oxidizing agents that can convert iodide to iodine, including iodate, bromine, cupric ion, and manganese dioxide, interfere with the method. These are interferences in all iodometric ASTM methods.

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

Chromate ion, an interference for the amperometric method, does not interfere with the electrode method. Color or turbidity are not interferences.

Electrode Life

Each electrode should last one year in normal laboratory use. In time, electrode slope will decrease and readings will start to drift, indicating that the electrode should be replaced. Before replacement, refer to **Troubleshooting Checklist** to verify that the symptoms are caused by the electrode.

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.

$$Cl_2 + 2I \rightarrow 2Cl^- + I_2$$

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.

$$E_1 = E_0 + \frac{S}{2} \log \frac{[I_2]}{[I^{-2}]}$$

$$E_1 = E_0 + \frac{S \log [I_2] - S \log [I^-]}{2}$$

where:

E_1 = potential developed by the platinum element
E_0 = a constant
S = monovalent electrode slope (58 mV/decade at 20 °C)
$[I_2]$ = iodine concentration
$[I^-]$ = iodide concentration

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

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

Where:
E_2 = potential developed by the iodide-sensing element
E_0' and E_0'' = are constants

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

$$E_1 + E_2 = \frac{E_0'' - S \log [I^-]}{2}$$

The combination of the platinum and the iodide-sensing elements thus 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 formed, iodide loss due to I_3^- formation is negligible. When this loss is not negligible, electrode response deviates from linear. 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 as Cl_2. Diluting more concentrated samples brings the level into the region of linear response.

WARRANTY

For the most current warranty information, visit www.thermo.com.

The Thermo Electron Corporation, Orion products warranty covers failures due to manufacturer's workmanship or material defects from the date of purchase by the user. User should return the warranty card and retain proof of purchase. Warranty is void if product has been abused, misused, or repairs attempted by unauthorized persons.

Warranties herein are for product sold/installed by Thermo or its authorized dealers.

Any product sold by a U.S. or Canadian distributor must be returned to Thermo for any warranty work. Please contact our Technical Service department for further information. A Return Authorization Number must be obtained from The Technical EDGE℠ For Orion Products before returning any product for in-warranty repair or replacement.

In the event of failure within the warranty period, Thermo will at the company's option, repair or replace product not conforming to this warranty. There may be additional charges, including freight, for warranty service performed in some countries. For service, call Thermo or its authorized dealer outside the United States and Canada. Thermo reserves the right to ask for proof of purchase, such as the original invoice or packing slip.

Field Service is available on Orion BOD AutoEZ™, EZ Flash® GC Accessory and TEA Analyzer®. Contact our Field Service department for details on quotations, service, other field service-related activities.

The following products are warranted to be free from defects in material and workmanship in the period listed below from the date of purchase from the user or from the date of shipment from Thermo, whichever is earlier, provided use is in accordance with the operating limitations and maintenance procedures in the instruction manual and when not having been subjected to accident, alteration, misuse, abuse or breakage of electrodes:

Thirty-six months from date of purchase by the user (or forty-two months from date of shipment from Thermo)

- Waterproof Meters (Orion 630, 635, 830A, 835A, 260A, 261S, 265A, 266S, 130A, 131S, 135A, 136S, 1230, 142 and 842), Conductivity Meters (Orion 105Aplus™, 115Aplus™, 125Aplus™, 145Aplus™, 150Aplus™ and 162A), PerpHect® pH/ISE Meters (Orion 310, 320, 330, 350, 370) pH/ISE Meters (Orion 210Aplus™, 230Aplus™, 250Aplus™, 290Aplus™, 410Aplus™, 420Aplus™, 520Aplus™, 525Aplus™, 710Aplus™, 720Aplus™ and 920Aplus™), pHuture MMS™ Meters (Orion 535A and 555A), pH/Conductivity Meter (Orion 550A), Dissolved Oxygen Meters (Orion 805Aplus™, 810Aplus™, 850Aplus™ and 862A).

Twenty-four months from date of purchase by the user (or thirty-six months from date of shipment from Thermo)

- Orion ROSS Ultra® Electrodes, AQUAfast® IV Colorimeters, AQUAfast® IV Turbidimeter, Orion 925 Flash Titrator™, Series 100 DuraProbe™ Conductivity Cells and Series 800 Dissolved Oxygen Probes.

Twelve months from date of purchase by the user (or eighteen months from date of shipment from Thermo)

- Laboratory pH Meters, (Orion 301, 611 and 940), SensorLink®, pHuture™ pH Meters (Orion 610 and 620), Smart Chek™ meters, Sage® Pumps, Cahn® Balances, 930 Ionalyzer®, 950 ROSS™ FAST QC™ Titrator, 960 Titrator PLUS®, Karl Fischer Titrators, Autosamplers, Liquid Handling Devices, Liquid Handling Automation Workstations (Orion AS2000, AS2500 and AS4000), Pumps (Orion SP201, SP201-HR, SP201-S, Peristaltic and Rinse), pHuture® Conversion Box, Wine Master®, 607 Switchbox, rf link™, AQUAfast® II Colorimeters, Vacuum Degasser and Flowmeter.

- Orion EZ Flash® GC Accessory, Orion TEA Analyzer® 610 and 510 excluding consumable items carry twelve months warranty only.

- Orion Ion Selective Electrodes, ionplus® Electrodes, ROSS™ Electrodes, Sure-Flow® Electrodes, PerpHecT® Electrodes, AquaPro Professional Electrodes, No Cal™ pH electrodes, Standard Line pH Electrodes, Tris pH Electrodes, KNIpHE® electrode, ORP Triode™ (Orion 9180BN), pHuture™ pH Probes (Orion 616500) and pHuture MMS™ Quatrode™ and Triode™ (Orion 616600 and 617900), Orion 97-08 DO Probe, Series 100 Conventional Conductivity Cells, temperature probes and compensators (except those products noted).

- Orion 93 and 97 ionplus Series sensing modules are warranted to give six months of operation if placed in service before the date indicated on the package, except 93-07 and 97-07 Nitrate modules are warranted to give ninety days of operation if placed in service before the date indicated on the package.

Six months from date of purchase by the user (or twelve months from date of shipment from Thermo)

- Orion Flash Titration™ Probe (Orion 092518), pHuture™ Electrode (Orion 615700), pHuture MMS™ Pentrode™ (Orion 617500), Quatrode™ (Orion 617800) and Triode™ (Orion 615800), Low Maintenance Triode™ (Orion 9107BN), ORP Low Maintenance Triode™ (Orion 9179BN), and PerpHecT® Low Maintenance Triode™ (Orion 9207BN), Waterproof Triode™ (Orion 9107WP, 9107WL, 9109WL and 9109WP), QuiKcheK® Meters and Micro Electrodes.

Three months from date of purchase by the user (or six months from date of shipment from Thermo)

- Economy Line Electrodes, Orion 91-05, 91-06, 91-15, 91-16, 91-25, 91-26, 91-35, 91-36, 92-06. Warranty also includes failure for any reason (excluding breakage), except abuse, provided the electrode is not used in solutions containing silver, sulfide, perchlorate, or hydrofluoric acid; or in solutions more than one (1) Molar in strong acid or base at temperatures above 50 °C.

"Out-of-Box" Warranty - Should any of the following products fail to work when first used, contact Thermo immediately for replacement.

- Orion Solutions, Standards, Reagents, Cables, Ferrules, Tubing, Line adapters, Printers, Software, Cases, Stands, Probe Membranes, AQUAfast® Test Strips, EZ Flash® columns, Liquid Handling Probes, Adapter Plates and Racks and general accessories.

For products in the catalog not listed in this warranty statement, please visit our website at: www.thermo.com

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ORDERING INFORMATION

Orion	Description
977000	Residual Chlorine Electrode with U.S. Standard Connector
9770BN	Same as 977000 with BNC Connector
9770SC	Same as 977000 with Screw Cap, Requires Separate Cable
977001	Voltage Source for U.S. Standard Meters
977007	Residual Chlorine Standard (KIO_3), 100 ppm as Cl_2, 475 mL
977010	Iodide Reagent (five 2-oz. bottles), for Cl_2 Electrodes
977011	Acid Reagent, 475 mL bottle
948201	Polishing Strips

SPECIFICATIONS

Concentration range	0.01 to 20 ppm as Cl_2 3×10^{-7} to 10^{-4} M (higher concentrations are read after dilution)
Temperature range	0-50 ˚C continuously; 50-100 ˚C intermittently
Electrode resistance	Less than 1 megohm
pH range	0-14; samples are buffered at pH 4
Reproducibility	± 2%
Slope:	28 ± 2 mV/decade of concentration
Size:	Electrode length: 110 mm (excluding cap) Diameter: 12 mm Cap diameter: 16 mm Cap length: 30 mm Cable length: 1 meter

Environmental Instruments
Water Analysis

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